Ceres Trust Graduate Student Grant: Annual Report

Project title: Organic Forage Blends (Response of row cropping of mixed seeds of corn and soybean at different seeding ratios on forage yield, nutrient yields and quality grown under organic condition)

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Amount awarded: $ 10,000.00

ABSTRACT

A field plot study was laid out using a randomized complete block design (RCBD) with three replicates to evaluate two organic corn hybrids [MC 5300 (OC) and brown midrib (BMR) organic grazing corn (Masters Choice Mastergraze, MG)] with two organic soybeans [Viking 2265 (OS) and Vining (VS)] at four seeding ratios (R1 = 65:35; R2 = 55:45; R3 = 45:55, and R4 = 35:65 of corn and soybean respectively) in terms of forage yield, nutrient yields and quality. Forage was hand harvested at 101 d (MG corn with both soybeans) and 116 d (OC corn with both soybeans) after planting during the 2015 growing season, chopped, inoculated, packed into buckets, weighed, and ensiled for 90 d. Buckets were then re-weighed, opened, and forage samples collected and analyzed for nutrient composition. No interaction of corn × soybean × seeding ratio was detected for biomass yield and nutrient yields. The main effect of corn for dry matter yield (DMY) was greater ($P < 0.05$) for OC compared to MG (27.73 and 19.90 T/ha for OC and MG, respectively), while main effect of soybean for DMY was similar ($P > 0.05$, 23.77

and 23.86 T/ha for OS and VS, respectively). Main effect of seeding rate on DMY was higher ($P < 0.05$) for R1 and R2 compared to R3 and R4 (25.38, 24.48, 21.81 and 23.59 T/ha for R1, R2, R3 and R4, respectively). Yields of digestible dry matter (DDM; 19.55 and 13.67 T/ha) and CP (2.40 and 2.12 T/ha) were greater ($P < 0.05$) for OC compared to MG corn, similar ($P > 0.05$) for both soybean (DDM; 16.65 and 16.57 T/ha and CP; 2.33 and 2.19T/ha for OS and VS respectively) and higher ($P < 0.05$) DDM for R1 and R2 compared to R3 and R4 (17.70, 17.08,15.13 and 16.54 T/ha for R1, R2, R3, and R4, respectively). Yield of starch (7.78 and 2.45 T/ha for OC and MG) and 30 h NDF digestibility (NDFD30; 44.47 and 52.49 % for OC and MG) for main effect of corn were different ($P < 0.05$), while similar ($P > 0.05$) for main effect of soybean (starch yield; 5.25 and 4.98 T/ha; NDFD30; 48.58 and 48.38% for OS and VS, respectively). The combination of OC corn either with OS or VS soybean at the ratio of R1 or R2 resulted in the greatest yield of DM, DDM and Starch. The production of forge blends through mixed cropping of corn and soybeans holds great potential for increasing the forage and nutrient yields to meet the nutrient requirements of lactating dairy cows.

Key words: corn, soybean, organic forage, row cropping, mixed seeds

INTRODUCTION

Two noteworthy progresses are currently taking place in the area of forage production. One is the continuous sky rocking price of feedstuffs that is forcing many dairy producers to evaluate new ways to reduce production costs. The current dairy situation is becoming so risky that some have even suggested a slaughter program in order to stabilize the current market situation. At the same time, an increasing number of dairy producers are switching to organic dairy production in order to benefit from higher prices per product unit as demand for organic food remains high. The second approach is an increase in the number of organic dairy producers producing food according to the organic guidelines to meet the growing demand. Parsons et al. (2009) reported that organic producers in Vermont spent nearly $1200 per cow per year on purchased feed and 92% of those costs involved the purchase of concentrates to increase ration nutrient density in order to boost milk production.

