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Insect pests of chickpea in the Mediterranean area and possibilities for resistance

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SUMMARY - In the Mediterranean area the chickpea leafminer, *Liriomyza cicerina* is the main insect pest of chickpea (*Cicer arietinum*) causing up to 30 percent yield loss. Identification of host plant resistance has been the main approach to control and a continuous field screening of chickpea lines for resistance to leafminer has been conducted at ICARDA. Several chickpea lines showing different degrees of resistance were indentified, some with consistently low leafminer damage and yield loss. These lines need to be studied for their mechanism of resistance, for which different possibilities are suggested. The understanding of the resistance mechanism will allow by relating resistance with chemical substances to miniaturize the resistance screening and will make any resistance breeding program more effective.

*RESUME - "Les insectes ravageurs du pois chiche dans la région méditerranéenne et les possibilités de résistance". Dans la région méditerranéenne la mineuse du pois chiche (*Liriomyza cicerina*) est le principal insecte ravageur du pois chiche (*Cicer arietinum*). Il peut réduire le rendement en graines de 30%. La création de variétés résistantes à la mineuse a été la principale approche développée pour contrôler les ravages de cet insecte. Les variétés résistantes à la mineuse sont identifiées à l'ICARDA grâce à un crible réalisé au champ. Plusieurs variétés ayant des niveaux de résistance différents ont été identifiées. Certaines d'entre elles montrent un très faible niveau de dégâts et de pertes de rendement. Le déterminisme génétique de la résistance de ces lignées doit encore être étudié, mais plusieurs hypothèses sont avancées. La compréhension du mécanisme de résistance permettra, en association avec la lutte chimique, de réduire le travail de crible des lignées au champ et d'améliorer l'efficacité du programme d'amélioration de la résistance.*

Introduction

In general, chickpea (*Cicer arietinum*) is not very favorable for insect feeding and thus attacked by only a few species. However, some of these do cause extensive damage and control methods need to be developed.

In the Mediterranean region the chickpea leafminer, mainly *Liriomyza cicerina* but also *Phytomyza lathyri,* is the main insect pest occurring in several countries in high densities every year. *Heliothis* spp. is a secondary pest, heavier attacks are restricted to some regions and years. *Aphis craccivora* is important as a vector of the chickpea stunt virus.

Screening is conducted to find resistance to the virus rather than to the aphid. In storage *Callosobruchus* spp. can cause severe damage, especially when the seeds are not properly stored. While all these pests are monitored continuously to be able to early detect any changes in their pest status, studies at ICARDA concentrate on the chickpea leafminer. In this paper different approaches to control, especially the possibilities and methodology for the identification of host plant resistance, are discussed.

Chickpea leafminer

Damage and life cycle

The adult leafminer females puncture the upper surface of chickpea leaflets with their ovipositor and feed on the exudates from these, which causes a stipple pattern on the leaflets. In some of the feeding punctures eggs are inserted just under the epidermis. The leafminer larvae

feed in the leaf mesophyll tissue forming a serpentine mine which later becomes a blotch. The mining activity of larvae reduces the photosynthetic capacity of the plant and heavy infestation will cause desiccation and premature fall of leaves. The fullgrown larva leaves the mines to pupate in the soil. Insecticide trials in Syria have shown that yield losses due to leafminer range from 0 to 30% seed yield.

In Syria the first leafminer generation emerging from diapause appears in late March. The 2nd generation reaches peak population in mid May. With the maturity of the chickpea plants the leafminer disappear and it is suspected that they survive the summer and winter as pupae in diapause.

Control methods

At ICARDA different approaches to control of the chickpea leafminer have been studied, in particular host plant resistance and chemical control.

Host plant resistance

Most emphasis has been and will continue to be given to studies on host plant resistance. The identification of resistance first requires practical methods to measure resistance, for which several possibilities exist in the case of insects (Fig. 1). In the assessment of insect population levels different sampling methods of one of the following categories can be used, (1) direct observations, (2) sweepnet and vacuum sampling, (3) trapping. Plant resistance can also be expressed in terms of its deleterious impact on insect development and reproduction, which can be measured by duration of development, mortality, fecundity, etc.. Finally the analysis of insect behaviour to plant stimuli can be an important element in determining the nature of resistance.

The ultimate criteria in the analysis of plant resistance are crop yield and quality in response to insect attack. Since yield and quality assessment are very time labour intensive they are more suitable for advanced stages of germplasm development. At earlier stages of evaluation of large quantities of germplasm measurements of insect damage are preferable to yield analysis. If the plant defense mechanisms and their qualitative effects on the insect are known, resistance screening could be miniaturized by directly relating resistance with chemical substances in the plant.

In the studies on resistance to the chickpea leafminer all of the measurements mentioned above are or will be taken into account. Every year a large number of chickpea germplasm is evaluated in a mass screening in the field under natural leafminer infestation using a visual damage score. The score (1 to 9) is based on the intensity and extent of damage measuring the percent mining and defoliation of the plant. Leafminer only cause indirect damage and a complex of factors influence the relation between leaf injury and reduction in yield. To be able to better correlate leafminer injury, i.e. the visual damage score with yield loss the score has been revised this year and is as following:

- Vegetative stage

1 = no mining.
3 = a few mines in less than 20% of the leaflets.
5 = mines common in approximately 30-40% of the leaflets.
7 = many mines in 50-70% of the leaflets.
9 = many mines in almost all the leafkets (> 90%).

