CROP PROTECTION PROGRAMME

Promotion of an Integrated Pest Management (IPM) Programme for Pigeonpea in India and East Africa

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FINAL TECHNICAL REPORT

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Project Leader
G V Ranga Rao

Project Leader's Institution
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Patancheru 502 324, Andhra Pradesh, India

Executive Summary

Insect pests continue to be one of the most important constraints to pigeonpea production throughout its distribution. The main purpose of the present project was to develop and share an environmentally safe and economically feasible pest management strategies with pigeonpea farmers in India to provide short- and long-term answers for sustainable plant protection. The project worked in partnership with National Agricultural Research Systems (NARS), Non-Governmental Organisations (NGOs) and farmers in farmer-participatory research mode, in 55 villages covering more than 1000 farmers.

This project was mainly focused on four research outputs. The primary output dealt with the development and promotion of effective pest management strategy for pigeonpea. This was very well addressed in all the selected locations with appropriate contacts. All the partners were involved from the inception of the project with in-depth discussion, and training at International crops Research Institute for the Semi-Arid Tropics (ICRISAT), as well as village-level. Extension materials depicting the importance of project activities such as information bulletins, handouts, video tapes in English and local languages were made available to all partners. Since the availability of Integrated Pest Management (IPM) components was the prime constraint in the promotion of IPM, this project devoted substantial time in strengthening those areas. In this connection, all partners were encouraged to improve neem seed collection, processing, storage, and utilisation. Seven full-fledged *Helicoverpa* Nuclear Polyhedrosis Virus (HNPV) production units were strengthened at village-level to meet the on-going demand for good quality virus at farm-level. Due to strengthening of these units, the production of HNPV touched 171,500 larval equivalents (LE), which was used effectively on several crops including pigeonpea, cotton and vegetables.

Discussions with African counterparts, scientists at the International Centre of Insect Physiology and Ecology (ICIPE), and surveys in pigeonpea fields revealed the complexity of pest problem. Among various pests that attack pigeonpea crops in East Africa, *Maruca*, blue butterflies, *Helicoverpa armigera* and *Clavigrella* are of major importance. However, the importance of the above species varies according to the altitude and the crop maturity group. The first field demonstration of HNPV on pigeonpea yielded fruitful results at Kiboko farm of Kenya, which is one of the examples of successful inter-institutional collaboration made possible through bridge financing of this project.

Maruca pheromone developed at Natural Resources Institute (NRI) and found effective in West Africa, did not reveal any clues with little influence on the adult behaviour indicating the need for in-depth studies in future programme, to address the issue, of better pheromone trapping technology. . Observations on larval parasites of *Helicoverpa* from different hosts revealed high parasitization of larvae on *Lagascea* sp (19%) compared to 1% on sorghum and 2% on pigeonpea. Studies on the evaluation of various IPM components for the management of *H. armigera* at ICRISAT-Patancheru indicated 46% reduction in pod damage in IPM plots where neem, HNPV, manual shaking, and one chemical spray was used compared to 30% reduction in pod damage in manual shaking alone, 33% reduction in HNPV alone and 28% in neem alone, and 37% in chemical alone. However, the economics worked out to be 1:7 cost benefit ratio with shaking alone, compared to 1:5.6 in IPM and 1:6 in chemical alone, indicating the economic feasibility of the effective cultural control. Although, it is not easy to assess the real impact of this IPM project over such a short period, IPM farmers reduced their inputs on chemical pesticides (up to 100%) without sacrificing the yields.

Thus this DFID project had strengthened the ongoing pigeonpea IPM program in India with improved profits and better environment. The village-level biological pesticides production units acted as a model for future extension where biopesticides can be produced at an affordable price for small farmers for use on several crops including cotton and vegetables.

Background

Pigeonpea plays an important role in rural Indian economy and diet. In India where a large proportion of population is vegetarian, pulses are the major source of protein for the rural poor. Pigeonpea productivity in India is variable (0.2 - 2.5 t ha^{-1}) with an average yield of 700 kg ha^{-1} and it is grown mostly in rainfed marginal lands. Pigeonpea is attacked by several species of insect pests of which *Helicoverpa armigera* (Hubner) is the most important, and *Maruca vitrata* (F.) the second most important in India and Africa. Current control relies on use of chemical pesticides but misuse by farmers and increasing resistance by *H. armigera* are undermining this approach. Recent crop surveys in farmers' fields have revealed that in spite of extensive use of chemical insecticides there are severe crop losses due to *H. armigera*. Annual worldwide losses due to *H. armigera* alone in pigeonpea are now estimated to be more than US$ 310 million. Hence there is a clear need to develop new, less chemically dependent IPM approaches to pigeonpea pest management.

