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# 2012 Small Grain Forage Trial Nitrogen Fertility and Harvest Date

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The UNIVERSITY of VERMONT EXTENSION

# 2012 SMALL GRAIN FORAGE TRIAL: NITROGEN FERTILITY AND HARVEST DATE

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## INTRODUCTION

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 fertility management. Improved quality of homegrown forages can help to reduce expensive grain purchases. The goal of this project was to determine yields and quality of annual cool season forage harvested at various growth stages and under different 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. Support for this project came from the Organic Valley Farmers Advocating for Organics fund.

## METHODS

In 2012, an organic small grain forage trial was conducted at Beidler Family Farm in Randolph Center, VT. Trial information is presented in Table 1. The farm is certified organic by Vermont Organic Farmers, LLC. This recent crop rotation in this field included 7 years of pasture, one-year annual forage of millet and turnip, one-year spring wheat, and one-year forage oats. Liquid manure was applied in the fall. The seedbed was prepared by conventional tillage methods including soil prep with a rotor tiller. Forage oats (*Avena sativa* var. *Everleaf*) were planted with a six-inch single disc opener grain drill on 13-Apr. The experiment was a randomized complete block design. Plots measuring 10' x 15' were fertilized on 30-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' 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'. It is mined from Northern Chile and has a guaranteed analysis of 16-0-0. The use of Natural Nitrate of Soda was allowed for organic production with restrictions in 2012, however, its use is prohibited after October 2012. 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 four stages of small grain forage development: vegetative (Feekes stage 4), 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 the ground, dried at 40°C, and weighed to determine dry matter yield. Oven dry samples were coarsely ground with a Wiley mill (Thomas Scientific, Swedesboro, NJ) and sent to Cumberland Valley Analytical Services, Inc. (Hagerstown, MD) for quality analysis. Results were analyzed with an analysis of variance with SAS (Cary, NC).

**Table 1. Organic small grain forage trial information 2012.**

| Trial Information | Beidler Family Farm<br>Randolph, VT |
|---|---|
| Soil type | Buckland stony loam |
| Previous crop | Spring Wheat |
| Spring Forage | 'Everleaf' forage oat |
| Row width (in.) | 6 |
| Seeding rate | 125 lbs $acre^{-1}$ |
| Planting date | 13-Apr |
| Harvest dates: | |
| Vegetative | 8-Jun |
| Boot | 3-Jul |
| Milk | 18-Jul |
| Soft Dough | 24-Jul |
| Manure applications | liquid manure applied in fall |

### SILAGE QUALITY

Silage quality was analyzed by Cumberland Valley Analytical Forage Laboratory in Hagerstown, Maryland. Plot samples were dried, ground and analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and various other nutrients. The Nonstructural Carbohydrates (NSC) and Total Digestible Nutrients (TDN) were calculated from forage analysis data. Performance indices such as Net Energy Lactation (NEL) were calculated to determine forage value. 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. 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 (dNDF) will result in higher energy values, and perhaps more importantly, increased forage intakes. Forage NDF digestibility can range from 20 to 80%. The NSC or non-fiber carbohydrates (NFC) include starch, sugars and pectins.

### LEAST SIGNIFICANT DIFFERENCE (LSD)

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 close in proximity to Randolph Center, VT is reported in Table 2. This season had above average temperatures and precipitation in May and June. Growing Degree Days (GDD) for the small grain growing season in Randolph Center was 3433 which are 333 GDD above the 30-year average.

**Table 2. Seasonal weather data collected near Randolph Center, VT, 2012.**

| Randolph Center, VT* | April | May | June | July |
|---|---|---|---|---|
| Average Temperature (F) | 43.9 | 58.8 | 64.6 | 70.9 |
| Departure from Normal** | 1.5 | 4.9 | 1.0 | 2.9 |
| | | | | |
| Precipitation (inches) | 3.1 | 5.2 | 4.2 | 4.1 |
| Departure from Normal | -0.3 | 1.6 | 0.1 | -0.2 |
| | | | | |
| Growing Degree Days (base 32) | 408 | 839 | 979 | 1207 |
| Departure from Normal | 51 | 160 | 31 | 91 |

Based on Northeast Regional Climate Center data from observation station in Bethel, VT.
** Historical averages for 30 years of NOAA data (1981-2010).