Organic milk production has been increasing every year from 1.9 % of total fluid milk production in 2006 to 4.4 % in 2013 (USDA, 2014). One reason for the growth in the organic sector has been the steadily increasing milk price, going from $22.97 in 2004 to $28.84 in 2006 to $29.35 in 2007 to $38.10/cwt in 2016 (CROPP Cooperatives, 2016). However, net profits from organic milk production are headed in the opposite direction as production costs continue to rise. Organic dairy farmers must place an emphasis on forage quality to feed their livestock in order to be successful. Any time of the year, the forage quality determines what other feeds need to be included for balancing the nutrients in the dairy cow ration. Quality forages provide a nutritional base that maintains digestive function, improves animal health, and supplies nutrients to the dairy cow in a most efficient manner. Forage quality decreases the amount of grains dairy producers need to purchase to meet their production goals of their dairy cows.

Legumes are useful for assimilating natural N through crop rotations and forage production, which ultimately decrease the use of fertilizer and cost. For forage production, forage soybeans serve particular well as a foundation for producing mixed crops with corn, as shown through preliminary research. Numerous studies have reported that intercropping soybean and corn resulted an increase in biomass yield by 20 - 40% (Singh et al., 1986) and crude protein (CP) by 11-15% (Putnam et al., 1986). The reason for increased silage yield with intercropping compared to monocropping is due to the efficient utilization of available sunlight, moisture and soil nutrients (Etebari and Tansi, 1994). Silage quality and CP concentration increased when soybean were planted with corn in alternate rows as 1 corn - 1 soybean or 1 corn - 2 soybean rows compared to the sole cropping of corn (Altinok et al., 2005). Smith (2000) reported increased silage yield and crude protein yield while intercropping corn and pole bean together. However, intercropping of corn and soybean together generally produced less DMY, but higher quality silage (increased CP). Practicing alternate-row sowings and benefiting from climbing types of legumes as a component crop had better performances than same-row sowings and dwarf type legume (Geren et al., 2008). Since MG corn has a high level of total sugar and NDFD, and vining soybean has indeterminate type growth, we hypothesized that intercropping of mixed seeds of MG corn with VS soybean in a same row produced more biomass and nutrient yields, as well as, silage quality compared to other combination of corn and soybeans.

OBJECTIVES

The objectives of this study were to compare the row cropping of mixed corn and soybean seed at different seeding ratios on yields of biomass, nutrients, silage quality, and estimated milk yield per ha grown under organic condition.

MATERIALS AND METHODS

An organic field at the Dairy Research and Training Facility (DRTF) of South Dakota State University, SD was used to conduct this research in the 2015 crop growing season. The plot area was a grass pasture for several years prior to this study.

Field preparation

Soil preparation consisted of plowing, disking, leveling and layout. The field was prepared without addition of chemical fertilizers, herbicides and pesticides. However, liquid manure from dairy farm was spread on the field 15 d prior to planting. A total of 48 plots having an area of 29.2 m^2 (5.4 m × 5.4 m) with 8 rows planted at 76.2 cm per plot.

Corn and soybean varieties

The OC, (MC-5300) having a 103 d maturity, is well known for strong emergence and seeding vigor for organic production and reduced tillage operation, has very good tonnage and bushels per acre with excellent nutrition. It has wide leaf, showy robust plant, excellent dual purpose white cob variety for livestock feed that drives performance (Masters Choice Seed Corn, Anna, IL).

The MG corn (Masters Choice, Anna, IL) is a conventional organic corn hybrid for higher quality digestible forage. It has ability to be grazed and harvested during summer, fall, and winter with the potential to produce up to 12.21 DM T/ha in 7-8 weeks under ideal growing conditions. The MG qualities include 20-30% higher fiber digestibility, 15-20% higher CP potential, lower lignin, sweet, and palatable due to a high sugar content.

The Viking 2265 organic soybean (OS) is medium-tall, bushy type plant with very good lodging resistance, has excellent emergence and very strong phytophthora field tolerance, and excellent white mold tolerance. It is an excellent cover crop, livestock feed, or smother crop, which also used as a trap crop for deer. Biomass and grain yield is comparable to conventional, roundup ready and large lad soybean (Johnny’s selected seeds, Winslow, ME).

