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# CROP LOSSES CAUSED BY INSECT PESTS IN THE DEVELOPING WORLD

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ABSTRACT

Information on crop losses caused by insect pests is essential for pest management research but such data are lacking, particularly in the developing world. Many of the available data have been collected from trials on research station farms where conditions are very different from those in farmers' fields. Natural selection has ensured that the farmers of the developing world have inherited crop genotypes and farming systems that reduce the risks imposed by pests and other constraints. The best available estimates indicate that losses to insects average 20% or more, but there is enormous variation in time and space. Recent changes in agricultural practices, including the introduction of irrigation, fertilizer, high yielding cultivars and new farming systems, are being accompanied by changes and increases in pest problems. The need to monitor such changes, and to provide the farmers with pest resistant cultivars and pest management practices to prevent sole reliance on pesticide use, is stressed.

## INTRODUCTION

The "developing world" covers an enormous range of agroclimatic conditions, from swamps to deserts and tropics to tundra. With such diversity, most generalisations are of little value but we do know that most farmers in the developing world are well acquainted with risks imposed by droughts, floods, pests and diseases. Most of these farmers are the descendants of ancestors who survived because of their ingenuity in overcoming these risks by selecting seeds, farming systems and other methods that would provide enough food to keep their families alive, even in the bad years. Thus, natural selection has ensured that most farmers are not incompetent. Traditional methods of farming, which limit the risks of losses to the major crop yield reducers, including pests, have been developed over centuries. Integrated pest management was being practiced long before the phrase was invented!

However, we live in a changing world in which new methods of increasing agricultural production and reducing risks are becoming increasingly available. The farmers of the developing world need no longer limit their expectations to growing enough to keep their families alive. With increasing urbanisation providing markets for food in all countries, the farmers can expect to generate a cash income that will enable their families to enjoy some of the amenities that the world now offers to those who can afford to buy. Most farmers are eager to try the new methods of increasing crop production, which are brought to them by the extension services from the commercial, national and international research network.

This is the environment within which entomologists, such as myself, are now working; we are searching for methods that will enable the farmers to reduce their risks and losses to the insect pests. To establish our

priorities we need to know the extent of the losses caused by the insect pests, for such data are basic to any pest research programs and so should be readily available. However, we appear to be still at the stage of asking how such data can be obtained. For example in a recent IOBC/Gerdat Colloquium (1982) concerning cotton, rice and maize, which are probably the most important crops of the developing world, the discussion mainly centered upon how crop loss assessment and economic threshold evaluation should be attempted.

At the All India Seminar on Crop Losses Due to Insect Pests held at Hyderabad in 1983, most of the participants stressed the enormous variability, in time and space, that they had encountered when summarising the crop loss assessment data that were available, and the paucity of good data collected systematically. Speaker after speaker showed data with losses to insect pests ranging from very little to 100%. They emphasised that most of the available data were from research station farms where ecological conditions were atypical of those in farmers' fields. They called for increased efforts to (a) develop standard methodologies for collection of crop loss data and (b) to apply these methodologies to an adequate well organised survey of the real world of the farmers' fields.

This is the crop loss assessment situation in the developing country which probably has the greatest number of well qualified and able entomologists of any country in the world. Most developing countries do not have India's wealth of entomological talent. In most countries the few entomologists available spread themselves thinly, attempting to develop immediate answers to pest control problems on the major crops in their area. They seldom have the time or resources even to consider the possibility of organising crop loss assessments on any of their crops on a national scale.

The paucity of crop loss data is not restricted to the developing world. Schwartz and Klassen (1981) while attempting to estimate the losses caused by insect pests in the USA found that data were not available for many crops and pests.

## CROP LOSS ASSESSMENT

There is no shortage of publications giving advice on the methodology of crop loss assessment. The best known of these is probably the FAO Manual (Chiarappa, 1971) which, together with more recent supplements, provides a useful guide. However, even the simplest approach to crop loss measurement, that of paired plot comparisons with one of each pair of plots protected by pesticide use, is fraught with difficulties. Economic entomologists appreciate that pesticidesgive the greatest returns when used on close spaced, well fertilized, high yielding cultivars, so any paired plot comparisons tend to be carried out under such conditions. Such comparisons often give massive yield differences and so give very high estimates of pest caused losses. However, in the real world of the developing countries at present, most farmers' crops are still wide spaced, often intercropped and of land race cultivars that have been selected over hundreds, if not thousands, of years for tolerance of pest damage. Few entomologists will consider it worth-while to lay out paired plot comparisons on such fields, but if they did they would often find that pesticide use would give very small yield increases!