## Fertility x Harvest Stage Interaction

There were significant fertility by harvest stage interactions for dry matter yield, crude protein, neutral detergent fiber (NDF), starch, total digestible nutrients (TDN) and net energy for lactation (NEL). This indicates that the oats responded to the fertility treatments differently at each harvest date. To understand these interactions, it is useful to look at the data in one graph. All of the fertility treatments increased yield above the control at the boot, milk or soft dough stages, however, the control had the highest yield when the forage was harvested in the vegetative stage—although this was not statistically significant (Figure 1).

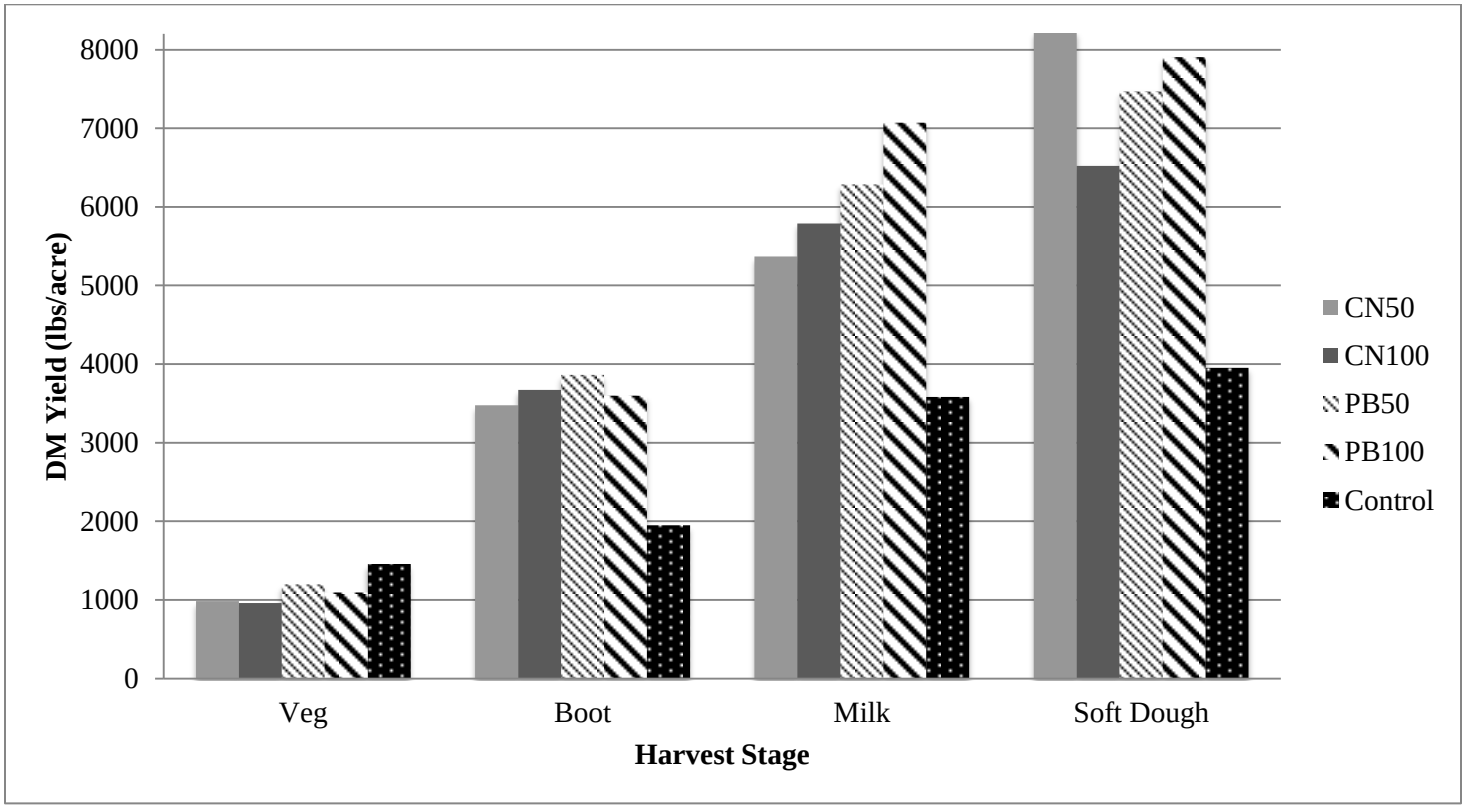


**Figure 1. Dry matter yield of forage fertilized with two fertilizers at two rates and harvested at four different stages of maturity.**

