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PULSE ENTOMOLOGY

Proceedings of the

GROUP DISCUSSION: PULSE PEST MANAGEMENT

ICRISAT Center
Patancheru, India

05-10 Dec 1983

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
ICRISAT Patancheru P.O.
Andhra Pradesh 502 324, India

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Edited by
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Introduction

Insect pests are known to cause severe losses of yield in the pulse crops, both in India where such crops are of particular importance and in the many other countries of the world where pulses are an important component of the agricultural production and in the diet of the people. There is an increasing need to increase the yields of the pulses to help provide an adequate and popular diet for our increasing populations. It will not be possible to increase production substantially without improved pest management. There is now a renewed interest in the development of practicable pest management in the pulses and there are many entomologists who are working towards this goal.

In this meeting we invited several of the more active and senior research entomologists who are working on pulses to join together in a discussion that would lead to the formulation of ideas and plans for improved research and development. The meeting was designed to give the entomologists adequate opportunity to interact, in the discussion room, in the fields and during the free time in the evenings. Much of the discussion centered upon the work that is in progress at ICRISAT and there were several valuable suggestions of ways in which ICRISAT could further benefit the programs of the national entomologists.

PROGRESS IN HOST PLANT RESISTANCE WORK AT ICRISAT

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The major pulse crops, pigeonpea (Cajanus cajan) and chickpea (Cicer arietinum) suffer great losses caused by insect pests, yet these are generally grown without pesticide protection in the farmers' fields. So, our aim is to provide the farmers with cultivars that are more resistant to insect pests and that yield more in the low input systems than the currently available materials.

For finding the sources of resistance to the major pests, particularly to Heliothis armigera in both these crops and also to podfly (Melanagromyza obtusa) in pigeonpea, we initiated two research projects in 1975, with the following objectives:

(a) To refine screening techniques and trial methodology.

(b) To screen and select material from the available germplasm, pathologists', breeders' and AICPIP material.

- that is resistant to individual pest attack;
- is less susceptible to loss caused by pest complex;
- is tolerant to pest damage (including compensatory habit);
- yields more than currently utilised cultivars under farmers' conditions of no, or minimal insecticide use.

(c) To investigate the effect of biochemicals in the plants on pests and their variability between cultivars.

(d) To supply the selected material to the breeders for incorporation into their programme of resistance breeding.

(e) To test the selections at various locations in India in close cooperation with AICPIP and at our sub-centers, for pest reaction in respect of varied geographic and climatic factors.

(f) to ascertain the mechanism of resistance in the selected material.

Pigeonpea:

As the major pests affect the crop only at the podding stage when the plants are large, open field screening appeared to be the only possible initial approach, particularly since the pests behaved atypically in field cages.

We developed a field screening methodology and a grading system (Lateef and Reed, 1980, 1983), that allows us to distinguish the different susceptibilities of pigeonpea to the major pests. The available germplasm of more than 8,400 accessions, as well as genotypes developed by our breeders, including *Atylosia* x *Cajanus* crosses and selections found resistant to various diseases have been screened. Genotypes that had less damage or better yields than the checks in pesticide free conditions have been further tested in replicated trials each consisting of a narrow range of maturities. Balanced lattice square designs have been found to give increased precision, hence, these are used to test the advanced selections, which are also compared under pesticide protection. The search was not only for resistance but also for the ability to compensate for early losses. The best of these selections are now being utilised by our breeders in crosses that are intended to intensify resistance and to combine it with other desirable traits. In the early and mid-maturity genotypes our efforts have been concentrated on resistance to *H.armigera* and in the late maturing types we have been more concerned with podfly resistance. We now have a number of genotypes with moderate resistance to each of these pests and also have resistance to both and multi resistance characters in few of our selections. Although we have selected some useful material from the *Atylosia* x *Cajanus* crosses, we have been at least as successful in selecting from the pigeonpea germplasm. We have also selected genotypes that compensate well for loss of the first flower flush to pests.

Results so far show considerable and consistent differences between plant types and selections in susceptibility to both pod borer and podfly losses, inspite of problems introduced by the high incidence of outcrossing and the considerable spatial and temporal differences in pest distribution.

Chickpea:

H.armigera is the dominant pest on chickpea in almost all areas where it is grown in the Old World so all of our efforts have been concentrated in a search for resistance to this pest. We developed an open field screening technique using natural populations of *H.armigera*, occasionally supplemented by laboratory reared insects. So far, we have screened the available germplasm, consisting of more than 12,000 accessions, and genotypes provided by our breeders and pathologists. Genotypes with less damage or greater yield than the relevant checks have been tested in replicated trials, each containing materials of a narrow range of days to maturity. In these trials we have identified lines with considerable differences in their susceptibility to *H.armigera*. The best of these have been handed over to our breeders who have been crossing these in an attempt to intensify the resistance. As most of our selections have been found to be very susceptible to *Fusarium* wilt, they are being crossed with wilt resistant genotypes. We are now screening progenies from the crosses. Unfortunately single plant selection from segregating populations has proved to be difficult, for we have found very high coefficients of variation in the percentage of pod damage among individual plants. Our tests have also shown that the differences in percentage pod damage are much less when resistant and susceptible plants are alternated in plots than when whole plots of resistant and susceptible plants are grown. We need to find means of improving upon our single plant selection so that this work can go ahead with more precision.

We have been testing our materials at Hissar and at several other locations in India through the AICPIP entomologists. Our early maturing resistant selections have been found to be resistant at locations in southern India. At Hissar and other locations in northern India, these early maturing selections have not been so impressive, but in general the resistant and susceptible materials retain their relative rankings of pest damage percentage.

__Mechanisms of resistance studies__:

We are collaborating with the Max-Planck Institute, Munich, West Germany, and our Biochemistry Unit, in attempts to determine the mechanisms of resistance, which could allow us to reduce our dependence on field screening.

Preliminary studies of the methanolic pod washate and extraction of essential oils from the leaves of certain pigeonpea cultivars have shown that some volatile substance attracts the __Heliothis__ moths for oviposition.

In chickpea, all the green parts have a dense cover of glandular hairs which exude a very acidic liquid. This exudate, with a pH of approximately 1.3 and a high content of malic acid, is thought to be a factor in limiting the range of pests that attack this crop. There appear to be differences between cultivars in the amount of concentration of the exudate and this may be associated with the differences in observed susceptibility. Further, intensive studies are underway to establish such differences.

Our field and laboratory studies have shown that there is oviposition preference in pigeonpea to the susceptible genotypes. antibiosis was recorded in some of the wild relatives of pigeonpea, particularly in __Atylosia scarabaeoides__.

In chickpea, fewer larvae were recorded on the resistant cultivars. We also found variability in concentration of acid exudate in respect of climatic variations, locations and age of the crop.

Now most of our work is transferring from germplasm screening and testing to selection from the progenies provided by our breeders. This process is slow and difficult. However, we do have encouraging results showing through. We do not expect to produce plants that are high yielding, tasty and totally resistant to pests. We may however, produce cultivars that either suffer much less damage or to recover quickly enough to produce worthwhile crops in the presence of the pests and diseases.

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GERMPLASM : A RESOURCE FOR PULSE ENTOMOLOGISTS

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Available pulse genetic resources:

Genotypes of crops differ in their susceptibility to pests (and diseases). Large germplasm collections are now available with ICRISAT Genetic Resources Unit, which include worldwide collections of pigeonpea (ca 10,000 accessions) and chickpea (ca 13,000 accessions). ICRISAT has the world mandate to collect, maintain, evaluate, document and supply these genetic resources to scientists and scholars in developing and the developed countries. In addition we maintain 134 accessions of 37 wild species in 6 genera related to pigeonpea, and 47 accessions of wild *Cicer* spp. Perennial *Cicer* species, however, are difficult to maintain.

Maintenance and evaluation.

Depending upon demand, pulse samples are grown when needed for agro-morphological characterization and supply. Characterisation is done according to the descriptors and descriptor states developed at ICRISAT in consultation with many breeders and other pulse scientists (IBPGR/ICRISAT, 1981). Further screening is done by other disciplines, such as screening for *Heliothis* resistance. ICC-506 (P-12475 from Andhra Pradesh) is an example of success by screening a large collection, and careful verification over seasons. Our seeds are conserved at +4 C and 30-35% RH, and their viability will most probably exceed 20-25 years. Long-term cold storage (-20 C) is under construction.

Use for pulse entomologists:

Pulse entomologists screen germplasm to find host plant resistance in their respective areas. It is also their task to study pest epidomiology, alternate hosts and migration. In this respect the wild relatives also play a role. Some wild species are resistant or have antibiosis against e.g. pod borers and podflies, although most *Cajaninae* are also attacked to some extent by pigeonpea pests. This has been observed during collection trips, and verified by entomologists. For instance, *Atylosia scarabaeoides* has a thick pod wall and anti-feeding properties which are still under investigation. Host specificity often restricts pest to attack only pigeonpea and wild pigeonpea or somewhat more distantly related genera in the subtribe *Cajaninae*. The prime and most useful resource is the collection of cultivated genotypes, however, differences in susceptibility have been found. Contributing to tolerance may be the hairiness or lack of it, and glandular secretion of acids. Some observations on the presence of pests on wild chickpeas have been reported by van der Maesen (1979). Rough and tuberculated seedcoats (e.g. *Cicer bijugum*, *C. echinospermum*) have deterred oviposition by storage seed beetles (Bruchids). The attributes of wild relatives of pigeonpea have been discussed by Remanandan (1981).

The following table lists some of the germplasm lines selected by the ICRISAT pulse entomologists as resistant or tolerant to pests, lepidopteran borers, particularly *Heliothis armigera*, and podfly, *Melanagromyza obtusa*.

PROMISING SELECTIONS FROM THE GERMPLASM

Lines with low incidence of podborer		Podfly
Pigeonpea	Chickpea	Pigeonpea
ICP-810-E1	ICC-12475	ICP-909-E3
909-E3	to -12496	1691-E1
1903-E1		1811-E3
4070-E2		3009-E3
5036-E2		4307-E3
8127-E3		6840-E1
8229-E1		7537-E1
8325-E1		7941-E1
8583-E1		7946-E1
8595-E1		
8606-E1		
10466-E3		

Seed supply: As the collections are large, only small quantities of seeds can be stored and supplied. Usually 100-200 seeds are sent. Large amounts of samples are more difficult to supply, and not easily handled. Please direct your requests to the Genetic Resources Unit, ICRISAT and specify the number of samples, any restrictions on duration and morphology you may wish to apply, and furnish information about the purpose of the request. Through the IDMRS retrieval system the computer can select those accessions falling within a specific range. The descriptors and descriptor states (ICRISAT/IBPGR, 1981) facilitate the use of common denominators. The GRU would also be pleased to receive any genotype you have collected or selected as tolerant to pests, for maintenance and conservation.

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CHICKPEA BREEDING IN RELATION TO PEST MANAGEMENT

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INTRODUCTION

For many reasons, including the size and mobility of many pests, host plant resistance to insects has proved much less tractable in crop improvement than disease resistance. Nevertheless, sufficient examples of economically worthwhile and durable resistance in plants to insect pests have been documented to indicate host plant resistance as worthy of consideration as a component of pest management.

Here, I wish to use our attempts at ICRISAT to breed for resistance in chickpeas to *Heliothis armigera*, which because of its polyphagous nature is probably more difficult than other more specific pests, to illustrate the rationale used by breeders to determine whether to initiate a breeding program and some of the problems faced and the assistance needed in conducting an effective breeding program for insect resistance.

BREEDING OBJECTIVES

In establishing breeding objectives, the breeder has three main questions. These are:

1. Is the objective important?
2. Is there sufficient plant variability to give a reasonable expectation of achieving the objective?
3. Are there methods available for selecting in breeding populations for the required plant characteristic?

For *Heliothis* resistance in chickpeas the answers to some of these questions are not clear. Undoubtedly *Heliothis* is the main pest of chickpeas in terms of its occurrence and damage caused. However, surveys by our entomologists, if they provide an accurate assessment of crop loss, suggest that percentage pod damage in farmers' fields in India is relatively small, ranging from 0 to about 30% with a mean of 8%.

The absolute cost of conducting a breeding program is a negligible proportion of even the smallest loss caused to an important crop - for example here, 8% of six million tonnes is almost a half million tonnes worth about US $ 150 million annually to India alone and almost as much as the cost of running the entire international agricultural research system.

More important are: 1. whether resistance can be incorporated without sacrificing existing yield levels, which is not always possible, and 2. whether other breeding objectives would give a better return on our resources.

For national programs such considerations are extremely important and may preclude the initiation of a program - such activities therefore become very firmly the responsibility of the international network, developing resistant sources and making them available to national programs.

With regard to the availability of resistance there seems little doubt that worthwhile levels exist. Several germplasm accessions and breeding lines identified by our entomologists have given consistently less than 10% pod borer damage in unsprayed conditions when the best adapted cultivar has recorded between 15 and 18% damage.

We do not know the basis of the resistance. Polyphenols, malic acid and other plant chemicals have been variously implicated, conditioning both antibiosis and preference mechanisms. Genotypes which produce good seed yields despite high borer damage suggest tolerance mechanisms may also occur. Avoidance may be feasible in north India, by the utilization of short duration cultivars which can mature before pest populations reach damaging levels.

Whatever the mechanism, the most important consideration is whether we can effectively select for resistance in breeding populations. Evidence from entomology and breeding studies is not encouraging. At present, only field screening is possible, and although it has enabled the selection of genotypes exhibiting reduced borer damage, the variation within and between seasons in _Heliothis_ incidence and damage caused is too high to allow effective selection for resistance in breeding populations. In particular, plant to plant variation is extremely high and is a major hindrance in breeding.

