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Breeding for resistance to Empoasca kraemeri.

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1.- Introduction

Resistance to insects in plants is defined by Painter (1951) as the heritable characteristic of a variety of plant species to produce a larger crop of a better quality than other varieties at the same level of insect population.

In this definition resistance is limited to differences within a plant species. Difference in insect attack among species fall in the category of host-plant selection. The definition also says that the characteristic is inherited from parents to offspring. Apparent resistance may also be due to for instance a fertilizer response or escape from attack and are examples of noninherited resistance.

Resistant plant varieties have many advantages over those which are not resistant. Insects are controlled without intervention in other species; there is no pollution and once the resistant variety is developed, it can be used without extra costs which is of special importance to low income producers.

Some of the disadvantages of resistance are the time and cost involved to develop a resistant variety, which is however much cheaper than the cost of the development of an insecticide. Very few examples are known where resistance to an insect has broken down. This is in contrast to pathology, where new races often are formed as rapidly as new resistant varieties are produced. In parthenogenetic reproducing insects some examples are known of lost resistance.

2.- Resistance Mechanisms

Resistance, as observed in the field was divided by Painter (1951) into three mechanisms based on insect-host-plant interaction. Mostly a combination of these 3 mechanisms is present in resistance. These are:

a.- Non-preference: a variety is less preferred than another variety for oviposition, feeding or shelter.

b.- Antibiosis: a variety has an adverse effect on the biology of the insect. This is probably the least desirable form of resistance as it places a selection pressure on the insects.

c.- Tolerance: This is the ability of a plant variety to repair, recover or withstand insect attack. This is the most favorable and natural form of resistance in my opinion, as it does not create selective forces to break resistance. Plants and insects in their individual struggle for survival have found a status in which no evolutionary forces to break this status are present. It also permits continuous insect populations as hosts for parasites and predators. It requires however training of the crop grower to convince him that no economic losses will result, within certain limits (the economic threshold population), despite the presence of insects.

3.- <u>Literature on resistance in beans to E. kraemeri</u>

In the literature, eg. Gutierrez et.al. (1975), <u>E. kraemeri</u> is reported as the principal bean pest in Latin America. It does not transmit virus diseases but it is suspected that it induces growth regulating substances in the plant tissue. The wide distribution of the leafhopper and its high population numbers, especially in dry season conditions, contribute to its importance.

The literature on <u>E. kraemeri</u> is limited, while most research has been done on <u>E. fabae</u>. The two species were separated in 1957 by Ross and Moore and <u>E. fabae</u> seems to be limited to the USA while <u>E. kraemeri</u> is reported from Florida, Latin America and the Caribean. <u>E. kraemeri</u> does not transmit virus diseases in beans. The only leafhopper known to transmit virus diseases in beans in America is the beet leafhopper Circulifer (=Eutettix) tenellus, which transmits curly top. Resistant varieties to the beet leafhopper like Idaho Refugee (reported resistant to E. fabae) Burpee Stringless Greenpod and Landreth Stringless Greenpod do also have reduced virus incidence. (Hallock, 1946).

Chalfant (1965) tested 28 varieties for leafhopper (E. fabae) resistance. He found a highly significant positive correlation ($r = 0.64$) between insect counts and damage scores. The number of nymphs per leaf ranged from 0.15 (on Topcrop) to 2.21 (on White Half Runner), while the damage on a 0-10 scale ranged from 0.4 (C 14) to 3.5 for Mountaineer.

McFarlane and Reeman (1943) tested 27 varieties of Ph. vulgaris for E. fabae resistance. They found Henderson Bush Lima most resistant while Idaho Refugee ranked 3rd. The resistance ratings of the same varieties over the 4 replicates was very uniform, indicating homogeniety of infestation.