All the fertility treatments had greater crude protein than the control at the vegetative stage (Figure 2). At the boot stage, Pro-Booster 100, Pro-Booster 50, and Chilean nitrate 100 had greater protein levels than the control. At the milk stage harvest, only Pro-Booster 100 and Chilean Nitrate 100 were higher than the control. Finally, at the soft dough harvest, Pro-

Booster 100 was the only treatment to have higher protein than the control. The effects of the soluble fertilizer at the low rate, Chilean nitrate 50, created a quick increase in protein levels, but the effects were not stable over the growing season. However, fertilizing with Pro-Booster, a mix of complex organic materials had a lasting effect on crude protein, such that this treatment was the only treatment significantly different from the control by the soft dough harvest.

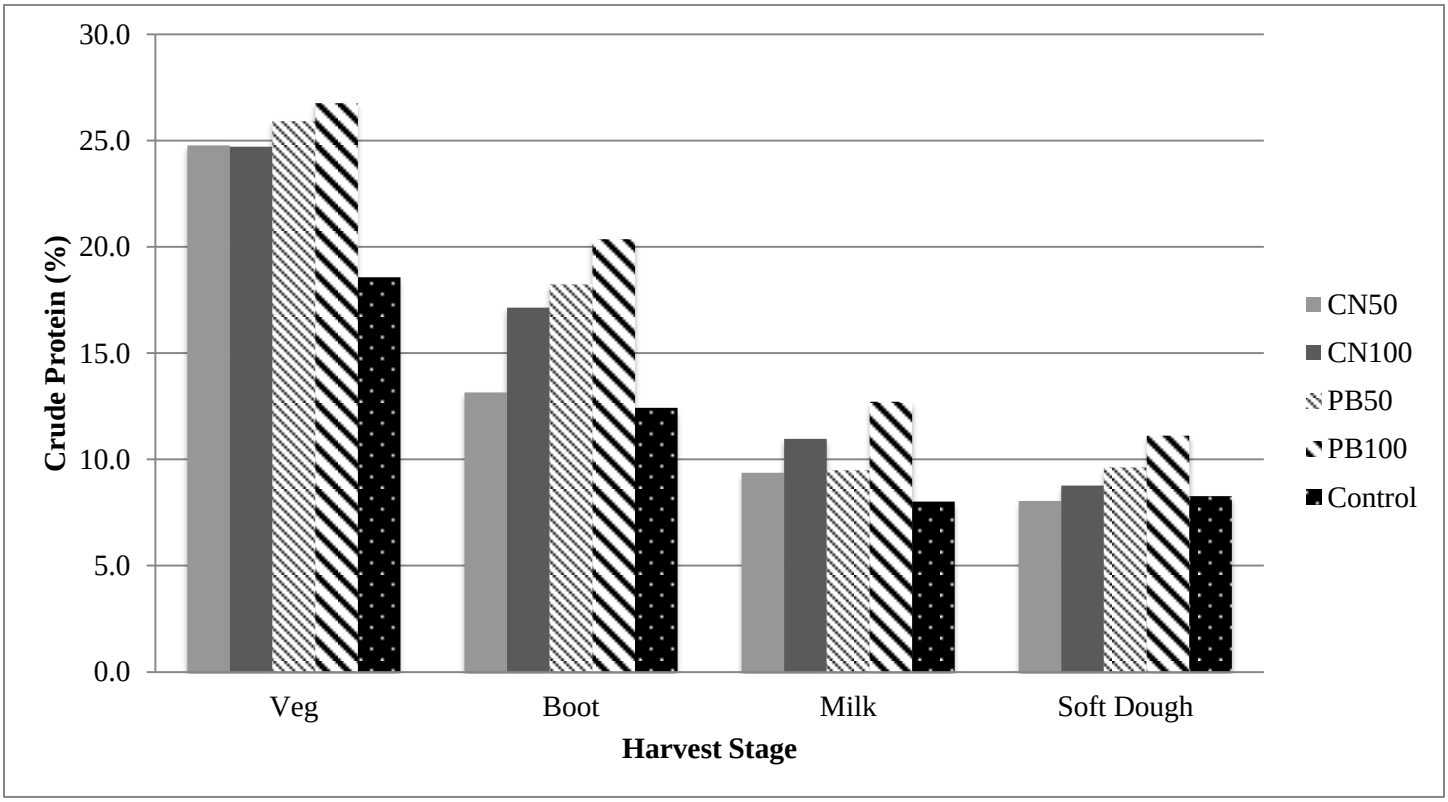


**Figure 2. Crude protein of forage fertilized with two fertilizers at two rates and harvested at four different stages of maturity.**

**Harvest Stage**

The small grains were harvested at the vegetative stage—when the grass was 8-10 inches in height, and the boot, milk and soft dough stages. Yield and quality of the forage oats varied significantly by harvest stage. Yields increased with maturity, averaging 6816 lbs acre$^{-1}$ dry matter in the soft dough stage (Table 3). Crude protein levels were highest in the vegetative stage averaging 24.2% (Figure 3). Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), digestible NDF, Total Digestible Nutrients (TDN) and Net Energy of Lactation (NEL) were all most favorable in the vegetative stage. The highest forage quality is generally seen during the leafy, vegetative stage of growth, and the results of this study follow that trend. However, this is also the period of lowest yield. NDF, 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 vegetative stage. ADF, 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 value in this trial was below 35% for the vegetative and boot stage harvests, indicating that the oats are a good option for forage when harvested at these stages.

The vegetative stage represents forage for pastured 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. The soft dough forage had a starch content of 13.5%. 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 3. Spring forage yield and quality results averaged across treatments.**

| Harvest Stage | DM Yield lbs ac$^{-1}$ | CP % | ADF % | NDF % | dNDF % | Starch % | TDN % | NEL Mcal lb$^{-1}$ | NFC % | NSC % |
|---|---|---|---|---|---|---|---|---|---|---|
| Vegetative | 1137 | **24.2** | **28.1** | **41.9** | **61.4** | 1.07 | **67.4** | **0.704** | 22.6 | 10.3 |
| Boot | 3310 | 16.3 | 34.5 | 53.5 | 58.9 | 2.55 | 63.6 | 0.657 | 20.8 | 11.5 |
| Milk | 5618 | 10.1 | 40.0 | 60.8 | 44.1 | 6.98 | 60.5 | 0.624 | 21.9 | 13.8 |
| Soft Dough | **6816** | 9.2 | 36.1 | 55.2 | 43.1 | **13.5** | 64.7 | 0.672 | **28.8** | **20.0** |
| Trial Mean | 4220 | 14.9 | 34.7 | 52.8 | 51.9 | 6.03 | 64.1 | 0.664 | 23.5 | 13.9 |
| LSD (p<0.10) | 686 | 1.06 | 0.926 | 1.29 | 1.67 | 0.778 | 0.846 | 0.0096 | 1.09 | 0.824 |

Top performer in **bold**.

