THE STATUS OF INSECT PESTS IN ASIAN LEGUME CROPS 10[1] YEARS FROM NOW

John A. Wightman
Principal Legumes Entomologist
ICRISAT, Patancheru, Andhra Pradesh,

ABSTRACT

A look at what is currently happening in Asian agriculture gives clues to the status that the insects living on legume crops will have over the next 10 years. The overuse of insecticides will continue to induce out-breaks of new and established pests, to the extent that the role of insecticides will diminish. However, we shall see insecticide management systems coming into existence. Changes in cropping pattern, especially the introduction of irrigation systems, have also allowed new pest problems to develop. The food processing industry will call for the large scale planting of the more commercial crops-soy and mung bean, groundnut. The positive way to the future is for insecticide management, accompanied by resistance monitoring and a public awareness campaign, and for a greater effort to be put into seeking alternative approaches to chemical control techniques.[2]

INTRODUCTION

The current status of legume crop production in Asia

Legume crops, as a whole, are important throughout Asia because many of the people of this continent are vegetarian by choice or because they cannot afford to buy meat. The wide range of grain and green vegetable legumes[3] that supplement the basic diet of rice or wheat products supply additional protein, minerals and vitamins. Pulses are also processed in the home or on an industrial scale to produce fermented products (e.g. tempeh), noodles and a host of 'snacks' and sweets. Groundnut oil is a popular cooking medium in South Asia. It is extruded on-farm and on a commercial scale. Soybean is gaining importance as an oil and process crop.

1. The title of this paper originally referred to '30 years' hence. Observations made by the author between the time the abstract was prepared and the full paper was drafted have shown that certain decisions will have to be made much sooner than be originally thought.
2. Submitted as Conference Paper CP by THE INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS (ICRISAT)
3. In the context of this paper 'legumes' includes pulses (gram), which are the dried, and often hulled, seeds of pigeonpea, chickpea, lentils, green gram (= mung bean), black gram, horse gram (= lathyrus), cowpea, *Phaseolus*, etc. as well as multipurpose crops like groundnut and soybean, together with, usually, the pods of *Phaseolus* spp., and *Vigna* spp. and the seeds of *Pisum* and *Vicia faba* that are eaten as green vegetables.

There is little doubt that legume production is important in a part of the world where, with exceptions, there is an apparently uncontrolled human population growth rate and where there is much poverty by contemporary western standards.

In trying to comment on legume production during the next 10 years, it is a useful exercise to assess what has happened in the immediate past. When one examines the pan-Asian data for cereal production over the last 30 or so years (Table 1) there is some cause for complacency. There has been an increase in the area grown and a marked improvement in productivity. The data, being quoted on an annual basis, do not indicate that the increase in productivity is partly notional because irrigation schemes introduced during this period have encouraged the postrainy season production of rice and wheat, in particular.

Be that as it may, it is clear that there has been little or no spill over to pulse production, taken to represent legume production as a whole. The picture is of stagnation. In fact it is worse than this because the population of the continent has increased during this time. Table 1 does not show that pulse production in S. Asia has remained constant during this period at 12-14 Mt per year, production in E and SE Asia, though comparatively small, has increased from 0.8 to 2.0 Mt per year, but is off-set by a decrease in production in China (from 8.5 to 5.6 Mt per year).

Table 1. Area sown, production and productivity of cereals and pulses in Asia, 1961-1986 : FAO/IFPRI data.

			'61	'66	'71	'76	'81	'86
Cereals	Area	Mha	239	249	260	268	272	271
	Production	Mt	248	309	385	445	528	626
	Productivity	$t\ ha^{-1}$	1.04	1.24	1.48	1.66	1.94	2.31
Pulses	Area	Mha	37	34	32	33	32	33
	Production	Mt	23	19	29	21	20	22
	Productivity	$t\ ha^{-1}$	0.62	0.56	0.62	0.64	0.62	0.67

Why have the principals of the 'green revolution' (= the provision of varieties that are better adapted to a given zone than those that were previously grown, irrigation, fertilizers and pesticides) not spun-off to promote legume production? Is there competition for land? This may be true in some places but Table 1 shows no encroachment overall. The trend has been for sequential cropping, with a legume crop being sown before of after a cereal, e.g. mung bean in paddy fallows, chickpea before wheat or for seasonal rotation, as with groundnut and pigeonpea for instance.

