NORTHWEST CROPS & SOILS PROGRAM

2013 Small Grain Forage Trial: Nitrogen Fertility x Harvest Date

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UNIVERSITY OF VERMONT EXTENSION
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2013 SMALL GRAIN FORAGE TRIAL: NITROGEN FERTILITY X HARVEST DATE

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Cool season annual forages, such as cereal grains, can provide early season grazing as well as high quality stored feed. However, it is unclear if quality and yield of these forages could be improved through better nitrogen (N) management. Improved quality of homegrown forages can help to reduce expensive grain purchases. The goal of this project was to determine yield and quality of an annual cool season forage harvested at various stages of maturity and under different organic N fertility regimes. The data presented here is from one replicated research trial in Vermont. Crop performance data from additional tests in different locations and often over several years, should be compared before you make decisions about planting small grains.

MATERIALS AND METHODS

In 2013, a forage oat trial was conducted at Borderview Research Farm in Alburgh, VT (Table 1). The previous crop in this location was grass sod, and the seedbed was prepared by conventional tillage methods. The field was disked and spike tooth harrowed in early April to prepare for planting. Forage oats (*Avena sativa* var. *Everleaf*) were planted with a six-inch Kincaid cone seeder on 23-Apr at a seeding rate of 125 lbs acre^{-1}. The experiment was a randomized complete block design. Plots measuring 5' x 20' were fertilized on 14-May with two different organic fertilizers at two application rates (50 and 100 lbs N acre^{-1}). The amendments used were Pro-Booster (10% N) and Natural Nitrate of Soda (16% N). The OMRI approved 'Pro Booster' (PB) is a fertilizer manufactured for North Country Organics in Bradford, VT. The blended fertilizer is composed of vegetable and animal meals and natural nitrate of soda. It has a guaranteed analysis of 10-0-0. The OMRI approved Natural Nitrate of Soda is more commonly known as 'Chilean Nitrate' (CN). It is mined from northern Chile and has a guaranteed analysis of 16-0-0. The use of Natural Nitrate of Soda is currently allowed for organic production with restrictions. Be sure to check with your organic certifier before using Chilean nitrate on your farm. In this trial, Chilean nitrate was used to represent a 100% soluble source of nitrogen fertility. An unfertilized treatment served as a control. Biomass samples were collected at five stages of small grain maturity: early vegetative (Feekes stage 4), late vegetative (Feekes 6), boot (Feekes 10.5.2), milk (Feekes 11.1), and soft dough (Feekes 11.2). Subsamples of approximately 2.5 ft^2 were cut to 3" above the ground, dried at 40^{o}C, and weighed to determine dry matter yield. Oven dry samples were coarsely ground with a Wiley mill (Thomas Scientific, Swedesboro, NJ), finely ground with a UDY cyclone mill with a 1 mm screen (Seedburo, Des Plaines, IL) and analyzed with an NIRS (Near Infrared Reflectance Spectroscopy) DS2500 Feed and Forage analyzer (Foss, Eden Prairie, MN) at the University of Vermont Cereal Testing Lab (Burlington, VT). Results were analyzed with an analysis of variance method of comparison in SAS (Cary, NC).

Forage quality analysis included crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and various other nutrients. The Total Digestible Nutrients (TDN), Net Energy for Lactation (NE_L), and Relative Feed Value (RFV) were calculated from forage analysis data. Mixtures of true proteins, composed of amino acids and non-protein nitrogen make up the crude protein (CP) content of forages. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of the plant are contained in the fiber fraction. The detergent fiber analysis system separates forages into two parts: cell contents, which include sugars, starches, proteins, non-protein nitrogen, fats and other highly digestible compounds; and the less digestible components found in the fiber fraction. The total fiber content of forage is contained in the neutral detergent fiber (NDF). Chemically, this fraction includes cellulose, hemicellulose and lignin. Acid detergent fiber (ADF) represents the least digestible portion of fiber: the lignin and cellulose. Recently, forage testing laboratories have begun to evaluate forages for NDF digestibility. Evaluation of forages and other feedstuffs for NDF digestibility is being conducted to aid prediction of feed energy content and animal performance. Research has demonstrated that lactating dairy cows will eat more dry matter and produce more milk when fed forages with optimum NDF digestibility. Forages with increased NDF digestibility (NDFD) will result in higher energy values, and perhaps more importantly, increased forage intakes. Forage NDF digestibility can range from 20 – 80%.

Table 1. General plot management.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Grass sod
Row width (in.)	6
Forage	'Everleaf' forage oat
Planting date	23-Apr
Harvest dates:	
• Vegetative 1	3-Jun
• Vegetative 2	18-Jun
• Boot	3-Jul
• Milk	16-Jul
• Soft Dough	6-Aug
Seeding rate	125 lbs/acre
Tillage methods	Mold board plow, disk, and spike tooth harrow

Variations in yield and quality can occur because of variations in genetics, soil, weather and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties is real, or whether it might have occurred due to other variations in the field. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). Least Significant differences (LSD's) at the 10% level of probability are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk. In the example below, A is significantly different from C but not from B. The difference between A and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these varieties did not differ in yield. The difference between A and C is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that B was not significantly lower than the top yielding variety.

Variety	Yield
A	6.0
B	7.5*
C	9.0*
LSD	**2.0**

RESULTS AND DISCUSSION

Seasonal precipitation and temperature recorded at a weather station in Alburgh, VT are shown in Table 2. From April to August, there was an accumulation of 4510 Growing Degree Days (GDDs), in Alburgh which is 18 GDDs more than the 30-year average.

Table 2. Seasonal weather data[1] collected in Alburgh, VT, 2013.

Alburgh, VT	April	May	June	July	August
Average temperature (°F)	43.6	59.1	64	71.7	67.7
Departure from normal	-1.2	2.7	-1.8	1.1	-1.1
Precipitation (inches)	2.12	4.79	9.23	1.89	2.41
Departure from normal	-0.7	1.34	5.54	-2.26	-1.5
Growing Degree Days (base 32°F)	348.5	847.8	967	1235	1112
Departure from normal	-35.55	91.35	-47	36.8	-27.2

[1]Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.
ƚ June 2013 precipitation data based on National Weather Service data from cooperative stations in South Hero, VT (http://www.nrcc.cornell.edu/page_summaries.html)

Fertility x Harvest Stage Interaction

There was no fertility by harvest stage interactions for the parameters studied in this trial. This indicates that the fertility treatments performed similarly, compared to each other, at each harvest stage (Figure 1). Further, we can look at the overall effects of fertility or harvest stage with confidence in the differences reported.