Project Purpose

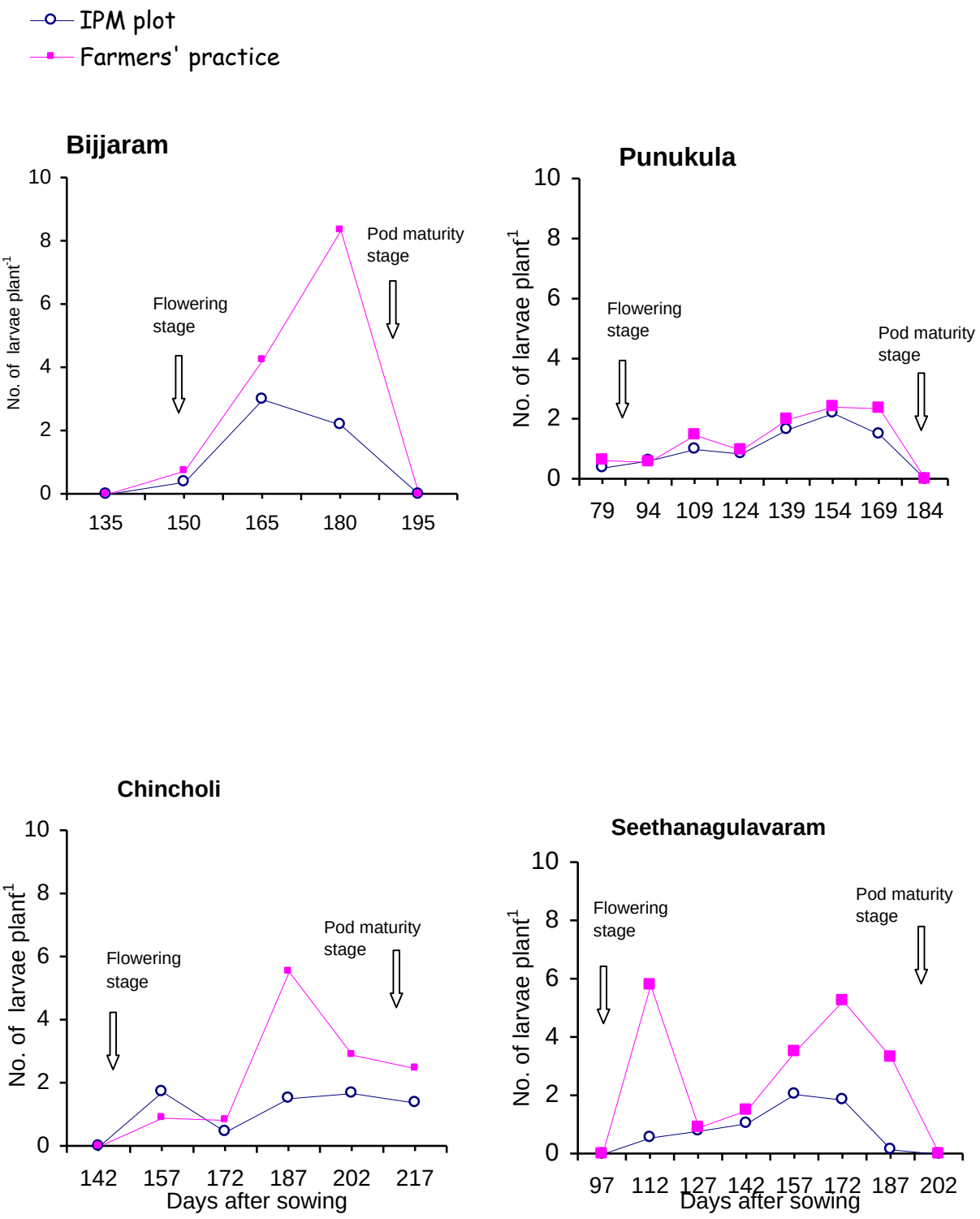
The purpose of the project and how it addressed the identified development opportunity or identified constraint to development.

- To evaluate IPM options on farmers' fields in partnership with stakeholders.
- To support development of simple, and effective strategies to generate IPM inputs at village-level.
- To identify and transfer knowledge of improved pest management practices to pigeonpea systems in Africa.

Research Activities

1.1 Pest status on pigeonpea. *Helicoverpa armigera* populations started appearing on pigeonpea crops from the second fortnight of September particularly on medium-duration varieties with 0.4 larvae plant^{-1} and reached the peak by mid-December with 5.0 larvae plant^{-1} in IPM farmers' fields. Most of the IPM farmers followed application of neem at flowering followed by HNPV and manual shaking with 10-15 days interval among treatments. The non-IPM farmers adopted 4-6 chemical insecticidal sprays with 15 days interval starting with the onset of flowering. The larval populations in non-IPM fields were always higher with 0.6 larvae plant^{-1} during September which increased to 9.1 larvae plant^{-1} by mid-November. Later the population dwindled to 0 level by the first fortnight of January. The details of the larval populations across locations during the cropping period are furnished in the Figures 1. IPM plots registered fewer larvae than non-IPM plots in all the locations.

Figure 1 : *Helicoverpa* Larval population in pigeonpea at different villages in Andhra Pradesh, rainy season 2000/2001.