One can point to economic factors-alternative sources of employment for farm labour, poor prices, and lack of markets-as being the cause of stagnant production. With the exception of the first factor, where machines have to some extent replaced the diminishing labour supply, there is no wide scale evidence for economic constraint, quite on the contrary. The activities of National Agricultural Research Systems NARS, bilateral crop improvement programs and International Agricultural Research Centres IARCs have resulted in a steady, but continuing improvement in the yield potential of the crop varieties. The fact that farmers cannot always purchase seed of the improved varieties can be mentioned in passing. Investment in and subsidisation of the rural sector have not only changed the annual cropping cycle by providing irrigation but has also given farmers access to artificial fertilizers and pesticides, that, although mainly intended for rice, are stretched out with the intention of boosting the yield of legume crops.

Now we are getting to the nub of defining the problem of stagnant legume production. Once a problem is defined, its solution is often apparent. The question that we must ask is 'is the technology that has boosted cereal production applicable to legumes?' It appears that there are reasons to believe that some of the problems that now beset legume growers have been induced as a result of the transfer of inappropriate technology. Unfortunately, it is not possible to rerun history to carry out experiments to 'prove' this supposition so that much of what I write is speculative. However, the following indicate the kind of situation I am referring to :

Examples

Lake Tempeh is 4 h drive to the north of Ujung Pendang, on the Indonesian island of Sulawesi. It is large and sufficiently shallow for 15,000 ha of rice to be planted around its periphery in the rainy season. As the water retreats after the rainy season, mung and soy bean are sown in the rice fallows. There is usually enough time to sow five successive legume crops before the next rainy season. The farmers often apply insecticides to the legume crops every two days to suppress high densities of flower and seed eating caterpillars. They know the insecticides are not tampered with because they still give the same 'sting' to their tongue. There is clearly an insecticide resistance problem but the facilities to monitor it do not exist in the locality.

Cotton is a valuable crop in the coastal region of Andhra Pradesh, India. In the 1987 season, farmers found that pyrethroid insecticides were failing to control the major pest *Helicoverpa (= Heliothis) armigera*. Eighteen committed suicide because they were unable to clear debts associated with high insecticide bills and minimal yields. McCaffrey *et al.* (1989) found that in October 1987 *H. armigera* larvae from this area had high levels (x56) of pyrethroid resistance. Larvae taken from pigeonpea on the ICRISAT farm, 2-300 km to the west of the cotton growing area, were slightly resistant to pyrethroids (x6) at this time. Two weeks later the ICRISAT larvae had x176 resistance which by 17 March 1988 and increased to x224. The ICRISAT populations were subjected to little pyrethroid pressure and are fairly isolated from local sources of infestation. Meteorological evidence indicates that moths were erried inland from the coast by cyclonic winds blowing east to west at this time. MaCaffrey *et al.* (1989) point to the possibility of the spread of insecticide resistance by long range moth migration.

Groundnut farmers on the Deccan plain of central India either use no insecticide or put on four to seven applications. The non-sprayers sometimes have moderate attacks of the groundnut leaf miner that are usually of no economic significance. The latter have crops attacked by *Spodoptera litura* and virus carrying white flies and usually lose some of their potential yield. White fly appeared in this region after there was a major change in cotton variety. Resistance to insecticides in *S. litura* in peninsular India was reported in 1984 (Ramakrishnan *et al.* 1984).

A technician working on a research station in Thailand applied a range of insecticides on 24 occasions to medium duration pigeonpea during a season without controlling a range of pests, including *H. armigera*, *Maruca testulalis*, and *Nezara viridula*.

Yadav (1981) provides evidence that links the provision of wells and pumps with outbreaks of white grub damage in northern India. Irrigation produces the high soil moisture levels that promote maximum rates of larval survival and reproduction.