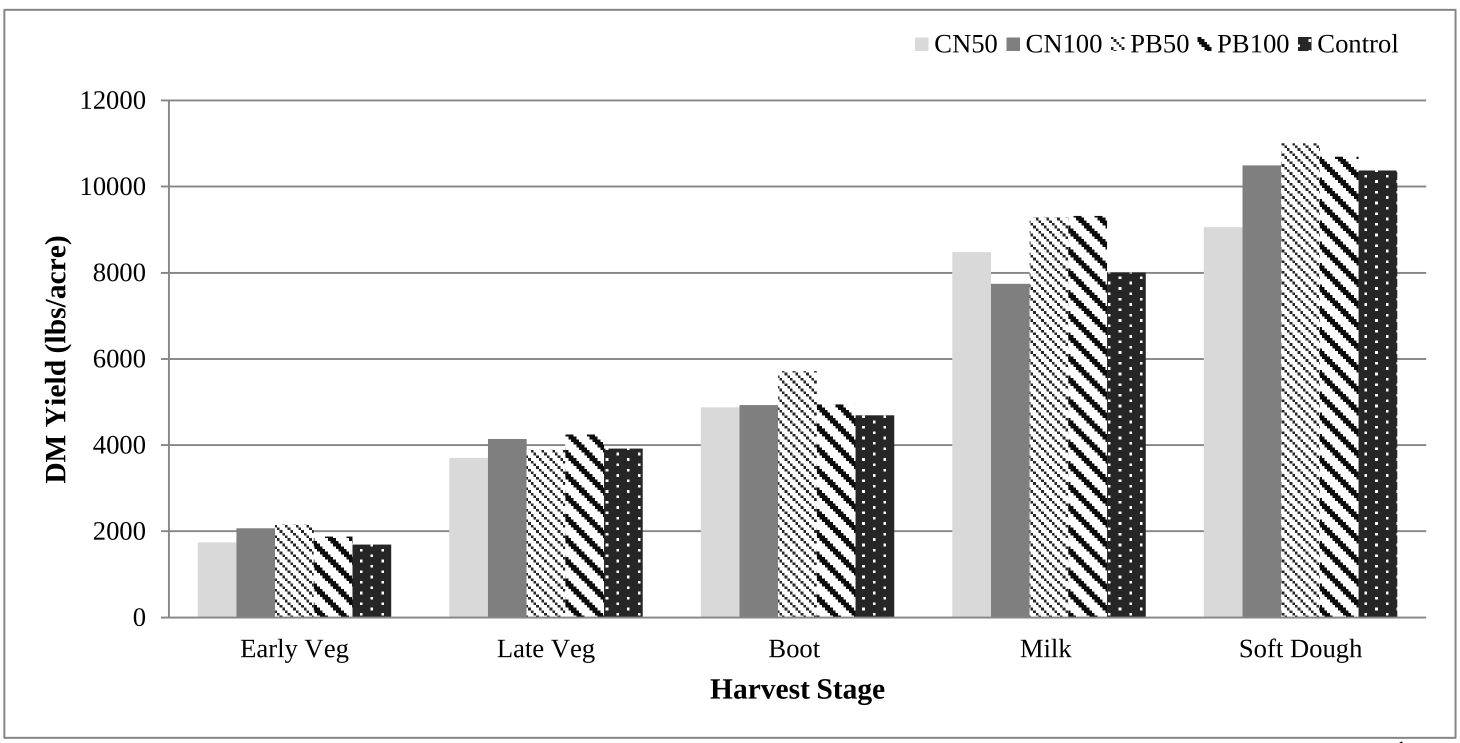

Figure 1. Dry matter yield of Everleaf oats fertilized with Chilean Nitrate (CN) or Pro-Booster (PB) at 50 or 100 lbs N acre^{-1} and harvested at five stages of maturity.

Harvest Stage

Everleaf oats were harvested at five stages of maturity: at the early vegetative stage on 3-Jun—when the grass was 12 inches tall, and 2 weeks later on 18-Jun when the grass was still in the late vegetative stage and 24 inches tall, at the boot stage on 3-Jul when it averaged 48 inches in height, at the milk stage on 16-Jul, and at the soft dough stage on 6-Aug. Yield and quality of the forage oats varied significantly by harvest stage (Table 3). Yields increased with maturity, averaging 10,324 lbs acre^{-1} dry matter in the soft dough stage. Crude protein levels were highest in the vegetative stage averaging 26.1% (Figure 2). In general, forage quality was greatest during the early vegetative stage and decreased with maturity. Fiber content generally increases with maturity, however the formation of starch in the soft dough stage dilutes overall fiber content. Neutral detergent fiber, the percent of cell wall material in the forage, is negatively correlated with intake potential in ruminants, and therefore, a lower number is desirable, which we saw in the early vegetative stage. Acid detergent fiber, the percentage of highly indigestible plant material in the forage, is negatively correlated with digestibility, and a number below 35% is desirable. The average ADF was below 35% for the early and late vegetative stage harvests, indicating that the oats are a good option for forage when harvested at these stages.

The vegetative stage represents forage at a stage that is ideal for grazing. In terms of stored feed, small grains are usually harvested in the boot or soft dough stage. The advantages of harvesting in the boot stage included increased yield while still having relatively high protein and high digestibility. Boot stage forage quality is often similar to first cut perennial forage grasses. Harvesting in the soft dough stages will provide the highest yields, but generally the lowest CP. The primary reason to harvest in the soft dough stage is to have higher starch in the forage. However, the fiber content increases due to the stem and stalks beginning to dry down. As the grain begins to fill with starch, this causes a dilution effect on other fiber components.

Table 2. Spring forage yield and quality results averaged across treatments.

Harvest Stage	DM %	DM Yield lbs ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
Early Vegetative	11.7	1908	**26.1***	**30.4***	**42.9***	**81.6***	**65.7***	**0.682***	**140.7***
Late Vegetative	**9.8***	3981	17.8	35.0	46.1	73.5	65.0	0.678	119.2
Boot	12.0	5033	14.8	39.0	52.6	62.4	61.5	0.645	99.6
Milk	19.5	8567	11.2	42.3	59.5	50.0	58.6	0.610	81.9
Soft Dough	37.1	**10324***	10.3	39.8	58.6	41.4	58.4	0.593	92.1
Trial Mean	18.0	5963	16.0	37.3	51.9	61.8	61.8	0.642	106.7
LSD (p<0.10)	1.2651	798	0.8568	0.7661	0.8757	1.8010	0.5858	0.0068	2.6287

*Varieties with an asterisk did not perform significantly different than the top performer (**in bold**).