BREEDING FOR RESISTANCE

Since 1978, we have made 220 crosses in breeding for _Heliothis_ resistance: 98 have been in diallel combinations, to study the inheritance of borer resistance and to recombine different sources of resistance in an attempt to strengthen existing levels; 101 have been with adapted cultivars to transfer the trait to different agronomic backgorunds; and, 21 have been made to combine _Heliothis_ and wilt resistance to which most of the _Heliothis_ resistant lines are highly susceptible. Different parents have been used as new sources of resistance have been identified and confirmed. They include desi and kabuli and short to long duration types.

The evaluation of breeding populations has been conducted entirely in unsprayed conditions in the field at a spacing of 60 x 20 cm. The general procedure has been to visually select on the basis of borer damage, including badly damaged plants for comparison, and total pod number. Percent damaged pods and seed yields are then recorded for each plant. Those either combining less than 10% damage and good seed yield or with very heavy seed yields irrespective of pod damage are advanced for further testing. A few high borer plants are usually included for comparison.

Using these methods, we have screened 227 F2s and 5131 F3 and more advanced progenies. In the F2s, population sizes of 200 to 500 plants have been maintined depending on seed availability. Progenies are sown in single rows of 4 m length with Annigeri and K-850 every 20 progenies for comparison. Two sets are sown. Earlier, screening was practised only at Hyderabad, but from 1982 onwards, F4 and more advanced progenies are separated according to duration and long durationprogenies are now being screened at Hissar.

In the progeny rows, percent borer damage has been determined on five random plants of 100 or more rows in each planting to compute correlations among generations and between plantings. Last season, we bulked progenies which have exhibited low borer damage across generations and these are now with the entomologists for replicated evaluation.

In the general breeding program we are now also selecting our single plants in unsprayed conditions and growing one planting of F5 to F7 progeny rows without insecticide in order to eliminate highly susceptibles.

INHERITANCE STUDIES

The parents and F1s of several diallel series, both desi and kabuli and of differing duration, have been used to examine the nature of inheritance. Indications from them are similar and are illustrated by data from trials of desi crosses conducted at Hyderabad in 1980-81 and 1981-82.

In both trials, there were significant differences in borer damage among entries, despite a very high c.v. in 1981-82. In 1980-81, the two high borer parents showed significantly higher borer damage than the others, in accordance with expectation. In 1981-82, although all the parents were considered to be low borer, one of them had significantly greater borer damage than the others and similar to that of the high borer check, Annigeri. In both years, the F1s tended to be intermediate between their parents and general combining ability variances were significantly greater than zero and much larger than variances due to specific combining ability.

These data are encouraging because in spite of the variability we are encountering and the quantitative nature of the variation, there does appear to be a genetic basis for borer damage and the genetic variation is mainly additive so can be handled by conventional breeding methods.

EFFECTIVENESS OF SCREENING METHODS

Comparisons of the percent borer damage of plants selected visually for low or high borer damage indicate that visual selection can effectively separate low and high borer damaged plants so that tedious and lengthy counts of damaged and undamaged pods are unnecessary and the selection process can be speeded up.

However, the repeatabilities of borer damage scores, both within and between seasons, are not high. One example of this variability is illustrated by a comparison of the borer damages for some F2 single plants in 1979-80 and their F3 progenies in 1980-81. While some maintain low borer damage across the two seasons, some which were low in F2 are high in F3 and others which were high in F2 show low damage in F3.

There may be several reasons for such variability but the most likely cause is field variability in insect infestations and this is illustrated by the variation in the percent borer damage of Annigeri which, in these tests ranged between 13.1 and 21.2% but in others has been even greater (from virtually zero to 60%). Segregation in early generations and the small sample sizes used to estimate the borer damages of the progeny rows are other sources of variation.

Whatever the reasons for such variability, the correlations among generations, although usually significantly greater than zero, are low and account for only a minor proportion of the variation in borer damage. Furthermore, they become smaller with increasing difference in generation. Correlations among different plantings in the same years are larger but, the heritability of resistance is extremely small, so that selection for the trait will be ineffective and expected genetic advances small. Thus, while in F5 progenies of the first crosses made, 65% of the individuals sampled showed less than 10% borer damage, in the earlier F3 and F4 generations the percentages were only 35% and 30% respectively, following selection of plants all of which had less than 10% borer damage in F2.

OTHER CHARACTERS

A further problem is to combine *Heliothis* resistance with other desirable characters. To date, most of the work has been confined to Hyderabad and while the resistance of short duration types adapted to peninsular India has been firmly established, the resistance of medium and long duration types suited to central and northern India requires confirmation.

It has also become evident that the genotypes with the most resistance to pod borer are also highly susceptible to fusarium wilt. We are therefore screening progenies of earlier crosses in a wilt sick plot at Hyderabad and have identified single plants and progenies with wilt resistance and these are being screened for pod borer resistance in the unsprayed area and again for wilt resistance to identify those progenies which combine the two resistances. We have also intercrossed wilt and pod borer resistant genotypes and their F2s are being screened initially for wilt resistance and F3 progenies for resistance to pod borer and wilt.

PROSPECTS

Good sources of resistance to pod borer have been identified and these have been incorporated in breeding programs. While borer damage is highly variable probably due to variability in insect infestations which will make effective screening for resistance extremely difficult there have been some encouraging signs.

The trait has been found to be heritable and under predominantly additive genetic control and so is theoretically manageable by conventional breeding techniques. Furthermore, while there was little progress from selection in F2 and F3, correlations among generations are positive and usually significant and by the F5 generation selection had been effective in increasing the proportion of individuals with less than 10% borer damage to about 0.65. Thus, although we can expect many escapes, especially in early generations, repeated selection for low borer damage will be effective in identifying resistant genotypes. However, the effectiveness of the selection and the efficiency of the program would be considerably improved if we could ensure more uniform field infestations of Heliothis larvae or had laboratory or biochemical screening procedures.

One other point. Breeders are frequently accused by entomologists of producing high susceptibility by breeding under an insecticide umbrella. I believe this is rarely the case and it should be remembered that the breeders have many characters to consider and there will always be some materials that require protection. In chickpeas, I believe we have a situation where borer susceptibility ranges between moderate and very high and that the level of insecticide protection usually given is low enough to allow these differences to be expressed and the discarding of the high susceptibles merely because they yield poorly. In support of this, in tests of low borer and breeders' lines in sprayed and unsprayed conditions, we find little evidence of interactions between genotypes and insecticides, although Annigeri does yield poorly without protection and responds better to insecticide. Similarly, many of the low borer lines listed by entomologists are in fact selections from the breeding program. Thus, there is little evidence that in chickpeas, we have selected for high susceptibility - our problem now is how to move towards higher resistance.

Finally, we should keep the problems of breeding for *Heliothis* resistance in proper perspective. Breeding for seed yield is a major objective of most plant improvement programs, yet in these studies in no case was there a positive correlation among generations nor between plantings of the same generation for seed yield. If we are to question the effectiveness of breeding for *Heliothis* resistance, we should certainly query the utility of breeding for yield.

PROGRESS IN RESEARCH ON BIOLOGICAL AND CULTURAL CONTROL OF PULSE PESTS AT ICRISAT

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Introduction:

The scope for biological and cultural control is obviously limited to only as supporting the impact made by resistant varieties and/or insecticide use in our pulse crops. Research at ICRISAT during 1976-83 has been mainly directed towards collecting basic information, and the 'action phase' is yet to start. We have collected extensive data on natural enemy activity within and between seasons to understand the variations and gaps in the natural control of pests. The Pulse Entomology unit studied a number of pests in the sole crop situation, while our Cropping Entomology unit provided substantial base data on natural enemies of *Heliothis* in relation to intercropping. The points mentioned in this write up are based on the contribution by both these units at ICRISAT.

Basic information on complexity of natural enemy activity:

Natural egg parasitism of *Heliothis* was found to be very low (generally below 1%) in both chickpea and pigeonpea. Larval parasitism of *Heliothis* in different months (1977-82) ranged from 2 to 42% in pigeonpea with many species emerging dominated by dipterans, particularly *Carcelia illota*. On chickpea, the parasitism ranged from 0 to 19% in the same period, with fewer species emerging and the hymenopteran parasites were dominant, particularly *Campoletis chlorideae*. In pigeonpea, there was a drop in larval parasitism observed in November/December and ascending to greater levels during January/February.

We examined the parasitism of podfly (*Melanagromyza obtusa*), which was very little understood. Our extensive sampling has shown the occurrence of *Ormyrus* and *Eurytoma*, in addition to *Euderus* which was the only genus reported previously on this pest. A cooperative survey with AICPIP entomologists confirmed that all these parasites are fairly well distributed in most pigeonpea growing regions, accounting for 10 to 20 parasitism.

We observed that the other pests like plume moth (*Exelastis*) and leaf tier (*Cydia*) also were parasitised, but the parasites on them did not shift to *Heliothis*; nematodes (*Hexamermis*/*Ovomermis*) do occur in several lepidoptera including *Heliothis*, early in the season but are seldom found active later. Only an ichneumonid (*Eriborus*) and tachinid (Palexorista) occur on both *Heliothis* and *Adisura*, both these pests occur almost together during the fruiting phase of pigeonpea and so offer little scope for useful shift.

The natural enemies of *Heliothis* infesting sorghum do not seem to be shifting effectively on to the same host on the later fruiting pigeonpea, though available in the same location. Egg parasites (*Trichogramma*) do not transfer to chickpea also, while the dominant larval parasite (*Campoletis*) is seen to be active on chickpea. This parasite was also seen to be able to survive on 20 different plants all through the year following its host (*H.armigera*). Such data are available for number of *Heliothis* parasites. Of the 27 species of parasites found on *H.armigera*, 8 were detected also on *H.peltigera* (mainly on safflower), and 5 on *H.assulta* (mainly on *Datura* weed). On *Campoletis*, 10 species of hyperparasites were observed to occur.

Limited attention was also paid to the study of predators. We now know of the potential of a number of arthropods and a few birds as predators on *Heliothis*. Sampling methods were evaluated for a new common group of predators. We attempted some quantification of predation by birds by covering strips of infested crops of chickpea by bird proof netting.

Increasing the plant density and introduction of resistant cultivars resulted in some reduction in *Heliothis* parasitism, but this effect was too small to be considered important.

Efforts towards manipulation of natural control:

Introduction of a tachinid parasite (*Eucelatoria bryani*) from the USA was evaluated for four seasons. While several interesting results were obtained in laboratory and field cage tests, besides successful rearing of over 60 continuous generations, we could not get them to establish in our fields. The evaluation of other promising exotic agents may be taken up soon.

The natural egg parasitism is low in pigeonpea, and laboratory tests suggest repellancy to be mainly from the pods. We recently initiated a collaborative study of several varieties to see if ther are chances to employ varieties which are less repellant to such egg parasites (*Trichogramma* species).

Limited testing has been made to confirm the utility of virus (NPV) in *Heliothis* control on chickpea.

Scope for cultural control:

The major thrust is on employing beneficial cropping systems and cropping entomologists have produced considerable data on intercropping. We also studied the effect of a range of plant densities in pigeonpea (2.2, 4.4, 13.3 and 26.6 plants/m) and chickpea (8, 16, 33 and 67 plants/m), with several cultivars, under pesticide free conditions. There was generally no benefit apparent in such manipulations. The *Heliothis* populations increased with closer spacing, but with no significant change in % pods damaged and/or yield. Tests with resistant versus susceptible cultivars also indicated that there were no substantial changes in pod damage (at harvest) due to these plant density alterations.

The gaps and the scope for future work:

We have yet to identify economical methods of augmentation of the native natural enemies. These may include cheap mass rearing and release systems, besides others. We may continue to monitor the impact of promising practices/inputs/cultivars on the natural enemy activity, so to be least disruptive to naturally occurring biological control. We could be considering more actively the utilisation of virus in *Heliothis* control.

PROSPECTS FOR NATURAL ENEMY UTILISATION IN PEST MANAGEMENT ON PULSES

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Introduction:

Grain legumes form an important part of the essential diet of vast numbers of people in the tropical countries, where they are mostly cultivated by farmers in small holdings with inadequate provision for effective control of pests that often cause serious yield losses. Chickpea (*Cicer arietinum*) and pigeonpea (*Cajanus cajan*) are grown over about 10 million ha in India, the former occupying about three-fourths of the area. They are also cultivated in many other countries. The potential of high-yielding crop varieties is not always matched by resistance to pests and pathogens or by the available agricultural inputs such as water, fertilizer and pesticide that are generally beyond the reach of poor farmers, even assuming that all these will be used rationally. According to a recent estimate (Reed and Pawar, 1982), the annual loss caused by *Heliothis armigera* (Hb.) to chickpea and pigeonpea in India may exceed $300 million. This is only one of the major pests of these crops. Others undoubtedly add to this enormous loss. Therefore, pest control measures will have to be adopted and the present strategies improved to maximise pulse production. The best approach to this goal is through pest management, including the utmost utilization of existing and promising additional biological control agents in a manner that reduces the recurring investments in pesticides and equipment and at the same time helps to maintain the ecological balance in the crop fields. The role of biotic agents in integrated control of pests has been discussed by the author elsewhere (Sankaran, 1977). In this brief paper the possibilities of using indigenous and introduced natural enemies of the more important pests of chickpea and pigeonpea are considered.

Key Pests of Chickpea and Pigeonpea:

In India chickpea and pigeonpea are both attacked by a large number of insect pests, mostly polyphagous species causing only minor or localised damage, and many of them are common to these two crops. However, pigeonpea attracts a larger complex of defoliating, pod-boring and sap-sucking insects. *Heliothis armigera* is considered to be the most destructive and widespread pest of both pulses. The podfly *Melanagromyza obtusa* (Mall.) is the second most common pest. The pyralid borers *Etiella zinckenella* (Treit.), *Marasmarcha pumilio* (Zeller) and *Maruca testulalis* (Geyer) are an important group of pests attacking both these pulses while the plume moth complex consisting of *Exelastis atomosa* Wlsm., *Sphenarches anisodactylus* Wlsm. and *S.caffer* Zeller, with their larvae inflicting similar damage, is confined to pigeonpea (Davies and Lateef, 1975).