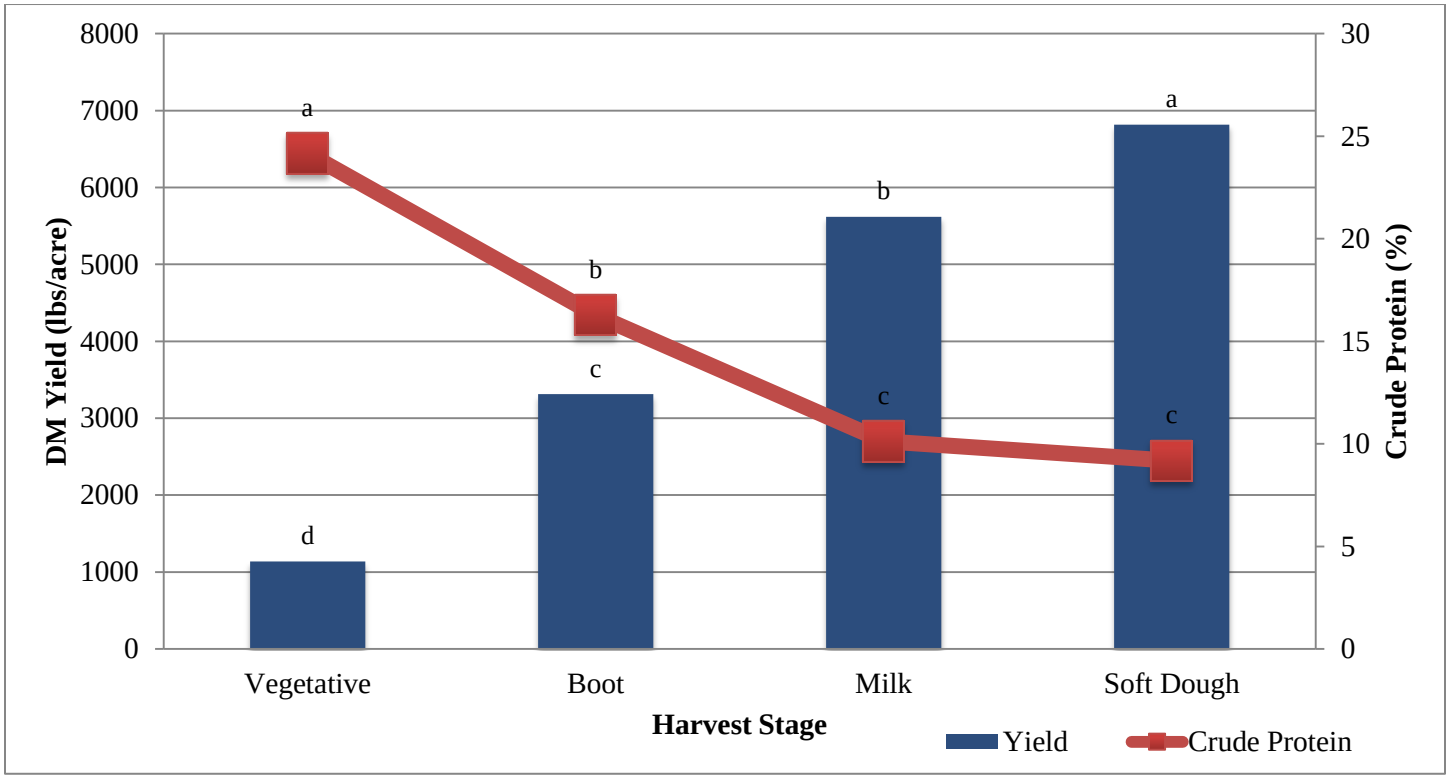


**Figure 3. Yield and crude protein of forage oats at four different harvest stages, Randolph Center, VT.**

## Fertility Treatment

Overall, yields of all the fertility treatments were greater than the control (Table 4, Figure 4). Crude protein was highest in forage fertilized with Pro-Booster at 100 lbs. acre$^{-1}$ N. Pro-Booster 100 also had the lowest ADF and NDF, and the highest TDN and NEL. The control of no treatment had the highest digestible NDF, non-fiber carbohydrates and nonstructural carbohydrates.

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

| Treatment | DM Yield lbs ac$^{-1}$ | CP % | ADF % | NDF % | dNDF % | Starch % | TDN % | NEL Mcal lb$^{-1}$ | NFC % | NSC % |
|---|---|---|---|---|---|---|---|---|---|---|
| CN50 | 4515* | 13.8 | 35.6 | 54.0 | 51.3* | 5.19 | 62.9 | 0.651 | 23.3 | 13.4 |
| CN100 | 4234* | 15.4 | 34.6* | 52.8* | 52.2* | 5.78 | 63.9* | 0.664* | 23.0 | 13.5 |
| PB50 | 4702* | 15.8 | 34.6* | 52.2* | 51.0 | 6.27* | 64.0* | 0.662* | 23.1 | 13.8 |
| PB100 | **4916*** | **17.8** | **33.6** | **51.4*** | 51.7* | 5.83 | **64.8*** | **0.672*** | 22.2 | 13.1 |
| Control | 2734 | 11.8 | 34.9 | 53.9 | **53.1*** | **7.11*** | 64.7* | **0.672*** | **26.1** | **15.7** |
| Trial Mean | 4220 | 14.9 | 34.7 | 52.8 | 51.9 | 6.03 | 64.1 | 0.664 | 23.5 | 13.9 |
| LSD (p<0.10) | 767 | 1.2 | 1.03 | 1.45 | 1.87 | 0.869 | 0.945 | 0.012 | 1.22 | 0.921 |

