

Parasitism of *Diatraea saccharalis* (Lepidoptera: Pyralidae) eggs by *Trichogramma exiguum* (Hymenoptera:Trichogrammatidae): Influence of *Zea mays* leaf pubescence

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Abstract. *The effect of maize foliar pubescence on the oviposition of D. saccharalis and egg parasitism by T. exiguum was assessed. Sixty-eight maize cultivars were classified by hair density on the upper leaf face into “high pubescent” (HP) and “low pubescent” (LP) classes. No differences in total egg masses/plant and total eggs/plant were found between HP and LP cultivars. More egg masses/plant and eggs/plant were found in the lower face of leaves of HP cultivars, but no differences were found between leaf faces in LP cultivars. The percentages of parasitised egg masses and eggs were higher on LP cultivars, and the egg masses and eggs on the lower leaf face showed a higher level of parasitism than the ones on the upper face. The results suggest the advantage of incorporating low hair density as a trait for the development of resistant maize cultivars, since this character would increase the oviposition activity of T. exiguum.*

Introduction

Integrated pest management (IPM) programs have traditionally focused on pest control by means of host plant resistance or biological control, and the combination of both methods has been discussed extensively (Campbell and Duffey 1979, Obrycki *et al.* 1983, Huffaker 1985, Duffey *et al.* 1986, Duffey and Bloem 1986, Orr 1986). Basic information about host plant-insect interactions (e.g. phenological relationships, mode and degree of damage, oviposition and feeding sites, plant quality) is fundamental for the development of cultivars that are resistant to insects. Success of biological control programs based on parasitoids also requires an understanding of host-parasitoid interaction. The development of theory and its application to the IPM programs will only be possible if these interactions are analysed as a tritrophic system (Price *et al.* 1980, Whithman 1983).

Chemical as well as physical traits of the host plants play an important role in tritrophic interactions (Price *et al.* 1980, Barbosa and Letourneau 1988). Host plant quality determines the effectiveness of control by natural enemies by altering oviposition behaviour, total fecundity and final fitness of the herbivore (Walde 1995). Reduction in fecundity may enhance the ability of natural enemies to control local populations of herbivores. Particular aspects of the physical structure of the leaves, like pubescence, can affect the spatial pattern of oviposition of both herbivores and parasitoids, constraining the ability of natural enemies to control pest populations (Turner 1983).

A negative correlation between hair density and feeding and oviposition behaviour has been shown for many species of insects (Levin 1973, Khan *et al.* 1986, Sánchez *et al.* 1991). Obrycki *et al.* (1983) demonstrated that the combination of sticky hairs of hybrid potatoes and natural enemies was more effective in reducing a population of aphids than separate effects. However, both control techniques seem not to be compatible for other crops like tobacco (Rabb and Bradley 1968).

Diatraea saccharalis (Fabricius) is a major pest of corn (*Zea mays* L.) in Argentina, and causes yearly yield reductions of 24% (1000 kg/ha) (Dagoberto and Parisi 1980). *D. saccharalis* damages the plant by feeding and tunnelling the stalks, disrupting nutrient transfer, and reducing the number and size of grains. It also debilitates and breaks the stems, hampering harvest. This feeding behaviour makes

the application of insecticides ineffective and expensive. *Trichogramma exiguum* Pinto, Platner and Oatman (Hymenoptera: Trichogrammatidae) is the most important mortality factor of its eggs (Cueva 1980). Also, insecticides commonly used to control lepidopterous pests are known to adversely affect *Trichogramma* spp. (Campbell *et al.* 1991). For these reasons, management alternatives such as biological control need to be considered.

The effects of differential pubescence of maize cultivars on both the oviposition of *D. saccharalis* and egg parasitism by *T. exiguum* have not been investigated. Neither has maize pubescence been considered as a resistant trait for this species. The objective of this study was to assess the effect of maize foliar pubescence on the oviposition of *D. saccharalis* and egg parasitism by *T. exiguum*.

Materials and Methods

Identification and choice of pubescent and smooth cultivars

Maize leaves have an upper pubescent face and a glabrous lower one. Although pubescence is an important resistance factor in many crops (Maxwell and Jennings 1980), it has not been considered an agronomic trait for maize, and there is no classification of cultivars based upon trichome density.