The induction of pest problems by changes in farm management practices

To develop the point about irrigation further, such schemes have extended the growing season on many farms in India, for instance. This has certainly helped rice production, and has also permitted some farmers to grow successive groundnut crops, for instance. This is understandable because this crop gives a high return per unit weight but is a high risk crop undr rain-fed conditions. Also the post-rainy season (rabi) crop invariably gives a better yield than the rainy season (kharif) crop. The latter is more likely to suffer form fungal foliar diseases and a range of insect pests. However, now the rabi crop is also attacked by insects-but by a different spectrum. It is not attacked by white grubs and the hairy caterpillars because their single annual generation appears in the rainy season. However, *Spodoptera* *litura*-once limited to tobacco in India-is a serious pest in the major growing areas of the south east. It is multivoltine and appears to have become adapted to this crop since the time that irrigation schemes permitted sequential sowing. This practice provides a continuous supply of one host plant and the opportunity for an insect to switch its host preferences.

The groundnut leaf miner *Aproaerema modicella*, although recognised as a groundnut pest for many years, has also become more prolific in the rabi crop in the south east of India. It is possible to predict that this is because the drought stress, that besets crops towards the end of the season as irrigation water becomes scarce, boosts the reproductive capacity of this species (Wheatley *et al.* 1989).

Taking pigeonpea, another ICRISAT crop as an example, it is also possible to indicate how the activities of breeders and agronomists can make notable progress in increasing the yield potential of a crop but at the same time can, quite unwittingly, create new problems. Pigeonpea in its native form is perennial. A common strategy among perrenial legumes for dealing with the depredations. caused by waves of flower and seed eating insects is to produce copious flowers and seeds on the basis that some will eventually survive. This fits in with the farmers' needs when the seeds are edible by humans. He has a continuous supply of food if he can get at it before and protect it from insects.

The trend for regimentation in agriculture has resulted in crops being sown in lines and for a crop being allowed to occupy a piece of land for a finite period. In the case of pigeonpea, this has led to the selection of varieties of small stature that flower in much less than about 9 months and which are grown in farming systems that finish up with virtual monocrops of pigeonpea. The monocrop is either intentional, because that is how it was sown, or incidental because the drought resistant nature of pigeonpea means that other crops have to be harvested well before it has finished producing. Such monocrops favour the proliferation of pests like *H. armigera* and *M. testulalis* (Reed and Pawar 1981). The shortening of the duration of the crop means that there is less of a chance that one or more flush of flowers and seeds will survive insect attack.

Generations of selection has resulted in farmers having a chance to grow pigeonpea with a much shorter duration but with little natural host plant resistance. However, there are exceptions to this because Indian National Program scientists in conjunction with ICRISAT have been instrumental in selecting and exploiting whatever host plant resistance there is in the germplasm. Breeding line ICPL 332 has, in fact, recently been released in India because resistance to *H. armigera* is included in its characteristics.

To look into the future, it is possible to predict that the patterns of farming in Asia will change. In many countries industrialisation and then urbanisation will take people from the land. This will result in the creation of food markets that will be filled by commercial organisations. Such firms will not be able to rely on the current small farm systems because there will be no labour to run them. Therefore, for the sake of efficiency and mechanisation, there will be an amalgamation of land holdings following land purchase and we shall see legume crops grown on a broadacre basis for packaging and marketing in the cities. No reference is needed-the same phenomenon occurred in Europe in the nineteenth century.

Such farms will be backed by capital and will therefore be high input in terms of water, fertilizer and pesticides. Such farms, that will undoubtedly be managed on a monocrop basis along western lines, and will be breeding grounds for many insects. However, many of the pests are already resistant to many of the pesticides available. Unless the managers of such farms are well advised about wise pest control procedures the economic development (= industrial development) of the relevant countries will slow because labour will flee from the high food prices in the cities to the country to grow their own food.

Change to farming systems and potential changes to social systems have induced pest problems. The easy solution to such problems is to advise the application of insecticides. Such advice can come from many sources includings extension officers, local shopkeepers, neighbours and economists. Their, usually good intentioned, advice have frequently lead to further problems :

- Non-target insects (etc.) have been killed by insecticides. Natural enemy populations cannot recover as fast as their prey so that further pest outbreaks occur. There is invariably more defoliation in groundnut plots that have been sprayed with insecticide than in unsprayed plots (Wightman and Amin 1988).
- The large fauna of insects that are neither pest nor beneficial are killed by insecticides so that a treated field is no longer attractive to general predators, especially birds.
- Suitable application equipment may not be available. Furthermore, the personel employed to apply the insecticides are probably not trained and may not be able to read the instructions on the label of the chemical container.
- Repeated applications of insecticides, especially misapplied insecticides, result in the development of insecticide resistance.
- Insects become 'new pests', presumably because of the interaction of the above factors. The whiteflies and *H. armigera* that are causing concern to groundnut farmers in south east India are a

good example of the latter. The wide range of defoliating caterpillars and Hemiptera that are found on vegetable legumes all through Asia are also good examples of new pests.