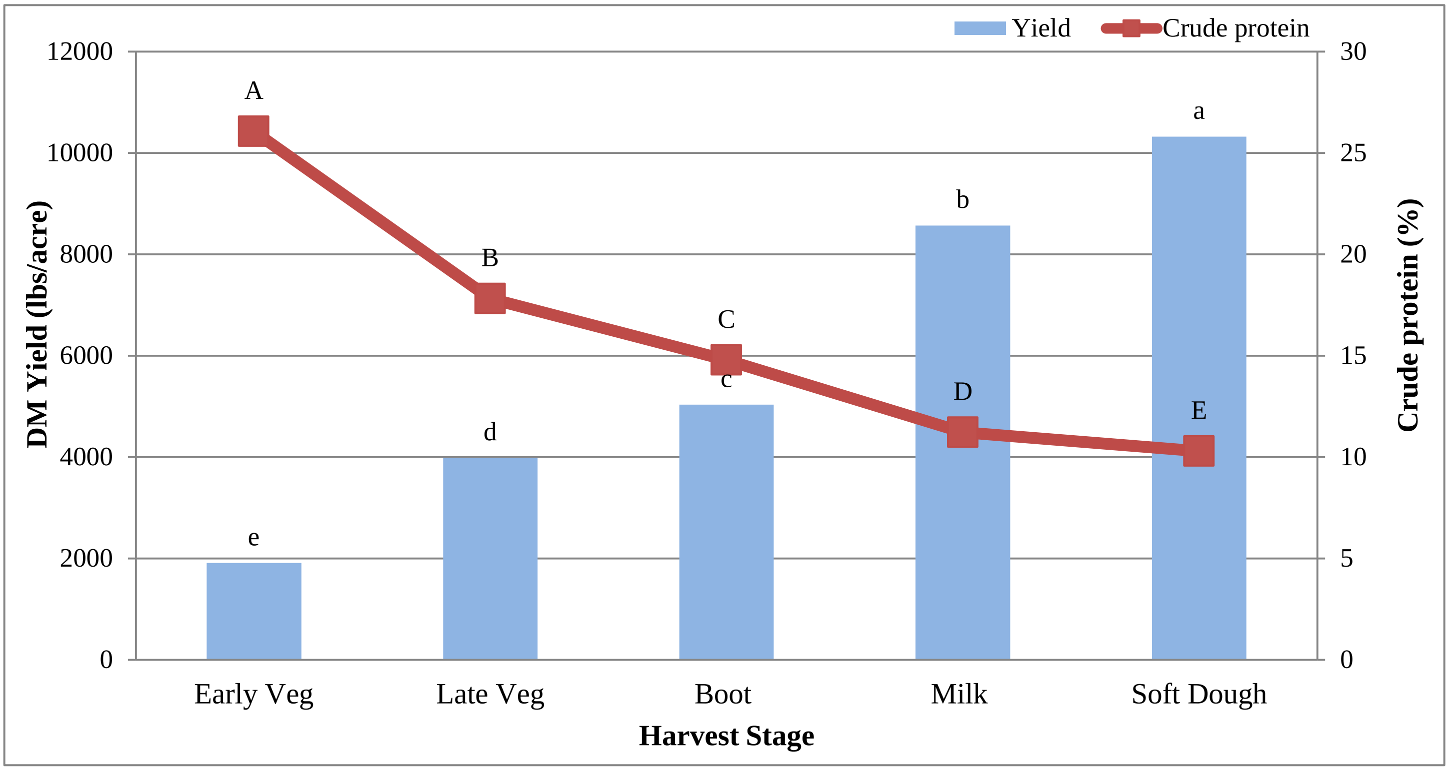

Figure 2. Yield and crude protein of Everleaf oats at five harvest stages. Harvest stages with the same letter did not significantly differ from one another.

Fertility Treatment

Overall, there was no difference in yields of the fertility treatments averaged across harvest stages (Table 4, Figure 3). Crude protein was highest in forage treatments fertilized with Chilean Nitrate 50 and 100, and Pro-Booster at 100 lbs. acre^{-1} N. Those three treatments also had the highest NDFD, TDN and NE_L (Figure 4). Based on this experiment it appears that additional application of organic N sources can improve the quality of annual forages.

Table 4. Spring forage yield and quality results averaged across harvest stage.

Fertility	DM %	DM Yield lbs ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
CN50	17.8	5573	16.5*	36.9	51.6	62.8*	62.3*	0.647*	107.8
CN100	17.6	5878	**17.1***	37.1	51.6	**62.9***	**62.3***	**0.648***	108.0
PB50	18.0	6410	15.7	37.7	52.4	61.1	61.3	0.636	105.3
PB100	17.8	6216	16.4*	37.4	52.2	62.6*	61.8*	0.641*	106.5
Control	18.9	5736	14.4	37.4	52.0	59.5	61.5	0.638	105.9
Trial mean	18.0	5963	16.0	37.3	51.9	61.8	61.8	0.642	106.7
LSD (p<0.10)	NS	NS	0.8568	NS	NS	1.801	0.586	0.007	NS

* Varieties with an asterisk indicate that it was not significantly different than the top performer in **bold**.