The VS soybean line was developed by a South Dakota State University soybean breeder (Dr. Xingyou Gu) through intensive selection processes starting with wild soybeans. Growth is indeterminate type and climbs the corn if planted together. Preliminary research demonstrated excellent potential for the organic forage soybean to increase the CP content of silage (Unpublished, Plant Science Department, South Dakota State University).

Experimental design and treatments

A field plot study was laid out using a completely randomized design (RCBD) to evaluate two corn hybrids [MC5300 normal organic corn (OC) and BMR grazing corn (Masters Choice Mastergraze, MG)] with two soybean cultivars [Viking 2265 organic (OS) and Vining line (VS)] at four seeding rates (R1 = 65:35; R2 = 55:45; R3 = 45:55, and R4 = 35:65 of corn and soybean respectively) having a 2 x 2 x 4 factorial treatment design replicated three times.

The organized outline of the 16 individual treatments were:

Treatment 1 (65% MC 5300 corn + 35% Viking 2265 soybean)

Treatment 2 (55% MC 5300 corn + 45% Viking 2265 soybean)

Treatment 3 (45% MC 5300 corn + 55% Viking 2265 soybean)

Treatment 4 (35% MC 5300 corn + 65% Viking 2265 soybean)

Treatment 5 (65% MC 5300 corn + 35% Vining soybean)

Treatment 6 (55% MC 5300 corn + 45% Vining soybean)

Treatment 7 (45% MC 5300 corn + 55% Vining soybean)

Treatment 8 (35% MC 5300 corn + 65% Vining soybean)

Treatment 9 (65% Mastergraze Corn + 35% Viking 2265soybean)

Treatment 10 (55% Mastergraze Corn + 45% Viking 2265soybean)

Treatment 11 (45% Mastergraze Corn + 55% Viking 2265soybean)

Treatment 12 (35% Mastergraze Corn + 65% Viking 2265soybean)

Treatment 13 (65% Mastergraze Corn + 35% Vining soybean)

Treatment 14 (55% Mastergraze Corn + 45% Vining soybean)

Treatment 15 (45% Mastergraze Corn + 55% Vining soybean)

Treatment 16 (35% Mastergraze Corn + 65% Vining soybean)

The required number of total seeds required for each experimental plot were calculated based on seed corn planted at 86,487 seeds/ ha and soybeans at 3,58,302 seeds/ha. Mixed seeds of corn and soybean were planted using a 4 row cone plot planter (Almaco, 1986 model KK4RPPSEM) having a row spacing of 76.2 cm.

Weeding, harvesting, ensiling, and sampling

Weeds were removed 3 times during the cropping season at 25 and 50 d by using a small rotary tiller and manually at 75 d after planting. No irrigation was provided throughout the study period. The MG corn combined with both soybeans (OS and VS) were hand harvested at 101 d after planting, whereas OC combined with both soybeans (OS and VS) were hand harvested at 116 d after planting, because of maturity differences among OC and MG corn hybrids. The center 2 rows of each experimental plot were harvested and weighed to measure fresh biomass yield. Plants were wilted, chopped (Patriot Inc., Pewaukee, WI), inoculated with Silo-King (Agri-King, Inc., Fulton, IL) at recommended dose, packed into buckets, weighed, and ensiled for 90 d. Buckets were then re-weighed, opened, and forage samples collected and submitted for nutrient analysis (Analab, Inc., Fulton, IL).

Sample analyses

Fresh (0 d) and ensiled (90 d) forage samples were analyzed for DM, CP, soluble protein (SP), acid detergent fiber (ADF), neutral detergent fiber (NDF), ADF insoluble CP (ADIP), NDF insoluble CP (NDIP), starch, nonfiber carbohydrates (NFC), net energy of lactation (NE_L), 6-C sugars, ether extract (EE), nitrates, in vitro DM digestibility (IVDMD), NDF 30 hr digestibility (NDFD30), lignin, ash, ammonia-N (NH_3-N), pH, lactic acid, acetic acid, butyric acid, Na, Mg, P, S, K, Ca, Cl, Mn, Fe, Cu and Zn (Analab, Inc., Fulton, IL). The AOAC (2006) methods were used for analysis of DM (935.29), CP (990.03), SP (Krishnamoorthy et al., 1982), ADF (973.18), NDF (2002.04), ADIP (Goering and Van Soest, 1970; Goering et al., 1972), NDIP (2002.04 minus sulfite and 976.06), starch (996.11, enzymatic method analyzed on RFA using Glucose Trinder), NFC (100- NDF – CP – Fat – EE), NE_L (NRC, 2001), 6-C sugar (Ethanol extract, HPLC with ELSD), EE (920.39), nitrates (968.07), IVDMD (ANKOM technology - 08/05), NDFD30 (ANKOM technology method 3), lignin (973.18), ash (942.05), NH_3-N (University of Wisconsin Extension SKU:A3769, MAP 4.3 adapted from USEPA 351.2 and ISO