Pod losses due to *M.obtusa* may be as high as 86% and due to *E.atomosa* 20%. Available information on the biology of these pests has been summarised by Saxena (1978) and Davies and Lateef (1978). *E.zinckenalla* and *M.testulalis* have a wide geographical distribution spanning Africa, Asia, Australia and the Americas, that of the former pest even extending to Europe. *H.armigera* is cosmopolitan, extremely polyphagous and often migratory. These three pests have been more closely and extensively studied than the others.

Davies and Lateef (1975) have also pointed out some of the lacunae in our knowledge of these pests, for example, how some of the species carry over from one crop season to another during the dry season. The first international workshop on *Heliothis* management has brought together a large volume ov valuable data (ICRISAT, 1982).

Assessment and Use of Indigenous Natural Enemies:

Surveys carried out by CIBC and ICRISAT entomologists and others in India have shown that *Heliothis armigera* has a large complex of native parasites and predators and there is similar information for *Heliothis* spp. in Eurasia, the USA and other countries. Several tachinids attacking *Heliothis* spp. are known from Central and South America (King *et.al*, 1982; Greathead and Girling, 1982). The absence or low incidence of egg parasitism of *H.armigera* by *Trichogramma* on chickpea and pigeonpea has been known for some years and is considered to be a factor contributing to the build-up of large populations resulting in heavy yield loss (Bhatnagar, 1981; Yadav and Patel, 1981). Sithanantham (1981) found that the females of *Eucelatoria bryani* Sabrosky, a neotropical tachinid that was introduced into India by CIBC and later became established in the field, preferred the larvae of *H.armigera* on pigeonpea to those on chickpea. Similar studies on all indigenous (and introduced) parasites would indicate their limitations in checking the same host insect on various alternative plant hosts. Chickpea plants produce an exudation containing malic and oxalic acids (Purseglove, 1968), which may discourage some species of parasites. Susceptible and resistant varieties of crops show differential levels of parasitims of pests. Such plant characteristics and various aspects of plant/pest/parasite inter-relationship should be investigated before augmentative and inundative releases of native parasites are carried out.

H.armigera and *Maruca testulalis* have a very wide host plant range, although the latter is mostly restricted to the family Papilionaceae (Taylor, 1978). Our knowledge of the parasites of *Melanagromyza obtusa* and Pterophorid pod borers is meagre. Some of the important parasites of *Etiella zinckenella* and *M.testulalis* are listed in a status paper of CIBC (CIBC, 1978). Very little is known about the parasites that are specific to *M.testulalis*.

There is considerable scope and urgent need for intensifying research studies on the natural enemies of the major pests of chickpea and pigeonpea. Conservation and augmentation of native natural enemies are valuable aids in pest management and should not be impaired by incompatible pesticide treatments. Farmers are often persuaded to use pesticides that are readily available in the local market but not really effective, and safe to non-target organisms. Official recommendations and regulation of pesticide usage have therefore to be carefully enforced to ensure the success of pest management objectives. Some basic information on the relative toxicity of several categories of pesticide to arthropod parasites and predators is already available (Croft and Brown, 1975). It is also desirable to select strains of natural enemies that are resistant to pesticides and to use them.

Techniques for mass-breeding of hymenopterous and dipterous parasites of _Heliothis_ are known and can be employed in inundative release programmes. Bennett (1960) has described the methods used for breeding six common species of parasites of _Ancylostomia stercorea_ (Zell.), which are worth trying, with modifications if necessary, for parasites of other lepidopterous pod borers of chickpea and pigeonpea. _A.stercorea_ is a pest of both these pulses in Central and South America. Among predators, _Chrysopa_ spp. are amenable to mass-breeding and have been used aginst _Heliothis_ on cotton. Their use on pulse crops merits consideration. Wherever methods of large-scale production of natural enemies have been standardised they could be taken up by commercial insectaries for extended use by farmers.

The potential of microbial control agents is yet to be fully exploited in India. A nuclear polyhedrosis virus of _H.armigera_ has given promising results in field trials on chickpea (Narayanan, 1980). _Bacillus thuringiensis_ Berliner merits field evaluation against lepidopterous pests of chickpea and pigeonpea but has become the target of much ill-founded criticism of it as a threat to the silk industry. Mulberry is grown only in certain limited areas and sericultural operations are mostly carried out away from crop fields. An expert committee set up by the Indian Council of Agricultural Research with Dr.H.R.Arakeri as its chairman weighed all the evidence from various sources and conclusively recommended that _B.thuringiensis_ is safe and suitable for use in crop protection in India.

Introduced Natural Enemies in Pest Management:

Introduced parasites have been used successfully to control grain legume pests in some countries. Once established, an introduced species becomes an integral part of the ecosystem and therefore subject to interaction with other factors of the environment in the same way as native biocontrol agents are. In several instances of successful classical biological control occasional disruptions, such as the subsequent use of non-selective pesticides against the same or other pests and the removal of wild plants that may be used by the adults of certain parasites as sources of nectar, etc., may cause upsurges in pest population by acting adversely on the natural enemies. Classical biological control and pest management strategies should not be viewed as being mutually exclusive in their scope and the concept of pest management as only including the utilisation of native natural enemies. Introduced natural enemies, to be successful in controlling the target pests, have to possess advantageous intrinsic characteristics, such as high reproductive potential, ability to search for their host/prey even at low density levels, and adaptability to the physical environment. If species having these superior traits are available they would be of greater value than native species in pest management.

Three notable examples of successful biological control of grain legume pests by exotic natural enemies are the control of *Etiella zinckenella* and *Maruca testulalis* on pigeonpea in Mauritius by parasites of *Ancylostomia stercorea* introduced from Trinidad, that of the beanfly *Ophiomyia phaseoli* (Tryon) in Hawaii by parasites brought in from East Africa, and of *Epilachna varivestis* Muls. in the USA by a parasite shipped from India. With the last of these pests the introduced parasite is unable to survive the winter and is being released inoculatively every year. The parasite has high fecundity and host-searching ability which help it to prevent pest build-up (Stevens *et.al*, 1975). However, the search for additional natural enemies has continued and an ectoparasitic mite from Central America has also been introduced into the USA and is being evaluated.

These examples would show that concerted efforts to introduce promising additional parasites against pests of chickpea and pigeonpea in India and other countries are warranted. The National Centre for Biological Control, Indian Institute of Horticultural Research (IIHR), Bangalore, has arranged with CIBC to obtain three species of hymenopterous larval parasites of *Heliothis*, namely *Apanteles marginiventris* (Cresson), *Campoletis flavicincta* (Ashm.) and *Chelonus insularis* Cresson, from the neotropical region. A laboratory colony of the first of these has been established at IIHR. All the three species are polyphagous. Nucleus stocks of *Apanteles kazak* Telenga and *Hyposoter didymator* Thbs. from southern Europe are expected to be imported shortly through the CIBC Station in Switzerland. Both these parasites have been shipped to Cape Verde Islands during 1982-83. In New Zealand A.*kazak* released against H.*armigera* during 1978-80 was first recovered in 1981 and has since then spread to new areas, giving up to 60% parasitism (CIBC Annual Report, 1982-83). A number of of other potentially valuable parasites of *Heliothis* exist in different areas (ICRISAT, 1982) and these should be tried in others where they are absent.

Melanagromyza obtusa is not known to be a pest outside the Indian sub-continent. Parasites of related beanflies occurring in other parts of the world should be investigated and evaluated as possible biocontrol agents against M.*obtusa*. Similarly, the natural enemies of plume moth borers require detailed studies and assessment.

The chances of successful natural enemy introductions are directly proportional to the magnitude of the efforts made to study, obtain and evaluate the maximum number of promising species. The present scale of operations in relation to pulse pest management is inadequate. In view of ICRISAT's special concern with pests of chickpea and pigeonpea it is suggested that it may include the introduction of natural enemies of these pests in its on-going programmes. ICRISAT Center at Patancheru has a quarantine facility working in close collaboration with the Plant Protection Adviser to the Government of India who is the authority vested with statutory power to permit the introduction of exotic beneficial organisms into this country. CIBC will be in a position to assist with the study, selection and supply of natural enemies for use in pulse pest management.

Discussion:

Pest management techniques call for adequate scientific knowledge of pests in relation to their natural enemies, including a proper assessment of the control value of native parasites, predators and pathogens, and of the ways in which existing species may be made more effective and also more efficient species can be introduced from other areas, if possible, to give better results. Predators are general feeders but some of them are very important and amenable to manipulation and augmentation by artificial methods. However, very little has been done to explore this aspect in the control of pulse pests. Such work has been done mostly for pest management in cotton. The prospects for introducing additional predators to control pests of chickpea and pigeonpea are not very encouraging. With the information already available concerning the parasites of *Heliothis armigera* and related species in India and other countries the transfer of promising species from one area to another is feasible and could be taken up immediately. More extensive surveys and detailed studies on other lepidopterous pests and on beanflies and their natural enemies are necessary and should receive high priority in future research programme. The successful biological control of some of the major legume pests in Mauritius, Hawaii and continental USA has demonstrated the benefits of natural enemy introductions and the prospects for this approach as a tool in the management of pests of chickpea and pigeonpea. Since these two crops are mostly grown in small holdings by farmers with a low income, natural enemy introductions are possible only with institutional support. Other complementary practices like the use of resistant varieties, conservation of native natural enemies, and change in crop schedule etc. are best organised through farmers' cooperatives and extention agencies. Commercial insectaries have a useful role to play in promoting inundative releases of native natural enemies.

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PROGRESS IN INTERCROPPING AND INSECTICIDE WORK AT ICRISAT

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Intercropping - pest and parasitoids:

Intercropping, growing two or more crops together on the same piece of land, is an age old practice evolved in the farmers' fields. There is no doubt about the merits of this system over the sole system in many traits including insect pests and diseases. The reason why crops like pigeonpea are largely grown as intercrops while crops such as chickpea are grown as sole crops have been explained in the literature.

Intercropping at ICRISAT is being researched largely for its development so that the farmers can derive maximum benefit from it. All aspects including entomology are being studied before an orderly developed intercropping system is recommended to the farmers. Until now, the most studied intercrops are sorghum/pigeonpea and maize/pigeonpea. Millet/pigeonpea, groundnut/pigeonpea, blackgram/pigeonpea etc. are now being studied.

We have, over the years, largely studied *Heliothis*, which is a pest of all crops, and in intercrops is common to both the components. *Heliothis* and its parasitic and predatory fauna did not show much variation in sole and intercrops although [illegible] some effect on other pests which are specific to individual crop components. We recorded the parasite complex of *Heliothis* to be different in cereals and pigeonpea. Hymenopteran parasites, including the egg parasites *Trichogramma* spp, which are most common on cereals do not transfer subsequently to pigeonpea which picks up *Heliothis* attack with the harvest of the cereal. Dipteran parasites are seen largely on pigeonpea.

Insecticide use in pigeonpea:

Unlike many other crops, pigeonpea is highly attacked by insects. The pod borer *Heliothis armigera* which attack the crop in flowering and podding stage damage the crop heavily. In the absence of insecticide application, the complete crop is lost to this insect in some years. Most farmers, in spite of awareness of this damage, do not apply insecticide on this crop and those who do often fail to get good control. The reasons for this have been studied at ICRISAT, and practical solutions have been worked out for the benefit of the farmers. We advocate the following to the farmers.

1) Intercropping the pigeonpea with sorghum, maize, millet, blackgram, greengram or soyabean involving the combination as 1 row of pigeonpea and 2 rows of the other crop. With the harvest of the

companion crop which is normally before flowering of pigeonpea a sufficinet space is obtained between the rows of pigeonpea. This eases the maneuvering of the spray machine through the crop.

2) Ultra low volume spraying using the controlled droplet application technique wherein a light and handy spray machine is used has been tested successfully. This has no problem of manoeuvering through the crop, and has no requirement for a high volume of water.

3) It is essential to use a suitable insecticide, formulation, and dosage. Timing the application with egg and larval counts in the field will give the optimum results.

We have now researched these aspects enough at our research center and have been taking up demonstrations in the farmers' fields under our on farm research project going on in different states in India for the transfer of the Vertisol watershed technology developed by ICRISAT.

SUMMARY OF CHICKPEA PEST MANAGEMENT RESEARCH IN NORTH AFRICA AND WEST ASIA

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In North Africa and West Asia, kabuli type chickpea is largely grown and the crop has few insect problems. The chickpea leaf miner, Liriomyza cicerina Rond. and the pod borer, Heliothis spp. are the most important field pests in the region. In storage Callosobruchus chinensis L. is the predominant species. Research on these pests of importance in this region and their management is in progress at the International Center for Agricultural Research in Dry Areas (ICARDA).

Yield losses due to leaf miner and pod borer attack have been calculated as 18% in winter planting and 20 to 25% in spring planting. Repeated yield trials have suggested that in northern Syria leaf miner accounts for approximately 85% of the total losses due to insect attack. In southern Syria and northern Jordan Heliothis seems to be more important, the average pod damage being 15%. Yield trials to measure actual losses have not been conducted outside Syria. Likewise, quantitative estimates of losses due to C.chinensis are not available.

The host range and diapause potential of the leaf miner and the pod borer have been relatively well studied but the role of the environment in the build-up of these species has to be more thoroughly investigated. Recent results indicate that if winter planting becomes a generalized practice in the region this may have an impact on Heliothis infestation levels. A routine monitoring of insect pests of chickpea in winter and spring plantings is now in progress.