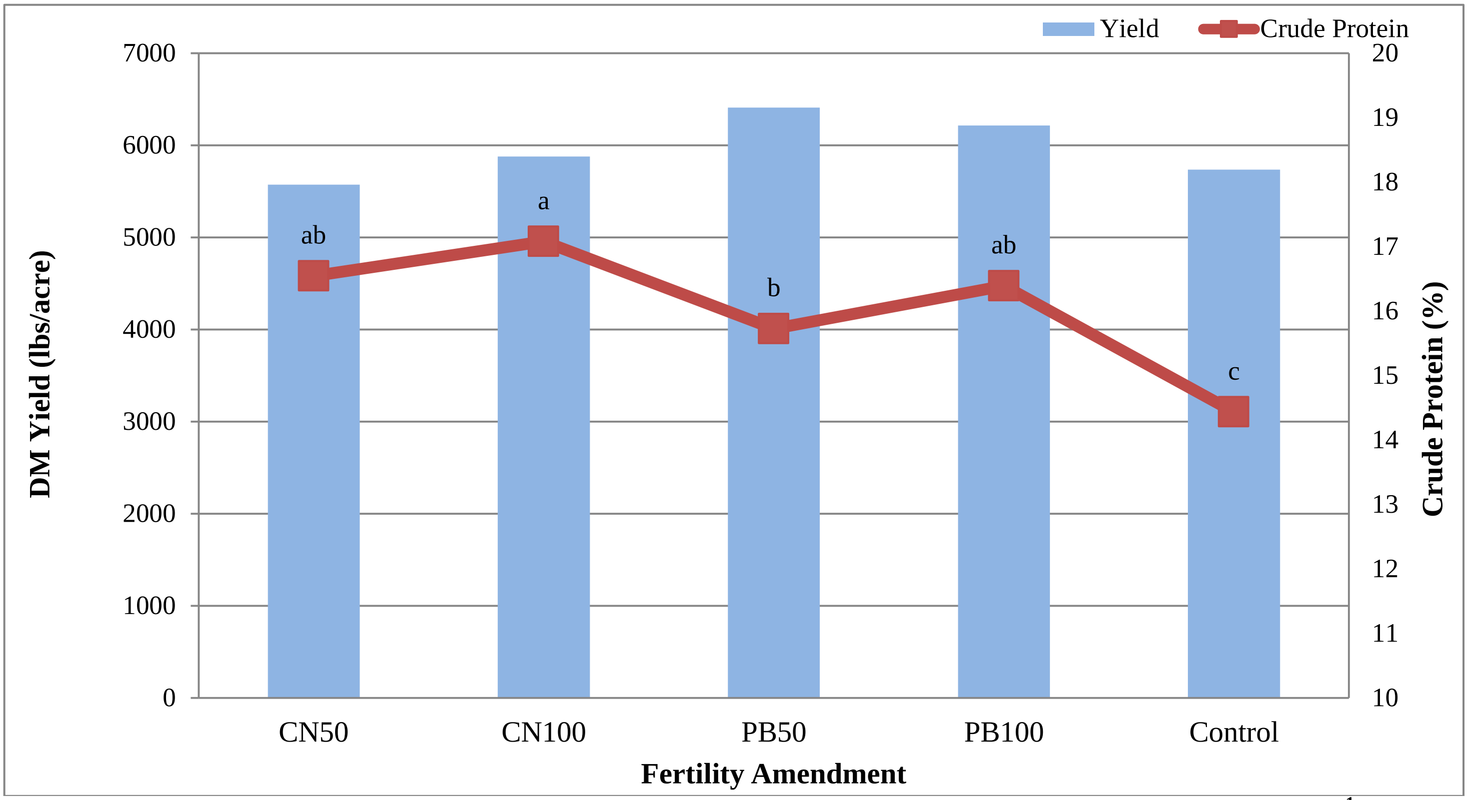

Figure 3. Yield and crude protein of Everleaf oats fertilized with Chilean Nitrate or Pro-Booster at 50 or 100 lbs. acre^{-1} nitrogen. Treatments with the same letter did not significantly differ from one another.

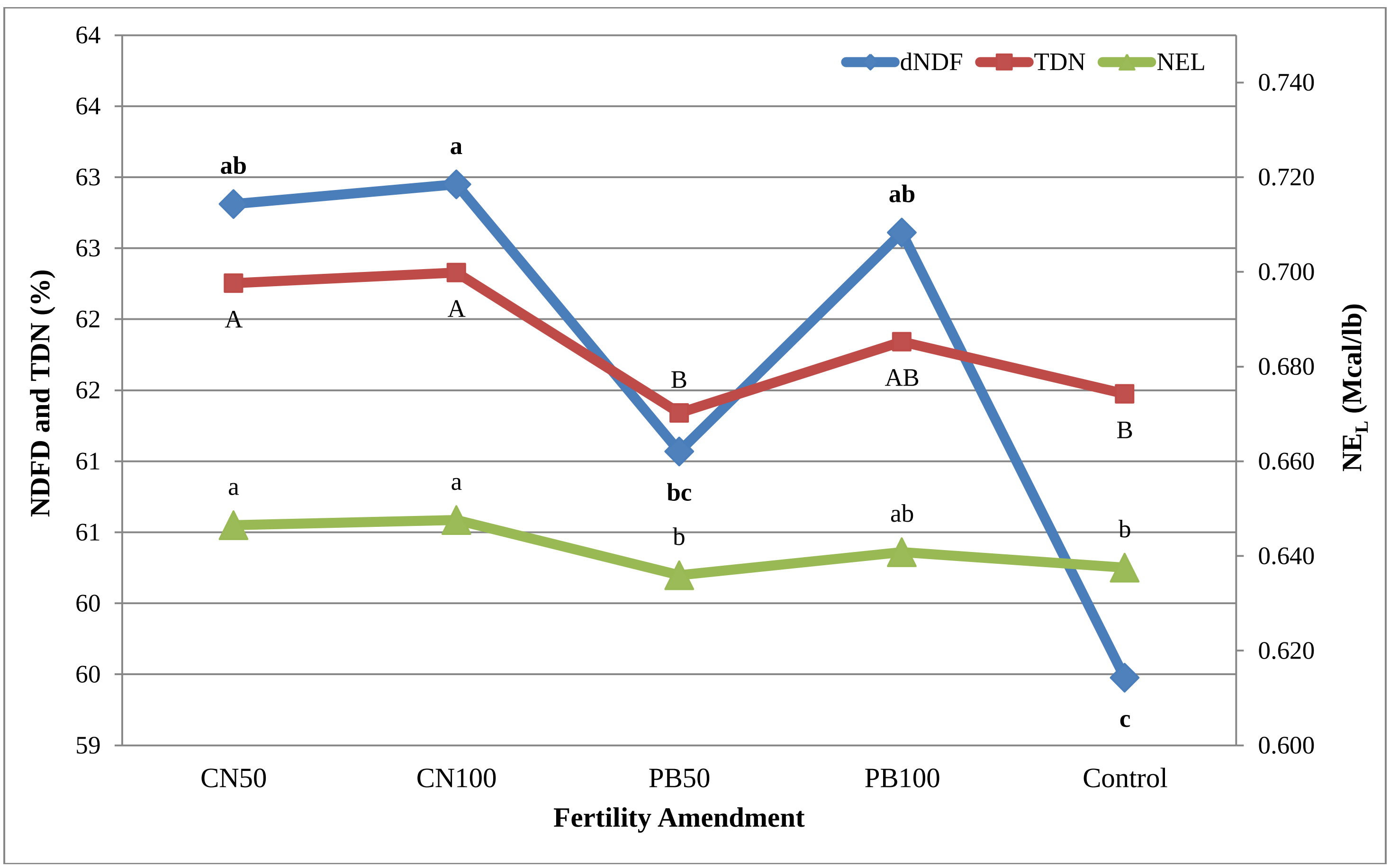

Figure 4. Digestible neutral detergent fiber (NDFD-diamonds), total digestible nutrients (TDN-squares), and net energy of lactation (NE_L-triangles) of Everleaf forage oats—averaged across five harvest dates. Treatments with the same letter did not significantly differ from one another.