11732), pH (981.12), lactic acid (LC-GC Vol. 11 No. 10), acetic acid (LC-GC Vol. 11 No. 10), butyric acid (LC-GC Vol. 11 No. 10) and minerals (Ca, P, Mg, K, Na: 985.01; S: 923.01; Cl: 915.01; Mn, Fe, Cu, ZN: 985.01).

Estimation of total nitrogen accumulated by the crop

Total crop N accumulation (T/ha) can be calculated as:

$$\text{Total N} = \Sigma\,(\text{DMY} \times \text{N}\,\%)$$

Where DMY is the yield of DM (T/ha) and N is the concentration of plant N. Crude protein content of forage was used to calculate total nitrogen content. Once DMY per ha was multiplied by nitrogen percentage, we can get total nitrogen uptake by treatment forage on per ha basis.

Net return

$$\text{Net return (\$/ha)} = GI - (S + Mc + L + C + R + CI + Mi + I)$$

Where GI is gross income ($/ha), S is seed costs ($/ha), Mc is machinery expenses ($/ha), L is labor cost ($/ha), C is compost/manure cost ($/ha), and, R is rental land cost ($/ha), CI is crop insurance cost ($/ha), Mi is miscellaneous cost ($/ha), and I is interest on variable cost ($/ha).

The current prices of grain and silage published by USDA livestock, poultry and grain market news as of 6th January, 2016 was used to estimate GI from the grain or silage. The prices of organic corn silage (adjusted to 35% DM) and organic soybean silage (35% DM) were $95.98, and $141.23 per ton, respectively. Proportion of corn and soybean in the forage blends were estimated based on seeding ratios during planting. Gross income from forage blend was estimated based on 35% DM yield of corn and soybean forage multiplied by the respective market price. The total forage production cost was calculated by using the cost formula estimates from Iowa State University developed by Plastina (2016). Total cost of forage production ($1,743.99/ha) includes seed cost ($320.84/ha), machinery cost ($345.95/ha), labor cost $172.97/ha), compost cost ($160.62/ha), rental land cost ($ 657.30/ha), crop insurance ($30.15/ha), miscellaneous ($24.71/ha), and interest on variable cost ($31.46/ha).

Statistical analysis

All data were subjected to least square analysis of variance (ANOVA) using the PROC MIXED procedure of SAS (SAS Institute Inc., Cary, NC, Version 9.4) using a randomized complete block design (Steel and Torrie, 1980). The statistical model used was:

$$Y_{ijk} = \mu + C_i + S_j + R_k + (C \times S)_{ij} + (C \times R)_{ik} + (S \times R)_{jk} + (C \times S \times R)_{ijk} + e_{ijk}$$

Where,

Y_{ijk} is the dependent variable

μ is the overall mean,

C_i is the i^{th} main effect of corn (i = 1,2)

S_j is the j^{th} main effect of corn (j = 1,2)

R_k is the k^{th} main effect of seeding ratio (k = 1,2,3,4)

$(C \times S)_{ij}$ is the interaction of corn and soybean

$(C \times R)_{ik}$ is the interaction of corn and seeding ratio

$(S \times R)_{jk}$ is the interaction of soybean and seeding ratio

$(C \times S \times R)_{ijk}$ is the interaction of corn, soybean and seeding ratio (treatment)

e_{ijk} = error term

Least squares means were tested for heterogeneity of variances and statistical significance was declared at $P \leq 0.05$. If the interaction term had a P value greater than 0.15, it was removed from the model.

