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Constraints to effective pest management in pigeonpea

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Abstract. Pigeonpea (*Cajanus cajan* (L.) Millsp.) is well suited to low input farming in the semi-arid tropics, but insect pests cause large losses. In particular, *Heliothis armigera* takes a heavy toll over much of India, where over 90% of the world's crop is produced; and the podfly (*Melanagromyza obtusa*) causes extensive damage in the central and northern parts of India. Most farmers practise no conscious pest management, but the landraces that they grow can compensate for early pest damage and may mature before the peak pest threats in their areas. A recent increase in the market price of pigeonpea may encourage more farmers to use pesticides, but adequate coverage of a well-grown landrace crop is difficult with the available conventional application equipment. Non-availability of water at the time the crop suffers pest damage also discourages the use of water-based spraying. Two avenues of research and development appear worthwhile: 1. The adaptation and adoption of controlled droplet application, together with breeding for more compact plants that will yield well in dense planting. This could be of benefit to farmers who can purchase and use pesticides, particularly in the assured rainfall areas. 2. Selection of cultivars that are pest-resistant, and augmentation of the natural control elements. This would be for the majority of farmers who are unlikely to use pesticides. Research on these and other aspects of pest management is in progress at ICRISAT.

Introduction

Over 90% of the world's recorded production of pigeonpea (*Cajanus cajan*) is grown in India, where this crop is the second most important pulse. Almost all the pigeonpea in India is harvested as dried seed, then dehusked and split to make *dhal*. *Dhal* is relished by most Indian families of all income levels and forms an important component of the protein intake, particularly among vegetarians. In recent years, cereals production in India has risen markedly, but pulse production has not. This has led to a shortage of *dhal* in the markets and consequently in a price increase, forcing a reduction of pulse intake by poorer families.

Pigeonpea is a perennial shrub, usually grown as an annual. It fixes nitrogen through *Rhizobium*-containing nodules on the roots and so is generally regarded as a useful crop, if only as an intercrop, in a rotation. Most cultivars are relatively resistant to drought and will produce a crop, albeit a small one, on very poor soils and in drought conditions where most other crops would fail completely.

One of the major constraints to pigeonpea production was considered to be losses caused by the insect pests. As there appeared to be no broad survey data available in the literature on insect-caused losses to this crop, ICRISAT embarked on an extensive survey project in cooperation with the national entomologists. Scientists visit those pigeonpea fields that are in the vicinity of motorable roads, averaging one field visit every 20 km. The surveys are timed to coincide with the maturity stage of the crop. Data, including field size, cropping pattern and pesticide use, are collected and samples of pods are taken back to ICRISAT where they are analysed for pod damage. We have so far surveyed over 1000 fields, across the 13 States of India that have a sizeable pigeonpea production.

Over 80% of the fields surveyed were intercropped, the major companion crops being sorghum, millet and cotton. Pigeonpea is a relatively slow growing crop, at least in its early stage, so it is usually sown in lines between faster-growing and earlier-maturing crops. Most of the companion crops are harvested well before the pigeonpea completes its growth. On fertile soils with good moisture availability, it is possible to harvest an almost full crop of cereals, then allow the pigeonpea to grow on to give almost complete ground cover and produce substantial yields much later. Almost all pigeonpeas are grown without irrigation, often in quite extensive areas. Most of the fields surveyed were larger than 1 ha and some exceeded 5 ha.

Insect pests

Several insect species feed upon pigeonpea (Davies and Lateef, 1978), starting at the seedling stage when beetles, in particular, can cause extensive foliar damage. However, the plants recover well from almost complete defoliation, and insect-caused plant death is rare. Severe damage at the vegetative stage may delay flowering, but it is questionable whether such damage causes any substantial yield loss.

