Insect Pest Management on Chickpea

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Integrated pest management is a fashionable phrase, but unlike most fashions it is unlikely to disappear or diminish in importance with time. It is a concept that is essential for the continuing progress of man's twin needs to produce more food while at the same time to avoid deterioration of the enviornment and ecosystem. The concept has been forced upon us largely as a consequence of the overuse of, and overdependence on, chemical pesticides since 1950. The ecological disasters following overdependence upon chemical pest control are well documented (Carson 1962; Apple and Smith 1976), and although they have on occasion been overemphasized to a point where the integrated pest-management movement has "acquired the impetus and characters of a religious revival" (Price Jones 1970), there can be few specialists in plant protection now who do not acknowledge that chemicals should be used to supplement cultural and other methods of pest control rather than to replace them.

Integrated pest management has been aptly described as the optimum mix of elements of pest-damage reduction and crop improvement that will give us the best returns, taking into account not only the economics and yield of the current crop but also the effects on the environment and on the future potential of the area. The approach does not preclude the use of chemicals; indeed, insecticides will have an increasingly important role in pest management, particularly in the semi-arid tropics. To date, the chemical pesticides are underutilized on most crops in countries such as India, and ecological disasters as a result of overuse of chemicals are not of immediate concern in most of our areas. Hopefully, however, we can learn from the mistakes elsewhere and develop pest management on crops such as chickpea to include chemical pesticide as one element within an optimum mix of other measures.

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Survey of the Insect Problems on Chickpea

It is obvious, both from the literature and from our observations and those of others, that chickpea has remarkably few insect pest problems. The great exception is that of *Heliothis*, the larvae of which feed voraciously on the crop from the seedling stage to crop maturity. Throughout the Old World *H. armigera* is the major pest of chickpea, while in the Americas, *H. virescens* takes over the leading role. Further, *Heliothis* appears to be increasing as a problem on many crops in areas where agricultural production is being intensified.

ICRISAT's extensive surveys of the pest situation on chickpea in farmers' fields show that *Plusia* spp, *Spodoptera* spp, and *Agrotis* spp can be locally important lepidopteran pests and that termites and aphids are of concern in some localities. Birds and small mammals can also cause substantial loss in some localities. But *Heliothis* is undoubtedly the most damaging pest on the crop in most areas and in most years, so chickpea entomology research at ICRISAT is concentrating on this pest.

Insecticide Use

Our surveys in India have indicated that less than 20% of chickpea farmers use insecticides on their crops. Of those, many use insecticide dusts, and almost all use the persistent chemicals DDT, BHC, and endrin. A similar situation appears to hold in the chickpea-growing areas of the Middle East. Recommendations to use pesticides, such as endosulfan, that are less persistent and less harmful to the beneficial insect complex appear to be generally ignored. The reasons for this are very probably the relatively high cost of such pesticides and their restricted availability in the local markets. The relative costs of effective doses of DDT and endosulfan, expressed in kilograms of chickpea per hectare, are illustrated in Figure 1. It can be seen there is a wide disparity in cost, which has not been reduced over the last few years. It is unlikely that many chickpea farmers will choose to pay three times as much to control *Heliothis* in response to concern about the environment or beneficial insects!

Preliminary results at ICRISAT indicate little, if any, net economic benefit from pesticide use even when severe *Heliothis* infestations are controlled, largely because of the marked compensation for early losses observed in the cultivars tested. Elsewhere, the observed returns from insecticide use have varied greatly. A benefit:cost ratio of at least 3:1 is probably needed before chickpea farmers should be encouraged to embark upon pesticide use, given the variable responses and attendent risks. All too often pesticides are obtained and used after much of the pest damage has been done. Use of pesticides on large larvae can be detrimental, killing more beneficial insects than *Heliothis*. Correct timing of pesticide use is essential if it is to be of value; the larvae should be controlled when they are in the early instars and before they have eaten their fill. Such timing will only be possible if pesticides and application equipment are readily available for use as soon as the eggs or small larvae are noticed in densities that will cause economic injury levels on the crop. This requires a level of preparedness, knowledge, and observation that is not available with most farmers, but may be supplied by local extension workers.

