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Effect of Sugar Beet Root Aphid, *Pemphigus fuscicornis* (Homoptera: Pemphigidae), on Sugar Beet Yield and Quality in Iran

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Abstract: *Pemphigus fuscicornis* (Koch) is a pest of sugar beet root in warm and dry regions of Iran. This belongs to the Middle East and south east of Asia fauna. Nymphs establish colonies in root sutures and feed heavily which cause wilting and yellowing in beet near harvest. This study was conducted to determine infestation indices, damage occurrence and the necessity for control measures of this pest. Nymph colonies were monitored in different experimental fields that were planted with commonly used monogerm variety Afshari and then five infested places were selected. Damaged root specimens were sampled from five foci and ranked for infestation, yield and sugar concentration. Results indicated that there were no significant differences in weight, sugar concentration and impurities between indices 1, 2, 3 and none infested beets. Only the sugar concentration of indices 4 showed significant differences with zero infested beets. In the other hand, no specimens were found with the highest population density index (indices 5). Therefore, the sugar beet root aphid populations did not reach to the level of economic damage in these experimental fields. Thus, the control measures such as chemical application and use of resistant varieties may be used when the colonies density increases to the indices four and five throughout the foci in such fields.

Key words: Sugar beet, root aphid, *Pemphigus fuscicornis* (Koch), yield and quality loss, Iran

INTRODUCTION

The sugar beet root aphid, *Pemphigus fuscicornis* (Koch) was reported in 1995 from Esfahan province, the main area for planting spring sugar beet in Iran, for the first time (Ahmadi *et al*., 1995). *P. fuscicornis* is closely related to *P. betae* Doane which is a serious pest of beet in the US and Canada (Harper, 1963; Hutchinson and Campbell, 1991, 1995). However, Rezvani (1994) and Rezaei (1997) have reported that the *P. fuscicornis* is an anholocyclic aphid and is only found on beet, while *P. betae* has a complex life cycle, which involves migration between primary (cottonwood) and secondary (beet) hosts.

P. fuscicornis hibernates as adults on beetroots remaining in fields or on roots of some wild plants such as *Sonchus arvensis* (Asteracae) (Rezvani, 1994; Rezaei, 1997). The winged females deposit their eggs on beet stands in early spring. The nymphal instars establish their colonies on young beetroots. The parthenogenetic females continuously produce six to ten generations until early September (Rezaei, 1997). The infested plants exhibit symptoms of faded leaves, wilting and unclenching roots in a circular patches or foci. Different studies have been conducted on *P. fuscicornis* and *P. betae* loss assessment in the world. According to the Mamontova (1975), 33% of weight and 3.5-4.3% of sugar content decreased in outbreak condition of *P. fuscicornis* and Fedorenko (1987) reported outbreaks of this pest in dry years in Russia. Summers and Newton (1989) reported high infestation, 36-60% yield losses, of *P. betae* in California. Carter (1987) believed that the yield would decrease below 52.2% in some high-infested fields. Hutchinson and Campbell (1991) introduced an infestation root rating scale for estimating pest losses. In this trial, when infestation rate of *P. betae* was, 2.8 it reduced 50% of root weight and 50% of sugar content (Hutchinson and Campbell, 1993). Hutchinson and Campbell (1994) also reported that damage cost was $925/ha when pest infested only 10% of the field.

Iranian growers are concerned about *P. fuscicornis* attack because it affects beetroot quality and yield. There is not any information about economic importance of *P. fuscicornis* in Iran. Hereby, the present study was conducted to use different infestation rating scales to approximate damage caused by *P. fuscicornis* under the field conditions.

In this study, I purposed the following four questions: 1- What is the best method for calculating the pest damage in the field? 2- What is the effect of pest population on yields (weight and sugar concentration)? 3- Dose the pest population density occur economic damage? 4- What indices of infestation change the root quality (especially the amount of impurities).

MATERIALS AND METHODS

This study was conducted in north part of Esfahan province in center of Iran during 2003-2006. A warm and dry region with the highest infestation, Murche-Khort, was selected as the research site. Aphid specimens were collected from different fields for identification of species.