RESULTS AND DISCUSSION

Temperature and rainfall patterns during the growing season

The 2015 growing season was normal in terms of temperature and rainfall (Table 1) compared to the average temperature and precipitation for the past 30 years. Thus, the 2015 crop year can be considered as very good crop year in terms of biomass production of corn and soybean.

Forage biomass and dry matter yield

No significant ($P > 0.10$) interaction of corn × soybean × seeding ratio was detected for biomass yield and nutrient yields. The main effects of corn, soybean, and seeding ratio and the interaction of corn and soybean for fresh biomass and DM yields are presented in Table 2. The corn main effect for fresh biomass demonstrated that yield of OC (T/ha) was greater ($P < 0.05$) compared to the yield of MG corn, while the soybean main effect demonstrated a tendency ($P <$

0.10) for VS to yield more biomass (T/ha) compared to OS. The treatment OC-VS combination resulted in the greatest (P < 0.05) fresh biomass yield compared to the other treatment combinations. The R1 seed ratio of corn and soybean resulted in greater yields of (P < 0.05) fresh biomass compared to the R3 ratio, with the ratios of R2 and R4 being intermediate.

The corn main effect for DM yield (T/ha) was greater (P < 0.05) for growing OC compared to growing MG corn, but the soybean main effect for DM yield (T/ha) was similar (P > 0.05) for both OC and VS. The combination of OC-OS and OC-VS produced the greatest (P < 0.05) DM yields compared to the MG-OS, and MG-VS treatments. The seed ratios of R1and R2 produced more (P < 0.05) DM yield compared to the seed ratios of R3 and R4.

Dry matter loss during ensiling process

The corn main effect for DM loss (T/ha) was greater (P < 0.05) for ensiling OC compared to ensiling MG, but the soybean main effect for DM loss (T/ha) was similar (P > 0.05) for both treatments. The treatment combinations of OC-OS and OC-VS lost more (P < 0.05) DM compared to the MG-OS, and MG-VS treatments. The DM loss was similar (P > 0.05) among all seed ratios of corn and soybean.

Forage Nutrient Yields

The main effects of corn, soybean, ratios and the corn and soybean combination for different nutrient yields are presented in Table 2 and Figure 1. The corn main effect for digestible dry matter (DDM) yield (T/ha) was greater (P < 0.05) for growing OC compared to growing MG corn, while the soybean main effect was similar (P > 0.05) for both soybean varieties. The combination of growing OC-OS, and OC-VS produced greater (P < 0.05) yields of

DDM yield compared to growing the combination of MG-OS or MG-VS. The R1 and R2 seed ratios produced greater ($P < 0.05$) fresh biomass yields compared to the seed ratios of R4, with R3 being intermediate. The corn main effect for CP yield (T/ha) was greater for growing OC compared to growing MG (Table 2), but the soybean main effect for CP yield was similar ($P > 0.05$) for both soybean varieties. The corn soybean combinations of OC-OS and OC-VS produced greater ($P < 0.05$) yields of CP compared to corn soybean combinations of MG-OS, and MG-VS. The seed ratios of R1 and R4 tended ($P < 0.10$) to produce higher CP yields compared to seed ratios of R2 and R3.

The corn main effect for NDF yield (T/ha) was greater ($P < 0.05$) for growing OC compared to growing MG corn, while the soybean main effect was similar ($P > 0.10$) for both soybean varieties. Growing the corn soybean combination of OC-VS produced greater ($P > 0.05$) NDF yields compared to growing MG-OS and MG-VS, while growing OC-OS was intermediate. The seeding ratio of R1 tended ($P < 0.10$) to produce higher NDF yield compared to the seeding ratio of R3, while the seed ratio of R2 and R4 were intermediate. The corn and soybean main effects on the DNDF yield were similar ($P > 0.10$), while all combinations produced similar DNDF yields. In addition, the different seeding ratios resulted in similar ($P > 0.10$) DNDF yields.