Insects-the cause of stagnation in legume production in Asia?

Whilst I would not diminish the importance of fungal and viral diseases (the major constraint to groundnut production) and of abiotic constraints such as drought and soil mineral depletion as reducers in yield, certain crops seem particulaly susceptible to damage by insects. For instance, the paper by Marwoto and Neering (1990) in these Proceedings shows that the seed yield of a mung bean crop can be reduced to virtually nothing by thrips and *N. viridula*, depending on the time of sowing. The extent of the damage caused by agromyaiid stem flies to seedling mung and soybean and of pod-boring Lepidoptera to pigeonpea is also well known.

There is also evidence from Africa (Wightman 1989) that soil insects are more important than is generally realised, especially to groundnut farmers. White grub damage is well documented in northern India (Amin 1988) - but does the same problem extend through Thailand, where white grubs have been detected in high densities and in interlying Myanmar? Serious damage caused by doryline ants and buprestid (jewel) beetles has also been reported (ICRISAT 1987 and Manochai and Singha 1985), but the extent and overall level of their damage has not been determined.

Legume crops are also subject to many virus infections. As far as the plant protectionist is concerned they should not be considered to be the sole preserve of the pathologist. They are usually spread by insects (also mites, fungi and nematodes) and the basic principals of integrated pest management IPM apply to the control of vector and disease.

The future-the bad news first

The picture that is emerging is that the current stagnation in legume production in much of Asia is partly due to damage caused by insect pests. Sometimes the insects reduce yields considerably-there are cases on record (W.R. Dangelmaier unpublished) where pigeonpea growers have no crop to harvest because of insect damage and are therefore disinclined to grow that crop again. In other cases the cost of the insecticides that farmers feel are needed make the crop uneconomic. This is particularly true where insecticide resistance has developed.

Unless there is urgent action taken to halt the crop losses caused by insects to legumes there will be further malnutrition in Asia. Both legumes, as whole, and the insecticides that have been developed to protect them will be elected to be worthy of conservation.

The future-working towards good news

In planning for the next 10-years we could sit back and let the current situation continue. This is likely to lead to a worsening of the insecticide resistance and the appearance of more pests. The net result would be a further reduction in legume production. This we do not want. What can we do to reverse the current trends? One way is to incorporate methods of returning to the biotic balance between the components of natural systems that prevents major outbreaks of defoliators.

A reversal in the trend for more irrigation schemes to be introduced to the semi-arid and arid areas is unlikely and undesirable. It is likely that as the effects and control of salinisation and ground water depletion become better understood new irrigation schemes will be planned differently. Perhaps training in the least disruptive ways of exploiting such schemes could be part of the package. For instance, there should be encouragement at the village level for farmers to coordinate their rotation in such a way that crops are sown together at times that allow the flowers and developing pods to avoid pest attack. This implies that entomologiats should be in a position to tell extension workers when the cohort of insects that attack legumes are least likely to be active, of course, synchronised planting on a village or watershed basis would allow legume crops to grow and be harvested before pests had a chance to build up. A fallow period followed by a cereal crop would interrupt the cycle of the specialist legume pests.

This process would be assisted if the farmers were to be provided with varieties with resistance to the key pests of a particular agroecological zone. At the worst farmers should not be supplied with the seed of cultivars that may be high yielding but are highly susceptible to pests (and diseases). That is not the key to sustainable agriculture. It is realised that resistance to given pests may not exist at high levels within the germplasm of all legume crops. This appears to be the case for resistance to stem flies in mung and pod borers in short duration pigeonpea, for instance (Talekar 1980).

We can also plot out another plan for entomologists. They should :

- be able to describe the spatial and temporal distribution of the main pests of legumes (including soil pests) in their agroecological zone (s).
- be able to state at what density they are likely to start reducing the yield of the target crops.