There are not many alternatives for control of insect pests in chickpea. A few natural enemies have been identified but there seems to be little scope for using them in a pest management system. Neither the leaf miner nor the pod borer are responsive to changes in plant densities and planting dates within a given season. Most research has been done on chemical control and several efficient insecticides have been identified. Future research on chemical control will concentrate on the economic analysis of various alternatives as well as in the determination of critical periods of control and economic thresholds. In relation to this, a detailed study of the nature of leaf miner damage is now in progress.

Most emphasis is being given to the search for sources of resistance to the leaf miner. A visual rating score for leaf miner damage ranging from 1 to 9 has been developed for mass screening purposes. More than 6000 chickpea genotypes have been evaluated. From these, 25 have been selected as most resistant and 13 of them have been reconfirmed. Four highly susceptible checks have also been identified. A few selected genotypes were yield-tested under protected and non-protected conditions with promising results. A few crosses have also been made and the segregating populations will be evaluated in the 1983/84 season. Simultaneously, the mechanisms of resistance are being studied.

PARTICIPANTS PRESENTATIONS

RESEARCH ON PULSE ENTOMOLOGY AT NATIONAL AGRL. RESEARCH CENTER, ISLAMABAD

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The entomological research in the pulses programme at National Agricultural Research Centre, Islamabad was initiated in the beginning of 1983. The pulses programme has the mandate to improve the production of chickpea, mungbean, blackgram, lentil and pigeonpea. These crops are a major and cheap source of protein supplement to the diet of a large section of population in the country. Since chickpea meets 80% of the domestic requirements and occupies 76% of the area under pulses it is always a point of major focus. The main objectives of entomological research in the programme are to evaluate the losses caused by insect pest complex on these crops with special reference to the attack of pod-borer *Heliothis armigera*.

Of all the crops included in the program, the chickpea and pigeonpea crops were found to be most susceptible to *Heliothis armigera* at this centre. The damage caused by this pest to the rabi crops in 1982-83 (specially chickpea) was so severe that only a few kg of the seed could be procured from the large cultivated area. A heavy larval population of *H.armigera* was also seen damaging the lentil crop (*Lens culinaris*) during the late crop stage.

Survey of pulse crops at NARC:

A detailed survey of chickpea was conducted during the last rabi season to record pest infestation on this crop. The survey revealed heavy infestation of *Heliothis armigera* over the period extending from March to May. This year *Heliothis* infestation on pigeonpea at NARC was not noted to be alarming but a coreid bug, *Clavigralla gibbosa* appeared in great numbers in June and July and a cantharid beetle, *Mylabris pustulata* suddenly attacked the crop in the last week of October. Some heteropteran insects e.g. *Nezara viridula*, *Riptortis lineatus*, *Acrosternum graminea*, *Piezodorus rubrofasciatus*, *Cletus bipunctatus* and *Stenozygum speciosum* were also recorded on pigeonpea.

Pheromone trap catches:

In collaboration with ICRISAT three pheromone traps are in operation at this centre and ten at other coordinating units in all provinces of the country. These traps were installed in February 1983, with the objective to study the pattern of population fluctuation of *H.armigera* through different months. The moth catches during the last chickpea season are illustrated in Table 1. Besides population studies the pheromone traps may have reduced the chances of mating frequencies of *H.armigera* female thereby resulting in possibilities of increased non-viaibe egg laying.

Natural control elements:

During the last rabi season efforts were also concentrated in finding natural enemies (insect parasites) of *H.armigera*. These efforts resulted in finding two effective hymenopterous parasites parasitizing the 2nd stage larvae of *H.armigera* on wheat crop at this centre. The first parasite which infected the pest with high frequency was a braconid, *Apanteles ruficrus* (Holiday) and the second parasite was an Ichneumonid, *Campoletis chlorideae* (U) which parasitized 2nd stage larvae of this pest.

During the current rabi season (83-84) the first incidence of *Campoletis chlorideae* has been observed parasitizing *H.armigera* larvae in the 2nd week of November, in a chickpea sowing date and plant population trial, and the data on parasite incidence are being recorded.

Rearing of H.armigera on artificial diet:

The mass rearing of *H.armigera* on artificial diet was undertaken from the first week of April this year for conducting experiments on chemical and biological control of this pest as well as of screening for host plant resistance. The artificial diet developed at this centre for mass rearing of this pest has served the purpose well and by now the sixth laboratory generation of *H.armigera* is in progress.

A preliminary four replicated trial using adult inoculation of *H.armigera* on mungbean was conducted. Four pairs of laboratory reared 4th generation adults were inoculated in each of the one square meter nylon net cage one week prior to start of flowering. Each cage enclosed nearly 40 plants (row to row distance 30 cm, plant to plant distance 10 cm). Observation revealed that more than 95% of the flowers were eaten by the larvae of *H.armigera* and thus the [illegible] enclosed in the cages gave no yield. It is evident from the inoculation results of this experiment that although H.*armigera* is not normally a pest of mungbean due to its polyphagus nature, the tender shoots and flowers of mugbean were entirely eaten. This observation also contributes to the idea that at any moment with the passage of time, this insect can assume pest status on mungbean.

Future plan of work:

1. A country wide survey of major chickpea growing areas will be made to find out the distribution and losses caused by *H.armigera*.

2. Studies will be undertaken to identify chickpea germplasm lines resistant/tolerant to *H.armigera*.

3. Investigation would also be made to explore the possibilities for use of biological control elements in reducing the lepidopterous pest populations, with special reference to H.*armigera*.

4. Work on biology and ecology of major pests of food legumes would be initiated from the view point to study the pest population dynamics.

Table 1: Date of *Heliothis* pheromone trap catches collected National Agricultural Research Centre, Islamabad.

Months	Weeks	Trap 1 Average moth catches/ day	Trap 2 Average moth Catches/ day	months	Weeks	Trap 1 Average moth Catches/ day	Trap 2 Average moth Catches day
March 1983	2nd	29.1	39.0	May 1983	1st	10.0	12.7
	3rd	37.1	39.0		2nd	11.3	13.9
	4th	52.5	51.3		3rd	11.6	5.7
					4th	12.6	9.3
April 1983	1st	79.1	87.9	June 1983	1st	17.9	5.1
	2nd	164.4	180.1		2nd	52.3	33.7
	3rd	67.1	47.9		3rd	39.1	18.7
	4th	62.4	61.9		4th	7.3	9.6

CHICKPEA PEST STATUS IN JORDAN

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Chickpea (*Cicer arietinum* L.) is an important food legume crop grown in Jordan. The area planted to chickpea has decreased from 35,000 donum (=3,500 ha) in 1975 to 19,000 donum (=1,900 ha) in 1981. This decrease is due to many reasons, one of these being the attack by insect pests.

Preliminary surveys on chickpea indicated that the crop is attacked by several insect pest species. Much of the damage is caused by pod borers (*Heliothis* spp.) followed by leaf miner (*Liriomyza* sp.). The loss caused by pod borers reaches up to 20% in some areas . No estimate is available on the loss caused by the leaf miner damage. However, the loss may reach up to 10% or even more. Another pest frequently observed is the black aphid (*Aphis craccivora*), the known vector of the stunt disease.

A research project on chickpea pests started in 1982 season with main emphasis on the pod borers. Monitoring the pest population was initiated using sex pheromone traps supplied by Dr.C.Cardona (Entomologist, FLIP, ICARDA). Three traps were stationed at three different locations in northern and central Jordan. The peak of *Heliothis* population was in early June with early catches from 1st May. Low pod infestation levels were noticed early in the season and ranged from zero up to 12%. However, the losses at the maturity stage reached up to 20%.

Larval field collection indicated that 90% of the emerged adults were *H.armigera*. This percentage needs to be confirmed in the next season. The major mortality factor is parasitism; a large number of *Heliothis* larvae were parasitised by a hymenopteran parasitoid (unidentified).

No work is being conducted on the use of insecticides and host plant resistance. However, the following areas are important for future research:

1. Continue monitoring pest population.

2. Continue surveys on chickpea pests.

3. Conduct experiments on the use of insecticides.

4. Continue the work on the species composition of *Heliothis* complex.

5. Continue work on leaf miner damage throughout the season.

6. Continue studying the effect of planting date and

the interaction with chickpea varieties on the losses caused by insect pests.

7. Survey on naturally occurring bioagents should be started.

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PIGEONPEA PEST MANAGEMENT IN SRI LANKA

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Grain lgume crops presently cultivated in Sri Lanka are cowpea (*Vigna unguiculata*), green gram (*V.radiata*), black gram (*V.mungo*), soybean (*Glycine max*), pigeonpea (*Cajanus cajan*) and groundnut (*Arachis hypogaea*). Some of these crops have a long history of traditional cultivation, but it is only recently that they have attracted research attention.

In Sri Lanka there are over 40 species of insects which are recorded as pests of pigeonpea, affecting the crop at different stages of growth. Due to ravages by these pests the cultivation of pigeonpea is limited to a small extent.

In recent years, considerable work has been done in the following areas:

(a) Population dynamics, (b) Host plant resistance, (c) Biological control, and (d) Chemical control.

Population dynamics:

Studies on population dynamics have been carried out through light trapping and bimonthly planting of the crops. This work is very recent and has so far only enabled conclusion to be drawn for *Ophiomyia phaseoli*. The peak population of *O.phaseoli* could be avoided by adjusting the date of planting.

Host plant resistance:

It has been noted that some varieties of pigeonpea show various degrees of resistance to different pests. Plant architecture of pigeonpea has some influence on pest infestation. Short determinate plant types with a large number of tightly clustered flowers suffered a disproportionately high insect infestation.

Biological control:

Limited introductions of *Bracon* spp. against *Maruca testulalis* and *Microplitis* sp against *Heliothis armigera* were made in 1977 at Maha Iluppallama and around but this attempt has not been very successful.

Chemical control:

As effective alternatives have still to be developed insecticides still occupy a significant place in pest control. Pod borer complex of pigeonpea has made the cultivation of this crop virtually impossible without regular spraying of insecticides. Very little information is available on the comparative efficacies of insecticides against the individual grain legume pests. Information on the effect of insecticides on natural enemies is also conspicuous by its absence. Timing of insecticidal application in relation to plant growth stage has been studied and has revealed that protection of pigeonpea at flowering initiation stage is the most profitable.

Although present investigation on the populations dynamics, natural enemies of pests, and chemical control show some promising results, the current strategy in managing these pests lies in crop breeding. Therefore, screening of pest resistant/tolerant varieties of crops developed by breeders in Sri Lanka and also those received directly from agencies such as ICRISAT, should be continued.

PROGRESS OF PEST MANAGEMENT RESEARCH ON CHICKPEA AND PIGEONPEA AT THE PUNJAB AGRICULTURAL UNIVERSITY

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Major pests of chickpea and pigeonpea and losses caused in the Punjab state:

In chickpea, the only pest of importance is the gram pod borer, Heliothis armigera. In pigeonpea, we consider a complex of pod borers namely Heliothis armigera, Lampides boeticus, Exelastis atomosa and Melanagromyza obtusa besides the leaf webber Cydia critica and leaf hoppers Empoasca spp. to be the major pests.

Losses due to Heliothis in chickpea during the 1982-83, based on surveys in five locations in the districts of Ludhiana, Bhatinda and Faridkot, were estimated as 5.7% (in treated), 10.5% (in untreated) and as 6.7 and 10.7 per cent reduction in grain yield respectively. However, the maximum pod borer damage of 36.5% was recorded during the previous years.

In pigeonpea, the damage due to pod borer complex during different years ranged between 10.0 to 100.0 per cent, against 24.5 and 30.7 per cent in T 21 and AL 15, the standard varieties.

Progress made so far in research on the pest management:

(a) Pest Monitoring:

Monitoring of H.armigera through pheromone trap is being done at PAU, Ludhiana, since 13 Aug 1982. The data on average catch per day per trap (weekly mean), starting from 33rd week of 1982 to 44th week of 1983 reveals that the highest catch per day per trap (3.4) during 1982 was in the 38th week (Sep 1982). During 1983, the highest catch (101.3) was in 14th week (Apr 1983). The catches during 11th to 16th standard weeks of 1983 ranged between 38.0 to 101.3.

(b) Surveys:

Surveys in chickpea revealed that the damage of pods due to birds was quite high as compared to the damage done by the Heliothis. Among birds, the main damage was by the common "Mainah" and parrot. Bird damage was highest (29.3%) in Sangrur district, followed by Ludhiana (15.1%). Similarly, at the initial stage of the crop growth, plant mortality due to termites was highest (10.0%) in Sangrur district, followed by Bhatinda (8.8%).

In pigeonpea, damage due to pod borer complex during 1982 season ranged between 17 to 26 per cent in T 21 and 20 to 26 per cent in AL-15 in the districts of Ludhiana, Faridkot, Ferozepur and Ropar. During the 1983 crop season it ranged between 7.6 to 38.3 per cent in T 21 and 19.7 to 24.6 percent in AL 15 in the districts of Ludhiana, Gurdaspur, Jullundur, Amristsar and Ropar.

(c) **Host plant resistance:**

Chickpea:

Field screening of 1312 entries was done against *H.armigera*. More than a dozen entries have been identified to be in the less susceptible group (up to 10 per cent). Entry GL 645, a kabuli type had the least susceptibility even under controlled conditions of screening. This entry was identified in the less susceptible group at ICRISAT also. Work on the basis of resistance is in the initial stages. Perhaps high percentages of crude fibre, non-reducing sugars and low percentage of starch contents in the seed of this cultivar might be responsible for the low incidence of the pod borer. Similarly, high percentage of cellulose, hemicellulose and lignin in pod-husk have inhibited the damage of pods. Work on the effect of malic acid concentration in the pod exudate on the incidence of *H.armigera* has also been initiated.

Pigeonpea:

Field screening of 582 entries was done against the pod borer complex, *H.armigera*, *E.atomosa*, *L.boeticus*, *C.critica* and *M.obtusa*. Entry EC 4237 was identified to be a less susceptible type.