Five sugar beet fields (~ 2 ha each) of monogerm variety Afshary, with no known resistance or tolerance to root aphid, were selected to monitor aphid population in late March. These fields were irrigated 6 h/day for five days and other cultural practices, except for insecticides application against the pest were followed.

Five wide foci (infected parts of field with aphid's colonies) were selected in each field in late summer and sampling was done with them. Sampling was done by using quadrants (1×10 m). This was replicated five times. Because of the difficulty in counting individual aphids on the beet, all harvested roots from five quadrants of five foci were ranked according to the following root rate infestation index in six different indices. This root rate index is close to the introduced infestation root rating scale of Hutchinson and Campbell (1994) for *P. betae*.

Index 0: Neither aphid colonies nor wax secretion was present on roots. It is as control specimens, or non-infested types.

Index I: Bellow 25% of root surface covered with one colony or its wax secretion diameter was ≤3 cm. According to Rezaei (1997), the number of nymphs may be 20-80 in each cm^2 of root surface.

Index II: 25 to 50% of root surface covered with one to more than one colonies or their wax secretion.

Index III: 50 to 70% of root surface covered with one to more than one colonies or their wax secretion.

Index IV: 70 to 90% of root surface covered with multiple colonies or their wax secretion.

Index V: Up to 90% of root surface covered with multiple colonies or their wax secretion, or aphids emigrated to the ground surface and established on leaves.

The individual aphid colonies in indices IV and V are indistinguishable and counting of number of nymphs in these levels of infestation is impossible.

All collected roots from these five fields, were ranked according to their infestation indices. The first, all roots were separately weighed in the field. Then total roots with same index in each replicate were grouped and the bulks of 20 kg of them were sent to the Esfahan Sugar Factory. Sugar quality analysis was done at the factory. The extracted paste (up to 26 g) from beet mass of each replicates of each index was transferred to the laboratory of factory for sugar percentage measuring of molasses and amount of different impurities. The Betalizer test was used for quantifying levels of each impurity such as, potassium (K), sodium (Na), harmful amino nitrates (HAN) and alkaline in ppm (which then transferred to g kg^{-1}). HAN was based on the fluorescence of free amino (NH_2) groups. A flame photometer was used to quantify Na^+ and K^+ ions. Collected data of weight, sugar concentration of root and molasses and impurities in different root rating index were analyzed in a RCB design by SAS software.

RESULTS AND DISCUSSION

In this study, only four indices of infestation (I-IV) were found. Infested roots with the highest population density of aphids or index V were not found. The maximum average size for each focus was about 5×1 m. It was low infested area in comparison to the *P. betae* reported by Hutchinson and Campbell (1993 and 1994). Also, means of different indices from total infested root samples were; 20% with Index I, 40% with Index II, 30% with Index III and 10% with Index IV. Thus it showed that *P. fuscicornis* has not any high population density in these experimental fields.

Data analysis of root infestation rating scales showed that there were no significant differences ($p<0.05$) between yield of infested samples (Index I-IV) and non-infested ones. The mean of yield ranged between 0.6-0.7 kg. This is similar to Rezaei (1997) study on yield losses of *P. fuscicornis* in the laboratory condition. However, Mamontova (1975) reported 33% of losses in weight in some fields which infested by a high population density of *P. fuscicornis* in Ukrine. It may be near infestation index V related to the present study. Other researchers who worked on *P. betae* explained different results in weight losses of this pest. They concluded that *P. betae* decrease the yield (weight) of infested fields near 10 ton ha^{-1} (Maxson, 1916) and 3-7.6 ton ha^{-1} (Harper, 1963) or make 36-60% of losses when its population is up to infestation index III in Canada and the US (Carter, 1987; Summers and Newton, 1989; Hutchinson and Campbell, 1994).