As chickpea is grown as a postrainy season crop in semi-arid areas, it is often difficult for the farmer to obtain water for spraying at the critical *Heliothis* attack period during and after flowering. Dusting is seldom as efficient as spraying, partly because it is difficult to distribute dusts evenly with cheap applicators. Developments in controlled-droplet application of insecticides at ultra-low volume may alleviate the application problems on this and other crops in the near future.

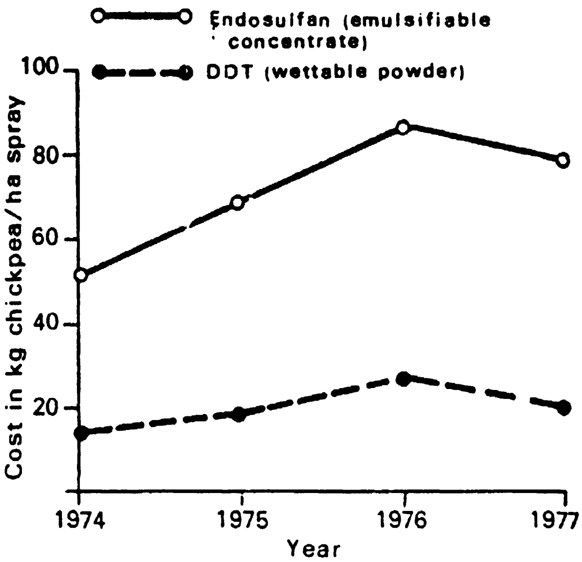

Figure 1. The costs of pesticides expressed in kilograms chickpea per hectare spray for the effective control of Heliothis armigera *in India.*

Resistant Plants

It is clear that most available chickpea cultivars are resistant to most potential insect pests. We must not be complacent about this situation, for we can undoubtedly breed more susceptible plants, if we continue to select and test under insecticide umbrellas on our research stations. At ICRISAT, we have embarked upon a project to select genotypes that are less susceptible to losses caused by insect pests, particularly *Heliothis armigera*.

In a preliminary trial we tested the effect of plot size on the evaluation of susceptibility to *Heliothis* among cultivars in open-field screening with natural infestations, with the results shown in Table 1.

The results from this trial were encouraging, for highly significant differences were recorded among cultivars, and the small plots appeared to be at least as efficient as the larger plots. In screening very large numbers of germplasm entries, however, we cannot afford the space, seed, and recording time required for adequate replication. In such tests, the major problem is uneven distribution of *Heliothis* infestations in space and time that allow chance escapes from damage. As an example of this, in 1976–77 we tested 8629 germplasm lines in unreplicated plots, of which 955 had no borer damage. However, the check cultivars, which were grown after each 20 plots of germplasm, gave higher proportions of borer-free samples (Table 2).

From these results, we concluded that the germplasm lines were generally more susceptible to *H. armigera* than were the well-adapted check cultivars, and that escape from attack by chance was likely to be a problem in unreplicated small-plot testing.

Analysis of the yields from this screening trial showed that the borer-free plots had produced less seed than the mean for the trial (Table 3). Observations during the green-pod period indicated greater *H. armigera* larval populations in the better grown areas. Thus, much of the escape from *H. armigera* was probably associated with relatively poor growth.

Subsequent testing of the borer-free germplasm entries in replicated trials in the

Table 1. Evaluation of plot size for testing the susceptibility of chickpea cultivars to *H. armigera*. Two trials were conducted, one with plot size 4.8 m², the other 20 m². Each was of randomized block design with 13 treatments and 4 replications, ICRISAT Center, 1976–77.