Sixty-eight cultivars provided by different Argentine breeders were sown in the Faculty of Agricultural Sciences Experimental Station (Buenos Aires province, Argentina, 35° SL) in 1991, in a randomised block design with three replications. Samples were taken in the phenological stage between heading and grain physiological maturity. Two or three fully expanded leaves were sampled at random from each cultivar. From each leaf we observed three randomly selected fields (0.22 cm²) under the binocular microscope (40x) and counted hair density (number of hairs/cm²). Hair densities among cultivars were analysed by ANOVA and cultivars were compared by Tukey test.

From the 68 cultivars, two contrasting levels of pubescence of the upper face (HP: high density of hairs and LP: low density of hairs) were identified according to two conditions: a) the difference in pubescence between cultivars within a group was statistically not significant, b) all pairwise comparisons across groups were significant. From both groups some cultivars were sown the next season.

Influence of leaf pubescence of maize on the oviposition of D. saccharalis

To assess the influence of the pubescence of the maize leaves on the oviposition behaviour of *D. saccharalis*, five cultivars classified as HP and six cultivars classified as LP were sown in the field in ten rows with a completely random design. Each row included the eleven cultivars at random. The number of *D. saccharalis* eggs masses per plant, the total number of eggs per plant, and the leaf face (upper-lower) on which the eggs were placed were recorded weekly from plant stages of 4-6 leaves per plant (February 2) to grain maturity (April 18).

The number of egg masses of *D. saccharalis* and the total number of eggs per plant of HP and LP cultivars were compared using a nested ANOVA (Sokal and Rohlf 1995) where the subordinate classification (cultivars) is nested within the higher level of classification (pubescence). A two-way ANOVA (factors: cultivars and faces) was used to compare the same variables between upper and lower faces of the leaves in HP and LP cultivars. Means were compared by Tukey tests.

Influence of leaf pubescence of maize on egg parasitism by T. exiguum

The number of parasitised and non parasitised egg masses/plant and eggs/plant on upper and lower faces of the leaves was recorded from HP and LP cultivars. Percentage of parasitised eggs/plant and parasitised egg masses/plant in HP and LP cultivars were compared for both faces by a two-way ANOVA. Within each type of cultivar (HP and LP) differences among cultivars were tested by one way ANOVA. A correlation analysis between percentage of parasitism (arcsine transformed) and the number of eggs/plant was performed to test for density-dependence parasitism.

Table 1. Mean leaf hair density, mean number of egg masses/plant and mean number of eggs/plant of *D. saccharalis* on the upper and lower faces of maize leaves of HP and LP cultivars.

Cultivars	Mean hair density	SE	Egg masses/plant	Eggs/plant	n
HP cultivars					
Dk636	121.08	12.21	1.28 a	17.44 a	18
Pioneer	122.58	4.13	1.44 a	20.28 a	18
CTh85	130.66	9.40	1.05 a	23.85 a	20
DK3F24	139.74	8.44	1.25 a	18.65 a	20
Maizal 86	106.69	5.72	1.45 a	31.20 a	20
Upper face			1.00 b	15.52 b	48
Lower face			1.58 a	29.33 a	48
LP cultivars					
Precoz 22	47.40	3.54	1.65 a	23.15 a	20
8712-1	38.82	5.49	0.92 a	16.58 a	12
8713-1	38.32	3.95	0.87 a	21.62 a	8
8919-1	46.40	5.63	1.37 a	19.50 a	8
NK5284	59.06	10.02	1.39 a	23.22 a	18
NK362	59.47	6.90	0.85 a	22.15 a	20
Upper face			1.09 a	20.53 a	43
Lower face			1.32 a	22.53 a	43

Values followed by the same letter, within each column and for each factor (type of cultivars and leaf face) are not significantly different at 0.05 level.

Results

Identification and choice of pubescent and smooth cultivars

A highly significant difference of hair densities among cultivars was found ($P < 0.001$). According to the analysis performed, cultivars with hair density $> 107 \pm 5.7$ hairs/cm² were considered as HP and those with hair density $< 59 \pm 6.9$ hairs/cm² as LP cultivars.

Influence of leaf pubescence on oviposition

No significant differences were found between HP and LP cultivars in terms of egg masses/plant and eggs/plant (nested ANOVA; $F=1.43$, d.f.= 1,40 and $F=1.41$, d.f.= 1,40). More egg masses/plant and eggs/plant were found in the lower face of leaves of HP cultivars ($P < 0.05$ and $P < 0.01$), but there were no significant differences between leaf faces in LP cultivars ($P > 0.05$) (Table 1).