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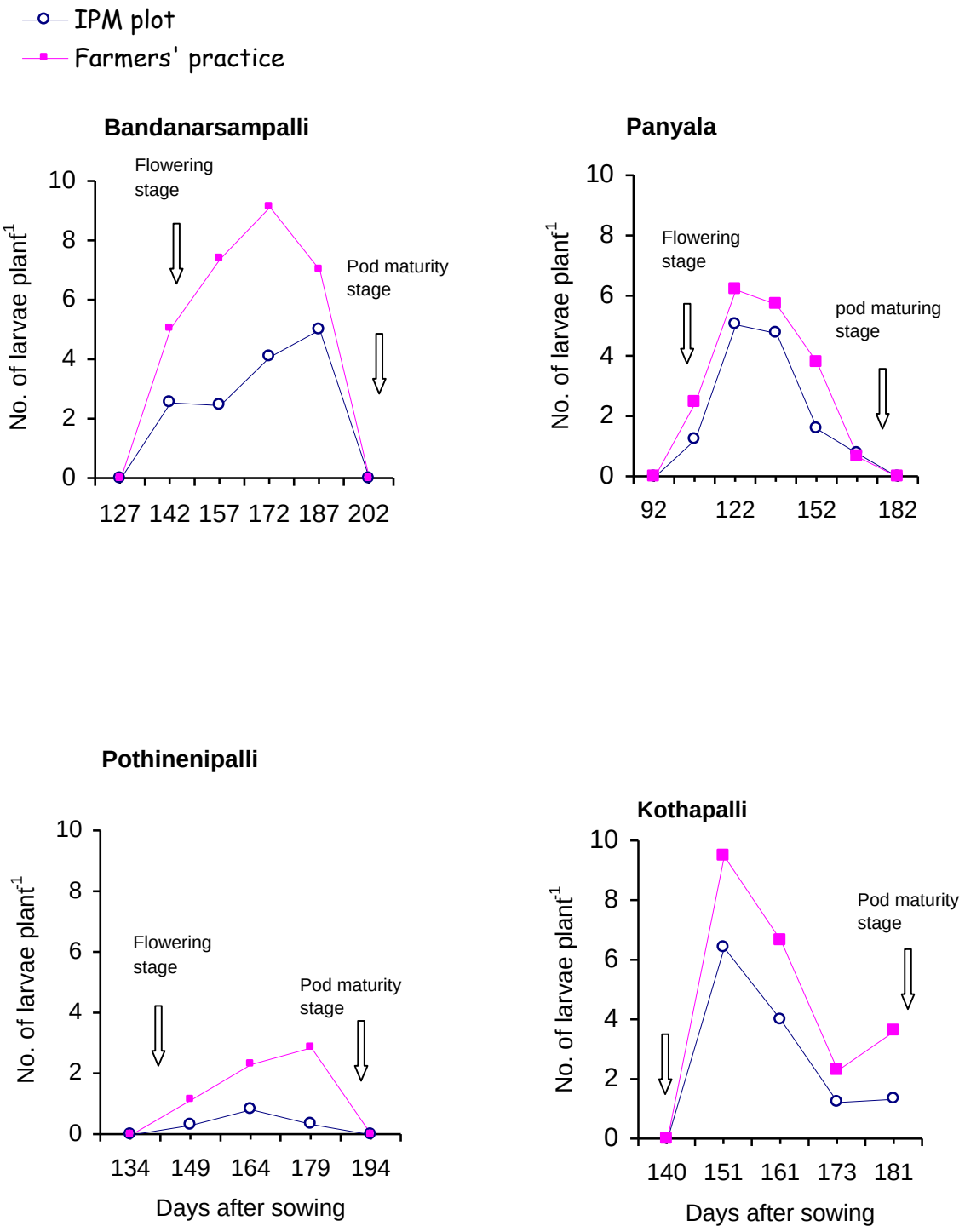
IPM plot
Farmers' practice
Bandanarsampalli
Flowering stage
Pod maturity stage
No. of larvae plant-1
0
2
4
6
8
10
127 142 157 172 187 202
Panyala
Flowering stage
pod maturing stage
92 122 152 182
Pothinenipalli
Flowering stage
Pod maturity stage
134 149 164 179 194
Days after sowing
Kothapalli
Pod maturity stage
140 151 161 173 181
Days after sowing

Pod damage assessment in IPM plots always showed superiority in pest management over non-IPM crops. The range of pod damage in IPM plots was 7.4-34% whereas in non-IPM plots the pod damage ranged from 18-60%, reflecting the ineffectiveness of chemical control against this species (Table 1).

Table 1. Observations on pod damage, and natural enemies in pigeonpea under IPM and non-IPM situations at different locations, Andhra Pradesh, rainy season 2000-2001.

Village	NGO	Percentage pod damage		Mean[1] number of beneficial insects per plant	
		IPM	Non-IPM	IPM	Non-IPM
Seethanagulavarm	CAFORD	11.8	18.9	0.24	0.00
Chincholi	CEAD	8.0	21.6	1.49	0.90
Pothinenipalli	PILUPU	11.8	24.4	1.67	0.46
Panyala	ROAD	14.8	23.7	1.00	0.65
Punukula	SECURE	12.9	18.3	1.24	0.77
Bijjaram	SEVA	7.4	22.2	1.12	0.50
Bavanandapur	TREES	17.9	26.8	1.37	0.60
Kothapalli		34.1	60.5	-	-

1. Mean of five fields in each location and twenty plants per sample.

1.2 Promotion tools for human resource development. This project gave high emphasis to empower partners in IPM knowledge through discussions at village-level and awareness camps. Published information and extension bullitins on the package of practices for pigeonpea and HNPV production strategies (Appendix I and II) were distributed to all partners. To enhance the utility of this information these bulletins were translated into local language Telugu. Video tapes emphasising the need for IPM and the importance of HNPV were produced.

