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Effect of planting density on nutritional quality of green-chopped corn for silage[1]

Gonzalo Ferreira,*[2,3] Mauro Alfonso,† Sebastián Depino,† and Esteban Alessandri†
*CREA Lincoln, Asociación Argentina de Consorcios Regionales de Experimentación Agrícola, (1041) Ciudad Autónoma de Buenos Aires, Argentina
†Forratec Argentina SA, Acceso Elguea Román 1158 (6740), Chacabuco, Buenos Aires, Argentina

ABSTRACT

The objective of this on-farm study was to determine the effect of corn planting density on the nutritional quality of whole-plant corn for silage. This study was performed in a commercial 1,900-cow dairy farm located in Piedritas (Buenos Aires, Argentina). Two commercial hybrids (A and B) were planted in experimental plots within a cornfield destined for corn silage. Hybrids were sown at a theoretical seeding rate of 60,000, 70,000, 80,000, and 90,000 seeds/ha in 4 replicates per hybrid. Plots were eight 50-m-long rows separated by 52 cm. Corn was planted with a no-till seeder equipped with a pneumatic dosing machine. Ten plants within each plot were cut by hand at 15 cm above ground. Whole plants were chopped, weighed, mixed thoroughly, and frozen until analysis. Nutritional composition was determined by near-infrared reflectance spectroscopy. Harvesting occurred at one-quarter milk-line [31.4% dry matter (DM)] and one-half milk-line (34.5% DM) stages of maturity for hybrids B and A, respectively. No interactions between hybrid and planting density were observed for any of the variables of interest. Planting density did not affect either plant DM weight or DM, crude protein, neutral detergent fiber, acid detergent fiber, or starch concentrations of whole-plant corn. Dry matter yield was significantly increased at higher planting densities. The similar per-plant biomass and nutritional quality among different densities can be explained by the abundant precipitation observed during this growing season (719 mm since the beginning of fallow until harvest). In conclusion, greater yields of silage can be obtained by increasing corn planting density without affecting its nutritional composition, although the effect of planting density with limiting resources (e.g., precipitation) still needs to be elucidated.

Key words: planting density, corn silage, nutritional quality

INTRODUCTION

Corn silage is a major energy and fiber source in diets for dairy cattle. Typical corn silage management decisions that affect forage quality, such as stage of maturity (Bal et al., 1997; Ferreira and Mertens, 2006), kernel processing (Schwab et al., 2002; Ferreira and Mertens, 2006), or cutting height (Wu and Roth, 2003; Kung et al., 2008) are focused on established corn crops. Although valid and transcendental, these decisions should not overlook that crop management decisions may also influence corn silage yield and quality.

Crop management practices for corn destined for grain are well established. Contrary to this, crop management practices for corn destined for silage are more controversial among farmers and consultants. For instance, in the western region of the temperate plains of Argentina, corn grain producers plant corn at relatively low densities (i.e., less than 75,000 seeds/ha), whereas dairy producers frequently plant corn at relatively high densities (i.e., more than 95,000 seeds/ha). A similar controversy is also observed from data within the United States. For instance, whereas Cusicanqui and Lauer (1999) observed maximum whole-plant DM yields when corn was planted at 97,300 to 102,200 plants/ha, corn hybrid trials for silage in the United States typically evaluated corn plots containing less than 90,000 plants/ha (Lauer et al., 2012; Shaffer et al., 2013).

Considering total biomass yield as the only priority, planting corn for silage at high densities may be an attractive approach for dairy farmers to recover forage inventories. However, some major concerns exist with this practice. First, high corn planting densities may exacerbate the negative effects of droughty conditions, thereby resulting in reduced forage yields when they are most necessary. Second, planting corn at high densities may decrease the energy concentration of the resulting

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[2]Current address: Department of Dairy Science, Virginia Tech, 175 W Campus Dr., Blacksburg, VA 24061.
[3]Corresponding author: gonf@vt.edu

silage due to reduced kernel pollination or development (Subedi et al., 2006; Boomsma et al., 2009). Data from Boomsma et al. (2009) show that the grain-to-stover ratio diminishes when planting density is increased and the corn crop is not fertilized. Also, Subedi et al. (2006) reported a greater number of barren plants when the corn planting density was increased. Finally, Boomsma et al. (2009) reported that planting corn at high densities increases the anthesis-silking intervals, which may also result in lower grain-to-stover ratios. In agreement with these observations, Cusicanqui and Lauer (1999) reported that increasing corn planting density results in whole-plant corn silages with greater concentrations of fiber and, likely, less energy-containing corn silages. The negative relationship between planting density and forage quality makes difficult to recommend high planting density based on biomass yield (Cusicanqui and Lauer, 1999).