The corn main effect for yield of NFC yield (T/ha) was greater ($P < 0.05$) for growing OC compared to growing MG corn, but the soybean main effect was similar ($P > 0.10$) for both soybean varieties. The combination of growing OC-OS, and OS-VS produced greater ($P < 0.05$) NFC yields compared to growing MG-OS, and MG-VS. The main effect of seed ratio of R1 produce greater ($P < 0.05$) NFC yields compared to the seed ratios of R3 and R4 with the seed ratio of R2 being intermediate. The corn main effect for starch yield (T/ha) was greater ($P < 0.05$) for growing OC compared to growing MG, while the soybean main effect was similar ($P > 0.05$) for both soybean varieties. The corn soybean combination of growing OC-OS and OC-VS produced greater ($P < 0.05$) starch yields compared to growing MG-OS, and MG-VS. The seed ratios of R1and R2 produced more ($P < 0.05$) starch yield compared to the seed ratios of R3 and R4. The corn main effect for NE_L yield (Mcal/ha) was greater ($P < 0.05$) for growing OC compared to growing MG, while the soybean main effect was similar ($P > 0.05$) for both soybean varieties. The corn soybean combination of growing OC-OS and OC-VS produced greater ($P < 0.05$) NE_L yields compared to growing MG-OS, and MG-VS. The seed ratios of R1and R2 produced more ($P < 0.05$) NE_L yields compared to the seed ratio of R3 with the seed ratio of R4 being intermediate.

Milk yields, net return, and nitrogen accumulation by crop

The estimated milk yields based on MILK2006 (Shaver et al., 2006), net return, and total N accumulation based on forage type are presented in Table 3. The corn main effect for estimated milk yield (T/ha) was greater ($P < 0.05$) for growing OC compared to growing MG corn, while the soybean main effect was similar ($P > 0.05$) for both soybean varieties. The combination of growing OC-OS and OC-VS produced greater (< 0.05) estimated milk yields compared to growing MG-OS, and MG-VS. The seed ratio main effect of R3 produced the lowest ($P < 0.05$) milk yield compared to remaining seed ratios.

In regards to the net return per ha, the corn main effect was greater ($P < 0.05$) for growing OC compared to growing MG (4981.82), while the soybean main effect was similar ($P > 0.05$) for both soybean varieties. The corn soybean combination of growing OC-OS and OC-

VS provided greater (*P* < 0.05) net returns per ha compared to growing MG-OS, and MG-VS. The seed ratio of R4 tended (P < 0.10) to provide greater net returns compared to the seed ratio of R3 with the seed ratios of R1 and R2 being intermediate and similar.

The corn main effect for N accumulation (T/ha) was similar (P > 0.05) for both corn, soybean, and the corn and soybean combinations. The total N accumulated by the seed ratio was greater (*P* < 0.05) for the R4 seed ratio compared to the seed ratios of R1 and R2, while the seed ratio of R3 was intermediate and similar.

Forage Nutrient Composition

The corn, soybean, and seed ratio main effects and the combination of corn and soybean grown together for forage nutrient composition are presented in Table 4. After wilting, the DM percentage was greater (*P* < 0.05) for growing OC compared to growing MG corn, while the soybean main effect for DM percentage was similar (*P* > 0.05) for both soybean varieties. Typical the dry down time required for BMR hybrids is longer, due to the higher moisture content at later maturities. The combination of growing OC-OS and OC-VS produced greater (*P* < 0.05) DM percentages compared to growing MG-OS and MG-VS. All seed ratios produced forage having similar (*P* > 0.05) DM content.