1.3 Natural enemies and status of other IPM components on pigeonpea. Observations on natural enemies always showed higher population in IPM plots than non-IPM plots, indicating the deleterious effects of chemicals in non-IPM situations (Table 1). Maximum number (5.9 plant^{-1}) of natural enemies were recorded from Potinenipalli village of Andhra Pradesh during second fortnight of November. Natural enemies include the generalist predators like spiders, coccinellids and chrysopids. There was substantial saving in plant protection in IPM fields compared to non-IPM fields throughout the locations. The consolidated data on grain yield, cost of cultivation, cost of plant protection, net income of IPM and non-IPM plots at different locations are presented in Table 2. The active involvement of all partners throughout the crop season resulted in the improvement of pod borer management and up to 100% reduction in chemical pesticide use in IPM plots. Backup research organized at ICRISAT research station identifying the role of various pigeonpea IPM components revealed 46% reduction in pod damage in IPM plots against control plots where one neem, one HNPV, once manual shaking and one chemical spray was applied. Individual treatments applied with 15 days interval at reproductive phase of crop, such as shaking alone, application of neem, HNPV and chemical pesticides resulted in 30%, 33%, 28% and 37% reduction of pod damage respectively against unsprayed control plots. The balance sheet worked out to be 1:7 with shaking alone compared to 1:5.6 in IPM and 1:6 in chemical alone, reflecting the economic feasibility of the cultural control (Table 3). The benefit from IPM treatment can be enhanced in future through the local HNPV and neem production.

Table 2: Consolidated data on pigeonpea grain yield, cost of plant protection, gross and net income of IPM and non-IPM situations at eight locations, Andhra Pradesh, rainy season 2000-2001.

Village (NGO)	Yield (t ha^{-1}) Pigeonpea	intercrop	Cost of plant protection (Rs ha^{-1})	Total cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1}) Pigeonpea	intercrop	Net income Rs ha^{-1} pigeonpea + intercrop
Tejapur (CEAD)							
IPM	0.79	1.04	1262	8418	16833	12062	20460
Non-IPM	0.58	0.78	3315	12182	15500	5787	5604
Bijjaram (SEVA)							
IPM	0.15	0.32	250	1617	1390	3201	2953
Non-IPM	0.25	0.65	1925	6453	2248	7125	2908
Kodipunjulavagu (SECURE)							
IPM	0.45	0.41	708	8980	5992	5405	2274
Non-IPM	0.4	0.48	1244	10751	6493	5916	1659
Punukula (SECURE)							
IPM	0.35	0.45	742	8645	4799	4972	1031
Non-IPM	0.41	0.38	1495	10195	5062	6030	398
Hamsanpalli (REEDS)							
IPM	0.3	0.13	756	4262	4655	1181	1556
Non-IPM				whole	Village	under	IPM
Panyala (ROAD)							
IPM	0.69	0.78	691	9052	12634	5555	4692
Non-IPM	0.59	0.45	1576	7879	8871	2071	2626
Bandanarsampalli (TREES)							
IPM	0.26	2.67	435	5135	3213	18270	7695
Non-IPM	0.21	2.3	1208	5043	2083	8415	5564
Seethanagulavaram (CAFORD)							
IPM	0.9	-	509	2809	9550	-	6866
Non-IPM	0.69	-	2249	4646	6187	-	1540

Mean of 10 IPM farmers and 5 non-IPM farmers at every location; - Sole crop;
1 = Maize; 2=Sorghum; 3=Green Gram; 4=Sesema

Table 3. Cost benefit ratio of different treatments against *Helicoverpa armigera* in Pigeonpea – ICRISAT Patancheru, rainy season 1999 – 2000.

Treatments	Grain yield (kg ha^{-1}) Gross	Extra yield over control	Total cost of insecticidal treatment Rs	Additional income Rs	Total income Rs	C : B ratio
IPM	632	222	1700	3180	9480	1 : 5.6
NPV	477	67	2100	1005	7155	1 : 3.4
Neem	462	52	1500	780	6930	1 : 4.6
Endosulfan + shaking	574	164	1340	2460	8610	1 : 6.4
Shaking	532	122	1120	1830	7980	1 : 7.1
Endosulfan	607	197	1475	2955	9105	1 : 6.2
Control	410	-	-	-	6150	-

1.4. Training and capacity building Thorough training to partners at various levels on biorational pesticide production, storage and utilisation was provided, with more emphasis on HNPV production, during the initial phase of the project. More time was devoted to develop effective extension activities emphasising the importance of IPM in general and the role of various components, the limitations and suggestions to overcome the present situation of misuse of chemicals for better crop protection and a healthy environment. This project organised three short-term IPM training workshops for extension specialists, Department of Agriculture, Andhra Pradesh, India. Members of the project also strengthened IPM workshops organised by NARS with their participation and inputs.

HNPV Training

This project assisted in IPM training of Bangladesh researchers, organised by another DFID project (R7540) with emphasis on HNPV production and utilisation during 8-23 Dec 2000. Fifteen researchers including senior Agricultural officers and Extension Managers attended this programme which was organised for the first time in Bangladesh. All participants showed interest in this training due to its wider adaptability on several crops where *Helicoverpa* is a major constraint. The training camp showed keen interest in finding local material for HNPV production for providing greater sustainability and stability in future use. Thus this project strengthened another DFID project (R7540) through technology exchange.

Issues and recommendations

- All participants decided to develop one IPM village including various crops and intensify the activities for the next 3 years to see the real impact of IPM on various issues such as pesticide residues, environment, health and profits.
- The group pointed the importance of organising awareness camps on the misuse of insecticides through different ways including media.
- The participants also felt the need for collaborators meet once in a season for effective follow up.
- The support given by IFAD/DFID/ICRISAT was highly appreciated and the group felt that ICRISAT should continue technical support for further strengthening legumes IPM programmes in Bangladesh.

2.1 HNPV at village-level units. Among various IPM options the availability of good quality HNPV was considered as a prime component for rapid spread of IPM. This project quickly identified and strengthened seven village-level units which have produced 171,500 LE during the current cropping season. The details of virus production are furnished in Table 4. This project empowered the farmers to produce good quality product at field-level with proper guidance and accessibility to locally available technical equipments.