Most land race cultivars of several crops in the tropics show

remarkable tolerance to many of the pest threats that they have to face. Perhaps we are too ready to assume that insect attack equals yield loss. For example stem borers are considered to be among the major pests of sorghum, but J.H.MacFarlane working in Nigeria (personal communication, 1983) has found no consistent difference in grain yield between plants that had no damage and other plants that had ten internodes, and more, bored by *Busseola fusca*! Similarly, Nwanze (1982) in Niger found that pearl millet plants bored by *Acigona ignefusalis* tended to have greater grain yields than those that were free from damage! In many crops compensation for damage, both within and between plants, can be spectacular. A good example of this is found in pigeonpea, a crop that is attractive to a large number of phytophagous insects. Pigeonpea in southern India can lose all of its flowers and young pods to *Heliothis armigera* but will produce a compensatory flush of flowers at least as great as that which was lost, provided climatic conditions allow (ICRISAT, 1981). Similarly on cotton, several workers including Brown (1965) have shown that removal of early flowers can lead to yield increases.

Although insect damage does not always result in yield loss there is no doubt that insects do cause massive losses of yield on many crops in the tropics. In a survey of pigeonpea in farmers' fields just before harvest over several years in India, S.S.Lateef (Bhatnagar et.al., 1982) found that half of the pods were damaged by insects in southern India, mainly by *Heliothis armigera* (Table 1). Such pod losses just before harvest cannot be compensated for.

TABLE 1

Pigeonpea pod damage by insects in samples from farmers' fields in India, 1975-1981

| | North zone | Central zone | South zone |
|---|---|---|---|
| Fields sampled (no.) | 359 | 416 | 443 |
| Pods damaged by lepidopteran borers (%) | 13.2 | 24.3 | 36.4 |
| Pods damaged by podfly (%) | 20.8 | 22.3 | 11.1 |
| Total pods damaged by insect pests (%) | 33.8 | 48.0 | 49.9 |

Lateef also found that in spite of such massive losses, less than 10% of the farmers attempted to use any pesticide on this crop. Such a low percentage of farmers using pesticides is certainly not because of a failure by the farmers to appreciate the pest problem, nor because of ignorance, apathy or laziness. For most farmers in developing countries, the problem of finding cash to pay for the pesticides and applicators, and of procuring water for spraying, are often insurmountable obstacles. It was also interesting to note that of the surveyed farmers who used pesticides, most used dust formulations of DDT or HCH. There is little doubt that this is because of the low cost of such chemicals. We are all aware of the objections by entomologists and environmentalists to the use of

such persistent chemicals, but most of us would use these if we were farmers in similar straitened circumstances. Pesticide pollution is not of immediate concern to most subsistence farmers in developing countries. We can warn them by quoting the pesticide caused disasters such as those in Texas (Adkisson, 1973) and the Australian Ord Scheme (Anon, 1982), but few people learn from others mistakes! With *Heliothis armigera* eating chickpea and pigeonpea to a value of US $300 million in India in each year, we can expect farmers to grasp at any means that might reduce their losses.

CHANGING PEST PROBLEMS IN THE DEVELOPING WORLD

Generally, pest problems tend to increase closer to the equator. In northern Europe the winters tend to reduce the need for economic entomologists! Similarly in north India the relatively cold winters generally reduce the insect pest problems. On pigeonpea and other crops after each winter there is a race between crop maturity and build up of the populations of insects such as *Heliothis armigera*, with the crops usually winning the race. In southern India temperatures do not fall to levels which prohibit insect multiplication. Here the annual fluctuations of populations of pests appear to be associated with host plant availability which is in turn controlled by soil moisture availability. The increasing use of irrigation in the semi-arid tropics will undoubtedly have a major effect upon the pest populations. There is an obvious danger that pests such as *H. armigera* which were formerly reduced to very low populations in each year, partly because of a shortage of host plants through dry seasons, may increase dramatically if irrigated crops are available. For example in Andhra Pradesh in southern India, irrigated tomatoes, which were virtually unknown a few years ago, are now a regular feature through each dry season. These tomatoes are heavily infested by *H. armigera* and many farmers spray their crops at least weekly to control this pest. Here we have a potentially dangerous situation, where the pest is being afforded a new host plant through the period when its population is normally reduced to a very low level. Much of that population is now subjected to pesticide resistance selection.

In addition to increasing irrigation, there are many other changes occurring in agriculture in the developing world. Breeders are producing high yielding varieties and hybrids which are being readily accepted by many farmers. Fertilizer use is increasing. Farmers are being persuaded to sow monocrops at high plant densities. Such changes are inevitably accompanied by changes in pest problems.