(d) Biological control:

Preliminary field trials to test the efficacy of Nuclear Polyhedrosis Virus (NPV) in killing the larvae of *H.armigera* in pigeonpea and chickpea have been conducted.

(e) **Insecticides:**

About two dozen insecticides including synthetic pyrethroids have been tested against the major pests of pigeonpea and chickpea. In pigeonpea, quinalphos, carbaryl, monocrotophos and endosulfan were found to be promising in controlling the borer complex. Decamethrin, fenvalerate and cypermethrin were also found to be promising against these pests. In chickpea, endosulfan and monocrotophos have been evaluated to be the promising. All the three synthetic pyrethroids isolated to be promising in pigeonpea were also effective in controlling *H.armigera* in chickpea.

Needs for future research:

Since the use of insecticides in controlling, even the major pests of pulses is not very popular amongst the farmers, there is an urgent need to concentrate more on identifying resistant material, which may help the breeders in evolving varieties resistant to pest or pests.

Collaboration with ICRISAT:

National programme will certainly be benefitted by having closer collaboration with the ICRISAT, particularly in the field of host-plant resistance by getting the promising germplasm material/cultivars in pigeonpea and chickpea.

A BRIEF REPORT ON PEST PROBLEMS AND PEST MANAGEMENT RESEARCH IN HARYANA

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Chickpea and pigeonpea are the major pulse crops of Haryana.

Important insect-pests and losses caused are:

Chickpea:

Heliothis armigera Hb. is the serious pest of chickpea. The insect is found in abundance during 2nd or 3rd week of March though the incidence starts much earlier. Late sown crops suffer more losses due to pod borer than the early sown. The crop-stage also affects the incidence. Percent pod damage fluctuates every year and is generally in the range of 10-40%. In 1981-82, its attack was more severe - 30-84%.

The termite, *Odontotermus obesus* is a problem in sandy and dry soils. Damage due to this termite varies from 5-60% in Bhiwani, Mahendergarh and Hissar districts of Haryana.

Cutworms, *Agrotis* spp. cause low to moderate losses in all growing areas.

Pigeonpea:

This crop is attacked by series of insect-pests, on foliage green jassid - *Empoasca kerri*, leaf webber - *Cydia critica*, greyweevil - *Myllocerus maculosus*, blue butterfly - *Lampides boeticus* on buds, and pods, *Maruca* spp., *Heliothis armigera*, Exelastis atomosa, Clavigralla *gibbosa* and *Melanagromyza obtusa*. Among these H.*armigera* and M.*obtusa* are the major problems. Early maturing cultivars suffer more damage due to *Heliothis*, while late maturing cultivars suffer more from M.*obtusa* - percent pod damage varies from 5-15%.

Research on Pest Management:

Cultural Control:

Studies on intercropping of chickpea with wheat have given indications that this practice reduces the incidence of gram pod borer. The same experiment should be repeated to reach a concrete conclusion. Effect of spacing on the incidence of gram pod borer was also observed and it was found to have no significant effect on pod borer infestation. The effect of moong as an intercrop on the pigeonpea pest complex is being evaluated.

Biological Control:

Studies of the biological control of *H. armigera* indicated there was almost 17% parasitization of the larvae. The parasites which were identified as *Apanteles sp.*, *Microbracon hebetor* and *Campoletis chlorideae* which attacked 2nd and 3rd instar larvae.

Host Plant Resistance:

Screening for resistance to *H. armigera* has been done in IET, GVT and promising material. Entries at advance stage testing from Badnapur, ICRISAT, and some from PPE Kanpur showed a good degree of tolerance to pod borer. ICPL-5--EB entry of pigeonpea was least damaged by pod borer and it suffered minimum loss while Pant A13 suffered the maximum.

Chemical Control:

Several insecticides have been evaluated in tests against pod borer. Endosulfan, monocrotophos, quinalphos and synthetic pyrethroids have been found very effective. One spray of endosulfan/monocrotophos at the time of pod initiation was found to be effective and economical. Neem products did not produce encouraging results against pod borers. Various other insecticides, the best time of application, the appropriate number of sprays and the threshold level of major pests (*H. armigera*, *M. obtusa*) are being studied.

Need for further Research:

1. Factors responsible for resistance both physical and chemical should be identified.

2. Biological control studies on pod borer and podfly should be intensified.

3. Research to bring about modifications in plant protection appliances should be taken up to apply pest control strategies on high yielding varieties of pigeonpea.

Collaboration with ICRISAT:

1. To provide germplasm resistant to *H. armigera*

2. To impart information and guidance with respect to biological control and host plant resistance studies.

A SAMPLING TECHNIQUE TO ESTIMATE LARVAL POPULATION OF *HELIOTHIS ARMIGERA* IN CHICKPEA

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Gram pod borer, *Heliothis armigera* (Hubner) is a serious pest of chickpea in many states, particularly in Madhya Pradesh, Andhra Pradesh, Uttar Pradesh, Bihar, Rajasthan, Punjab and Haryana. For the accomplishment of effective pest management programme for insect, accurate and timely monitoring of its population with appropriate sampling technique is essential. By applying this technique in the field, the pest status of this insect can be determined and recommendation can be made accordingly. Similarly sampling technique becomes imperative for running a smooth surveillance programme. No such information is available on this pest in chickpea. Studies were undertaken at Hissar on chickpea cv H 208 during 1982-83. The experiment was designed in an RBD with plot size of 7 x 7 m. Six sample sizes - 0.5 x 0.5 m, 1.0 x 1.0 m, 1.5 x 1.5 m, 2.0 x 2.0 m, 2.5 x 2.5 m, 3.0 x 3.0 m were evaluated. The pest counts were recorded by using ground-cloth-shake method (0.5 x 0.5 m) during flowering and pod formation stages at weekly intervals.

Sample sizes were compared by calculating percent relative variation (RV%) and relative net precision. The average RV% values were worked out to be 10.3, 5.5, 6.5, 8.0, 6.5 and 7.0 for sample sizes of 0.5 x 0.5 m, 1.0 x 1.0 m, 1.5 x 1.5 m, 2.0 x 2.0 m, 2.5 x 2.5 m and 3.0 x 3.0 m respectively, being minimum for 1.0 x 1.0 m size. Relative net precision was calculated by 1/RV% x t (hr.). The higher the net precision, the more efficient the method is. The relative net precision values were computed as 2.5, 3.8, 2.0, 1.3, 1.1 and 0.7 for all the six sample sizes in ascending order. Here also, the value was greatest in the case of the 1.0 x 1.0 m sample size. Therefore, the sample size of 1.0 x 1.0 m is more efficient than other sample sizes because it gave minimum relative variation and maximum relative net precision values (Table 1). The sample gave more accurate information (population) in less time, hence more efficient and practical also.

Table 1: Comparison of different sample sizes.

Sample size	Reelative variation(%)	Relative net precision
0.5 x 0.5 m	10.3	2.5
1.0 x 1.0 m	5.5	3.8
1.5 x 1.5 m	6.5	2.0
2.0 x 2.0 m	8.0	1.3
2.5 x 2.5 m	6.5	1.1
3.0 x 3.0 m	7.0	0.7

The appropriate number of samples of size 1.0 x 1.0 m to estimate the larval population of this pest for 11th and 12th standard week were 3 while for 13th and 14th, it was one. The number of samples required fell as the crop proceeded towards maturity. A simple reason for this was that the population of Heliothis became more uniform in distribution with the advancement of crop growth.

It is thus concluded that 3 samples in 11th and 12th standard week and only one sample in 13th standard week onwards of size 1.0 x 1.0 m is sufficient to estimate larval population of Heliothis in a plot size of 7 x 7 m by ground-cloth-shake method.

HIGHLIGHTS OF PEST MANAGEMENT RESEARCH AT THE PROJECT DIRECTORATE (PULSES), KANPUR, INDIA

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Major pest problems:

Chickpea: Gram pod borer - *Heliothis armigera* and semilooper - *Autographa nigrisigna*.

Early pigeonpea (Jun-Dec) - Leaf tier - *Cydia* (*Eucosma*) *critica*, spotted caterpillar - *Maruca testulalis*, tur pod (brown) bug - *Clavigralla* spp. and pod fly - *Melanagromyza obtusa*.

Late pigeonpea (Jun/Jul-Apr/May) - Blue butterfly - *Lampides boeticus*, plume moth, *Exelastis atomosa*; pod fly, *M.obtusa* and gram pod borer, *H.armigera*. However, *M.obtusa* and *H. armigera* are the "key pests".

Damage and loss assessments:

Attempts made to collect pods at maturity from farmer's fields during 1978-79 to 1981-82 in over 30 districts in Uttar Pradesh showed that in late pigeonpea the mean percent grain damage due to lepidopteran borers ranged from 4 to 10 percent and due to podfly from 19 to 21 percent, whereas total damage due to borer complex and pod sucking bugs was found to vary from 25 to 36 percent. The overall mean grain damage for all the years and pests was nearly 30 percent.

In case of chickpea mean pod damage was found to range from 3 to 33 percent, with an overall average of 15 percent. Monetary loss every year due to pod borer complex infesting pigeonpea and chickpea may be nearly Rs.100 crores in Uttar Pradesh.

Bio-ecological studies:

Information on succession of crop pests infesting chickpea and pigeonpea, population dynamics of borer complex, mode and extent of damage, biology and natural enemies etc. has been collected during 1978-79 and 1982-83.

Heliothis armigera, an important pest both on chickpea and pigeonpea, begins its infestation from October but attains peak only from 1st or 2nd week of March onwards. Maximum crop losses occur during middle of March to last week of April. Pupae undergo diapause, with the pupal period of up to 110 days. An ichneumonid parasitoid, *Campoletis chlorideae* is active, usually during pre-winter months i.e. October-December (20-50% parasitization) but is not very active during the winter and post-winter months (January-April).

The podfly, M.obtusa is a major pest of pigeonpea only and remains active throughout the reproductive phase of the crop i.e. October-April, both on early and late types. It is more serious on late types than an early types. The intensity of damage keeps pace with the increase in number of pods. The percent podfly damage recorded at the 5% podding stage is not much different from the damage recorded at maturity or 100% podding stage. Although, three parasitoids viz. Eudarus sp., Eurytoma sp. and Ormyrus orientalis have been recorded, none appears to be potent enough to keep an effective check on its population build up.

Pest control studies:

(a) Against chickpea pests:

Most of the work has been done against H.armigera, the key pest of chickpea. Date of sowing plays an important role in minimizing or maximizing pod damage. The early sown crop (15-30 October) usually escapes the damage. Planting density also influence the pod damage. Higher planting density (20 x 5 cm to 30 x 10 cm spacing) showed more pod damage, than lower planting density (30 x 20 cm and 40 x 10 cm spacing). Chickpea when grown as sole-crop suffers much more damage than when grown as mixed crop with crops such as wheat, linseed and mustard. Neem seed kernel extract (5%) has been found effective if sprayed at 10-12 days interval. Ultra low volume application of available EC formulation has been found at par or better than High Volume application.

(b) Against pigeonpea pests:

Observations have shown that late maturing pigeonpea occupies most of the area in north India and the crop can escape the onslaught of H.armigera, if it matures by the 1st or 2nd week of March. Trials with variety Bahar have shown evidence for this. Varieties which could mature 4-5 weeks earlier in comparison to existing cultivars or local land races, can evade the Heliothis damage to a larger extent. Insecticides such as dimethoate, monocrotophos and quinalphos against podfly, and endosulfan and quinalphos against lepidopteran borers, have been found effective but pose a problem for their application. The quantity of water needed (800-1000 l/ha) is too much and the crop to be treated is difficult to enter due to its tall height (2-3 m) and bushy nature. ULV application has been found almost at par to HV and has better scope in the future.

Host plant resistance:

The available germplasm, over 2000 in case of chickpea and 3500 in case of pigeonpea, has been screened against H.armigera in chickpea and M.obtusa and H.armigera in pigeonpea. Three years of study has led to the conclusion that it is a long drawn programme and will take many years before a resistant, i.e. moderate to highly resistant variety with desirable agronomic characters, could be released to farmers.

The success in chickpea has been more rewarding than in pigeonpea. Outcrossing and segregation are two major problems associated with pigeonpea work. Some of our PDE-1 to -7 lines of chickpea have proved quite promising in AICPIP multilocation tests. No such success has so far been obtained in pigeonpea. However, the work is in progress and there is some promising material.

__Needs for future research__:

The following aspects need to be further studied as a priority:

(a) Succession of crop pests, their relative importance extent of damage, etc. in relation to each agro-climatic niche e.g. rainfed vs irrigated, short duration vs medium and long duration, determinate vs indeterminate, compact vs spreading, monocropping vs mixed cropping, etc.

(b) Economic threshold levels for major pests, both individually as well as collectively.

(c) Bio-ecology of major as well as minor pests.

(d) Life tables of all important pests.

(e) Intensive research on plant resistance, biological control, cultural control and other newer methods and their integration.

(f) Operational research projects on integrated pest control.

__ICRISAT collaboration__:

ICRISAT in collaboration with ICAR and the Agricultural Universities can help to strengthen the research work in the following ways:

(a) By supporting "problem-specific" research projects.

(b) By taking up collaborative projects on the national level e.g. identification of 'endemic areas' of major pests by regular surveys, collection and identification of natural enemies and their relative importance, collection of local landraces for identification of low pest damaged lines, etc.

(c) By organising operational research projects.

(d) By arranging inter-institutional visits both within and outside the country.

(e) By holding seminar/group discussior etc. more frequently and on regular basis.

(f) By disseminating the latest information through publications.

