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Effect of planting density on yield, nutritional quality, and ruminal in vitro digestibility of corn for silage grown under on-farm conditions

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ABSTRACT

The objective of this on-farm study was to determine the effect of planting density on yield, nutritional composition, and fiber digestibility of corn silage. This study was performed during the spring and summer seasons of 2014 and 2015 at 2 commercial dairy farms located in Virginia. The study included 7 cornfields with different growing and harvesting conditions. In each cornfield, corn was planted in plots at a theoretical seeding rate of 55,000, 70,000, 85,000, and 100,000 seeds/ha (55K, 70K, 85K, and 100K, respectively). Each seeding rate had 4 replicates within each cornfield. The preceding crop was annual ryegrass that was harvested for silage within 10 d before planting corn. Plant DM biomass decreased linearly (376 vs. 253 g of DM/plant for 55K and 100K, respectively; $P < 0.01$), but DM yield increased linearly (19.8 vs. 26.0 Mg/ha for 55K and 100K, respectively; $P < 0.01$) when planting density increased. The number of kernels per ear and the stem width decreased proportionally as corn population density increased. Planting density did not affect, or minimally affected, the concentrations of ash, CP, NDF, ADF, ADL, starch, and sugar of fresh corn and corn silage. Also, planting density did not affect ruminal in vitro NDF digestibility of fresh corn and corn silage. In conclusion, increasing corn planting density increased forage yield when planted in a double-cropping system, minimally affecting nutritional quality and ruminal in vitro digestibility of corn silage.

Key words: planting density, corn silage, nutritional quality, fiber digestibility

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), kernel processing (Schwab et al., 2002), or cutting height (Kung et al., 2008), are focused on established crops. In addition to these, crop management decisions such as fertilization (Rossini et al., 2011), row width (Van Roekel and Coulter, 2012), or planting density (Cusicanqui and Lauer, 1999) may also affect corn silage yields and quality.

The effects of increasing planting density have been studied extensively on corn for grain. A common conclusion from these studies is that the greatest grain yields at higher planting densities were related to an increased number of kernels per unit of land area, despite having plants with fewer and smaller kernels per plant (Van Roekel and Coulter, 2011; Rossini et al., 2012; Maddonni and Martínez-Bercovich, 2014).

Although extensively studied for corn grain, limited information exists about the effect of planting density on yield and nutritional quality of corn for silage. Similar to corn for grain, Cusicanqui and Lauer (1999) observed maximum whole-plant DM yields when corn was planted at 97,300 to 102,200 plants/ha, although they also reported that increasing plant density results in corn silages with greater concentrations of fiber. In an on-farm study, Ferreira et al. (2014) also reported increased whole-plant DM yields when corn planting density was increased, although nutritional quality was not affected. Ferreira et al. (2014) attributed the greater yields of similar nutritional quality at the highest planting densities to the abundant precipitation during the crop cycle (i.e., 719 mm), to the long fallow period linked to the preceding crop (i.e., corn for grain), or to a combination of both.

Double cropping is a management practice that consists of 2 crops planted, grown, and harvested within the same year or growing season (e.g., a cool-season grass immediately followed by a summer crop, such as ryegrass and corn, respectively). Double cropping is a common practice in dairy farming systems (Ward et al., 2001). Ferreira et al. (2014) hypothesized that under double cropping conditions, water accumulation and nutrient mineralization could be reduced, thereby limiting resources for the following corn crop destined for silage.

To test the mentioned hypothesis (Ferreira et al., 2014), the objective of this on-farm study was to determine the effect of planting density on DM yield, nutritional composition, and digestibility of corn silage when corn was planted immediately after harvesting ryegrass for silage.

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MATERIALS AND METHODS

Animal Care and Use

The Institutional Animal Care and Use Committee of Virginia Tech approved all procedures involving dairy cows for collecting rumen contents.