Table 4. HNPV production at seven villages in Andhra Pradesh and Maharashtra during 2000/2001.

Village (NGO)	State	HNPV Quantity (LE)
Gottipadu (ANGRAU)	Andhra Pradesh	114,000
Hamsanpalli (REEDS)	Andhra Pradesh	33,000
Kothapalli	Andhra Pradesh	2,000
Palvancha (SECURE)	Andhra Pradesh	6,000
Bandanarsampalli (TREES)	Andhra Pradesh	7,500
Ashta (NCIPM/CRS)	Maharashtra	5,000
Chincholi (CARD)	Maharashtra	4,000
Total		171,500

ICRISAT: 105,000 LE

Activity 2.1 Content of HNPV samples collected from Indian IPM villages in December 2000.

The data in Table 5 summarises the results of counting-chamber eye-counts of samples of HNPV collected from four IPM village units in India. Samples were double counted using standard heamocytometer techniques (Jenkins & Grzywacz 2000) by two enumerators and each enumerator made at least two separate counts of each sample. All counts were made on a high quality Leica DMRB microscope with x 400 magnification and under phase contrast illumination. Enumerators standardised the counts against a pure reference samples of HNPV of known Indian origin (NRI reference #0210).

Viral DNA from some representative samples was subjected to restriction enzyme (REN) analysis to characterise the virus strain but some of the results are still being analysed as it was difficult in some cases to extract sufficient viral DNA.

Precise counts of microsporidae (MSP) were not made. Bacterial contamination was noted but total viable counts, spore counts and species identification has not been carried out as yet.

Table 5. Details of observations of HNPV samples from various locations.

Sample	Actual average PIB ml^{-1}	Comments
Chettupali Thanda (1)	$1.88x10^7$	MSP present at medium level.
Chettupali Thanda (2)	$3.69x10^6$	MSP present at medium level.
Chettupali Thanda (3)	$5.88x10^7$	MSP present at medium level.
Gottipadu crude (1)	NPV not detected	Sample is MSP only.
Gottipadu crude (2)	$1.47x10^8$	MSP present at medium level.
Gottipadu crude (3)	NPV not detected	Sample is MSP only.
Gottipadu Guntur (1)	$3.25x10^7$	MSP present at medium level.
Gottipadu Guntur (2)	$2.57x10^8$	MSP present at medium level.
Gottipadu Guntur (3)	$2.24x10^8$	MSP present at medium level.
VJ 15 (Kothapalli)	$3.22x10^7$	Low level of MSP present.
VJ 25 (Kothapalli)	$2.63x10^6$	Medium level of MSP present,

All the samples are significantly lower in NPV content than the intended 6 x 109 Polyhedral inclusion bodies (PIB) ml-1 and two crude samples contain no detectable NPV. Samples with NPV counts of less than 1 x108 PIB ml-' can be presumed to have doubtful insecticidal activity against any but the smallest (younger than II instar) target insects at the application rates used by farmers.

Initial results from the DNA characterisation indicate a number of samples contain strains identical to the HNPV strain COIM-B.

Many samples contain high levels of microsporidean parasites probably of the genera Variamorpha spp. It has been reported before (Grzywacz 1997, Jenkins and Grzywacz 2000) that in HNPV production systems, where inocula are recycled without adequate purification, MSP can multiply in the production system displacing NPV. At each cycle the MSP content increases and NPV declines until MSP is dominant and the NPV can decline to below detectable levels. MSP infections typically are transmitted vertically from generation to generation via the ova. Infected insects show a decline in viability and fecundity but rarely die of the infection unless massively infected.

One feature of note is that in one set of samples (VJ15 & 25) the NPV content appears to decline over the series of samples. This would be consistent with a drop in virus yield with each cycle of virus production indicating that with each recycling of product to inoculate new batches there is a drop in yield of NPV of up to 90%.

Unfortunately the simple purification procedures used in these village production systems cannot separate NPV from MSP or bacterial spores. These can be separated but require the use of the technique of gradient centrifugation, using sucrose or glycerine gradients, and centrifuges capable of generating g forces in excess of 25,000. Given the relatively low g forces of the low-cost centrifuges used in the villages this technique is not viable with this equipment.

In addition, all samples contain medium to high levels of contaminating bacteria of various types principally Bacillus (including spores) and Streptococcus. These have yet to be fully enumerated or identified. While MSP do not present any significant health hazard they indicate sub-optimal NPV infection and poor post-harvesting processing.

A significant problem relating to the presence of large numbers of spores and MSP is that the HNPV is difficult to count accurately unless the enumerators have both adequate training and the correct equipment, i.e., phase contrast microscopes. Any counting of these samples by inadequately trained staff or staff using poor optical equipment is likely to result in inflated HNPV counts and lead to overestimation of HNPV content by a factor that could vary from x10-1000 depending upon the level of contamination.

2.2 Recommendations on improving quality of village-level HNPV production

The results of the admittedly limited survey reported in 2.1 above raise significant questions about the quality of products produced in the village IPM units. In many cases HNPV content was only 1 % of the nominal or target HNPV content and in some cases no PIB could be detected.

Some samples did contain significant quantities of HNPV at (>lx 108 PIB ml-1) but if used at the application rates suggested (250 LE ha 7l in chickpea) these would fall short of the HNPV application rates that have been shown to give effective control of podborer (Cherry et al 2000, Grzywacz 1998). Farmers reported effectiveness and we did see HNPV kills of podborer in field sprayed with these materials, spraying at these low HNPV rates will probably cause some significant infections. However the use of such low application rates has not been validated for effective rapid control of podborer especially when pest pressure is high and could produce control failures in years when pest pressure is high.