This implies the need for them to survey the main legume growing areas and to carry out well directed experiments to determine the relationships between the intensity of insect attack and yield loss. Neither task is as easy as it may appear.

Once this is done it is possible to plan an insecticide application strategy that is dependent on rational decisions rather than the current farmer policy that is often beyond the understanding of professional practitioners.

Insecticide resistance

One of the most serious issues that is facing legume farmers today-even if they cannot see-it is insecticide resistance. If the current approach to pest control continues, i.e. the uncontrolled application of pesticides, alone and as tank mixes, there will be few effective insecticides available in 10 years from now. Although our attention is frequently drawn to pyrethroids as being particularly susceptible to resistance build up, other classes of chemicals are equally fragile in this respect (Chou *et al.* 1984, Ramakrishnan *et al.* 1984). The cabbage growers of Thailand, in particular, are well aware of this because of the problem they now have with controlling the diamond back moth (see Proceedings of the Symposium in these Proceedings).

Insecticide conservation

On talking to many people in Asia about the apparent failure of insecticides to kill insects one gets the impression that indeed pan-Asian, pan-legume pests like *M. testulalis, N. viridula,* and *H. armigera* and *S. litura* have become resistant in many places. However, even though these impressions may be shared by many observers, they remain as impressions and, as such, are insufficient to impress other scientists and the administrators who are in a position to reverse trends that will soon be irreversible.

Irreversible? One of the options available in insecticide management programs is to synchronise insecticide usage. For example, in month 1 farmers could apply a carbamate, an organophosphate in month two and a pyrethroid or endosulphan in month 3 : the cycle to restart in month 4. If key pests are resistant to all classes of insecticides, this approach, which is showing a fair degree of success in Australia where pyrethroid resistance in *Helicoverpa* on cotton is a problem (Rorrester and Cahill 1987), will not be available. Ironic though it may be, we have to think in terms of insecticide conservation. It is unlikely that the proponents of IPM, and I am one, will be able to find ways of rendering insecticides unnecessary within the next ten years.

Action Plan

Before resistance management plans can be implemented, it is necessary to determine the extent of the problem i.e., the geographical distribution of insecticide incidence patterns, and its intensity.

This can be effected by :

- equipping training laboratories for running courses on insecticide resistance detection at suitable centres in Asia, perhaps associated with IARCs,
- running regular training courses on resistance detection for technicians drawn from NARS,
- providing and equipping regional or provincial labs in and from which trained technicians can monitor insecticide resistance,
- installing a 'central' data collection unit within Asia to act as a collation centre for the scheme,
- encouraging laboratories in the developing world to exploit serological and other techniques for detecting and characterising insecticide resistance,
- locating and influencing donor agencies, including especially the private sector, to found the various levels of this exercise,
- raising the consciousness of high level officials to what wide scale insecticide resistance means to food production in the countries of Asia during the next ten years.

Getting off the insecticide treadmill

As has already been implied it is necessary to provide some alternatives to insecticide application and to point out how insecticides can be used without inducing insecticide resistance, and hazards to the health of natural ecosystems, humans and other organisms. The judicious use of insecticides involves refinements such as timing applications to coincide with the hatching period of a pest. This means low doses of a 'soft' insecticide can be applied, thereby preserving natural enemy populations.

The need to provide cultivars with insect resistance must remain as a high priority, but it should be realized that they may not always exist. Crops like pigeonpea counteract pest attack by producing large quantities of seed and have low levels of antibiotic activity. The production of insect resistant varieties of this crop have been the result of huge screening programmes that may be beyond the resources of many organisations. However, molecular biology techniques may enable us to transfer insect resistance factors from other plants.

Cultural control methods remain as an area where there is much scope. Some techniques have already been alluded to - synchronised planting etc. Other methods include the enrichment of the environment in such a way that natural enemy populations are conserved. For instance, this can be achieved by growing plants that are a food source and refuge for the adults of parasites or by leaving a few weeds in the fields to shelter spiders, carabids, frogs and other predators.

Such approaches have to be evaluated in relevant environments and, where suitable, inculcated into the thought patterns and practices of the relevant farmers. We would then have integrated pest management (IPM) in action.