Early Vegetative Stage

There was no statistical difference in yield of Everleaf oats harvested in the early vegetative stage (Table 5, Figure 5). However, all of the fertility treatments had higher digestible neutral detergent fiber levels than the control. Chilean Nitrate 100 and Pro-Booster 100 had the highest crude protein, over 26.7%.

Table 5. Spring oat forage yield and quality when harvested in the early vegetative stage, 3-Jun 2013.

Early Vegetative	DM %	DM Yield lbs ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
CN50	11.8	1745	26.0	29.3	41.8	81.2*	66.6	0.692	143.5
CN100	**10.6***	2073	**27.7***	30.2	42.8	**84.1***	66.7	0.694	141.0
PB50	11.8	2149	26.3	30.9	43.5	81.7*	64.9	0.672	139.6
PB100	11.8	1879	26.7*	30.8	43.1	82.7*	65.4	0.678	140.4
Control	12.6	1692	23.6	30.8	43.0	78.3	65.1	0.676	139.0
Trial mean	11.7	1908	26.1	30.4	42.9	81.6	65.7	0.682	140.7
LSD (p<0.10)	0.7844	NS	1.0789	NS	NS	3.1374	NS	NS	NS

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NS - None of the varieties were significantly different from one another.

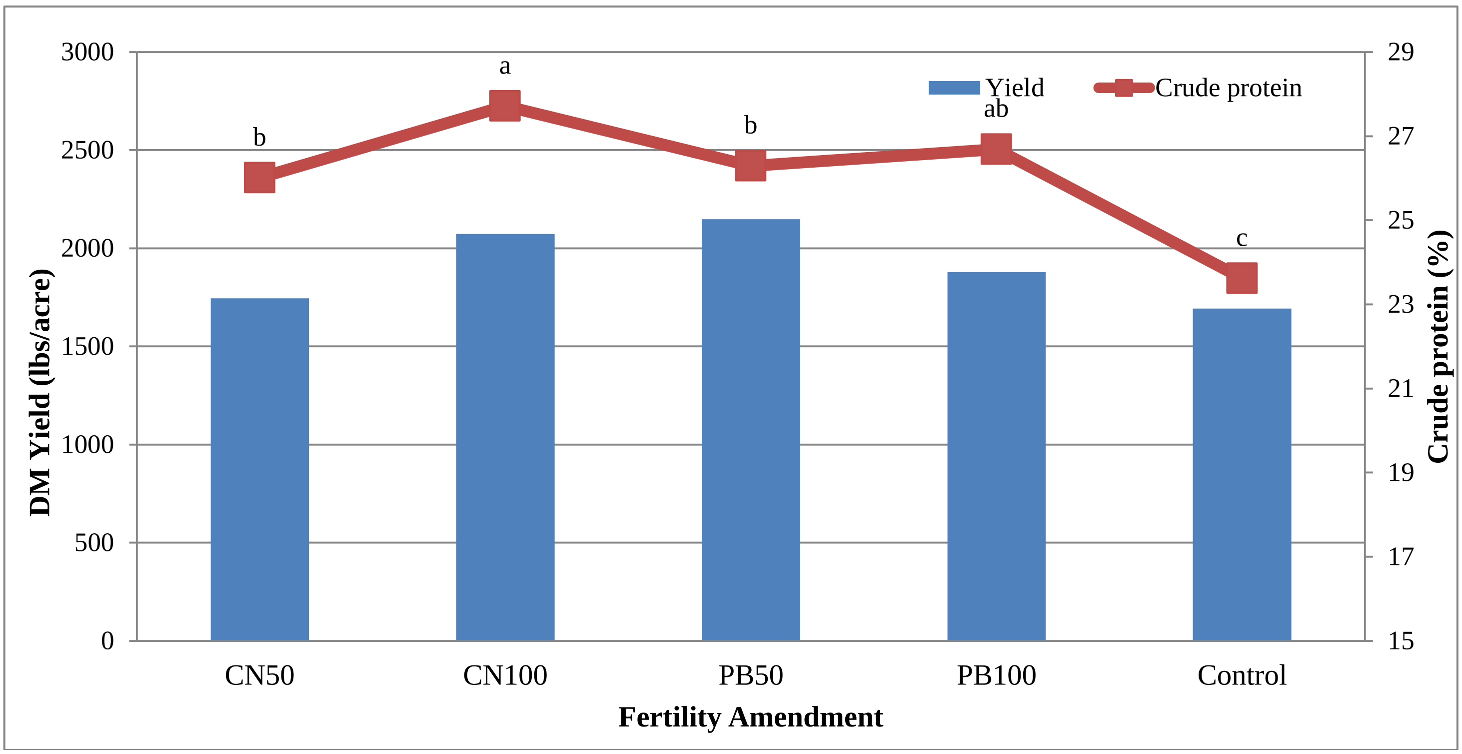

Figure 5. Yield and crude protein of Everleaf oats in the early vegetative stage. Treatments with the same letter did not significantly differ from one another.

Late Vegetative Stage

Overall, there were no differences in yield or quality amongst the treatments when the forage was harvested in late vegetative stage (Table 6 and Figure 6). Average yields were 3981 lbs $acre^{-1}$, over 2000 lbs $acre^{-1}$ more than the early vegetative harvest, harvested two weeks earlier. Overall, forage quality decreased compared to the early vegetative stage.

Table 6. Spring oat forage yield and quality when harvested in the late vegetative stage, 18-Jun 2013.

Late Vegetative	DM %	DM Yield lbs ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
CN50	9.6*	3707	18.1	34.7	45.7	73.9	65.3	0.680	120.6
CN100	**9.0***	4146	19.1	34.8	46.5	75.4	65.2	0.680	119.4
PB50	10.0	3892	17.5	35.2	46.5	73.2	64.6	0.674	118.0
PB100	9.5*	4247	18.6	34.9	45.7	74.2	65.2	0.680	120.3
Control	11.2	3916	15.8	35.1	46.2	71.1	64.6	0.676	117.7
Trial mean	9.8	3981	17.8	35.0	46.1	73.5	65.0	0.678	119.2
LSD (p<0.10)	0.8552	NS	NS	NS	NS	NS	NS	NS	NS

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NS - None of the varieties were significantly different from one another.

