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Chemical composition and rumen degradability of three corn hybrids treated with insecticides against the European corn borer (*Ostrinia nubilalis*)

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ABSTRACT

This experiment determined the chemical composition, rumen degradability (aNDF in stalks and starch in kernels) and *in vitro* gas production of kernels from three corn hybrids treated (TT) or not treated (control, CTR) with insecticides against the European corn borer (ECB, *Ostrinia nubilalis*). Two whole-plant silage hybrids belonging to the FAO rating 600 and 700 maturity class (S600 and S700, respectively) and one selected for grain production (G600, FAO rating 600, Dekalb-Monsanto Agricoltura S.p.A., Lodi, Italy) were sown in two main plots (TT and CTR) of an experimental field. Two subsequent treatments of pyrethroids (25 and 1.2 g/ha of cyfluthrin and deltamethrin, respectively) were applied to the TT plots. The insecticide treatment reduced the number of damaged plants (4.5 broken plants/plot *versus* 0.3 broken plants/plot, $P<0.01$) and increased the total grain yield by 11% (13.8 t/ha *versus* 12.4 t/ha), while hybrids did not differ. ECB larvae which bored into the stalk tunnels modified the chemical composition of stalks and kernels. In stalks, total sugars content (*i.e.* glucose, fructose, sucrose) was about twice that in TT *versus* CTR plants (123 g/kg *versus* 60 g/kg DM, $P<0.01$), while aNDF content was higher in CTR stalks (765 *versus* 702 g/kg DM, $P<0.01$). DM degradability after 48 h of incubation of stalks was higher in TT than in CTR, both *in vitro* (0.360 *versus* 0.298, $P<0.01$) and *in situ* (0.370 *versus* 0.298, $P<0.05$), while there were no differences in aNDF degradability. Kernels from TT plots contained less DM (615 g/kg *versus* 651 g/kg, $P<0.01$) and more CP (84 g/kg and 78 g/kg DM, $P<0.05$) than those from CTR plots, while *in situ* rumen starch disappearance and *in vitro* gas production were similar. Corn hybrid selected for yield of grain (G600) differed from S600 and S700 due to a higher ($P<0.01$) content of aNDF, ADF and lignin(sa) in the stalks, and a higher starch content (696 g/kg *versus* 674 and 671 g/kg DM, $P<0.01$) and CP (87 g/kg *versus* 77 and 76 g/kg DM, $P<0.05$) in grain. The G600 hybrid produced stalks with a lower ($P<0.01$) aNDF rumen degradability than the S600 and S700.

On field ECB insecticide treatment improved corn grain yield, reduced broken plants and increased stalk sugars content at harvesting, but did not change the rumen degradation of either stalks or grain.

Abbreviations: ADF, acid detergent fiber; CP, crude protein; DM, dry matter; ECB, European corn borer; ha, hectare; NDFD, aNDF degradability; aNDF, neutral detergent fiber with α-amylase; OM, organic matter; RSE, residual standard error.

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1. Introduction

Corn (*Zea mays* L.) is often the main ingredient of diets fed to dairy cows as corn silage, corn meal, high moisture shelled and ear corn. In the last few decades, corn hybrids have been selected for yield of grain or whole-plant silage, as well as traditional selection traits including yield and quality traits such as grain to stalk ratio, stover digestibility, grain endosperm type, kernel crude protein and oil content, while drought and herbicide tolerance, molds, injuries and insect protection are additional breeding goals (Johnson et al., 1985; Roth, 1994; Verbič et al., 1995; Xu et al., 1995; Thomas et al., 2001; Hartnell et al., 2005).

Among insects, the European corn borer (ECB), *Ostrinia nubilalis* (ord. Lepidoptera, fam. Crambidae, Hübner) is the main maize pest in several European countries and causes substantive yield losses in stressed corn plants (Chiang et al., 1954; Lynch, 1980; Godfrey et al., 1991a; Lozzia and Manachini, 2003). The larvae of ECB live in stalk tunnels and cause losses in grain yield and quality by reducing the photosynthetic rate, stomatal conductance and intercellular CO_2 concentration, as well as by increasing leaf temperature (Godfrey et al., 1991b). Moreover, the larvae in stalk tunnels can promote infection by *Fusarium* and *Aspergillus* spp., ear rot in maize and consequent mycotoxin contamination of kernels (Logrieco et al., 2002; Giorni et al., 2007).

