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Summary

Irrigated corn residue was sampled across time in order to determine changes in quality and proportion of corn residue as the plant dried and was exposed to effects of weathering. Corn plants from two hybrids were planted on two different planting dates and harvested at periodic intervals from August 2012 to December 2012. Proportions of stem, blade/sheath, husk/shank, and cob made up smaller components of total plant DM as it matured, with the largest relative reduction occurring in the blade/sheath or stem. Hybrid impacted TDN values primarily because the 119 day hybrid was less mature at the early sampling dates.

Introduction

Residues of corn (*Zea mays*) have successfully been utilized as an economical roughage and energy source for ruminants. After grain harvest, the majority of what remains in the field is the forage portion of the plant. Residue proportions are estimated to be 40% stem, 45% husk/blade, 11% cob, and 4% grain for an irrigated field. Quality of the residue is largely dependent on plant part. This is supported by previous research showing husk being higher in quality compared with the blade, stem, and cob (2012 *Nebraska Beef Cattle Report,* pp. 11-12). Grain, the highest quality part of the corn plant, is typically found in minimal amounts in a residue field. Unlike grain, the forage is subject to decreasing quality as the plant matures, with the change in quality largely dependent on the effects of weathering. The objective of this trial was to determine the nutritional quality of corn residue over time.

Procedure

Two experiments were conducted in 2012 at the University of Nebraska–Lincoln Agriculture Research and Development Center near Mead, Neb. Standing corn plants were sampled from an irrigated demonstration corn plot and harvested at periodic intervals from August 2012 to December 2012. Experiment (Exp.) 1 was planted May 27 and Exp. 2 was planted April 27. Both experiments contained two hybrids, a 102 day (DKC52-59) and 119 day (DKC69-40) maturity of DeKalb brand corn. Corn plants in Exp. 1 were harvested at two week intervals August through October and then four week intervals through December while Exp. 2 was harvested at four week intervals from October through December. Corn was not harvested for grain; instead, the plant remained standing in the field for the duration of the collection period. Hybrids within each experiment were divided into quadrats and a sample from each quadrat was collected at sampling time for a total of four replications. Replications consisted of five plants in a row that were representative of the field. Plants were separated into stem, blade/sheath, husk/shank, cob, and grain. Data on black layer were not collected from the field. Instead, black layer was calculated with an equation using planting date, hybrid, and weather pattern data to estimate maturity relative to the time of sampling.

Plant parts for each sampling date were analyzed for DM and neutral detergent fiber (NDF) digestibility. Samples collected prior to November 1 were freeze-dried, and those collected afterwards were dried in a forced air oven at 60°C for 48 hours. Samples were ground through a 2 mm screen in a Wiley mill and placed in labelled, airtight bags. Dacron bags with a 50 µm pore size were used for *in situ* to determine NDF digestibility. Two steers were used for *in situ* work with a 28 hour incubation period. Duplicate 1.25 g samples were weighed into Dacron bags and 40 Dacron bags were placed in a mesh bag. Eight mesh bags were placed in each steer during each incubation period. After incubation, bags were rinsed and washed in NDF solution. Bags were dried in a forced air oven at 100°C for 12 hours and then weighed back for DM.

True digestibility of stem, blade/sheath, husk/shank, and cob were calculated in order to determine how much is fermented by the microbial community during retention time in the rumen. Solubles were considered 100% digestible and were calculated by subtracting the percentage of NDF from 100%. Therefore, true digestibility is the sum of the solubles and digestible NDF.

Results were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). The experimental unit consisted of the five competitive plants within each replication. Repeated measures was used to determine how plant parts changed over time in regards to NDF content, NDF digestibility and true digestibility. Hybrid was included in the model as a treatment.