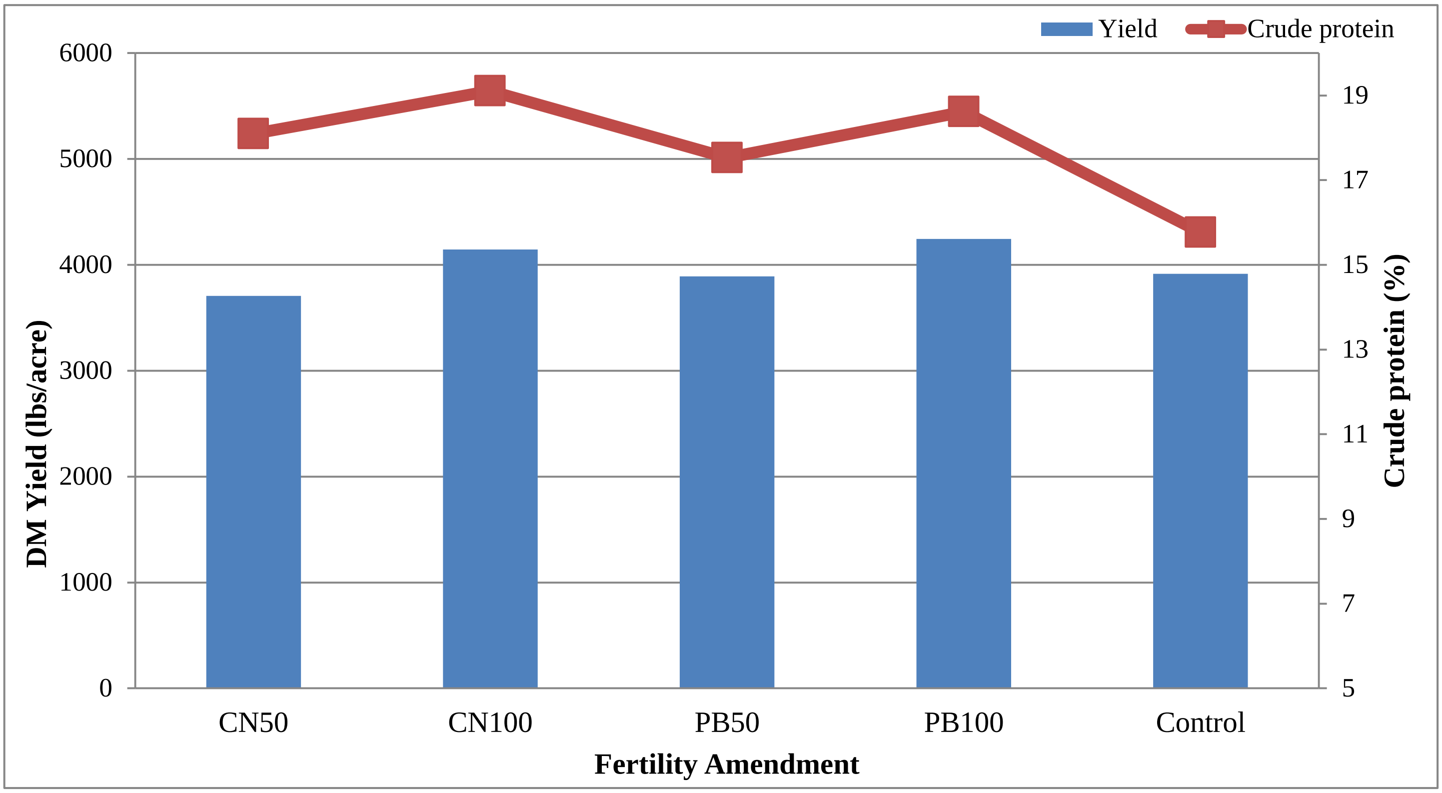

Figure 6. Yield and crude protein of Everleaf oats in the late vegetative stage.

Boot Stage

There were no statistical differences in yield or quality amongst the treatments when the forage was harvested in the boot stage (Table 7). Yields averaged 5033 lbs. $acre^{-1}$ dry matter and crude protein averaged 14.8% (Figure 7). Overall, yields increased and forage quality decreased from the late vegetative harvest, two weeks earlier.

Table 7. Spring oat forage yield and quality when harvested in the boot stage, 3-Jul 2013.

Boot Stage	DM %	DM Yield lbs ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
CN50	11.7	4876	15.7	38.5	51.9	64.0	62.0	0.651	101.5
CN100	11.6	4933	16.4	38.5	51.3	64.7	62.2	0.653	103.3
PB50	12.2	5715	13.9	39.9	54.3	62.4	60.6	0.634	94.8
PB100	12.3	4947	13.8	39.0	52.8	60.0	61.3	0.644	99.0
Control	12.1	4693	14.1	39.1	52.6	61.0	61.2	0.641	99.2
Trial mean	12.0	5033	14.8	39.0	52.6	62.4	61.5	0.645	99.6
LSD (p<0.10)	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Varieties with an asterisk indicate that it was not significantly different than the top performer in **bold**.
NS - None of the varieties were significantly different from one another.