Field information regarding the effect of planting density on corn whole-plant yield and quality should add knowledge to better decide on crop management practices to obtain high yields of good-quality forage. The objective of this on-farm study was to determine the effect of corn planting density on the nutritional quality of whole-plant corn for silage.

MATERIALS AND METHODS

Location, Hybrids, and Cultural Management

This study was performed in a commercial 1,900-cow dairy farm located in Piedritas (34°43′56″S and 62°57′59″W), Buenos Aires, Argentina. Two commercial hybrids, DK747MGRR2 (**hybrid A**; DeKalb; Monsanto Co., Buenos Aires, Argentina) and DUO548HXRR2 (**hybrid B**; Forratec Argentina SA, Buenos Aires, Argentina), were planted in experimental plots within a cornfield destined for corn silage. Hybrid A was the corn material used by the dairy farm during that cropping season to recover corn silage inventories. Hybrid B is a commercial material, typically used for silage, and was included to broaden our conclusions to more than a single hybrid. Plots were planted and managed according to on-farm standard operating procedures. The cornfield was on a no-till soil management system. The preceding crop was corn for grain. The planting date was October 13, 2012.

Hybrids were planted at a theoretical seeding rate of 60,000, 70,000, 80,000, and 90,000 seeds/ha in 4 replicates per hybrid according to a complete randomized block design with 4 blocks (i.e., 32 plots in total). Each of the 4 planting densities was randomly assigned to plots within each block. Plots consisted of eight 50-m-long rows separated by 52 cm. Corn was planted with a 16-row no-till seeder equipped with a pneumatic dosing machine (Agrometal TX Mega; Agrometal SA, Córdoba, Argentina). Corn crops were fertilized with 90 kg of N/ha and 31 kg of P_2O_5/ha. Weeds and insects were controlled following standard operating procedures for the cornfield. The total precipitation for the whole season (including fallow) was 719 mm.

Harvesting and Quality Determination

Harvesting was targeted to occur when the whole plant contained between 30 and 35% DM, which occurred on February 5, 2013. At harvesting time, 5 consecutive plants from the center rows and at 2 randomly selected spots within each plot (i.e., 10 plants per plot) were cut by hand at 15 cm above ground. Whole plants were chopped with an experimental forage chopper (TRF 70; Trapp, Jaraguá do Sul, Brazil) and weighed to determine plant biomass. After mixing thoroughly by hand over a 2-m by 2-m plastic sheath, a sample of the chopped material was placed in a bag and immediately placed in a cooler with ice until frozen.

Single plant biomass and standing plants at harvest were used to determine biomass yield. For this, we counted the number of plants within a 9.6-m row and in 2 adjacent rows. This procedure was performed for each of the 32 plots.

Whole-plant corn samples were then dried at 60°C in a forced-air drying oven until constant moisture was reached. Samples were then weighed to determine DM concentration of the field-moist samples. After drying, samples were ground to pass a 4-mm screen of a Wiley mill (Thomas Scientific, Swedesboro, NJ) and submitted to a laboratory. Within the laboratory, samples were reground to pass a 1-mm screen of a cyclone mill (LM 3100; Perten Instruments AB, Hägersten, Stockholm, Sweden) and finally analyzed with near-infrared reflectance spectroscopy (NIRS; Matrix I; Bruker Optics Inc., Billerica, MA). Coefficient of determination values for NIRS calibrations were 96.9, 93.3, 88.9, and 96.1 for CP, NDF, ADF, and starch, respectively.

Statistical Analysis

Data were analyzed using PROC MIXED of SAS 9.3 (SAS Institute Inc., Cary, NC) as for a randomized complete block design with a 2 × 4 factorial arrangement of treatments (i.e., hybrids and planting densities). The model included the random effect of block (df = 3), the fixed effect of density (df = 3), the fixed effect of hybrid (df = 1), the density by hybrid interaction (df = 3), and the residual error (df = 21). The linear, quadratic, and cubic effects of planting density were also evaluated by orthogonal contrasts.