Cultivars	Mean percentage of pods damaged by *Heliothis* Small plots	Large plots
L-345	3.0 (9.4)[a]	2.6 (7.6)
C-235	4.9 (12.7)	3.4 (10.2)
ICP-6037	4.9 (12.8)	6.6 (14.8)
RS-11	6.1 (14.4)	7.1 (14.8)
L-2937	7.0 (15.5)	6.9 (15.1)
BR-70	4.4 (11.9)	10.6 (18.6)
JGC-1	7.5 (15.7)	8.3 (16.3)
ICP-682	9.5 (17.7)	9.3 (16.0)
NP-34	12.0 (19.9)	8.1 (16.4)
NEC-143	13.3 (21.5)	11.0 (19.2)
Rabat	13.6 (21.9)	14.5 (21.6)
850-3/27	18.1 (25.2)	12.6 (20.3)
P-3090	19.2 (25.8)	16.6 (22.7)
SE	± 1.85	± 1.80
CV%	21.5	22.0

a. Numbers in parentheses are arcsin √%.

Table 2. Screening chickpea germplasm for susceptibility to *Heliothis armigera*. Plots found to be free from damage in harvested samples, ICRISAT Center, 1976–77.

	No. of entries harvested	No. without borer damage	% without borer damage
Germplasm lines	8629	955	11.1***
Check BEG-482	221	43	19.5*
Check C-235	219	61	27.9*

Differences significant at * p = 0.05, *** p = 0.001

Table 3. Screening chickpea germplasm for susceptibility to *Heliothis armigera*. Yield comparisons of all entries with the borer-free entries; ICRISAT Center, 1976–77.

	Single-plant mean yields (g) All entries	Borer-free entries
Germplasm lines	6.7 (8629)[a]	3.5 (955)
Check BEG-482	7.5 (221)	4.8 (43)
Check C-235	6.4 (219)	4.7 (61)

a. Number in parentheses is number of entries screened.

1977–78 season showed that none was immune to *H. armigera* attack, but that some had relatively little damage in all replicates. There were substantial differences in susceptibility among the cultivars and comparisons of 2 years' results indicated that these differences were inherited.

So far, our attempts to utilize field cages and inoculation of trials with laboratory-bred *Heliothis* eggs and larvae have not been successful in obtaining even pest distributions that would enable us to improve on our open-field screening. In the absence of any better method, we are now rejecting cultivars that are clearly more susceptible and yield less than the relevant checks in our unreplicated tests within which the entries are grouped according to maturity. The others are carried forward to replicated testing; the greater the replication, the less the chance of escape. In cooperation with the breeders, we have already started a crossing program with some interesting lines thrown up by this testing. We have also started single-plant selection from within promising selections, with some early indications of possible success. Tests at ICRISAT and elsewhere have indicated that the kabuli types are generally more susceptible to *Heliothis* and some other pests than are the desi types. We have found substantial differences in susceptibility and tolerance to, and recovery from attacks by *Heliothis* within the available materials, particularly among desi cultivars.

Acid Exudate

One obvious factor that may be involved in the comparative resistance of chickpea to insect pests is the very acidic exudate (pH = 1.4). The acidic fraction has been reported to consist of 94.2% malic, 5.6% oxalic, and 0.2% acetic acids, (van der Maesen 1972). We are now studying the composition of exudates in cooperation with the Max Planck Institute for Biochemistry in Munich. Preliminary observations indicate that the concentration of the exudate varies from cultivar to cultivar. We are analyzing the acids and other contents of the exudates from more- and less-susceptible cultivars and are studying the effects of varied concentrations of exudates and malic acid upon *Heliothis* moths and larvae in laboratory tests.

Cultural Practices

Pest attacks can be modified by a variety of cultural practices. If it is known that *Heliothis* attacks are likely to be severe at a particular time, then it may be possible to adjust the sowing date or to utilize a cultivar of appropriate flowering and maturity timing to ensure that the flowering and podding stage does not coincide with the peak *Heliothis* attack period.