Transgenic plants, resistant to insects due to expression of endotoxins encoded by genes isolated from *Bacillus thuringiensis* (Bt), now commercially available, are considered safe for animal feeding and are grown in several countries (Williams et al., 1997; Barrière et al., 2001). However, the use of transgenic corn hybrids is currently restricted in European Community (EC, 2001) and the use of chemical insecticides is still the main method for ECB control in field conditions (Labatte et al., 1996; Lewis et al., 1996), especially pyrethroids which are the most popular chemical insecticide used to counteract ECB infestation in Italy.

Estimated grain yield losses of corn plants due to damage by ECB vary from 5% to 45% (Lynch, 1980) and vary as a function of infestation time and the physiological stage of plant development (Everett et al., 1958; Kwolek and Brindley, 1959). As there is no information about effects of the insect on the nutritional characteristics of corn plants fed to ruminants, the objective of this experiment was to compare three corn hybrids naturally infected by ECB, or protected against infestation by in field pyrethroids application, in terms of chemical composition, rumen degradability of aNDF in stalks and starch in kernels and *in vitro* gas production in kernels.

2. Materials and methods

Two corn hybrids belonging to the same maturity class (*i.e.* FAO rating 600) and selected for whole-plant silage or for grain production (S600 and G600, respectively) and one hybrid selected for whole-plant silage production (*i.e.* S700, FAO rating 700) from Dekalb-Monsanto Agricoltura S.p.A. (Lodi, Italy) were grown in an experimental field (Cremona, Italy, 44°51′N, 7°30′E, medium textured soil) and treated (TT) or not treated (control, CTR) with insecticides against ECB.

2.1. Experimental site and treatment

The experimental field was divided in two main plots, one of which was chemically treated during cultivation and the other which did not receive insecticide treatment. The main plots were divided into 12 sub-plots (3.5 m × 6.5 m, 4 rows of plants at 80 and 22 cm inter-rows and within-rows plant distances, respectively), which were randomly assigned to one of the three hybrids (*i.e.* 4 plots for each hybrid).

The corn was sowed on 3 April 2008 and the agro-technical treatments were in accordance with the plant requirements and were the same for all hybrids (*i.e.* fertilization as dairy manure on October 2007: 40, 40 and 109 kg/ha of N, P_2O_5 and K_2O, respectively; fertilization as urea on October 2007 and June 2008: 150 and 110 kg N/ha, respectively). The hybrids were irrigated four times by flood, and a hailstorm on 15 July 2008 caused a uniform damage to plants and leaves.

Insecticide treatments were applied using a self-propelled sprayer on the TT main plot which consisted of two subsequent treatments of pyrethroids: 25 g cyfluthrin/ha (Hunter, Magan Italia S.r.l., Bergamo, Italy) on 15 July 2008 and 1.2 g deltamethrin/ha (Decis jet, Bayer Crop Science, Bergamo, Italy) on 28 July 2008.

2.2. Plant sampling

Plants from the central two rows of each plot were used to measure grain yield at the black layer stage of kernels maturity, while four plants for each experimental plot were randomly collected from the external rows (2 per row) when the kernels were in the half milk line stage of maturity. From these latter plants harvested on 24 and 27 August 2008 for the TT and CTR hybrids, respectively, the whole ear and the part of the stalk within the two internodes under the ear attachment were collected and analyzed for chemical composition, rumen *in situ* degradability and *in vitro* gas production. The stalks were immediately cut at 2 cm length and all samples were cooled at 4 °C and transferred to the laboratory where the kernels were manually separated from the cobs and all samples were dried to constant weight in a ventilated oven at 55 °C.

The remaining plants in the plots were harvested on 13 September 2008, at the physiological ripening (*i.e.* black layer stage, 703 ± 34 g/kg of DM content of the kernels), and grain yield, number of standing plants, total number of lodged and broken plants were measured.