The physical package for low technology production developed by ICRISAT is a major advance in the development of low cost biopesticide production systems and is to be commended. The chickpea inoculation and rearing system likewise seems a robust and simple system very suitable for low technology production of HNPV. However the key question remains - can this sustainably and consistently produce acceptable NPV and the answer would clearly appear to be that in its current set up it cannot. The question then arises can this system be modified to attain suitable quality and to do this we need to understand the current causes of low yield.

The larvae currently selected for production are too large for efficient and economic NPV replication. The current recommendations call for larvae of early 5th instar 2.0-2.5 cm long to be used. These late instars are much more resistant to HNPV than earlier ones and 5th instars may require relatively high doses of (>104 PIB) to initiate infection. In this systeminoculation rates appear to be 1.2 x108 PIB larva -1 with the expected average yield per insect for HNPV (Gryzwacz unpublished) is 2-3 x109, it can be seen that the maximum multiplication factor is around x20 per production cycle. In contrast if younger and smaller 3rd instars are used the same yield can be obtained using inoculation rates as low as 1 x106 or even 1 x105 (Grzywacz et al 1998, Cherry et al 1997), thus giving multiplication factors of x10,000. The significant effect of such a change would be to reduce the amount of inocula required in each cycle.

The significance of the inocula is that the real decline in HNPV production to effectively zero appears to occur after the producers have used up the initial batch of semi-purified inocula provided at start up and commence to recycle their own products as inocula. Field collected insects often contain other pathogens such as MSP. It appears that inocula made from these can contain MSP and when reinoculated into new insects the MSP multiplies in competition to the HNPV reducing the multiplication of the HNPV. Samples taken here might indicate that this reduction is as much as 90% during each cycle. Thus after a number of recycling episodes HNPV content can easily fall to 1 % or even 0.1 % of the target level.

The key to improving both the productivity and poor quality control is to improve the efficiency of the system to a point where producers do not have to recycle the NPV they produce. If the system instead of having a multiplication factor of x20 had an efficiency of x1000 then one small bottle of purified inocula could support a full year's production.

A question arises why did the existing quality control system at ICRISAT not detect these low levels of HNPV in village products? The existing system relies solely on microscope counts to enumerate the HNPV. However the optical microscope currently used is not a phase contrast system and with this it is impossible to reliably distinguish HNPV from contaminants such as MSP or bacterial spores. Thus the staff even though they are careful, conscientious, and keep good records, are unable to make an accurate HNPV count. In addition to new equipment it is recommended that they receive an intensive training in HNPV production and quality control techniques.

It is also recommended that they be trained to do bioassays and adopt them as part of a standard quality control protocol (Jenkins and Grzywacz 2000). Bioassays would provide a valuable independent cross check on HNPV quality and if integrated with NPV counts provide adequate quality control.

Recommendations

- The current system of production be improved by selecting only the optimum sized larvae and therefore reducing the inocula needed. Laboratory studies in NRI suggest *3rd* instar *Helicoverpa* inoculated with a dose of 1x105 or thereabouts should be used. This should be tested in developmental trials at ICRISAT to develop a better system.

Protocols for optimisation exist (Cherry et al 1997, Grzywacz 1998) that could easily be adapted. This would require 2-4 months experimental work.

- Once an appropriate system is developed it should then be tested by one HNPV village to use it for at least during the 2001-02. The results should be monitored by a group equipped and trained in HNPV quality control procedures.

- The current state of equipment at ICRISAT needs to be improved. The unit should be provided with a phase contrast microscope with x400 phase optical system. The staff requires advanced training in using this microscope and in bioassay procedures to check the activity of batches.

- In addition, the quality of NPV inocula be improved, by using only sucrose gradient purified NPV free from MSP, for making inocula for supply to NPV units. This would require access to an ultracentrifuge but this should be available at ICRISAT.

2.3 Report on village-level production of biopesticides in India

The above discussion is a technical assessment of the farm-level technology biopesticide production developed at ICRISAT. But to evaluate village-level production additional socioeconomic analysis is required. We intended to use data from Phase II of the Microbial uptake project but due to a delay in getting the approval from the Indian Council of Agricultural Research (ICAR), this has not started yet. However, Robert Tripp's project on Information and IPM uptake, has collected some very pertinent data on this subject. A full report is proposed on village-level production to be prepared by June, once the findings of Dr Tripp have been fully evaluated and integrated with the technical data. This report will develop into a scientific publication by the end of 2001. The findings of the report will be factored into a future IPM strategy.

3.1 IPM technologies developed in India which have potential for East African pigeonpea production

Farm surveys and participatory rapid appraisals (PRAs) identified the non-availability of good quality IPM components such as plant-based products, HNPV, pheromones, and seed of high-yielding tolerant varieties of the crops as primary constraints for rapid spread of IPM technologies. To overcome the above constraints this project encouraged farmers to collect neem fruits from their backyards for extraction of insecticide, and established village-based HNPV production units which yielded satisfactory results for adoption of IPM options. Though it is not easy to assess the real impact of IPM over such a short period, IPM farmers harvested increase in yield through better management of pests with 6-100% reduction in pesticide usage across the locations. This project had impact in terms of cash savings in plant protection, higher yields, and stability of income. The beneficial effects on health and environment should be considered as an additional bonus. The indigenous practice of manual shaking of pigeonpea plants involves collection and removal of pests from their feeding sites. This gentle shaking can dislodge up to 97% caterpillars instantaneously. Three persons can cover 0.4 ha in a day. This operation needs to be repeated twice or thrice in case of further infestation. This effective, cheaper and environment-friendly indigenous technology was appreciated and adopted by farmers at all the project locations.