PROGRESS OF PULSE ENTOMOLOGICAL RESEARCH IN MAHARASHTRA STATE

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Major pests on chickpea/pigeonpea in the state:

In Maharashtra state, *Heliothis armigera* is the most important pest causing damage to the extent of 20 per cent in chickpea. The pigeonpea pod borer complex (*H.armigera*, *Melanagromyza obtusa*, *Exelastis atomosa*) is proved to be responsible for substantial losses in the range of 25 to 40 per cent in pigeonpea.

The progress of entomological research:

1. Surveys:

Our previous surveys indicated that very few farmers (less than 5 per cent) had adopted plant protection measures. But since last two years due to the constant efforts made by extension workers and subsidies provided by the state and central government through plant protection campaigns, the adoption of plant protection in pigeonpea and chickpea has increased to the extent of 60 per cent. During the surveys it was observed that many cultivators have not used pesticides at proper stage or they have undertaken only one application as against the recommended two, and hence pest control was not effective.

2. Host plant resistance:

Over 1000 pigeonpea and 1500 chickpea lines were screened for their reaction to pod borers under natural pest population pressures. The pigeonpea cultivars which were found to be less susceptible gave varying results in the further testing. Our Badnapur-sponsored chickpea entries viz. C 10, S 76, and N 37 have shown promise at other AICPIP centres and at ICRISAT.

3. Natural enemies:

Apanteles sp. on *E.atomosa*, *Campoletis chlorideae* on *H.armigera* and *Euderus* sp. on *M.obtusa* were recorded at our station.

4. Cultural control:

Our preliminary research on cultural control aspects indicated that:

(a) Pigeonpea intercropped with sorghum and black gram recorded significantly low pod damage compared to pigeonpea sole crop.

(b) Early sown pigeonpea recorded low pod damage as compared to late sown crops.

(c) There were no significant differences in pod damage by *H.armigera* between chickpea crop sown at different dates.

(d) Chickpea intercropped in safflower recorded lower pod damage than did sole chickpea.

5. Chemical control:

About 30 pesticides were tested against the pigeonpea pod borer complex for their efficacy and most of them were found significantly superior over control. Endosulfan 0.07%, monocrotophos 0.04%, and quinalphos 0.05% showed consistantly good performance and are recommended. Among synthetic pyrethroids fenvalerate 0.006% and permethrin 0.075% were effective and 4% endosulfan, 5% malathion, 2% parathion, 10% BHC and 5% carbaryl showed promise among dust formulations.

The experiments (3 years x 3 locations) to test the efficacy of plant products showed interesting results as under.

Sl. No.	Treatment	Increased yield over control(%)	Net profit (Rs/ha)	Cost benefit ratio
1.	Karanja oil 0.2% + Soap 1%	42	620	1:2.99
2.	Neem Seed Kernel Extract 5% + Soap 1%	37	439	1:2.14
3.	Neem Leaf Extract	45	855	1:7.38
4.	10% BHC dust	58	1172	1:12.0
5.	0.07% Endosulfan	85	1661	1:9.22

In a chemical control trial against *Aceria cajani*, a vector of pigeonpea sterility mosaic agent Aldicarb granules at 2 kg a.i./ha showed promise.

In chickpea 20 spray and 12 dust formulations were tested for control of *H.armigera*. Endosulfan 0.07%, fenvalerate 0.02%, quinalphos 0.05%, monocrotophos 0.05% and carbaryl 0.2% among sprays and endosulfan 4%, malathion 5%, parathion 2% and carbaryl 5% among dust formulations were effective. Similarly neem seed kernel extract 5% and neem leaves extract 5% were also equally effective as the pesticides.

Most urgent needs for future research:

Attention to the following aspects would be useful.

(a) Studies on mechanism of host plant resistance.

(b) Systematic long term studies on population dynamics in relation to climatic factors so as to find out suitable time for insecticidal application.

(c) Studies on predators and parasites and their evaluation for pest control.

(d) Effect of various agronomic practices such as sowing dates, spacing, irrigation and intercropping to minimise *H. armigera* damage.

(e) Studies on the economic threshold levels so as to minimise the pesticide usage.

(f) To find low cost inputs for pest control.

(g) To evolve integrated pest control/management strategy for the benefit of the poor Indian farmers.

Scope for ICRISAT Collaboration:

For want of sophisticated laboratories, we are unable to carryout essential basic research which is of immense use. We look for ICRISAT help in this regard.

SOME ASPECTS OF MANAGEMENT OF PESTS ESPECIALLY PODFLY (*MELANAGROMYZA OBTUSA* MALLOCH.) ON EARLY VARIETIES OF PIGEONPEA IN NORTHERN MADHYA PRADESH

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Pigeonpea is one of the most important pulse crops in Madhya Pradesh specially in northern region. Late maturing local varieties are grown as mixed crops with pearl millet or sorghum. Pigeonpea is definitely one of the pulse crops most ravaged by insect pests, particularly during the reproductive phase.

The pest situation is also changing rapidly with the increase in irrigation potential in the region. With the increase in prices of pulses, farmers are taking to growing pigeonpea as a sole crop in double crop annual rotation with wheat. Efforts are also being made by the crop breeders and agronomists to grow it as a rabi crop. This is likely to result in pigeonpea being available in the field almost throughout the year in different stages of its growth. As such, the existing off-season restraint in the breeding of the major pest (podfly) may be largely eliminated rendering the situation very grave.

Major Insect Pests:

During the reproductive and ripening phases, the adults of orange banded blister beetle (*Mylabris pustulata*), larvae of plume moth (*Exelastis atomosa*), gram pod borer (*Heliothis armigera*), podfly (*Melanagromyza obtusa*) and the nymphs and adults of pod bug (*Clavigralla* spp.) cause considerable losses. Losses due to plume moth larvae have been reported to range from 6.6 to 14.1 percent in pods and 2.5 to 5.6 percent in grains and also 17.6 percent in pods and 6.7 percent in grains. Similarly loss caused by pod bug is low and some varietal preference has so far been reported.

Podfly is the most serious pest of pigeonpea in the region. During varietal screening some losses due to this pest have been reported by several workers.

Late varieties are reported to be comparatively more attacked by pod fly and the data from ICRISAT as given in their various reports support this view. We studied recently early varieties of pigeonpea vis-a-vis podfly attack in relation to plant resistance, effect of planting geometry and the effectiveness of some insecticides on podfly damage.

Forty four varieties were screened and the damage to green and mature pods and grains was estimated. The pod fly damage in green pods (in November) ranged from 9 to 35%. Percent damage in mature pods and grains was very heavy but varying significantly in different varieties; pod damage ranged from 39 to 99% and grain damage ranged from 26 to 89%.

Five combinations of row x plant spacing (25 x 15 cm, 25 x 25 cm, 37.5 x 25 cm, 50 x 15 cm and 50 x 25 cm) were tested with UPAS-120 and the infestation was not affected by the above planting geometries.

Based on one application of insecticide given at flowering and early green pod stage, it was found that monocrotophos (0.05%) was most effective followed by decamethrin (0.002%) and endosulfan (0.07%). BHC dust (2.5 kg a.i./ha) was least effective, though all of these treatments reduced the pod fly damage and increased the yield significantly.

Conclusion

Early maturing varieties and planting geometry appear to be ineffective in reducing podfly infestation. Monocrotophos and synthetic pyrethroids appear to be potentially useful. Manipulation of time of maturity of early varieties by early planting in Apr-May may prove helpful and deserves further testing, besides breeding for resistance.

EXTENT AND SUCCESSION OF INSECT FAUNA ASSOCIATED WITH AN EARLY VARIETY OF PIGEONPEA CROP AT PANTNAGAR AND ESTIMATION OF CROP LOSSES CAUSED BY THEM

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About 28 species of insects were observed to be associated with various stages of pigeonpea crop growth. Studies on their succession and field incidence show that the first major groups of insects to attak in the vegetative stages were the beetles, jassids and bugs followed by leaf webber in the late vegetative stages. Most dominant amongst these were jassids. The peak populations of the foliage feeding insects occurred in the late vegetative stage and thereafter declined as the crop entered cooler weathers. Flowers were attacked by a large population of thrips. During pod formation and maturity, the pod feeding insects consisting mainly of podfly, gram pod borer, legume pod borer and plume moth, constituted the dominant group. Amongst these, podfly was the most dominant.

Pest damage during crop growth did not have significant effect on plant height, number of pods per plant, number of grains per 100 pods, number of primary and secondary branches and plant populations, at levels of pest incidence observed in this study. However, yield characters such as the total grain yield and 1000 grain weight were significantly reduced. Maximum yield loss of 28.0 percent was observed when the crop was completely exposed to pest damage, as compared to crop completely protected by insecticide application. The minimum yield loss of 3.3 percent occurred when the crop was damaged during vegetative stages only. During reproductive stages of crop growth, maximum yield loss of 20.4 percent occurred when the crop was damaged during pod formation stages only. Yield loss was only 6.0 percent when the crop was damaged during flowering stage only. Pod borer damage was the major factor causing yield losses. Amongst pod feeders, podfly was the most dominant pest causing significant yield losses. Benefit/cost ratio of crop protection under different treatment exposures of crop growth was more than two when it was protected from flowering till maturity, during pod formation and maturity, and during pod formation stage alone. Maximum ratio of 3.0 occurred when the crop was protected during pod formation stage only, but maximum gain in yield occurred when it was protected from flowering till maturity.

BRIEF REPORT RELATING TO PULSE PEST MANAGEMENT RESEARCH AT VARANASI CENTER

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The work on pulse (pigeonpea) entomology was initiated in 1976 at Varanasi centre which represents eastern Uttar Pradesh. Every year the data on pest incidence were recorded insect-wise and the last two year's observations on pod damage seed damage and grain weight-loss are presented in Table 1. Podfly, pod bug, and lepidopteran borer complex are important in this region.

Podfly (*Melanagromyza obtusa*) is the most serious pest of pigeonpea causing considerable damage to all the cultivars of different maturity groups. The activity of the pest starts from November with pod initiation in early cultivars and will continue up to the harvest of late varieties in April. The fly population starts building up slowly and reaches its peak during February causing minimum damage to early, moderate to medium, and maximum to late cultivars. The second important insect is the pod bug (*Clavigralla gibbosa*) whose activity is entirely different from podfly. It causes maximum loss to early, moderate to medium and minimum to late cultivars. The third important insect group is the lepidopteran borer complex (LBC) which includes *Maruca testulalis*, *Cydia critica*, *Exelastis atomosa*, *Catochrysops cnejus* and *Heliothis armigera*. The damage caused by the whole group is not significant, when compared to the damage caused by podfly and pod bug.

Most urgent need for further research:

(a) Identification of the source of resistance/tolerance to podfly, pod bug and to the lepidopteran borer complex for breeding purposes.

(b) Search for high yielding varieties with less susceptibility to major pests of the region for immediate cultivation.

Scope for ICRISAT Collaboration:

(a) Supply promising seed material generated at ICRISAT for testing in multilocation trials.

(b) Organising short term training programmes to convey the background of any recent technology in pulse entomology.

(c) Provide facilities at least for one crop season to scientists wishing to work on a special project.

(d) Provide financial assistance to scientists for going abroad to acquire new techniques and for attending international conferences/ seminars.

Table 1. Insect damage in early, medium and late cultivars of pigeonpea at Varanasi, 1981-83.

Insect	Early			Medium			Late		
	1981-82	1982-83	Average	1981-82	1982-83	Average	1981-82	1982-83	Average
				PER CENT POD DAMAGE					
Podfly	16.5	10.9	13.7	10.4	40.3	25.3	52.0	34.7	43.3
Pod bug	39.3	68.8	54.0	45.4	21.5	33.5	19.2	9.7	14.7
LBC	5.4	6.6	6.0	4.4	0.8	2.6	6.1	0.7	3.4
Pulse beetle	1.1	8.4	4.7	1.7	0.2	1.0	0.3	1.3	0.8
Others	10.8	13.1	12.0	7.3	13.2	10.2	9.9	8.7	9.3
				PER CENT SEED DAMAGE					
Podfly	6.1	4.2	5.1	3.8	20.0	11.9	30.0	17.5	23.8
Pod bug	21.2	46.5	33.9	29.2	11.2	20.2	9.7	4.8	7.2
LBC	2.0	2.6	2.3	1.6	0.3	1.0	2.6	0.3	1.4
Pulse beetle	0.4	3.1	1.7	0.6	0.1	0.4	0.1	0.5	0.3
Others	3.8	4.9	4.3	2.6	4.9	3.7	3.6	3.1	3.4
				PER CENT GRAIN WEIGHT					
Podfly	3.4	2.3	2.9	2.5	12.7	7.6	19.7	11.9	15.8
Pod bug	11.8	25.7	18.8	8.5	4.5	6.5	4.0	1.5	2.8
LBC	1.8	2.3	2.0	1.5	0.3	0.9	2.4	0.3	1.3
Pulse beetle	0.1	0.7	0.4	0.1	0.0	0.1	0.1	0.1	0.1
Others	3.6	4.7	4.1	2.5	4.7	3.6	3.5	3.0	3.3

PEST PROBLEMS OF PIGEONPEA AND CHICKPEA IN BIHAR (INDIA)

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As a result of periodical surveys and field studies, the following pest problems were identified in respect of pigeonpea and chickpea.

PIGEONPEA

Termite (*Odontotermes obesus*) has been a serious pest in light and sandy soils. Pod fly (*Melanagromyza obtusa*) is the dominant species, causing 10 to 20% damage in medium and late varieties. Pod weevil (*Apion clavipes*), a new borer pest is observed since 1979 on medium and late varieties, causing serious damage in localised pockets. In some years, it was more damaging than podfly. Pod borer (*Heliothis armigera*) normally causes low damage to both medium and late varieties. Plume moth (*Exelastis atomosa*) is rarely seen. Early borer (*Maruca testulalis*) has been serious on early varieties only.