Very often basic knowledge, such as the life cycle of a given pest is lacking or not available. This means that there is a need to institute a formal method of information sharing among scientists. Hence, the need for an IPM network, possibly composed of a number of working groups dedicated to specific taxa or problems.

CONCLUSIONS

The amount of legumes produced in Asia during the last 30 years has stabilised, representing a net decrease in production per person. This gives cause for concern because they are an important part of the diet in many of the poorer parts of the continent. It is suggested that changes in farm management, such as the introduction of irrigation schemes and the misuse of insecticides, has resulted in an increase in both the number of insect pests attacking legumes and the intensity of their attack.

Whilst it is not possible to turn back the clock, it may be possible to reverse the current trend in which pests are forcing the 'extinction' of crops like mung bean in some areas. The means available include insecticide management, preceded by the initiation of insecticide resistance programs and the adherence to the principles of IPM-exploiting whatever host plant resistance is available in the germplasm of a crop, and manipulating the farm environment to favour the activities of beneficial animals and diseases.

REFERENCES CITED

Amin, P. W. (1988). Insect and mite pests and their control, pp 393-452 in : Groundnut (ed P.S. Reddy). New Delhi : Indian Council of Agricultural Research.

Chou, T.M., Rao,. C.H. and Cheng, E.y. (1984). The occurrence of insecticidal resistance in three lepidopterous pests on vegetables. *Journal of Agricultural Research in China 33* : 331-336.

Forrester, N.W. and Cahill, M. (1987). Management of insecticide resistance in *Heliothis armigera* (Huebner), in Australia, pp 127-137 in : Combating resistance in xenobiotics : biological and chemical approaches (ed M. Ford, B.P.S. Khambay, D.W. Holloman and R.M. Sawicki). Chichester, England : Ellis Horwood.

ICRISAT (1987). Annual Report of the International Crops Research Institute for the Semi-Arid Tropics for 1986 p 228. Patancheru, India : ICRISAT, Patancheru, AP 502324, India.

McCaffrey, A.R., King, A.B.S., Walker, A.J. and El-Nayir, H. (1989). Resistance to synthetic pyrethroids in the bollowrm, *Heliothis armigera* from Andhra Pradesh, India. Pesticide Science, 27 : 65-76.

Manochai Keerati-Kasikorn and Preecha Singha (1986). A study of the age at which pods were attacked by the subterranean ant. pp 261-263 in Proceedings of the Fifth International Groundnut Conference, Chiang Mai 19-21 March 1986.

Marwoto and Neering, K.E. (1990). Mungbean pest management by adaptation of planting date and supervised control. Proceedings of the First Asia-Pacific Conference of Entomology. in Press.

Ramakrishnan, N., Saxena, V.S. and Dhingra, S. (1984). Insecticide resistance in the population of *Spodoptera litura* (F.) in Andhra Pradesh. Pesticides 18 : 23-24.

Reed, W. and Pawar, C.S. (1982). *Heliothis* : a global problem. pp 9-14 in International Crops Research Institute for the Semi-Arid Tropics 1982 Proceedings of the International Workshop on *Holiothis* Management, 15-20 November 1981, Patancheru, AP., India.

Talekar, N.S. (1980). Search for beanfly resistance in soybean, mungbean, and snapbean, pp 293-295 in Processing of Legumes in the Tropics. Selangor, Malaysia : Faculty of Agriculture, Unversiti Pertanian Malaysia, Serdang.

Wheatley, A.R.D., Wightman, J.A., Williams, J.H. and Wheatley, S.J. (1989). The influence of drought stress on the distribution of insects on four groundnut genotypes. Bulletin of Entomological Research 79 :

Wightman, J.A. (1989). Contribution of insects to low groundnut yields in southern Africa. pp 129-140 in ICRISAT (International Research Institute for the Semi-Arid Tropics) 1989. Proceedings of the Third Regional Goundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502324, India : ICRISAT.

Wightman, J. A. and Amin, P. W. (1988). Groundnut pests and their control in the semi-arid tropics. Tropical Pest management 34 : 218-226.

Yadav, C.R.S. (1981). Integrated control of white grub. Jobner, Jaipur, India : Department of Entomology, University of Udaipur. 219 pp