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

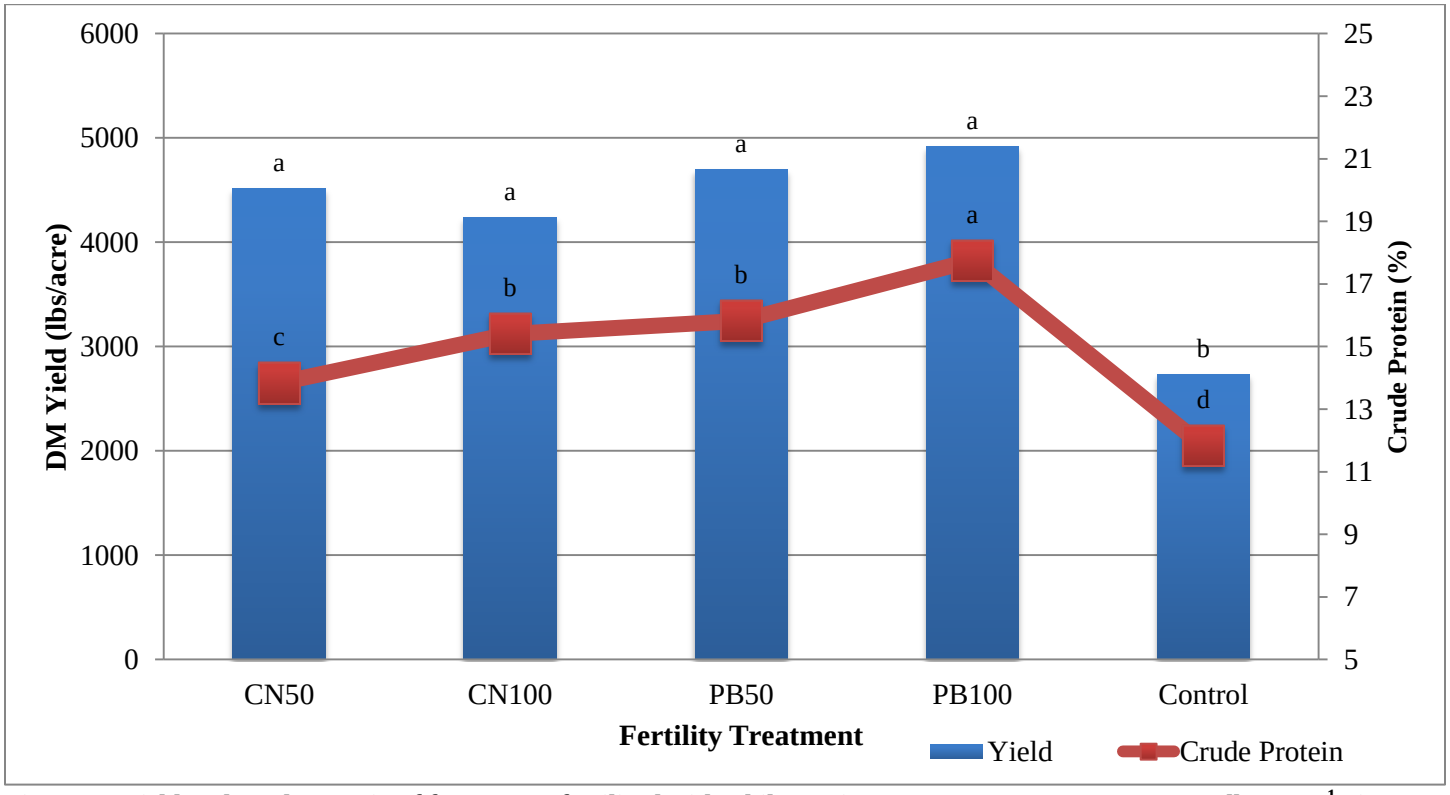


**Figure 4. Yield and crude protein of forage oats fertilized with Chilean Nitrate or Pro-Booster at 50 or 100 lbs. acre$^{-1}$ nitrogen, Randolph Center, VT.**