Fields and Cultural Management

This study was performed during the spring and summer seasons of 2014 and 2015 at 2 commercial dairy farms located in Museville (farm 1) and Gordonsville (farm 2), Virginia. The study included 7 different growing and harvesting conditions, hereafter named "fields" (Table 1). Fields 1 and 2 (from farm 1) were planted during 2014 with the commercial corn hybrid Pioneer 33F86 (Du Pont Pioneer, Johnston, IA). Field 3 (from farm 2) was planted during 2015 with the commercial corn hybrid SC 11AQ72 (Seed Consultants Inc., Washington Court House, OH). Fields 4, 5, 6, and 7 (from farm 1) were planted during 2015 with the commercial corn hybrid Pioneer P2088AMX (Du Pont Pioneer). Corn hybrids were those chosen and used at the dairy farms according to their respective cropping management plans. Fields 2, 5, and 7 were equipped with a pivot irrigation system.

In each cornfield, corn was planted in plots at a theoretical seeding rate (i.e., treatments) of 55,000, 70,000, 85,000, and 100,000 seeds/ha. Each seeding rate had 4 replicates within each cornfield, and each of the 4 seeding rates was randomly assigned to plots within each field. At farm 1 corn was planted with a 12-row Case 1240 AFS no-till planter equipped with a pneumatic dosing machine (Case IH, Racine, WI). At farm 2 corn was planted with a 4-row John Deere 7000 no-till planter equipped with seed plates (Deere & Company, Moline, IL). For both farms, plots consisted of 30-m-long rows separated by 76 cm. Plots were planted and managed according to on-farm standard operating procedures.

For all fields, the preceding crop was annual ryegrass that was harvested for silage within 10 d before planting corn. All cornfields were fertilized with N (Table 1) according to on-farm nutrient management plans. Weed and pest control was performed according to on-farm crop management plans.

Harvesting, Ensiling, and Analyses

Crop maturity at harvesting times differed among fields but not within fields (Table 1). At harvesting time, 5 consecutive plants from the 2 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 weighed and chopped with a Stanley CH2 wood chipper (GXi Outdoor Power LLC, Clayton, NC). After mixing thoroughly within a barrel, a sample of the chopped material was placed in a bag, immediately placed in a cooler with dry ice, and transferred to the laboratory for storage at −20°C.

Chopped samples were thawed, and a first subsample (hereafter named "fresh corn") was dried at 55°C in a forced-air drying oven (Freas 645, Thermo Electron Corporation, Marietta, OH) until constant weight was reached. The resulting DM concentration was used to calculate DM yield. The dried fresh corn was then ground to pass through a 1-mm screen of a cyclone mill (Udy Corporation, Fort Collins, CO) for chemical analyses. A second 400- to 500-g subsample of the thawed sample (hereafter named "corn silage") was placed into MR-1014 polyethylene embossed pouches (Doug Care, Springfield, CA) and double sealed anaerobically with a FastVac vacuum sealer (Doug Care) as described by Der Bedrosian et al. (2012). No inoculants were added to enhance fermentation. Mini-

Table 1. Crop management and rainfall information for cornfields used

Item	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7
Planting date	May 6, 2014	May 6, 2014	May 13, 2015	May 12, 2015	May 12, 2015	May 12, 2015	May 12, 2015
Harvesting date	Aug 14, 2014	Aug 14, 2014	Aug 19, 2015	Aug 12, 2015	Aug 12, 2015	Aug 24, 2015	Aug 24, 2015
N fertilization (total), kg/ha	175	175	165	240	240	240	240
Total rainfall,[1] mm	310	310	322	315	315	315	315
May	52	52	107	23	23	23	23
June	45	45	196	241	241	241	241
July	108	108	109	51	51	51	51
August	105	105	0	0	0	0	0
Irrigation, mm	—	100	—	—	51	—	51
Timing of irrigation	—	Before silking	—	—	Before silking	—	Before silking

[1]Rainfall from planting until harvesting. The amount of irrigated water is not included.