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Impact of farm-scale Bt maize on abundance of predatory arthropods in Spain

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Abstract

Transgenic maize expressing the Cry1Ab toxin from *Bacillus thuringiensis* (Bt-maize) has been grown in Spain since 1998, representing about 5% of the total maize area. As part of a Spanish specific monitoring program for Bt maize, a farm-scale study was initiated in 2000 to assess the potential impacts of Bt maize on predatory arthropods. The trials were conducted at two maize growing areas (Lleida and Madrid) over 3 years. In each locality three treatments (each with 3–4 replicates of 0.4–0.7 ha) were arranged in a completely randomised block design, Bt-maize (cv. Compa CB) being compared with the isogenic cv. Dracma under conventional farm practices, with or without the insecticide (imidacloprid) seed treatment. Predator abundance was monitored from late May to mid September in Lleida and from mid June to mid September in Madrid by visual surveys and pitfall traps. Anthocoridae, Coccinellidae, and Araneae represented about 90% of the total number of predators recorded in visual samplings whereas Carabidae and Araneae were the two prevalent predator groups (85–90% of the total predators) collected in pitfall traps. Their abundance varied from year to year and between locations, but no clear tendencies related to Bt maize was recorded. Insecticide treatment reduced anthocorid numbers occasionally but no consistent effects were found for the rest of predators. Our data suggest that Bt maize is compatible with the naturally occurring predators.

Keywords: Transgenic maize; Predators; Imidacloprid; Natural enemy; Bt

1. Introduction

Mediterranen corn borer *Sesamia nonagrioides* (Lefèbvre) (Lepidoptera: Noctuidae) and European corn borer *Ostrinia nubilalis* (Hübner) (Lep.: Crambidae) are the most damaging maize pests in Spain (Castañera, 1986) and the Mediterranean area. The control of corn borers involves chemical treatments, cultural practices, plant resistance, mating disruption, and biological control (Gutierrez et al., 1986; Mason et al., 1996; Eizaguirre et al., 1998; Albajes et al., 2002). Insecticides have limited utility because larvae develop mostly inside maize stalk whereas other control methods are only under experimentation or they are only used in high-value maize due to their high cost. Among insecticide treatments, imidacloprid seed dressing is the most common in Spain to control sap feeders and soil insect pests and it has shown to have an additional effect on *S. nonagrioides* (Pons and Albajes, 2002).

Transgenic maize varieties based on the insecticidal protein synthesized by *Bacillus thuringiensis* Berliner (Bt maize) are being used on over 9.1 million hectares worldwide (James, 2003). In the European Union most Bt maize commercially grown is in Spain (James, 2003). The most common cultivar until 2003 was Compa CB ®(Event 176, Cry1Ab toxin, Syngenta Seeds), a variety transformed from the hybrid Dracma® (Syngenta

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Seeds), and the only commercial variety grown between 1998 and 2002. Event 176 expresses the Bt toxin in green plant tissues, pollen and stalks, but not in the silks and kernels (Cannon, 2000).

The specificity of Bt toxin and the reduction of insecticides used under a Bt crop system are likely to result in a more favourable environment for the natural enemies of the target pests. Some laboratory experiments have suggested that Bt maize had a negative impact on natural enemies (Hilbeck et al., 1998; Dutton et al., 2002), whereas Orr and Landis (1997) reported that the population density of predators and parasitoids of corn borer eggs were similar in transgenic and isogenic maize. Pilcher et al., (1997) observed no detrimental effects on the abundance of coccinellids, anthocorids, and chrysopids in Bt compared to non-Bt maize. These studies were performed on small (25–50 m^2) experimental plots or along short periods in the USA, which might not necessarily reflect what is happening in commercial field conditions in Europe, and particularly in Spain where transgenic Bt maize covered an area of about 32,000 ha in 2003.