The corn main effect demonstrated growing MG corn resulted in greater (*P* < 0.05) concentrations of CP, SP, ADIP, and NDIP compared to growing OC corn. The soybean main effect indicated that growing VS resulted in significantly (*P* < 0.05) lower concentrations of CP compared to growing OS, but the concentrations of SP, ADIP and NDIP were similar (*P* > 0.05). The corn soybean combination of growing MG-OS produced greater (*P* < 0.05) concentrations of

CP compared to growing the OC-VS combination with growing the combinations of OC-OS and MG-VS being intermediate. The concentrations of SP, ADIP, and NDIP tended to follow the differences observed in the corn and soybean main effects. Given that MG and OS have the highest CP, seems reasonable expectation that growing the combination of MG and OS would result in the highest CP concentrations. The seed ratio of R4 produced forage having the greatest ($P < 0.05$) CP concentration compared to the seed ratios of R1 and R3 with the seed ratio of R2 being intermediate. All corn and soybean seeding ratios produced forage having similar ($P > 0.05$) SP and ADIP concentrations, with slight seeding ratio differences for NDIP.

The carbohydrate fractions of NDF, ADF, Hemicellulose, cellulose, sugar, lignin, and lactic acid concentrations were higher for growing MG compared to growing OC corn hybrids (main effect). In contrast, starch, NFC, and acetic acid concentrations were higher for growing OC compared to growing MG corn hybrids. The MG hybrid typically does not produce much of a corn ear, so the sugar concentration will be higher and the starch and NFC concentrations would be expected to be lower compare to normal corn hybrids. The higher sugar content can be converted to lactic acid for enhancing ensiling characteristics, however, the pH were similar ($P > 0.05$) among corn hybrids. However, where the MG outperforms the OC hybrid is in the concentration of digestible fiber (DNDF, % of DM) due to a higher digestibility of the NDF fraction of the corn silage (NDFd). Digestible fiber can be a limiting nutrient for milk production by lactating dairy cows.

The carbohydrate fractions of NDF, ADF, Hemicellulose, cellulose, sugar, lignin were lower when growing OS compare to growing VS. In contrast, starch concentrations were higher for growing OS compared to growing VS, while NFC, pH, lactic, and acetic acid concentrations were similar among both soybean varieties. The growing of VS would appear to result in a slightly higher carbohydrate concentrations and especially structural fiber, due to the plant's vining characteristics to climb a corn plant.

The corn and soybean combination resulted in similar ($P > 0.05$) concentrations of ADF, and lower ($P < 0.05$) concentrations of NDF, hemicellulose, cellulose, sugar, lignin, lactic acid, while starch, NFC and acetic acid concentrations were higher ($P < 0.05$) for growing OC-OS compared to growing MG-VS, with other combinations being intermediate and sometimes different ($P < 0.05$) and sometimes similar ($P > 0.05$). Even though these observations are reflective of the main effects, significant differences were still observed in nutrient composition of the ensilage forages when grown in combination. These nutritional changes will have an impact on feeding lactating dairy cows.

The seed ratio main effect resulted in similar ADF and acetic acid concentrations among ratios, while NDF, hemicellulose, cellulose, sugar, lignin, and lactic acid concentrations increased, while starch, NFC, and pH decrease among seed ratios. The seed ratio of R4 produced greater ($P < 0.05$) concentrations of digestible fiber (DNDF) compared to the seed ratios of R1 and R2 with the seed ratio of R3 being intermediate. These nutritional concentrations differences tended to follow the general relationship of increasing the ratio of soybeans to corn had a direct influence on carbohydrate fractions. Forage soybeans would contain higher fiber and lower starch and NFC concentrations, which would varying with increasing ratio of soybeans being plant relative to corn. However, increasing the ratio of soybean to corn resulted in higher concentrations of digestible fiber, which would be benefit to the early lactation dairy cow.

The corn main effect for NE_L (Mcal/kg) and IVDMD was greater ($P < 0.05$) for growing OC compared to growing MG (1.50), however the NDFd was greater for growing MG than growing OC. The improvement in NDFd could offset the decrease in DM digestibility for lactating dairy cows (NRC, 2001). The soybean main effect for NE_L (Mcal/kg) was greater ($P > 0.05$) for growing OS compared to growing VS, which is related to the greater ($P > 0.05$) fat concentration (EE) for OS compared to VS, while the digestibility of DM and NDFd were similar among the soybean treatments. These difference translated into the observed differences between the corn and soybean combinations is that growing OC-OS resulted in the highest concentrations of NE_l and IVDMD, with the lowest NDFd, compared to the MG-VS combination, with the other treatments being intermediate. The seed ratios produced forage blends having similar ($P > 0.05$) NE_L, EE, and IVDMD, while NDFd increased with increasing ratio of soybean to corn in the forage blend with the R4 ratio having greater ($P < 0.05$) NDFD30 compared to the seed ratio of R1and R2 with the seed ratio of R3 being intermediate.