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The most damaging insect attacks occur at and after flowering. There is a complex of flower and pod feeders, and the composition of the complex varies from area to area and year to year. By far the most important pests are the pod borer, *Heliothis armigera* Hub. and the podfly, *Melanagromyza obtusa* Mall. Of the other lepidopteran pod borers, the plume moth, *Exelastis atomosa* W., can be particularly damaging later in the season and the blue butterflies, *Lampides boeticus* L. and *Catochrysops strabo* F., are damaging in some areas. *Callosobruchus* spp. are commonly found feeding in pods in the fields as well as in stored seed. A hymenopteran pest, *Tanaostigmodes* sp., is common in some areas, but is not easily noticed because of its small size. Sucking bugs, particularly *Clavigralla* spp., are also of importance in

The pod samples that we collect from mature fields give us a measure of the pod damage caused by the differing pests, but obviously underestimate pest-caused losses where extensive flower feeding and shedding of young, insect-damaged pods reduce the pod number at maturity. The data from our surveys from 1975 to 1980 are summarised in Table 1. There are clear regional differences. *Heliothis armigera* is by far the major component of the pod borer complex, being most damaging in southern and central India, but with the podfly causing equal or greater damage in the north. Variation in pest attack was great, not only between areas and years but also between fields in the same area and season.

TABLE 1. PERCENTAGE OF PIGEONPEA PODS DAMAGED BY INSECT PESTS IN INDIA: ICRISAT SURVEYS OF FARMERS' FIELDS 1975 – 80

	Lepidopteran borers	Podfly	Hymenoptera	Bruchid
Northern States (n* = 272)	12·6	19·1	0·1	0·3
Central States (n* = 289)	30·0	24·8	3·0	3·6
Southern States (n* = 362)	34·1	9·0	2·1	7·2

n* = no. of fields sampled

A single podfly larva destroys only one seed and as pods usually contain four or more seeds, 25% pod damage by podfly will approximate to only 6% of real seed loss. However, *H. armigera* and other lepidopteran borers usually destroy most seeds in the attacked pod, so here 25% pod damage probably results in 20% seed loss.

Pesticide use

In spite of the generally high level of pest-caused loss, few farmers use pesticide on this crop. In our surveys of 996 farms, where it was possible to obtain definite information about the pest management practices, only 45, or less than 5%, had been treated with pesticide.

The yields from this crop are generally low, the reported average being around 700 kg/ha across India, but several farmers, particularly in southern India, harvest much lower yields. Much of the crop is consumed on the farm but there is a ready market, with prices paid to farmers having recently risen by more than Rs.2.00 (US $0.25) per kg. The cash return for the average crop, of US $175, is low by most standards but yields of 2000 kg/ha are commonly reported from research stations where the crop is grown on fertile soil and is protected by pesticides.

Results of trials reported by the All-India Coordinated Pulse Improvement Project entomologists in their annual reports generally indicate that one or two applications of pesticide gave economic returns. Pesticides that will control *H. armigera* should be applied at the flowering stage or, preferably, according to pest counts.

The most commonly recommended pesticide for use against *H. armigera* on pulses in India is endosulfan, but in our surveys we found that the use of this chemical, on pigeonpea, is generally restricted to research farms and those areas where there has been an intensive campaign. Almost all the farmers contacted in our surveys, who utilised pesticides, used either DDT and/or BHC, in wettable powder or dust formulations. It is not difficult to discover the reasons why most farmers use DDT/BHC rather than the recommended pesticides. The cost of chemicals, per hectare spray, found sufficient to give adequate control of *H. armigera* at ICRISAT are:

Endosulfan 35% emulsifiable liquid (0·7 kg a.i./ha) = Rs.125
DDT 50% wettable powder (1·0 kg a.i./ha) = Rs.40

BHC is also cheap but is generally found to give comparatively poor control of *H. armigera*. DDT and BHC are readily available in many village retail outlets, while endosulfan is less widely available. The more costly pesticides are in demand for use on the high-value crops including cotton, rice and vegetables, particularly where these are irrigated.

There are many unconfirmed reports that DDT and BHC are not adequately effective in controlling *H. armigera* in many parts of India. The reason for this is frequently attributed to adulterated pesticides, but resistance is also suspected.