## Vegetative Stage

There was no statistical difference in yield of the forage harvested in the vegetative stage (Table 5, Figure 5). However, all of the fertility treatments had higher crude protein levels than the control, with Pro-Booster 100 having the highest crude protein 26.8%. The control had the highest levels of non-fiber carbohydrates and non-structural carbohydrates.

**Table 5. Spring oat forage yield and quality when harvested in the vegetative stage, 8-Jun 2012.**

| Vegetative Stage | DM Yield lbs ac$^{-1}$ | CP % | ADF % | NDF % | dNDF % | Starch % | TDN % | NEL Mcal lb$^{-1}$ | NFC % | NSC % |
|---|---|---|---|---|---|---|---|---|---|---|
| CN50 | 984 | 24.8* | 27.6 | 40.3 | 61.3 | 0.93 | 67.7 | 0.708 | 23.1* | 10.3 |
| CN100 | 958 | 24.7* | 26.8 | 41.0 | 65.1 | 0.98 | 68.7 | 0.720 | 23.1* | 10.2 |
| PB50 | 1193 | 25.9* | 28.7 | 40.8 | 57.1 | 1.18 | 66.4 | 0.690 | 21.4 | 9.9 |
| PB100 | 1093 | **26.8*** | 28.3 | 42.1 | 59.3 | 1.05 | 67.1 | 0.698 | 20.1 | 9.1 |
| Control | 1455 | 18.6 | 29.1 | 45.2 | 64.1 | 1.20 | 67.2 | 0.703 | **25.1*** | **12.0** |
| Stage Mean | 1137 | 24.2 | 28.1 | 41.9 | 61.4 | 1.07 | 67.4 | 0.704 | 22.6 | 10.3 |
| LSD (p<0.10) | NS | 2.84 | NS | NS | NS | NS | NS | NS | 2.24 | 1.13 |

* 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.