Results

Experiment 1

No effect of hybrid was found so results were combined. There was a quadratic change in the proportion of

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residue DM over time for stem, blade/sheath, and husk/shank, with few changes in DM proportion occurring once grain was estimated to reach 15.5% moisture ($P < 0.01$; Table 1). A quadratic increase in NDF content occurred over time for blade/sheath, husk/shank and cob ($P < 0.01$; Table 2). An increase in the amount of NDF is correlated with a decrease in solubles of the plant part. The amount of NDF has been shown to increase with plant maturity. Stem had a linear decrease in NDF content ($P = 0.01$). This implies that the stem increased in solubles over time. This is unlikely and is not supported by previous research since solubles are metabolized by the plant as it matures. It is unclear what displaced NDF in the stem as it remained in the field.

A quadratic decrease in NDF digestibility occurred over time for cob, with the majority of the decline occurring prior to normal grain harvest ($P < 0.01$; Table 3). Digestibility of NDF of the other plant parts remained relatively constant for each sampling point, with the blade/sheath at 30% and stem less than 10%. The true digestibility of cob showed a quadratic decrease over time, with true digestibility remaining relatively constant once grain reaches 15.5% moisture ($P < 0.01$; Table 4). A linear decrease in true digestibility occurred for blade/sheath ($P < 0.01$), while there was a linear increase for the stem. As the plant matures, true digestibility is expected to decrease due to the increase in fiber and reduction in solubles. For this experiment, the increase in true digestibility of the stem is due to the decline of NDF content which suggests cell solubles are increasing in the stem. As previously stated, it is unclear what displaced NDF in the stem and it seems unlikely that the true digestibility of the stem increased over time based on previous research.

Table 1. Changes in residue proportion over time for Experiment 1.

	Days from Black Layer								*P*-value	
	-18	-4	10	38	52	66	81	S.E.	L	Q
Blade and sheath	39	19	34	10	24	22	25	1.27	<0.01	<0.01
Cob	14	17	15	17	18	16	19	1.27	0.8	1
Husk/shank	8	10	8	23	9	8	12	1.27	<0.01	<0.01
Stem	40	54	43	51	49	54	45	1.27	<0.01	<0.01

Table 2. Total neutral detergent fiber content of plant parts over time for Experiment 1.

	Days from Black Layer								*P*-value	
	-18	-4	10	38	52	66	81	S.E.	L	Q
Blade and sheath	61.1	63.3	65.3	71.3	73.3	73.5	73.1	1.43	<0.01	<0.01
Cob	69.2	78.6	83.1	80.7	84.3	77.6	80.3	1.43	<0.01	<0.01
Husk/shank	74	79.1	78.1	83.1	80.3	81.4	77.3	1.43	0.04	<0.01
Stem	70.6	68.7	65.6	72.1	64.7	59.4	64.3	1.43	0.01	0.5

Table 3. Total neutral detergent fiber digestibility of plant parts over time for Experiment 1.

	Days from Black Layer								*P*-value	
	-18	-4	10	38	52	66	81	S.E.	L	Q
Blade and sheath	29.5	30.8	31.8	33.1	34.2	31.3	31.9	1.38	0.4	0.7
Cob	30.7	26.5	25.2	23.2	24.1	22.3	22.6	1.38	0.01	< 0.01
Husk/shank	36	40.2	38.9	40.6	44.1	41.2	42.6	1.38	0.06	0.5
Stem	6.5	4	4.3	6.7	11	8.1	4.1	1.38	0.4	0.4

Table 4. True digestibility of plant parts over time for Experiment 1.

	Days from Black Layer								*P*-value	
	-18	-4	10	38	52	66	81	S.E.	L	Q
Blade and sheath	58.1	56.3	55.5	52.3	51.8	49.5	50.4	1.20	<0.01	0.03
Cob	51.9	42.3	37.8	38.1	35.9	39.8	37.7	1.20	0.001	<0.01
Husk/shank	53.4	52.7	52.3	50.8	55.1	52.1	55.7	1.20	0.4	0.3
Stem	33.8	34.1	37.2	32.8	42.6	45.3	38.3	1.20	0.01	0.3

Experiment 2

A quadratic decrease in proportion of residue DM was evident for stem, while a quadratic increase occurred for husk/shank and cob ($P < 0.01$; Table 5). After grain harvest, the DM proportions of the residue are believed to remain relatively constant unless acted upon by environmental effects. The low number of sampling time points taken after grain harvest may play a contributing role in the difference over time for the stem, husk/shank, and cob in terms of residue proportion.