In this experience, data analysis of sugar content of molasses and amounts of different impurities (K, Na, HAN and ALC) of infested samples (Indices I-IV) also showed no significant differences ($p<0.05$) between different indices and between infested roots (Indices I-IV) with non-infested ones (Fig. 1). This is the first report of the effect of *P. fuscicornis* on impurities in beetroot. Thus, there is not any other information about this species. But Hutchinson and Campbell (1994) discussed that loss to

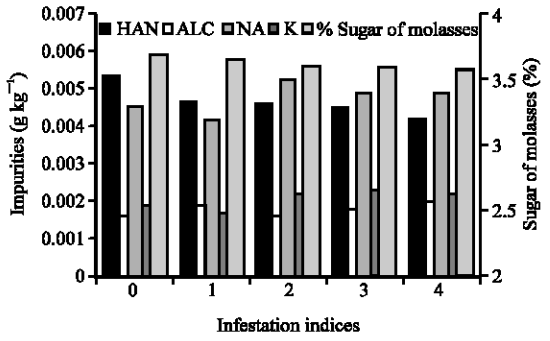

Fig. 1: Effect of different infestation indices on some Chemical characteristics of roots (No significant differences in all parameters)

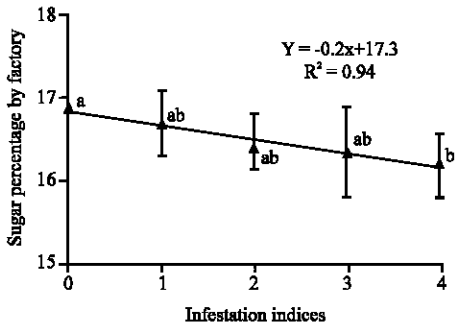

Fig. 2: Linear relationship between sugar content and infestation indices

molasses and Harmful Amino Nitrogen (HAN) were significantly reduced whenever the *P. betae* rating index was near III. In addition, amount of Na was usually higher for aphid infested beets and K was always lower.

In this study, only significant difference ($p<0.05$) was observed in sugar concentration between index IV and the other indices and non-infested roots (Fig. 2). In this situation, only near 1% of sugar concentration was decreased. This is close to the result of Rezaei's (1997) study. He mentioned that sugar concentration decrease 0.15-1.95% when over 80 nymphs per one cm^2 infested roots after four months of planting time in laboratory condition. This is also close to the *P. betae* effects on sugar concentration which occurred only 2 degree of losses in index IV and V even if the weather was warm and dry or the irrigation was poor (Hutchinson and Campbell, 1991, 1994, 1995).

The linear regression of aphid population density showed positive relationship between infested roots (indices I-IV) and sugar content (Fig. 2). A linear regression for *P. betae*, which was fitted to 1990 and 1991 collected data by Hutchinson and Campbell (1994) showed $r^2 = 0.96$ and 0.97, respectively that is very close to the result of *P. fuscicornis* ($r^2 = 0.94$).

These results indicated that the population density of *P. fuscicornis* in indices I, II and III, were lower than the index required for reducing in yield and sugar content. Only, sugar losses may occur in index IV when 70% to 90% of the roots surfaces are covered with multiple aphid colonies. Differences of damage levels between two species *P. fuscicornis* and *P. betae* are related to their abilities and some ecological conditions. Summers and Newton (1989) believed that different species of genus *Pemphigus* and the biotypes of its different species cause losses in different levels. In the other hand, these pests outbreak in high humidity condition of soil (generally up to 60%) and their population increase in clay soil (Federenko, 1987; Summers and Newton, 1989). In this relationship, the *P. fuscicornis* population density could not reach to its economic injury level in the studied area because of these experimental fields had sandy and dry soil conditions. In addition, Hutchinson and Campbell (1994) noted on the role of weeds in increasing of *P. betae* population density. Growers generally use a high dosage of herbicides in their fields and do not let for growing of different kinds of weeds especially some inter host of root aphid like *S. arvensis* in Iran.

Thus, it seems that economic damage will only occur whenever up to 50% of roots in each focus are infested with a high population of aphids or the mean infestation root rating scale of all foci is about index III in some fields with clay soil and high irrigation. Therefore, it is not necessary to use any control methods about this pest.

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