3.2 Crop surveys in Kenya. Discussions with Kenyan project partners followed by on-farm visits have thrown sufficient light in defining the important pest fauna that are critical to pigeonpea production. The pest problem in Kenyan pigeonpea varied with the altitude and crop duration. The crops planted at the same time (2°d fortnight of November) at different altitudes not only differed in crop phenology but also in pest complex. At 545 m above mean sea level (MSL) the crop during late February 2001 was close to flowering while the crop at 272 m above MSL attained its peak maturity phase. The blue butterfly was the predominant pest at higher altitude while *Maruca*, *Helicoverpa* at flowering stage and *Clavigrella sp.* at pod maturity phase predominated at lower altitudes (Table 6). This clearly suggests the need for the development of different crop protection strategies for different areas.

Table 6. Some salient features of insect pests of pigeonpea in relation to altitude in Kenya during February 2001.

Insect/ pest	Kabate (272 m MSL)	Kiboko (545 m MSL)
Blue butterflies	Severe 2-5 eggs/bud	Nil
Maruca	Nil	Severe (5-7 larvae plant-)
Helicoverpa	Traces	Moderate (1-2 larvae plant-)
Bugs	Traces	Severe (3-4 bugs & 1-2 eggs masses plant-1)
White flies	On weeds	Nil
Jassids	Present	Present
Blister beetles	Nil	Moderate (one in 5 plants)
Pollinators	Not many *	Active at least one plant
Birds	Not many *	Active (10-15 birds in 0.1 ha field) mostly Mynahs and Swallow tails.
Wilt	Present (< 1 %)	Severe (up to 15-20% in some plots)
Crop stage	Pre-flowering	Pod maturity
Soils	Red	Red

* Time of visit was around 1530 hrs at Kabate location and 0830 hrs at Kiboko

Issues and recommendations

- Since the HNPV demonstrations on pigeonpea were successful, it is necessary to further strengthen the collaboration between ICIPE and ICRISAT, Kenya for more elaborate field trials in farmers' fields

- Pigeonpea pest problems are complex in Kenya with the occurrence of *Maruca* during the early phase and followed by *Helicoverpa* and pod-sucking bugs at the pod maturity stage. Hence it is necessary to develop strategies tackling all the three groups for successful management of the crop

- During discussions with the ICIPE and ICRISAT, Kenya scientists it was felt reasonable to try HNPV in combination with *Metarhyzium* where ICIPE has expertise to tackle different pest fauna of pigeonpea
- Discussions with Dr Maniania, Insect Pathologist at ICIPE who has wide experience in the management of termites and thrips through insect pathogens can be of great importance to ICRISAT groundnut aflatoxin as well as bud necrosis virus management
- In view of ICIPE's experience in the production and usage of insect pathogens it may be synergistic to have close collaboration with ICIPE scientists in our plant protection activities.

First Ever HNPV Field Trial in Kenya a Success

The first *Helicoverpa* NPV local isolate from Kenya has been successfully field tested on pigeonpea at the Kenya Agricultural Research Institute (KARI), Kiboko Research Station, Kenya. Dr S Sithanantham of the International Centre of Insect Physiology and Ecology (ICIPE), Kenya, and Mr. Joseph Baya (M.Sc. student with Kenyatta University, Nairobi, Kenya) collected a large number of *Helicoverpa* larval samples from different crops in various locations of Kenya starting from the coastal lowlands to the highlands and the Lake Victoria basin. They painstakingly isolated the polyhedral virus occlusion bodies in the laboratory, then bioassayed them on live *Helicoverpa* larvae to test for potency.

Similar viruses have been isolated in India and other parts of Asia through long processes that took a number of years to reach the farmers. The feedback from these farmers has been encouraging. On learning about these developments, ICIPE sent Mr Baya to ICRISATPatancheru to acquaint himself with HNPV production and utilisation under the guidance of Dr G V Ranga Rao. Dr J M Lenne, Deputy Director General visited the project at ICIPE in 2000 and indicated ICRISAT's interest to collaborate in further development of this local biocontrol agent. Based on the discussions for a joint ICRISAT-ICIPE field trial, Dr E Minja of ICRISAT-Nairobi formulated the HNPV collaborative field trials in 2000, and the shortduration pigeonpea genotype ICPL 87091 was established in mid November. The first spray of HNPV was applied on 16 January 2001. During a joint monitoring visit by E Minja, S Sithanantham, J Baya, and GV Ranga Rao on 20 February 2001, the crop was in the reproductive phase with large numbers of flowers and pods. By then, three HNPV sprays had been applied in virus treatment plots. The scientists observed several HNPV infected larvae, particularly in virus sprayed plots, testifying to the field efficacy of this local biopesticide. The harvest data can bring more detailed information about the relative advantage of this selective biopesticide compared to other management strategies. The team will be happy to share information about this fruitful inter-institutional collaboration.