Forage Blend Mineral Composition

The corn, soybean and seed ratio main effects and the combination of corn and soybean on the mineral composition of the forages and forage blends are presented in Table 5. The corn main effect for macro- (Ca, Mg, K, Na, Cl, and S) and micro- (Mn, Fe, Cu, Zn, and Al) mineral concentrations were significantly lower ($P < 0.05$)) when growing OC compared to growing MG corn, while concentrations of P and Cl were similar between corn hybrids. This is rather interesting that different corn hybrids would have this range in macro- and micro-mineral concentrations. The soybean main effect for macro-mineral demonstrated an increase in Ca and S for growing OS compared to growing VS varieties, while the remaining mineral concentrations were similar ($P > 0.05$). The macro and micro-minerals concentrations tended to follow the main effects, however, significant differences were observed for growing OC-OS and OC-VS having the lowest mineral concentrations and growing the combinations of MG-OS and MG-VS, except for P, which was similar ($P > 0.05$) among all corn and soybean combinations. The seed ratio for mineral concentrations tended to follow the amount of soybean seed in the ratio, which was lowest for ratio R1 and highest for ratio R4, with ratio R2 and R3 being intermediate for Ca, P, and S and the micro-minerals Mn and Cu, while the remaining macro- and micro-minerals were similar amount the different seeding ratios.

CONCLUSIONS

Highly digestible forages are the basis of feeding lactating dairy cows to meet their nutrient requirements. The production of forage blends holds promise as a means to increase the energy and nutrient supply to lactating dairy cows while reducing the dependence/inclusion rates of purchased grains and protein sources. The planting of an organic conventional seed corn hybrid out produced the grazing BMR seed corn hybrid in many parameters, except for the amount of digestible fiber produced per hectare. The planting of a vining soybean compared to organic soybean was similar for many parameters. One study observation was that the grazing BMR seed corn hybrid appeared to allow more sunlight to reach the soybean plant to enhance biomass growth. Further work is needed on forage blends to refine the agronomy programs for optimization of the biomass yield. In addition, current nutritional models are based on starch, energy and CP, while digestible fiber is at a disadvantage. Future studies, are planned to evaluate a MG-VS for dairy cattle.

ACKNOWLEDGEMENTS

The authors would like their sincere appreciation to Ceres Trust, Chicago, IL for providing partial funding of this study. Thanks is also extended to Masters Choice, Anna, IL for donation of seed corn varieties and to Johnny's selected seed, Winslow, ME for donation of the soybean seed. The authors express appreciation to all colleagues, graduate students, and Ms. Kathy Grady for assistance in planting, weeding, and harvesting of crops.

OUTREACH AND EXTENSION

We are planning to publish research outcomes in igrow SDSU extension. A paper presentation has been scheduled for the joint annual meeting of ADSA and ASAS on Salt Lake city, Idaho (July 19-23 2016). In addition, a publication is in progress for Journal of Dairy Science.

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Table 1. The 2015 growing season climatic conditions[1].

Months	Temperature, °C		Precipitation, mm	
	Mean	Deviation[2]	Total	Deviation[2]
April	8.3	1.9	7.6	-49.6
May	12.8	-0.7	119.1	10.8
June	19.4	0.5	58.4	-52.7
July	21.7	0.4	100.6	20.3
August	19.4	-0.5	176.8	101.6
September	18.3	3.2	43.7	-35.4
October	10.0	2.4	29.5	-15.7
November	3.3	4.3	33.5	15.2

[1]Data collected from South Dakota State University weather station located approximately 3 km from research plots.
[2]Deviation = actual minus 30 year monthly average.