Most research on resistance in beans to E. fabae has been published by Wolfenbarger and Sleesman in 1961. They also found a highly significant positive correlation between hopperburn rating and nymphal counts ($r = 0.90$), however they also found tolerance to nymphal attack. This was expressed in FM-52 which had a hopperburn rating of 0, while the nymphal population per leaf reached 15.0. They value resistance scores based on nymphal population higher than hopperburn ratings as this also included preference for oviposition. Low nymphal counts were obtained from PI 151-014 and PI 173 - 024 with 0.3 and 0.4 nymphs per leaf, respectively, while Dutch Brown with 19.7 nymphs per leaf was the highest recorded. They obtained a correlation of r = -0.19 (n.s.) for number of epidermal hairs and nymphal population. Therefore hair density was not related to resistance but hair type still may be. In other Phaseolus species thay also found great differences in resistance ranking among the varieties. High levels of resistance were found among Ph. aureus and Ph. lunatus and Ph. radiatus sources. They found in interspecific crosses between resistant and susceptible materials indications that resistance was recessive. Plant characteristics that were studied for association with resistance showed, that pod color, leafarea, and growth habit were uncorrelated with nymphal counts, however taller plants had significant fewer nymphs, and also intermediate maturing varieties and those possessing mosaic resistance were more resistant. Pink seeded varieties were more resistant than those with a mottled seed color.

Medina and Guerra (pers. comm.) found Empoasca resistance, in Negro 66 and Canario 101, which were also resistant to the Mexican bean beetle and the bean pod weevil. Avalos (pers. comm.) also found large differences in Empoasca resistance among bean lines, with some lines giving equal yields in protected and non-protected plots.

4.- CIAT's Empoasca kraemeri resistance program.

CIAT's entomology program has as main objective to reduce the economic importance of pests by increasing the resistance to these pests in new bean varieties. It is hoped that in this way the need for insecticides will be reduced and that in absence of chemical control measures a reasonable yield can still be obtained.

Development of resistance to Empoasca kraemeri, the principle bean pest of Latin America, is the first objective in our program.

To achieve above objectives for E. kraemeri varieties were screened for resistance to E. kraemeri. First commercial varieties were tested, and as the levels of resistance found were not high enough, resistance sources mentioned in the literature were tested, followed by the screening of the CIAT 's germplasm bank (about 8000 have been screened, which is the available part). Until now we have not encountered levels of resistance high enough to ensure good yields under high leafhopper populations. Some attention is paid to levels of resistance in other crossable species with Ph. vulgaris, like Ph. coccineus. However the main emphasis is placed on a large hybridization program within Ph. vulgaris to raise the level of resistance, or to combine different resistance mechanisms to raise reistance in this way.

After screening the available material in the germplasm bank of CIAT, 395 entries were selected for advanced testing. These entries will be planted in replicated plots to score damage, in the form of hopperburn and to make nymphal counts and instar distribution of the nymphs, which we hope will indicate antibiosis type of resistance. Until now, field tolerance was the main type of resistance selected for. Some materials, reported resistant, were not classified among the most resistant entries.

Mechanisms of resistance.

Lines selected for resistance in the field did show average leafhopper populations. In detailed laboratory tests with few varieties we found a significant ovipositional non-preference in ICA-Tui, a black seeded variety being least preferred. But placing the varieties individually, in cages without choice, no differences were found in oviposition rate, indicating a low level of non-preference. The non-preference was as well for oviposition as for feeding when tested with males only. Antibiosis in these selections and in 54 additional ones tested, was not found.

The level of resistance found so far is sufficient in the wet season, when leafhopper populations are generally low. Selection 73 Vul 3624 yielded equal with and without insecticidal protection, but in the dry season under high population pressure the yield increased 4.2 fold following protection. This clearly indicated that resistance is present, especially when data are compared with susceptible lines, which gave a 3 and 36 fold yield increases in the wet and dry season, respectively. The 36 fold yield increase was obtained with the most popular Colombian variety, Diacol-Calima.

5.- Future research

Fourteen of our best selections entered a diallel crossing program to measure which crosses give best increase in resistance (combining ability). Individual plants, selected in the F_2 will be crossed and tested again. With this recurrent selection procedure we hope to raise the level of resistance sufficiently. Also crosses are being made between the 14 selections and a susceptible variety to test inheritance of resistance and detect different genes for resistance.

Studies are underway to refine screening procedures both to better screen individual plants in segregating populations and to make the evaluation scale sufficiently sensitive to detect small differences in levels of resistance. When the level of Empoasca resistance can be raised sufficiently by hybridization and selection, more emphasis will be placed on similar programs for leaf feeding beetles (Diabrotica, Cerotoma, etc) and mites.

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