Pesticide application

By the time most locally utilised cultivars start flowering and podding and so reach a stage susceptible to *H. armigera* and podfly attack, they may be 2 m tall, and a well-grown sole crop will form an almost impenetrable jungle at that stage. Flowering and podding usually occur in the dry season when the large quantities of water that are required for high volume spraying may not be readily available. Some farmers use dusts and apply them using muslin bags tied to sticks that are shaken above the crop. This is not an easy or pleasant occupation. In a few areas, a high volume, rocker-type sprayer is mounted upon a bullock-drawn cart which is then driven through the crop with men spraying the crop to each side. This gives a crude coverage and the bullocks and cart wheels cause substantial crop damage, but this ingenuity well indicates the extent to which farmers are prepared to strive to protect their crops. Lever-operated knapsack sprayers are sometimes used, but adequate coverage of the tall plants with such sprayers is difficult. Motorised knapsack mistblowers are used at medium volume on cash crops in several areas, and on pigeonpea on several research farms, but they are expensive and not generally used on this crop in farmers' fields, except where the pigeonpea is intercropped with cotton. Aerial spraying has been suggested for use in some areas, but the effectiveness and economics of this are yet to be evaluated on this crop.

Pigeonpea appears to be ideally suited to controlled droplet applicator (CDA) usage, and we have done some work on this at ICRISAT. It may be possible to use drift spraying over 5 m swaths in the sole crop, using paths left through the crop, but much more experimentation is needed. Some indigenously manufactured, battery-operated, spinning disc applicators are available in India but formulations of pesticides that can be used for such spraying on pigeonpea and will kill *H. armigera* are not yet available. Some of the synthetic pyrethroids have recently been tested at many centres, including ICRISAT, in India and have proved to be very effective against *H. armigera* at low dosages. But they are not yet commercially available and are likely to be very costly. They may, however, be particularly suitable for CDA use on this crop.

H. armigera presents an exposed target for all of its life history apart from the pre-pupal and pupal stages, which are usually found in the soil or plant debris. It is, therefore, vulnerable to contact pesticides. The podfly poses a greater pesticide control problem, for the only stage vulnerable to contact pesticides in its life history is the adult. The egg is laid through the pod wall and the larva develops to the pupal and adult stage inside the pod where it is protected from most natural enemies and all but the very costly systemic pesticides.

The presently utilised landraces of pigeonpea, found in most farmers' fields in India, evolved in the pesticide-free environment and are clearly unsuited to pesticide protection. It may be advantageous to breed for a relatively small plant that will yield well in a dense stand and which can be conveniently treated with the currently available spraying and dusting equipment. CDA use would also be relatively easy on such a crop. We are investing some of our resources at ICRISAT in research towards such a plant type and technology.

Host plant resistance

We are also investing some of our resources in a host-plant resistance programme on pigeonpea and other crops, for we think that most of our target farmers may be growing their crops without pesticide protection in the foreseeable future. We are searching not only for resistance but also for the ability to compensate for early losses and for high-yielding plants that will flower and mature when the pest attack is at a low ebb. At and around ICRISAT Centre, *H. armigera* attacks peaked in November in each of the last few years, and any unprotected pigeonpea that was in the flower or pod stage at that time was devastated. Local farmers generally grow pigeonpeas that flower and pod in December, or later, and so avoid the most damaging *H. armigera* attack, but even then their crops suffer a great deal of damage. The ability of some pigeonpea cultivars to compensate for early loss is spectacular, provided adequate moisture is available in the soil. Such compensation complicates the establishment of 'economic threshold levels' for pests on this crop. It appears that we have some cultivars that give yields in pesticide-free conditions at least equal to those in fully protected conditions, but these results are from small-plot trials and need to be studied in much larger isolated plots. Our host-plant resistance programme is still in its infancy, but we do have lines that have consistently shown differing susceptibilities to both *H. armigera* and to podfly. We have nothing that is anywhere near immune to either pest, not even in the wild relatives of pigeonpea.