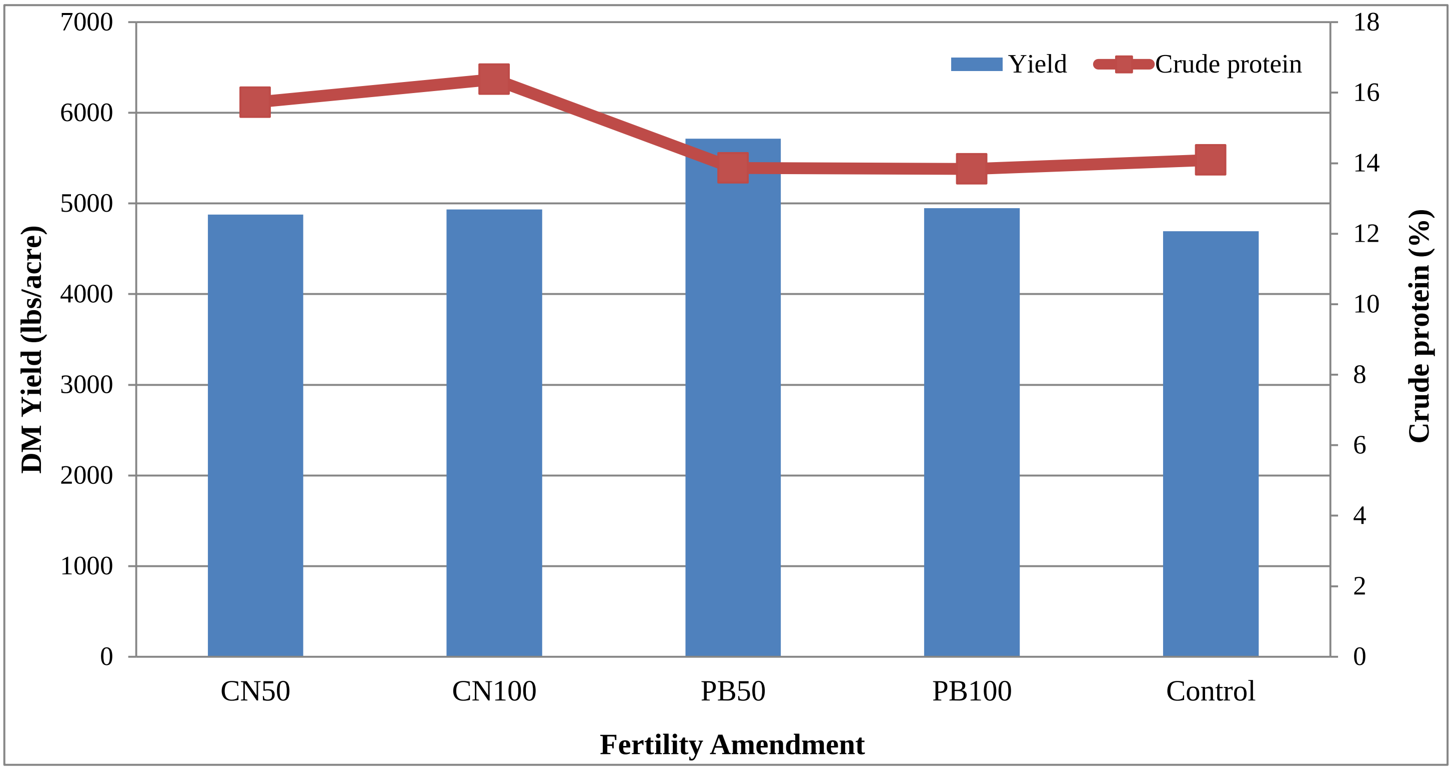

Figure 7. Yield and crude protein of Everleaf oats in the boot stage.

Milk Stage

In the milk stage, there was no statistical difference in yield or quality amongst the fertility treatments (Table 8). Yields averaged 8567 lbs acre^{-1} and crude protein averaged 11.2% (Figure 8). Overall, yields increased and forage quality decreased from the boot stage harvest, two weeks earlier.

Table 8. Spring oat forage yield and quality when harvested in the milk stage, 16-Jul 2013.

Milk Stage	DM %	DM Yield lbs ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
CN50	19.4	8480	11.8	41.9	58.6	50.5	58.9	0.612	84.6
CN100	19.5	7742	11.3	42.2	59.1	48.5	58.8	0.613	82.8
PB50	19.3	9290	11.1	42.5	59.9	49.8	58.5	0.609	80.7
PB100	19.4	9317	11.9	41.8	59.8	52.0	59.0	0.613	82.3
Control	19.8	8006	10.1	43.0	60.1	49.2	58.0	0.603	79.3
Trial mean	19.5	8567	11.2	42.3	59.5	50.0	58.6	0.610	81.9
LSD (p<0.10)	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Varieties with an asterisk indicate that it was not significantly different than the top performer in **bold**.
NS - None of the varieties were significantly different from one another.