Research Progress:

Among early varieties cv.BS1 was least damaged by *Maruca*. Medium and late varieties that escape borer damage are not yet identified. Monocrotophos (0.04%) spray and malathion and quinalphos dusts have proved effective against *Maruca*. Endosulfan (0.07%), monocrotophos (0.04%), dimethoate (0.03%) and fenitrothion (0.05%) sprays and malathion, methyl parathion and BPMC dusts have been found efficacious against pod borer complex. Plant products - neem seed kernel extract (5%), neem leaf extract (5%), neem oil and karanja oil (each 2%) have also given encouraging results against borers. Termites could be effectively controlled with soil application of heptachlor or aldrin dust.

Need for Future Research:

i) Resistant or at least tolerant varieties for pod borers need to be identified. ii) Work on biological control to be intensified.

Scope for ICRISAT Collaboration:

ICRISAT may arrange promising germplasm materials for testing against pod borers at different coordinating centres of the country.

CHICKPEA

Cutworm (*Agrotis ypsilon*) is a regular and serious pest in flood affected areas, comprising a vast tract growing mixed crops of gram, pea, lentil etc. Pod borer (*Heliothis armigera*) has been a regular pest, causing 15-20% damage.

Reseach Progress:

Agrotis appears in an epidemic form when flood recedes earlier in October and fails to assume serious proportions if there is revisitation of flood as a result of heavy rains during November. Extremely dry weather during April-May adversely affects cutworm multiplication. Monocrotophos (0.04%), endosulfan (0.07%) sprays, BPMC 4%, BHC 10%, methyl parathion 2% and quinalphos 1.5% among dusts and neem seed and neem leaf extract (5%) have been found efficacious against *Heliothis*. Chickpea sown by the first week of November suffers less from the pod borer damage.

Need for Future Research:

I) Development of resistant materials. II) Exploring the possibility of biological control. III) More research on ecological aspects.

Scope for ICRISAT Collaboration:

To supply resistant or tolerant materials for testing under different agro-climatic conditions.

PEST MANAGEMENT RESEARCH IN CHICKPEA/PIGEONPEA IN DELHI AREA

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The following pests have been commonly observed on pigeonpea and chickpea in Delhi and its neighbouring areas.

Red gram (Pigeonpea):

Galerucid beetle	*Madurasia obscurella* Jacoby
Jassid	*Empoasca kerri* Pruthi
Grey weevil	*Myllocerus undecimpustulatus* Desbrochers
Tur pod fly	*Melanagromyza obtusa* (Malloch)
Pod borers	*Heliothis armigera* (Hubner) *Maruca testulalis* Meyrick *Anarsia ephippias* Meyrick *Adisura atkinsoni* Moore
Plume moth	*Exelastis atomosa* (Walsingham)
Thrips	*Megalurothrips distalis* (Karny)
Blue butterfly	*Lampides boeticus* Linn.
Leaf folder	*Cydia critica* (Meyrick)
Mite	?

Bengal gram (Chickpea):

Pod borer	*Heliothis armigera* (Hubner)
Cutworms	*Agrotis ypsilon* Hubner *A. flammatra* Schiffer-Mueller
Aphid	*Aphis craccivora* Koch

In demonstration of pest control technology in pigeonpea, the avoidable loss was observed as 46.9% in Kharif 1981 specially by pod borer (AICPIP, 1981). In case of dimethoate 0.03% (two sprays) the maximum cost-benefit ratio (1:22.4) was recorded. In case of chickpea, maximum cost-benefit ratio (1:33.7) was observed with 0.07% endosulfan spray.

Progress made so far in the research on pest management in following area:

(a) Surveys have been conducted in surrounding Delhi villages and pest control technology was transferred to an adopted village Pochanpur. Demonstrations were also laid to convince the farmers to adopt the pest control technology.

(b) Varieties were screened under 'initial evaluation', 'coordinated varietal trials' and 'advanced yield trials' under All India Coordinated Pulse Improvement Project'. The data on reaction of various cultivars to major insect pests have been accumulated. In observations on mutants of chickpea, a line was identified as resistant to pod borer.

(c) Experiments are in progress in collaboration with Insect Pathologists to incorporate the strains of NPV and _Bacillus_ sp. in reducing the pod borer damage. Recently a tachinid fly (_Eucelatoria bryani_) was obtained from CIBC, Bangalore. The larval parasite has already established in laboratory trials. In the coming season, these parasites will be released in the field.

Apart from making use of available potent insecticides of cyclodiene, organophosphate, carbamate and synthetic pyrethroid groups, mode of action of insecticide derived from 'Neem' will also be worked out. Recently we were able to formulate the dust and wettable powder from neem kernel powder and emulsifiable concentrate of neem oil which will be tested in large scale field trials. Their efficacy has already been worked out in laboratory specially against Bihar hairy caterpillar, _Diacrisia obliqua_ [illegible].

The urgent need is to make use of pest management components to keep the pest below the economic threshold level.

Scope of ICRISAT collaboration:

Providing germplasm material of pigeonpea and chickpea with view for identifying resistant cultivars.

ICRISAT should provide the pheromones which will help in monitoring the pod borer incidence.

PULSE PEST RESEARCH IN TAMIL NADU

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The major pests on chickpea/pigeonpea in this area are:

Chickpea Pod borer, *Heliothis armigera*

Pigeonpea

i) Pod borer — *Heliothis armigera*

ii) Podfly — *Melanagromyza obtusa*

iii) Plume moth — *Exelastis atomosa*

iv) Spotted pod borer *Maruca testulalis*

The progress made so far in the research on pest management is summarised below:

(a) Pest monitoring, surveys, economic threshold levels:

Heliothis pheromone traps and light traps have been set up at Coimbatore and Vamban and daily catches of adult moths are being recorded.

(b) Host plant resistance:

(i) **Chickpea:** Screening of gram germplasm materials, testing of promising materials supplied by the Project Coordinator (Pulses) of AICPIP (All India Coordinated Pulses Improvement Project), Kanpur, screening of materials of Gram Initial Evaluation Trial (GIET), Gram Coordinated Varietal Trial (GCVT) and International Chickpea Screening Nursery (ICSN) (against pod borer, *Heliothis armigera*) are being carried out at Coimbatore Centre of AICPIP (All India Coordinated Pulses Improvement Project).

(ii) **Pigeonpea:** Screening germplasm entries and materials of coordinated trials (against pod borers and podfly) are being carried out at Vamban and Coimbatore centres of AICPIP (All India Coordinated Pulses Improvement Project).

At Coimbatore, four lines of pigeonpea, viz., AS 71-37, ICP 8514, JA 5 and P 1236 have been found to be promising against *Heliothis armigera* and further studies on these lines are in progress.

(c) **Biological control, cultural control and insecticide usage:**

Biological control: For the control of pod borer, H.armigera on chickpea and pigeonpea spraying of virus (NPV) alone or with insecticides has been found to be effective.

Chemical control: For the control of pod borers of pigeonpea and chickpea, efficacy of various insecticides including sprays, dusts, synthetic pyrethroids and plant products have been evaluated. Among the sprays, endosulfan 0.07%, monocrotophos 0.04% and carbaryl 0.1% are effective. In the dust formulations, BHC 10%, endosulfan 4%, phosalone 4% and quinalphos 1.5% are effective. Spraying with synthetic pyrethroids inclduing fenvalerate or deltamethrin or cypermethrin is effective for pod borers. Natural products such as neem seed kernel extract, neem oil, neem cake and neem leaf extract are also useful.

The most urgent needs for future research:

(a) Since pulse crops are mostly grown under rainfed conditions, cheap and effective pest control measures have to be evolved. Hence intensive research work has to be carried out on biological control development of resistant varieties and use of cheap dust formulations and plant products. For this, uniform methodology has to be formulated and used.

(b) More effective exchange of technical information is needed.

(c) The economic threshold for major pests should be worked out and a comprehensive pest management programme which is economically feasible and ecologically safe has to be developed.

(d) The damage by the pulses beetle (Bruchus sp) is severe during storage of pulses grains. Hence intensive work has to be carried out to evolve a safe, cheap and effective control of this beetle. Work on use of activated clay, vegetable oils etc., should be intensified and popularised among the farmers.

PROGRESS OF PEST MANAGEMENT IN PIGEONPEA AND CHICKPEA IN GUJARAT

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Pigeonpea:

The area under pigeonpea as a sole crop is increasing in middle Gujarat and now occupies 1,88,000 hectares. A late maturing variety with bold white seed is grown as sole and intercrop. The pod borer *Heliothis* damage is not so serious as plume moth, blue butterfly and podfly. The other pests are jassids, brown/green bugs, mealy bugs, blister beetles, termites etc. Endosulfan 0.07% at 750 l/ha at 50% flowering and a second spray with monocrotophos 0.04% after 15 days interval are found superior for control of pod borers. The pod borers and podfly damage vary from 18.9% to 36.4% and 19.6% to 35.7% respectively. The Department of Agriculture carried out aerial spraying in pigeonpea in 1980, 1981 and 1982 in areas of 800, 4000 and 1537 ha.

Chickpea:

Chickpea is raised as a sole crop mostly in inundated area of Ghed in Junagadh and Bhal tract of Ahmedabad. The cultivators grow the crop on residual moisture in Panchmahals district. The area under cultivation increases according to favourable late rains. The major pest is pod borer *Heliothis*. The pod borer damage on cultivator's fields in unsprayed area varied from 4.0% to 19.0%. Endosulfan 0.07% at 500 l/ha spraying once at 50% flowering is found significantly superior for pest control. The Department of Agriculture carried out aerial spraying in Ghed of Junagadh on 10,000 acres from 1980 onward. The cultivators in Panchmahals are using Methyl parathion 2% dust against pod borers.

RESEARCH ON THE PROBLEM AND MANAGEMENT OF PESTS ON PULSES IN MADHYA PRADESH

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In Madhya Pradesh, amongst the pulses, pigeonpea and chickpea are the major pulse crops in kharif and rabi respectively, which are mostly grown under rainfed situation. The production and yield as indicated in the Table 1 do not show any encouraging position. The average yield of both the crops are quite low which may be due to rainfed condition, poor management but the most important factor is the losses caused by insect pests. In chickpea, the reduction in yield is due to severe damage caused by gram pod borer, *Heliothis armigera*, which ranges from 30 to 40 per cent. The other serious pest is cutworm, which also damages the crop, particularly in heavy soils, whereas termites are reported to damage the crop in light soil areas. In pigeonpea, though the crop is subjected to attack by aphids, grasshoppers, leaf webbers etc. during the vegetative phase, it is seriously damaged from the initiation of flower buds to pod formation and maturity of pods. The most important and serious pests which are recorded in M.P. are the tur pod bug, plume moth, podfly and pod borers, which together are responsible for economic loss to the extent of 30 to 40 per cent. In M.P. the varieties mostly cultivated are of late duration which suffer more from pest damage. It is observed that after the maturity of gram crop, the *Heliothis* attack is more severe on pigeonpea.

Progress made so far in the research on pest management:

(a) Pest monitoring, surveys, economic threshold:

Pigeonpea:

The survey on pigeonpea in M.P. reveals that severe damage to the crop is caused by tur podfly and pod borers, particularly *H.armigera*, whereas at some locations tur pod bug and plume moth also damage in high proportion. Generally on the late varieties (local), the attack of pod borer and podfly starts at the flowering stage of the crop and by January-February heavy attack is observed with an average 30 to 40 per cent pods found damaged by the pests.

Chickpea:

The major pest is gram pod borer H. *armigera*, which alone is responsible for serious damage to the crop. The pest incidence varies from year to year, mostly governed by ecological conditions. During 1981-82, the incidence was very high and 30 to 40 per cent pods were damaged by the pest, whereas in 1982-83, it was quite low and 10 to 15 per cent pods were damaged by the pest. Winter rains, high temperature and cloudy weather are most congenial for pest multiplication. It is observed that the larval population starts building up by the 2nd or 3rd week of November and reaches the peak in February and declines by 1st and 2nd week of March.

The economic threshold of gram pod borer on the chickpea crop has been worked out at J.N.Krishi Vishwa Vidyalaya, Jabalpur which is 2 to 3 larvae/m row length, particularly at flowering stage of the crop.

(b) Biological control:

In M.P., Campoletis chlorideae, the only parasite on early instar larvae of gram pod borer is found active during December-January and about 15 to 25 percent parasitization was recorded at Jabalpur.

(c) Cultural control:

Intercropping of chickpea with wheat in 1:1 proportion showed less per cent pod damage by gram pod borer as compared to other proportions and chickpea alone.

Insecticidal usage:

In M.P., plant protection measures are generally adopted on gram crop and mostly dusts such as BHC, parathion, carbaryl, DDT alone or in 1:1 proportion are used. The experiments being conducted on chickpea with chemical control against pod borer showed that amongst the dusts, BHC, carbaryl, parathion, malathion and quinalphos were found to be very effective, provided they are true to quality. Monocrotophos 0.04% and endosulfan 0.07% sprays were more effective than dusts. Amongst the synthetic pyrethroids, fenvalerate 0.02% and cypermethrin 0.006% were found to be most effective. One or two timely applications at the economic threshold level of the pest, particularly at flowering and podding stages of the crop, can control the pest effectively.

On pigeonpea, only dusts are being used by the cultivators at the podding stage of the crop and that too in limited areas. They are found to be ineffective due to crop height and luxuriant growth. Two to three application of monocrotophos 0.04%, dimethoate 0.03% and endosulfan 0.07% at 50% flowering and podding stages were found to be more effective against the pod feeding pests.

Urgent needs for future research:

(a) Evolving varieties which are less susceptible or resistant against major pests of chickpea and pigeonpea should be given priority.

(b) In order to discourage chemical use and its hazards, more emphasis should be given to the biological control aspect.

(c) More information is needed on the mixed/intercropping of chickpea and pigeonpea as this practice is mostly followed by cultivators.