As part of an ongoing environmental risk assessment sponsored by the Spanish Ministry of Education and Science and the Ministry of the Environment, a farm-scale study was initiated in 2000 to assess the potential impacts of Bt maize on non-target arthropods. The project includes other topics on the risks of the deployment of Bt maize in Spain such as development of resistance to Bt in corn borer populations, field studies on effects of Bt maize on non-target herbivores and laboratory evaluation of Bt maize effects on predator development, survival and fecundity (Pons and Starý, 2003; Farinós et al., 2004; Lumbierres et al., 2004; Pons et al., 2004).

The objective of this study is to determine effects of transgenic Bt maize on the predatory fauna in the field. With this aim, the abundance and activity of predatory arthropods in field plots with Bt maize, cv. Compa CB, were compared with the isogenic cv. Dracma under conventional practices, with or without imidacloprid seed dressing. The study was carried out on two maize growing areas 400 km apart, during 3 years, following a similar protocol, according to the particularities of each locality.

2. Material and methods

The trials were conducted at two locations, one near Lleida (North–East Spain 41.36°N, 0.36°E) and the other near Madrid (Central Spain 40.06°N, 3.10°W) in 2000, 2001 and 2002. Plots used varied from 0.4–0.7 ha but they were uniform within each year and location. Standard cultural practices in each area were used except for insecticide treatments which were applied only in the imidacloprid seed dressing plot. In Lleida the farm crop rotations consisted of winter cereals (from November to June) and alfalfa and maize (this from late April or early May to October). Maize was therefore grown on the same plot on alternate years, whereas in Madrid maize was grown every year as a monoculture from late April to late October. Two days after sowing, the plots were sprayed with a herbicide mixture of 35% alachlor + 25% atrazine (Primdal, Agrodan, Brabrand, Denmark) at 6–8 l/ha in Lleida and with a mixture of 75% isoxaflutol + 47.5% atrazine (Spade + Atrazinax Flo, Rhône Poulenc, France), at 4–5 l/ha in Madrid.

The experimental set up was a randomised block design involving three treatments each with four (Lleida) or three (Madrid) replicates. The treatment were: (1) Bt transgenic maize (cv. Compa CB®, Event 176) (Bt^+), (2) the isogenic hybrid (cv. Dracma®) without treatment insecticide (Bt^-), and (3) the isogenic hybrid with imidacloprid insecticide seed-treatment (Dracma®-Gaucho® Bayer Crop Science, Germany) (Bt^-/I). In the latter the seed was dressed at 1400 cc of imidacloprid (Gaucho 35 FS®) per 100 kg of seed (4.9 g a.i./kg). In 2002 the Bt^-/I treatment was omitted in Lleida. Plots had not been treated with soil insecticide for at least 3 years.

Composition and abundance of aerial predatory fauna were determined by visual surveys of the plants, and the activity of ground predators was studied with pitfall traps. Between 10 and 25 maize plants per plot were inspected visually to cover the central part of the plot on each sampling date and the number of predators was recorded. The number of plants inspected in each plot varied according to the predator abundance. At early (before stage 7 of Hanway (1966)) and late season (late Hanway's stages 9) we inspected 25 plants whereas in mid stages we inspected 10 plants per plot. The number of visual samplings were 5 per season in Lleida (from late May to mid September) and 8 per season in Madrid (from mid June to mid September).

Three to five pitfall traps were distributed regularly in a straight line along each plot over 7 m from the field border. They consisted of a glass jar of 9 cm diameter and 17 cm depth (Lleida) or 12.5 cm diameter and 12 cm depth (Madrid) filled with water and detergent. Traps were left open for 3 days in Madrid and 7 days in Lleida every 2 weeks. This difference was due to the fact that irrigation days were less predictable in Madrid than in Lleida. The total sampling dates were eight per season in both Lleida and Madrid. Pitfall data in Madrid were multiplied per 2.33 to express data as weekly catches.

Sampling dates were distributed along the season to cover the period of usual population peaks of the main predatory groups. In Lleida the five dates of visual sampling were chosen in the following intervals of Hanway (1966) growth stages: (i) GS 0–4, (ii) GS 5–6, (iii) GS 7, (iv) GS 8, and (v) GS 9. In Madrid, countings