In the Sudan Gezira the introduction of groundnut into the cropping system enabled *H. armigera* to become established as a major pest (Balla, 1982). In India in 1968, only four insects were regarded as major pests of groundnuts (Rai, 1976), but by 1982 at least eight insects were considered to be major pests (Amin, 1983). The designation of major pests is subject to personal opinion, but one of the new major pests was *Spodoptera litura* which had been important as a pest of tobacco but was sporadic on groundnuts. It appeared in epidemic form in 1978 and since then it has been of major importance on groundnut in each season in south-east India, where many farmers have failed to control this insect with intensive pesticide use.

Pimental (1981), referring to the "Green Revolution", pointed out

that many of the high yielding cultivars may be more prone to pest caused losses than the old land race cultivars which they are replacing. Davies (1982), warned that the new high yielding, compact headed sorghums may be more susceptible than the older cultivars to several pests. Many crop plant breeders are selecting and testing genotypes under a "pesticide umbrella" on research stations. It is inevitable that plants selected under such conditions will be of little use in farmers' fields unless they are protected by pesticides. At ICRISAT, a pesticide free trial conducted by S.S.Lateef in which he compared chickpeas which had been selected under pesticide protected conditions with others selected in pesticide free conditions, well illustrates the danger (Table 2). The selections made in pesticide protected conditions will outyield the "pesticide free" selections only when protected.

TABLE 2

Comparison of entomologists' and breeders' selections of early maturing chickpeas in pesticide free conditions at ICRISAT Center, 1980-81

| Genotype | Selection history | Mean pod damage %[c] | Yield kg/ha |
|---|---|---|---|
| IC-7394-18-12-1P | Ent[a] | 14.6 | 2225 |
| ICC-506 | Ent | 5.1 | 2001 |
| IC-738-8-1P | Ent | 9.9 | 1963 |
| IC-73103-10-2-1P | Ent | 14.9 | 1900 |
| ICCC-9 | Br[b] | 18.0 | 1876 |
| Annigeri-1 (Check) | - | 20.0 | 1828 |
| ICCC-6 | Br | 17.8 | 1726 |
| ICCC-8 | Br | 14.9 | 1685 |
| ICCC-1 | Br | 28.0 | 1297 |
| S.E.M. | | ± 1.70 | ± 46.2 |

[a]Ent - Selected by entomologists in pesticide free fields in previous seasons.

[b]Br - Selected by breeders in pesticide treated fields in previous seasons.

[c] - Pod damage caused by *Heliothis armigera*.

ICRISAT has a large area (100 ha) of its farm designated as a pesticide free area on which pesticides never have been and, hopefully, never will be used. All the ICRISAT plant breeders' selections are eventually exposed in this pesticide free area to ensure that they are not more susceptible to pests than the cultivars currently used by farmers. This area is also being increasingly used in our host plant resistance select-

ion and breeding work. Unfortunately the ICRISAT pesticide free area appears to be unique for we know of no other research farm that has a similar facility.

FUTURE WORK

The rapidly changing pattern of agriculture in the developing world will ensure that the few reliable estimates of crop loss to insect pests that we have today will soon become obsolete. The most comprehensive estimate of crop losses that we have available is that by Cramer (1967). His estimate, of 12.3% loss worldwide and 17.7% loss in the continents that include most of the developing world, should now be regarded as historical, but we have no more recent estimate. The National Academy of Sciences (USA) in 1978 estimated that post harvest losses in the developing countries averaged between 10 and 20%; much of this loss being caused by insects. Thus, the best available estimates indicate that insects are destroying more than 20% of the developing world's agricultural production. This estimate should at least suffice to convince the world that it must invest in pest control research.

The crop loss assessment data being collected in the developing world at this time are unlikely to provide us with a basis from which we can usefully update Cramer's (1967) estimates. The best that we can hope for is that well planned crop loss assessments will be undertaken on major crops in farmers' fields in some of the developing countries. These surveys should be on a continuing basis so that we can assess the impact of new agricultural practices upon the pest caused losses. As agricultural production in the developing world increases, we may be hard pressed to retain the pest caused losses to the present unacceptable levels.

We have an admirable slogan - Integrated Pest Management - but will we be able to convert this slogan into action in the farmers' fields in the developing world? We have an ideal opportunity, for the farmers are accepting major changes in their agriculture and they are not yet locked into pesticide insurance. There is little doubt that chemical pesticides will be more widely used in the developing world in the near future. We have to supply other elements of pest management, including resistant cultivars before the farmers become convinced that pesticides are the only answer to pest problems.

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