A difference between hybrids was found for NDF content so results were separated. There was a linear increase in NDF content of stem for the 102 day hybrid over time ($P < 0.01$; Table 6). This is supported by previous research showing that NDF increases with increasing maturity, causing a corresponding decline in the amount of solubles. For the 119 day hybrid, NDF content of stem and husk/shank showed a linear decrease ($P < 0.01$;

Table 5. Change in residue proportion over time for Experiment 2.

	Days from Black Layer				*P*-value	
	51	93	108	S.E.	L	Q
Blade/sheath	23.9	22.4	20.5	1.26	0.9	0.9
Cob	16.1	20.7	20.5	1.26	<0.01	<0.01
Husk/shank	9.5	13	13.3	1.26	<0.01	<0.01
Stem	50.6	43.9	45.7	1.26	<0.01	<0.01

Table 6. Total neutral detergent fiber content of plant parts over time for 102 day hybrid in Experiment 2.

	Days from Black Layer				*P*-value
	51	93	108	S.E.	L
Blade/sheath	69.2	66.7	69.1	1.51	0.6
Cob	83.9	77.3	79.6	1.51	0.2
Husk/shank	75.2	70.4	72.8	1.51	<0.01
Stem	57.2	56.4	60.1	1.51	0.9

Table 7. Total neutral detergent fiber content of plant parts over time for 119 day hybrid in Experiment 2.

	Days from Black Layer				*P*-value
	51	93	108	S.E.	L
Blade/sheath	71.4	68.6	71.9	1.51	0.3
Cob	85.4	84.4	79.7	1.51	0.1
Husk/shank	80.3	74.4	76.2	1.51	<0.01
Stem	59	49.5	49.8	1.51	<0.01

Table 8. Total neutral detergent fiber digestibility of plant parts over time for Experiment 2.

	Days from Black Layer				*P*-value
	51	93	108	S.E.	L
Blade/sheath	18.5	21.4	25.1	2.41	0.6
Cob	20.5	15.9	19.8	2.41	0.04
Husk/shank	30.3	34.9	32.4	2.41	0.6
Stem	0	1.6	0.5	2.41	1.0

Table 9. True digestibility of plant parts over time for Experiment 2.

	Days from Black Layer				*P*-value
	51	93	108	S.E.	L
Blade/sheath	43	46.8	47.3	2.04	0.4
Cob	32.7	31.9	36.2	2.04	0.5
Husk/shank	46	52.9	49.8	2.04	0.04
Stem	41.9	47.9	45.3	2.04	0.1

Table 7). The NDF of stem of the 119 day hybrid is similar to results for the NDF content of stem in Exp. 1. No differences were found in NDF digestibility, with values remaining relatively constant (Table 8). The NDF digestibility of stem was close to zero for each sampling date. No differences were found in true digestibility, with values remaining relatively constant over time (Table 9).

Implications

Experiment 2 was planted one month earlier than Exp. 1 and was not sampled until after grain reached 15.5% moisture. While Exp. 1 evaluated the quality of the plant parts prior to black layer through the winter grazing period, Exp. 2 offers a smaller window for observation after normal grain harvest. The proportion of residue DM for both experiments remained relatively constant once grain reached 15.5% moisture. Therefore, any reduction in DM after normal grain harvest can be attributed to environmental effects.

Plant part is the major contributor to the quality of residue, with the husk being of the highest quality while stem is of the lowest. Cattle select and consume the highest quality components first based on what is available in the field.

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