Influence of leaf pubescence on egg parasitism

Percentage of parasitised egg masses/plant was higher in LP cultivars ($P=0.09$). The egg masses of the lower face, in both HP and LP cultivars, were more highly parasitised than the ones of the upper face ($P=0.03$). There was no interaction between cultivars and faces ($P=0.40$). No differences were found among cultivars within each group (HP: $P=0.30$; LP: $P=0.70$) (Table 2).

The percentage of parasitised eggs was higher on LP cultivars ($P=0.05$) and on the lower faces of both groups of cultivars ($P=0.001$). No interaction was detected between cultivars and faces ($P=0.54$) (Table 2). No differences were found among cultivars within each group for the percentage of parasitised eggs/plant (HP: $P=0.34$; LP: $P=0.83$).

The correlation between the number of eggs/plant and the percentage of parasitised eggs/plant was non-significant (correlation coefficient $r=0.18$; $n=90$), indicating that there was no density-dependent response in the number of attacks by *T. exiguum*.

Table 2. Percentages of egg masses of *D. saccharalis* parasitized by *T. exiguum* on the upper and lower faces of HP and LP cultivars.

	n	Egg masses/plant	SE	Eggs/plant	SE
HP	38	38.43 a	5.69	35.16 b	5.09
LP	40	51.99 a	5.55	48.96 a	4.96
Upper face	39	36.57 b	5.62	30.28 b	5.02
Lower face	39	54.20 a	5.62	54.19 a	5.02

Values followed by the same letter, within each column and for each factor (type of cultivars and leaf faces) are not significant different at 0.05 level.

Discussion

Although all maize cultivars tested have leaves with a hairy upper face, we could identify intraspecific differences in hair density. This trait did not affect the number of egg masses/plant and the number of eggs/plant of *D. saccharalis*. However, there were more egg masses and eggs/plant in the lower face (hairless) of HP cultivars than in the upper face. The differences between upper and lower faces of LP cultivars were non-significant for both variables.

These results suggest that a high pubescence (hair density > 107 hairs/cm²) could act as a physical barrier affecting the preference and searching behaviour of females, forcing them to choose the lower face of HP cultivars for oviposition. In sugarcane, oviposition by *D. saccharalis* is negatively affected by pubescence (Sosa 1988). With high pubescence, larval entrance into the stem is restricted, and the time of exposure to natural enemies and larval mortality is increased. Larval movements and stem boring should be faster on less hairy or glabrous surfaces. Thus, the use of pubescent clones has been proposed to reduce the damage caused by *D. saccharalis* on sugarcane, which has hairs on both sides of the leaves (Sosa 1988).

In general, pubescence alone does not appear to be a barrier to damage in maize. In contrast, the role of pubescence of maize leaves should be considered in analysing the interaction between the pest and its natural enemy. Our results show that there is a trend towards a greater percentage of parasitised eggs of *D. saccharalis* by *T. exiguum* on non-pubescent surfaces (lower faces of corn leaves of HP and LP cultivars) and on LP cultivars. In fact, percentage of parasitised eggs was higher on the lower face of LP cultivars, although there was no difference in the number of host eggs on the upper and lower faces, suggesting that leaf pubescence is an important factor in this three-trophic level interaction.

As observed in other species (Turner 1983), pubescence could alter the host searching and parasiting behaviour of *T. exiguum*. In maize, though a low hair density would not reduce the oviposition, it could affect positively the control of this pest by one of its natural enemies. The potential of *Trichogramma* spp. as biological control agents has been demonstrated repeatedly, and successful examples of mass rearing and inundative releases are present in the literature: *T. pretiosum* for *Helicoverpa zea* in maize (Ruberson and Kring 1993) and tomato (Oatman and Platner 1971), *T. minutum* for *Choristoneura fumiferana* in forest (Bouchier *et al.* 1993), and *T. exiguum* for *H. zea* in tomato (Campbell *et al.* 1991). Although *T. exiguum* is not currently being produced commercially in Argentina, any effort towards the conservation of natural populations is worthwhile.

This analysis of the tritrophic levels suggests the advantage of incorporating low hair density as a trait for the development of resistant maize cultivars to *D. saccharalis*, since this character would increase the oviposition activity of natural occurring populations of *T. exiguum*.

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