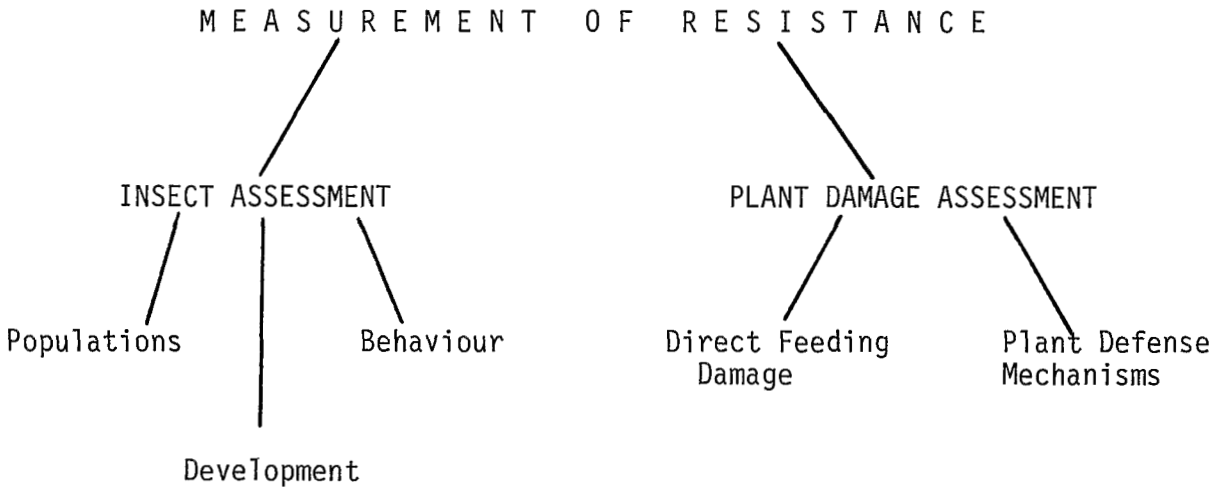

Fig. 1. Possibilities for measurement of host plant resistance to insects.

- Reproductive stage

1 = no mining, no defoliation.
3 = a few leaflets mined, no defoliation.
5 = defoliation in lower half of the plant and starting (0 - 10%) in the upper part of the plant.
7 = extensive defoliation (30 - 50%) in the upper part of the plant.
9 = almost complete defoliation.

Rating should be conducted twice in the season and once when the chickpeas are in the vegetative stage and once when they are in the reproductive stage. The first rating measures the percent mining of the plant and proved to be quite precise as it was highly correlated (r = 0.8) with the percent leaflets mined, when counted. The second rating measures the defoliation in the plant, indicating whether the plant could tolerate the mining and/or had any effective defense reactions to the initial mining. Especially the second rating is important, since the defoliation has higher impact on yield loss than the mining alone. Frequently plants were observed with a considerable percent of mining in the beginning but with little defoliation later. Then ratings measuring the mining are misleading.

Up to date the screening involved 5719 chickpea lines the ratings of which are given in Table 1. Promising lines are rescreened in the reconfirmation nursery and included in the Internantional Chickpea Leafminer Nursery. Of the 31 lines rated 3 and 4 initially 8 lines showed consistantly low leafminer damage and these together with more susceptible genotypes are grown in experiments without and with insecticide protection to further relate the degree of resistance to yield loss. In addition to plant damage assessment leafminer populations are measured by D-Vac sampling for the adults and by placing water trays between the rows to collect the larvae dropping from the leaves to the soil for pupation.

Table 1. Ratings of chickpea genotypes in the leafminer resistance screening.

VDS	Chickpea Genotypes	
	Number	Percent
<3	0	0
3	11	0.2
4	20	0.4
5	137	2.4
6	374	6.5
7	1174	20.5
8	712	12.5
9	3291	57.5

Now studies on the mechanisms of resistance under controlled conditions in the laboratory will be initiated. Possible mechanisms of resistance could be:

- Physical factors/morphology of the leaflets (hardness, hairyness, size etc.).

  Up to date most of the chickpea lines with some resistance have smaller leaflets whereas genotypes with large leaflets tend to be more susceptible. The effect of such factors on the insects biology i.e. development, mortality, fecundity need to be studied.

- Composition and amount of leaf exudates.

  Since the amount of malic acid was found to be correlated with the degree of resistance of chickpea lines to *Heliothis* spp. (Rembold, 1982) this likewise could be a factor deferring the leafminer females from oviposition.

- Absence of chemical signal substances (so-called kairomones), which are produced by the host plant and attract the insect for feeding and/or oviposition. If the characteristic host finding process is at least in part controlled by kairomones these would be specific for the chickpea lines and thus could be used on the basis of modern analytical chemistry as a sort of chemical fingerprint for the characterization of chickpea lines showing different levels of resistance.

The different approaches and possibilities in the process of identification of host plant resistance to the chickpea leafminer are summarized in Fig. 2.

Chemical control

Some insecticides providing effective leafminer control have been identified as well as the best time of application. The resulting recommendation is to have one application of Nuvacron or Thiodan at flowering (Table 2). However, the use of insecticides might neither be practicable nor economical for the small farmer in the region. Therefore alternative control methods are desirable. Insecticide experiments will be only conducted to assess yield loss in chickpea lines with different degrees of resistance/susceptibility.

Biological control

Preliminary studies at ICARDA revealed that a whole complex of parasites of leafminer is established in the region. The 2 dominant species occurring in high densities were identified as *Diglyphus isaea* (Eulophidae) and *Opius monilicornis* (Braconidae) (Dr. T. Huddleston, British Museum, London). Efforts should be undertaken to make use of the occurring natural enemies as biological control agents. The biology and effectiveness of the 2 parasites has to be studied and if they prove to be effective biological control could be combined with the use of chickpea lines with an appropriate degree of