4.1 Pheromones. *Helicoverpa* pheromone supplied by NRI was effectively utilised by all partners for monitoring the species throughout the cropping season. This eliminated the confusion of existing poor quality *Helicoverpa* septa from the local markets for proper timing of control strategies. However, the existing local technology needs to be rectified for improving the quality of septa in the local markets for strengthening IPM. Experiments conducted in the identification and evaluation of different blends of *Maruca* pheromones obtained from NRI did not reveal any clues. Testing four blends, virgin female and empty delta traps replicated five times during the peak pest situation (September-October) at ICRISAT-Patancheru was not successful. In view of the importance of the *Maruca* on several crops, it is important to have in-depth discussion with NRI pheromone experts to sort the existing problem of monitoring of this species.

4.2 Field studies with pheromones, conducted during the peak *Maruca* adult activity at ICRISAT-Patancheru did not yield any inference. The *Maruca* pheromone found effective by NRI and successfully evaluated in West Africa with four different blends was not successful in the Indian situation. This could be due to pheromone composition, existence of different species/biotype, trap design, and the quality of the pheromone itself. Since the importance of the pest is increasing year by year on several crops there is every need for developing effective monitoring. Dr Downham and the pheromone group at NRI should consider including this activity in the coming projects.

Outputs

1. An environmentally safe and economically feasible pest management strategy for pigeonpea farmers developed and promoted to farmers and extension workers in target villages in India. Supporting appropriate farmers and extension focused promotion tools.
2. Recommendations for the village-level production of biocontrol agents will be produced targeted at NARS, NGOs and scientific community.
3. A report detailing appropriate pest management for pigeonpea IPM in Africa will be produced and transferred to crop protection program (CPP) pipeline project.
4. Pheromone trapping for two pigeonpea pests developed and report prepared for NARS and NGOs on viability of the technique.

In output 1 all the partners were involved from the inception of the project with in-depth discussion and training at ICRISAT as well as at village-level. Extension material such as Information Bulletins, handouts, video tapes in English and local languages were made available depicting the importance of project activities.

In output 2, since the availability of IPM components is the prime constraint in the promotion of IPM, this project devoted substantial time in strengthening these areas. In this connection, all partners were encouraged to improve neem seed collection, processing, storage and utilisation. Seven full-fledged HNPV production units at village-level were strengthened to meet the ongoing demand for good quality virus at farm-level. This enabled the village-level units to touch their HNPV production around 171,500 LE during this season.

In output 3, the discussions with Kenyan project partners followed by on-farm visits have thrown sufficient light in defining the important pest fauna that are critical to pigeonpea production. The pest problem in Kenyan pigeonpea varied with altitude and crop duration. The crops planted at the same time (2°d fortnight of November) at different altitudes not only differed in crop phenology but the pest complex also varied.

Output 4, *Helicoverpa armigera* pheromone supplied by NRI was successfully used by all the partners for monitoring the species throughout the cropping season. However, *Maruca* pheromone developed at NRI which was found effective in West Africa, though four blends were tested during the peak pest activity, did not reveal any clues emphasising the need for in-depth research to address the issue.

Highlights of the project (2000-2001)

- •Awareness on economically feasible and environmentally safe pest management strategy was created at all levels in target areas
- The project implemented pigeonpea IPM in 55 villages covering more than 1000 farmers.
- This project was responsible for strengthening seven HNPV production units at village-level (Maharashtra and Andhra Pradesh) to cater to the needs of farmers
- Experts from insect pathology, impact assessment team from NRI, visited the locations for further strengthening the ongoing activities through their valuable suggestions
- Visits by senior administrators (DDG of ICRISAT) to some of the on-farm locations and their suggestions gave immense satisfaction and confidence to project partners

- Training camp in the production of insect pathogen (HNPV) was organised for Bangladesh researchers for the first time
- One Information bulletin and two extension handouts were produced in English and local languages and shared with all the partners
- Application of biopesticides was adopted by partners at all the locations
- Four graduate students, extension persons and farmers were trained in IPM of pigeonpea pests with special emphasis on HNPV production and use
- Three short-term workshops on IPM for extension specialists were organised at ICRISAT-Patancheru.
- Facilitate inter-institutional collaboration in initiating IPM in pigeonpea through technology exchange, training and resources with ICIPE, Kenya
- Opportunity was given to farmers to share their views on IPM through television.

IPM in News

Though good news spreads fast, the benefits of IPM from one location took some time to reach to the other locations primarily due to the lack of awareness amongst people and the involvement of very few organisations. Though IPM is a new concept, and proved its importance beyond doubt in several locations, it needs the commitment from all concerned. The partners involved in the present IPM project did their best to spread the novel concept of IPM to achieve the maximum impact. This project realised the role of media and appreciated their inputs from time to time in propagating IPM (some important news clippings on IPM in different locations enclosed). During the project the media published several articles on IPM covering HNPV production, importance of neem, role of natural enemies, manual shaking of pigeonpeas and the wise use of chemicals for achieving the stability and sustainability in pulse production. Scientific interviews and farmers' interviews covering various IPM activities and their perceptions were shown through local television.

Contribution of Outputs

The development and sharing of IPM strategies to the resource-poor pigeonpea communities resulted up to 100% reduction of inputs on chemical pesticides without sacrificing the yields. This in turn provided higher profits mainly due to the reduced investments on inputs. This project made headway in creating awareness (role of natural enemies, use of natural resources and need-based appropriate use of chemicals) through in-depth training and participatory approach. The strengthening of HNPV units at village-level further stimulated farmer participation and its use on several crops where *Helicoverpa* was a constraint. The involvementof committed NARS and NGOs encouraged the farmers about the use of neem from their fields, rather than depending on market products. Thus the strategy developed along these lines was adopted by all partners with significant impact on the profits with improved environmental quality through reduced use of chemical pesticides.

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