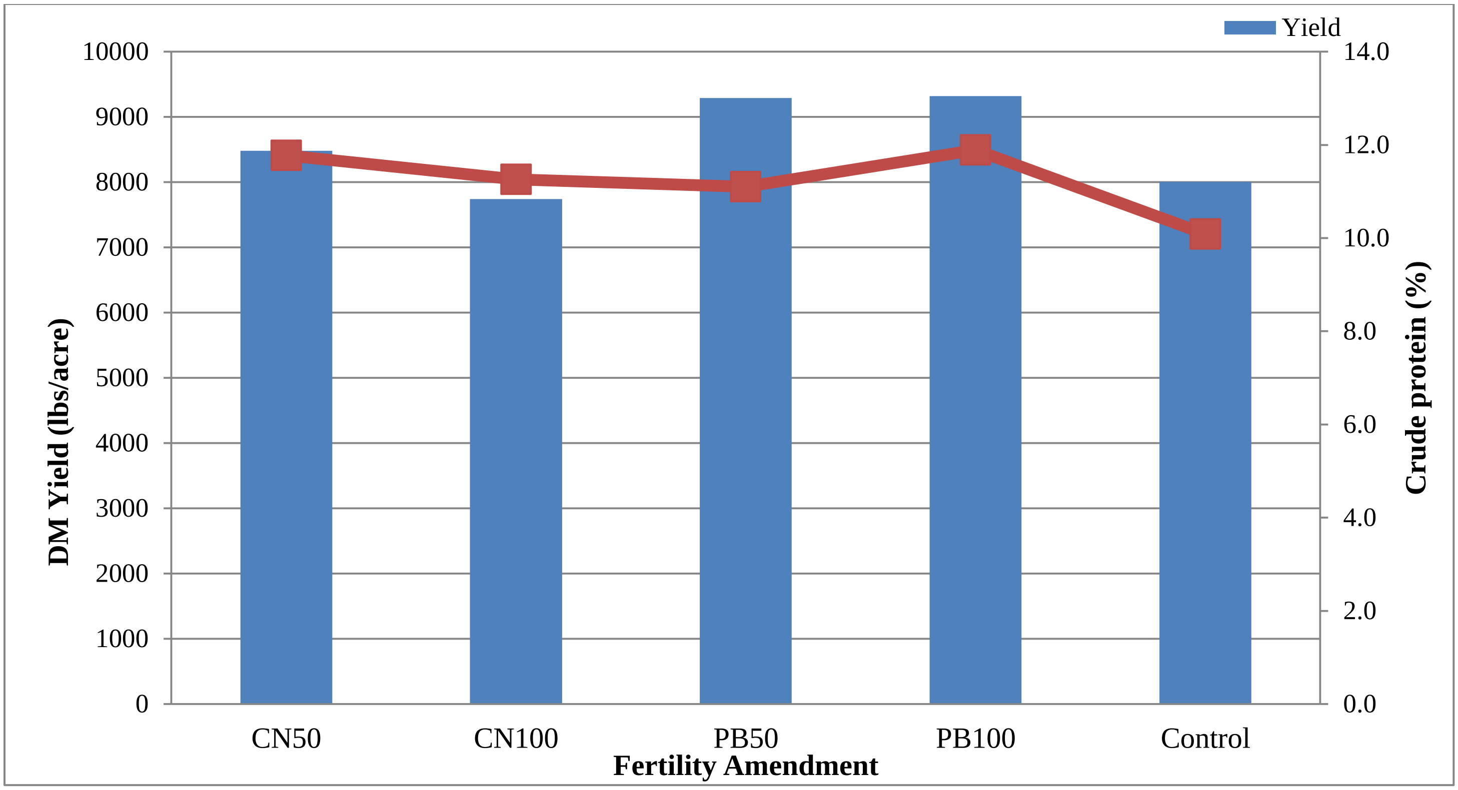

Figure 8. Yield and crude protein of Everleaf oats in the milk stage

Soft Dough Stage

Again, there was no difference in yield or quality amongst the fertility treatments when the forage oats were harvested in the soft dough stage (Table 9). Yields increased from the milk stage and averaged 10,324 lbs $acre^{-1}$ dry matter (Figure 9). Forage quality generally decreased from the milk stage harvest, two weeks earlier, except ADF and NDF fiber decreased slightly, which is most likely attributed to the increase in starch from the developing grain diluting the fiber content.

Table 9. Spring oat forage yield and quality when harvested in the soft dough stage, 6-Aug 2013.

Soft Dough Stage	DM %	DM Yield lbs ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
CN50	36.6	9056	11.1	40.3	59.7	44.5	58.6	0.596	89.0
CN100	37.5	10495	10.9	39.6	58.0	42.1	58.8	0.598	93.7
PB50	36.8	11004	9.9	39.8	58.1	38.3	58.1	0.591	93.3
PB100	36.0	10691	10.9	40.4	59.4	44.0	58.2	0.589	90.4
Control	38.8	10374	8.6	38.9	57.9	37.8	58.5	0.592	94.3
Trial mean	37.1	10324	10.3	39.8	58.6	41.4	58.4	0.593	92.1
LSD ($p<0.10$)	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Varieties with an asterisk indicate that it was not significantly different than the top performer in **bold**.
NS - None of the varieties were significantly different from one another.

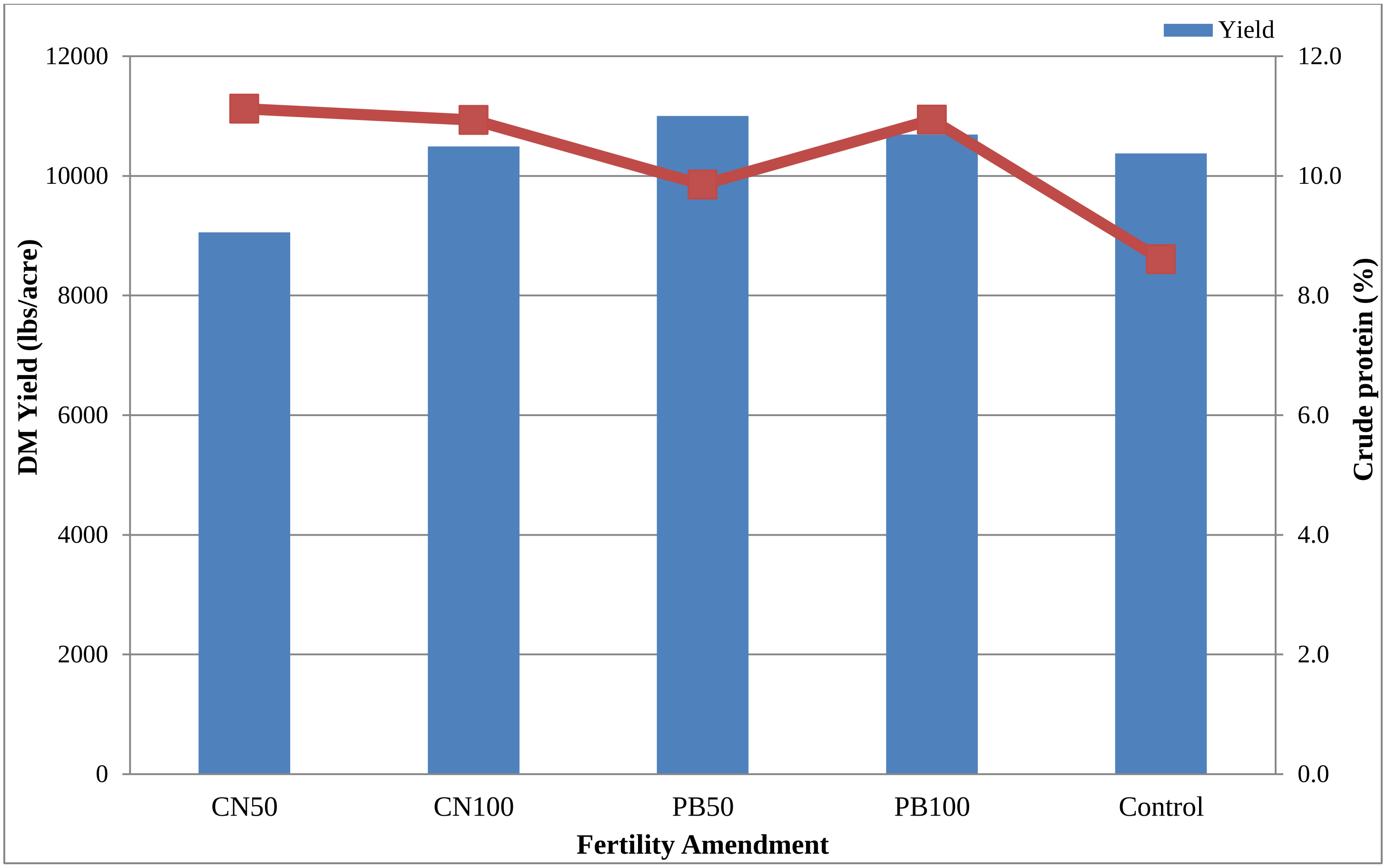

Figure 9. Yield and crude protein of Everleaf oats in the soft dough stage.

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to thank Roger Rainville and the staff at Borderview Research Farm. This information is presented with the understanding that no product discrimination is intended and neither endorsement of any product mentioned, nor criticism of unnamed products, is implied.

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