There is usually a pool of *Heliothis* in any area that may be supplemented or depleted by migration. By synchronous sowing of the crop in any area, the available pest population will be diluted by dispersion across the whole crop area. Early sown fields will probably act as magnets for the pests and may act as multiplication sites for a subsequent dispersal to the main crop. Late-sown crops may bear the brunt of the pest dispersal from the maturing main crop.

Poor plant stands are commonly said to be a major factor in the poor yields obtained from this crop by many farmers, but we have indications that close spacing harbors more *Heliothis* larvae per unit area (Table 4), so increased yields may be obtained only if the closer-spaced crop is protected by pesticide use. Thus, optimum spacing probably varies not only according to the cultivar used and to edaphic and climatic factors but also to the degree of pest control afforded.

Natural Enemies of *Heliothis*

Heliothis attacks on chickpea are generally accompanied by fairly heavy parasitism, particu-

Table 4. Counts of *Heliothis armigera* larvae and yields recorded from an unprotected spacing trial of chickpea. Four-replicate, randomized block design trial, ICRISAT, 1977–78.

	Spacing			
	Close	Medium	Wide	SE
Plants/m²	33.0	8.3	2.8	
Mean no. *H. armigera*/m²	15.3	5.5	4.2	±1.29
Yield (kg/ha)	396	626	645	±60.0

larly by the hymenopteran parasitoids. There appear to be relatively few arthropod predators within fields of this crop; perhaps they are deterred by the acid exudate. However, birds are not greatly discouraged, and several (often the mynahs and crows) are commonly seen enjoying a meal of *Heliothis* larvae in heavily infested fields. Unfortunately, the birds are not always beneficial, for some have been observed to feed on the seed from ripening pods.

We are looking at ways of augmenting the natural control of *Heliothis* on this crop. It may be possible to increase the native parasitoid populations by breeding in laboratories and inoculating the fields with booster populations early in each season. We are studying the possibility of introducing exotic parasitoids. A virus disease that kills *Heliothis* is one possibility for use on farmers' fields, but much more work on this is required.

Integrated Pest Management

Integrated pest management is unlikely to be a real success if applied only to an individual field or plot. There is a much greater chance of success if all farmres of the crop in an area coordinate in united action. Ideally the concept should apply not just to a single crop, but to all the crops in any area, particularly if the threat from a polyphagous pest such as *Heliothis* is to be reduced.

The timing of the differing crops and their juxtaposition should be considered in relation to pest buildup and dispersion. We do not yet have enough knowledge to design the ideal mix of pest-management factors and probably never will, for the pest complexes and timings will soon change to take maximum advantage of the changed systems. Nor can we pretend that the pests are of such overriding importance that agricultural systems should revolve around pest-management considerations! Pest-management planning in the distant future will undoubtedly be in the hands of specialists armed with a great deal of basic knowledge of the crop, its pests, their natural enemies, and computer simulations of the economics of management strategies. We cannot wait for such developments, and we have to suggest measures that we are confident will economically reduce pest losses now and not cause problems of pollution in the future.

The basic approach to any pest management system will undoubtedly involve group action along the following lines:

1. All farmers should sow synchronously at the optimum time and spacing.
2. All farmers should use a cultivar that is less susceptible to the problem pests.
3. If nonpolluting pesticides are known to be of undoubted economic value, then they should be applied as efficiently and as timely as possible, according to counts of eggs and young larvae.
4. The crop should be harvested as soon as it is ripe, and crop residues should either be removed or plowed in.
5. There should be a closed season during which the crop and, if feasible, the alternative hosts of the damaging pests are not grown in the area.

Additional measures, including attempts to augument natural control of the pests, can be incorporated into the system as our knowledge and expertise increase. We should not wait for the ideal; the sooner we start in farmers' fields, the faster we will make progress. We can pretend to look at integrated pest management in our research farm fields and computers, but we know that the only worthwhile testing and development will take place at the village level. When do we start?

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