Ecology of the pests

Very little is known about the population dynamics of the major pests of pigeonpea in the farmers' fields, so we are monitoring pest and natural enemy populations on this and other hosts throughout each year. The restriction of our *H. armigera* studies to pigeonpea would severely limit our understanding of the ecology of this pest for it is polyphagous, feeding on many other crops and weed hosts as well as on pigeonpea. It would be impossible to monitor this pest on all of its hosts across India, so we are attempting to set up a network of light traps which will give us some information on pest population build up. In particular we are hoping to gain evidence on the incidence and role of migration in *H. armigera* infestations.

There is a real need to assemble the quantitative data on this pest that have been obtained in India and in other countries so that simple models of the build-up and incidence of the pest, particularly in relation to climatic factors, might be constructed. We need to integrate our pest management efforts across areas, rather than across individual crops, and for this we need an overall understanding of the ecology of *H. armigera* and the other pests.

Natural control

It has often been said that *Heliothis* spp. are 'upset pests,' assuming damaging proportions on crops and in areas only where injudicious pesticide use has disturbed the natural control elements. This is certainly not the case with pigeonpea and other pulse crops in India, for *H. armigera* is frequently devastating and is persistent on pulse crops in many areas where no pesticide has been applied.

Although several species of parasites are known to attack *H. armigera* larvae, collected from pigeonpea, they do not cause a rapid population reduction. In particular, egg parasites are very uncommon in *H. armigera* eggs laid on pigeonpea, but on other crops, such as the cereals and cotton, egg parasitism can be very high and give a significant degree of pest reduction. Although we have found several larval/pupal parasites, the most common of these are tachinids which kill the large larvae or pupae after the crop damage has been caused. There has been very little work on the quantitative effects of the predators of *H. armigera* in this crop but there does appear to be a paucity of predators, particularly of birds, which are often seen feeding on *H. armigera* in other crops, including sorghum, chickpea and cotton. Pesticide use further reduces the already poor natural control.

In cooperation with the Government of India, ICAR and CIBC, we are multiplying and releasing *Eucelatoria* sp., a tachinid parasite of *H. armigera,* that was originally imported from the USA. We do not have the facilities to produce enough parasites for trials of inundative releases. The introduction of parasites that attack the eggs and early instars of this pest could be of greater benefit, but we have yet to find an egg parasite of *H. armigera* that will readily accept pigeonpea as a plant host.

Some larvae of *H. armigera,* when collected from the field and reared in the laboratory, develop disease symptoms and die. In particular a nuclear polyhedrosis virus can play havoc with laboratory rearing of this insect but the typical symptoms of this disease are not often seen in the field.

This virus would appear to offer attractive possibilities, particularly since it is now being used commercially, and apparently successfully, in the USA and Australia for the control of *Heliothis* spp. In India, however, we await decisions upon the regulations which will determine the use of the virus. By far the cheapest and easiest means of virus use would be to encourage the local entrepreneurs, or the farmers themselves, to apply sprays that contain mashed up larvae that had been killed by virus. This is already practised on a small scale for other pests and crops in some areas of India. Such a practice apparently presents potential health hazards but if the virus has to be purified the cost could well equal that of the cheapest chemical pesticides.

Work in farmers' fields

Perhaps the major constraint of pest management on this crop up to now has been a lack of confidence in, and knowledge of, the pest management components in the farmers' field situation. We hope to have accumulated enough knowledge in the near future to enable us to propose a village-scale operational research project for pest management on pigeonpea. Similar projects have already proved successful on cotton in some areas of India. At this time we would expect the major components of such an operation to include the synchronous sowing by all farmers of a less susceptible or tolerant pigeonpea cultivar of an appropriate maturity to suit the known rainfall and pest pattern of that area. Optimum spacing and, in some areas, appropriate intercrops will also be advised. The limited use of pesticide, applied according to the recorded pest populations, will probably be a major component in several areas, but in some cases it may be possible to reduce, or even avoid, pesticide use by augmenting the natural enemy populations.

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