Table 1: Area, production and yield of chickpea and pigeonpea in Madhya Pradesh.

	Years						
	60-61	65-66	70-71	75-76	77-78	78-79	79-80*
Crop-Chickpea							
Area (Thousand hectares)	1496	1600	1619	1917	1780	1739	2174
Production (Thousand tonnes)	861	847	855	1057	907	1032	924
Average yield (kg/ha)	576	530	529	520	510	504	425
Crop-Pigeonpea							
Area (Thousand hectares)	395	420	502	517	488	475	512
Production (Thousand tonnes)	342	218	409	292	352	317	229
Average yield (kg/ha)	866	520	821	553	725	671	449

* Drought year.

BRIEF REPORT OF WORK ON PULSE ENTOMOLOGY AT THE REGIONAL AGRICULTURAL RESEARCH STATION, LAM, ANDHRA PRADESH, INDIA

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RARS, LAM, Guntur, AP, India

Major Pests on Pigeonpea:

Pod borers such as *Heliothis armigera*, *Melanagromyza obtusa*, *Exelastis atomosa*, *Tanaostigmodes* sp. and the leaf webber, *Cydia critica* are the regular pests on pigeonpea crop in this area. *H.armigera* is predominant, causing economic losses in most of the seasons. Work on estimation of losses caused by these pests is in progress.

Progress made so far in research on pest management:

a) Pest monitoring, surveys, economic threshold levels:

In collaboration with ICRISAT, studies on monitoring were initiated in 1982. Monitoring of adult *Heliothis* with pheromone traps during and between the crop seasons revealed that the populations are relatively high in November to March .(7-13 per trap/day). These studies are in progress. The pod borer infestation exhibited large variation from season to season and based on the degree of infestation, the seasons can be grouped as low, moderate and heavy infestation.

Low infestation	(10-12%)	: 1972-73, 1976-77 and 1980-81
Moderate infestation	(17-40%)	: 1971-72, 1973-74, 1974-75, 1975-76 and 1982-83
Heavy infestation	(above 50%)	: 1977-78, 1978-79 and 1979-80

b) Host plant resistance:

Since the inception of the project, 2556 cultures have been screened for pod borer resistance in non-replicated trials. Though some of the cultures were identified as possessing 'recovery resistance', none of the cultures were found promising under high pest challenge conditions up to 1978-79 season. During 1979 five *Atylosia* species viz., *A.scarabaeoides*, *A.sericea*, *A.albicans*, *A.platycarpa*, *A.cajanifolia* were screened for pod borer resistance. Of these the first two species had comparatively negligible infestation while others recorded infestation up to 13%. LRG 30, a new variety evolved at this centre was identified as one of the promising cultures with recovery resistance, compensating for the damage of first floral flush. HY-4, T-21, AS-44, ME-175, Vm.75 and R-60 gave good yields ranging from 1.9 to 2.1 t/ha even under high pod borer stress at this center.

c) Biological control, cultural control and insecticide usage:

Though several parasitoids were identified on pod borers, attempts were not made to concentrate on these lines, as facilities are not available at this centre for multiplication and release of parasites and predators.

Of the several insecticides evaluated for the control of pod borers, endosulfan 0.07%, monocrotophos 0.04%, acephate 0.02%, UC 51672 0.035%, and cypermethrin 0.005% were found effective.

d) Integration of the methods:

Some work in this aspect is in progress.

The most urgent needs for future research:

a) Facilities are needed for artificial screening to identify pest resistant lines of new germplasm developed at different centres.

b) Collaboration in evaluating biological control methods to limit the populations of pod borers with least disturbance to the ecological balance in pigeonpea fields.

Scope for ICRISAT collaboration:

The work initiated on pest monitoring and forecasting should be continued by ICRISAT. Work on integration of pest management aspects should be geared up through evolving suitable techniques in cooperation with ICRISAT.

No work was done on chickpea at this centre and the work is to be initiated on similar lines as that of pigeonpea.

GROUP DISCUSSIONS

SUMMARY
GROUP DISCUSSION - HOST PLANT RESISTANCE

Chairman: W.Reed

The role of host plant resistance was recognised as being of utmost importance in the future of Pulse Pest Management. It was noted that there is a need for a well organised and intensive program to screen and breed for pest resistance in each crop and in each ecological region. AICPIP has recently made a great deal of progress in such organisation but more progress, particularly in breeding for resistance is urgently required.

In a discussion on the methodology, it was pointed out that there is a need for more information on the techniques that are suitable for the rapid and accurate screening for resistance to individual pests in pulses. Several efforts are in progress to identify resistant genotypes in open field screening using the natural incidence of the major pests, but in such screening, improvements can be made in the methodology and interpretation of results. It was emphasised that, all too often, unreplicated single year tests had led to reports of resistance that were in fact escapes. The need for mass rearing of pests, to supplement field infestations and to subject material to known levels of pest attack, was recognised, but the lack of facilities and know-how for such rearing was appreciated.

It was pointed out that there was need for a well organised system of multilocation testing. The problem of materials being found to be resistant in one location but susceptible in another was discussed. It was agreed that there would be a need for screening in several locations to overcome this problem.

Resistance was to be measured in relation to local check cultivars. It was pointed out that local check cultivars tended to be relatively resistant to many local pests through many generations of natural selection. There was some discussion over, whether susceptible controls should be included in field trials? There was no concensus on this, for there were good reasons for and against inclusion of susceptibles. It was appreciated that for trials intended to screen or test for resistance to the pests of the flowering and podding stages, only genotypes that were flowering at the same time can be compared in field tests, for pest population fluctuations could give very misleading results if genotypes that were flowering at different times were compared.

It was recognised that it is important to determine the mechanisms of resistance and the need for interdisciplinary research involving entomologists, chemists, physiologists and breeders was stressed.

SUMMARY
GROUP DISCUSSION - SURVEY AND SURVEILLANCE

Chairman : Dr.J.N.Sachan
Rapporteur: Dr.David Dent

The catches of *Heliothis* from light and pheromone traps have been shown to correlate poorly with direct field counts, but it is hoped that this situation may be improved with further work and identification of correction factors. Despite this poor correlation it was thought that the standard pheromone trapping system should be continued. This nationwide network of pheromone traps combined with records of crop damage in trap areas has already identified the timing of outbreaks in different areas of the country. It was recognised that this information is collected for pest surveillance and not for forecasting outbreaks and farmer action. This would require more money, coordination and a calculated threshold for action. The relative merits of crop damage surveys by local and specialised national entomologists were discussed. It was recognised that some local entomologists experienced difficulty in identifying pests and this was deemed particularly important in relation to the pheromone trap catches. It was decided that further collaboration and the publication of an identification book which included advice on sampling methods would help improve the situation.

SUMMARY
GROUP DISCUSSION - INSECTICIDE USE

Chairman : Dr.C.Cardona
Rapporteur : Dr.C.S.Pawar

The Chairman opened the discussion by emphasising that insecticide use in a pest management program should be on the basis of well researched economic threshold levels for the pests. However, in most crops and in most areas there appeared to be a lack of published data. The group then discussed the problems of establishing economic thersholds and economic injury levels. It is recognised that where a crop is grown over a wide range of environments there will be a consequent variation in the economic thresholds of pest populations and damage. Similarly where several genotypes are grown in an area, under a variety of cultural practices it is unlikely that a single, useful threshold will be identified.

The group decided that within India there was an urgent need for further study on the economic thresholds of two pests, H.armigera and M.obtusa, for both on pigeonpea and for the former on chickpea. It was recognised that there would be considerable variation in such thresholds across the large range of environments in which this crop is grown in India, so the entomologists in each ecological zone will have to establish the thresholds appropriate to there local environment and cropping conditions. However, it was stressed that there should be some coordination of these efforts and that a suitable methodology for the required research should be agreed and adopted.

There was some discussion concerning the appropriate stage of the insects that should be monitored. At ICRISAT crudely determined thresholds for H.armigera on pigeonpea had been set at 10 eggs and/or 3 small larvae per plant. At Hissar only the larvae are considered when establishing thresholds on chickpeas. It was pointed out that both these crops compensate for early damage to a considerable extent, providing the climate and soil conditions allow, and such compensation must be taken into account when establishing the thresholds, otherwise overuse of pesticides may result.

The value of survey data in establishing thresholds was questioned. It was agreed that such surveys could establish "hot spots" or endemic areas and so direct the scientists attention to the need for further research in such places.

The question of the development of resistance to pesticides in the pests, particularly in H.armigera, was raised. At this time there appears to be no well documented case of resistance in Heliothis reported in India. However, there are very well known cases of resistance in Heliothis species in several countries, particularly in the Americas and in Australia. TDRI London in cooperation with ICRISAT had been monitoring the enzymes in _H.armigera_ sent from various locations, including ICRISAT Center and had recently reported considerable resistance to DDT in the local population. It was agreed that such monitoring should continue and expand.

There was a feeling that recommendations for the use of insecticides on pulses were being made without adequate consultation with the pulse entomologists. It was agreed that the Pulses Directorate should convey this concern to the Plant Protection Advisor.

In a discussion on pesticide application techniques it was agreed that there was a need for further research. The CDA (ultra low volume) machines were now readily available in India, but suitable non-volatile formulations that are required for use by these machines were not yet available. There was a need to bring this situation to the attention of the relevant policy makers. the health and safety aspects of the CDA spraying methodology should be carefully studied and the precautions required should be emphasised. It was pointed out that economic benefits will come from pesticide use only if the chemicals are applied correctly at the right time and at the correct dosage.

The effect of insecticides on the natural enemies of the pulse pests was discussed. There was an appeal for more information on the toxicity of the commonly recommended pesticides to the common beneficial insects found in our pulse crops. Some information is already available but much more research is required.

The discussion ended with the Chairman stressing the need for more research on economic injury levels, insecticide application technique and safety to non-target organisms in pesticide application.

SUMMARY
GROUP DISCUSSION - BIOLOGICAL AND CULTURAL CONTROL

Chairman : Dr.T.Sankaran
Rapporteur : Dr.S.Sithanantham

The scope for the utilisation of promising native parasites such as Campoletis chlorideae in Heliothis control was discussed and research leading to augmentative releases was recommended. The need to collect local information on the activity of native natural enemies was considered to be basic for the formulation of a strategy for natural enemy utilisation. In particular, the present knowledge of the role of predators and the means of encouraging these was considered to be particularly meagre and it was recommended that such knowledge should be expanded by research efforts. The need to continue attempts to study the establishment potential of promising exotic natural enemies of Heliothis such as Apanteles kazak and Hyposotor didymator was also emphasised. Such attempts should also be considered for the natural enemies of other important borers such as Melanagromyza, Exelastis and Maruca. A beginning has been made in the field testing of Heliothis virus (NPV) and this should be actively pursued. The private agencies who may supply natural enemies for large areas release should be encouraged.

Among the cultural methods studied so far, the utilisation of intercrops to reduce pest caused losses seems to be one area worth studying in relation to each region, in close cooperation with agronomists. Plant density and planting date manipulations do not seem to offer any impressive role in reducing the damage due to pests. Weed management and its effect on pests and beneficials is well worth studying. Other approaches to manipulate pest population such as trap cropping, barrier crops, choice of varieties to enable 'pest escape' seem worth testing to suit local conditions.

SUMMARY
GROUP DISCUSSION - INTEGRATION OF PEST MANAGEMENT AND ITS ADOPTION

Chairman : Dr.Mike Irwin
Rapporteur : Dr.S.S.Lateef

The Chairman while opening the discussion on Integration of Pest Management, enlightened the participants on various aspects of integration and the coordination of different disciplines involved in the evaluation and transfer of the technology to the farmers.

Several participants informed the meeting about the methodology and process of transfer technology in their states and locations. The general consensus was that, if the scientists have a sound methodology which can be easily demonstrated at the farmers' level giving a substantial economic return, then it will be accepted by the farmers without any difficulty. Interdisciplinary integration for conducting demonstrations is desirable.

It was suggested that instead of training the extension workers, if a farmer is trained in the village quicker results can be achieved.

Prof.Hugh Bunting's caution, that we should not bl the extension workers for any faults within ourselves in evolving suitable methods for the farmers was stressed. If a new practice is obviously beneficial it will be readily accepted by farmers. If it is impracticable then the best extension in the World will not succeed in forcing farmers to adopt it! It was also suggested that, we should adopt one village completely for any programme implementation, instead of dealing with only one farmer and that the researchers should conduct the demonstrations by themselves.

FUTURE PLANS FOR COOPERATION AND ACTION

Chairman : W.Reed
Rapporteur : S.S.Lateef

The following recommendations were given general support.

1. That ICRISAT should publish a color illustrated brochure on the pests of pigeonpea and chickpea and the damage that they cause.

2. Sets of color slides illustrating pests and pest management practices should be provided by ICRISAT to national centers but not to individual scientists.

3. ICRISAT should provide short term training courses to National Program scientists engaged in Pulse Entomology research.

4. ICRISAT should identify short term research projects in Pulse Entomology that could be assigned as thesis projects for postgraduates in the universities.

5. ICRISAT should increase its pest survey/surveillance tours of India. (It was explained that ICRISAT has in fact greatly reduced such tours because of costs). ICRISAT should invite National Entomologists to join in such tours.

6. ICRISAT pheromone trap network should continue and expand.

7. ICRISAT should conduct fundamental research on pest resistance mechanisms within the Center instead of seeking cooperation with outside laboratories such as MPI. ICRISAT should develop biochemical facilities and extend such facilities to help the National scientists. (It was pointed out that the equipment needed for such basic analytical work was very expensive and that it was unlikely that ICRISAT could justify such costs).

8. ICRISAT should conduct village or area level demonstrations of integrated pest management in farmers' fields in cooperation with ICAR and State Governments.

9. It was unanimously agreed that all entomologists should direct their work towards integrated pest management and that host plant resistance must be an important component in such work.

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