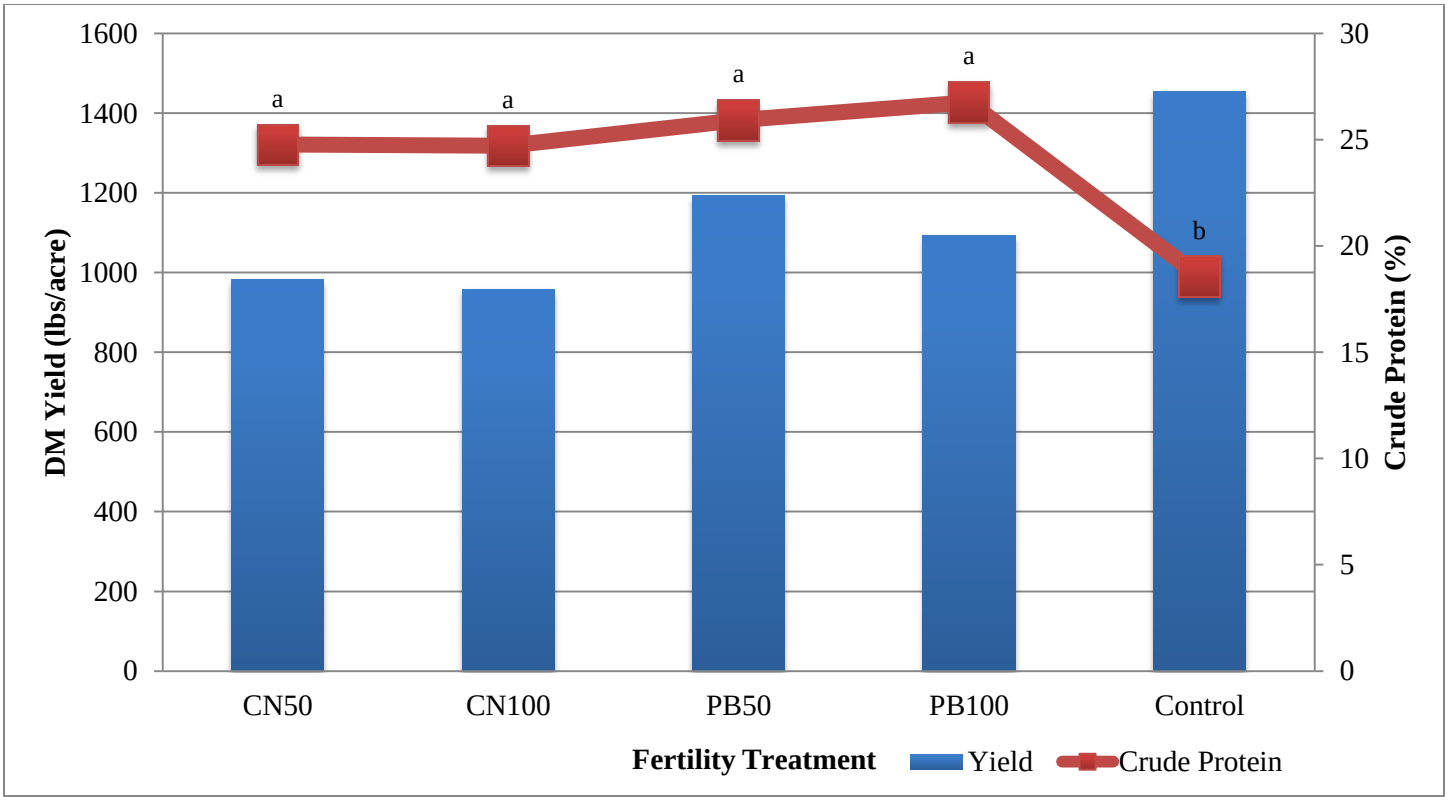


**Figure 5. Yield and crude protein at the vegetative stage of forage oats fertilized with Chilean Nitrate or Pro-Booster at 50 or 100 lbs. N acre$^{-1}$, Randolph Center, VT.**

## Boot Stage

All of the fertility treatments yielded more than the control when the forage was harvested in the boot stage; yields averaged 3310 lbs. acre$^{-1}$ dry matter (Table 6). Pro-Booster at 100 lbs acre$^{-1}$ N had the highest protein levels at this stage, 20.4% (Figure 6).

**Table 6. Spring oat forage yield and quality when harvested in the boot stage, 3-Jul 2012.**

| Boot Stage | DM Yield lbs ac$^{-1}$ | CP % | ADF % | NDF % | dNDF % | Starch % | TDN % | NEL Mcal lb$^{-1}$ | NFC % | NSC % |
|---|---|---|---|---|---|---|---|---|---|---|
| CN50 | 3475* | 13.2 | 36.0 | 55.8 | 57.0 | 2.83 | 62.1 | 0.640 | 21.5 | 12.1* |
| CN100 | 3669* | 17.2* | 34.4 | 53.0 | 58.6 | 2.68 | 63.5 | 0.658 | 20.4 | 11.3 |
| PB50 | **3861*** | 18.3* | 33.9 | 52.6 | 60.3 | 2.40 | 64.1 | 0.663 | 19.8 | 10.7 |
| PB100 | 3599* | **20.4*** | 33.0 | 51.2 | 59.4 | 2.10 | 64.9 | 0.670 | 19.1 | 10.4 |
| Control | 1947 | 12.4 | 35.2 | 55.2 | 59.4 | 2.75 | 63.4 | 0.655 | 23.3 | **12.9*** |
| Stage Mean | 3310 | 16.3 | 34.5 | 53.5 | 58.9 | 2.55 | 63.6 | 0.657 | 20.8 | 11.5 |
| LSD (p<0.10) | 824 | 3.86 | NS | NS | NS | NS | NS | NS | NS | 1.45 |

* 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.

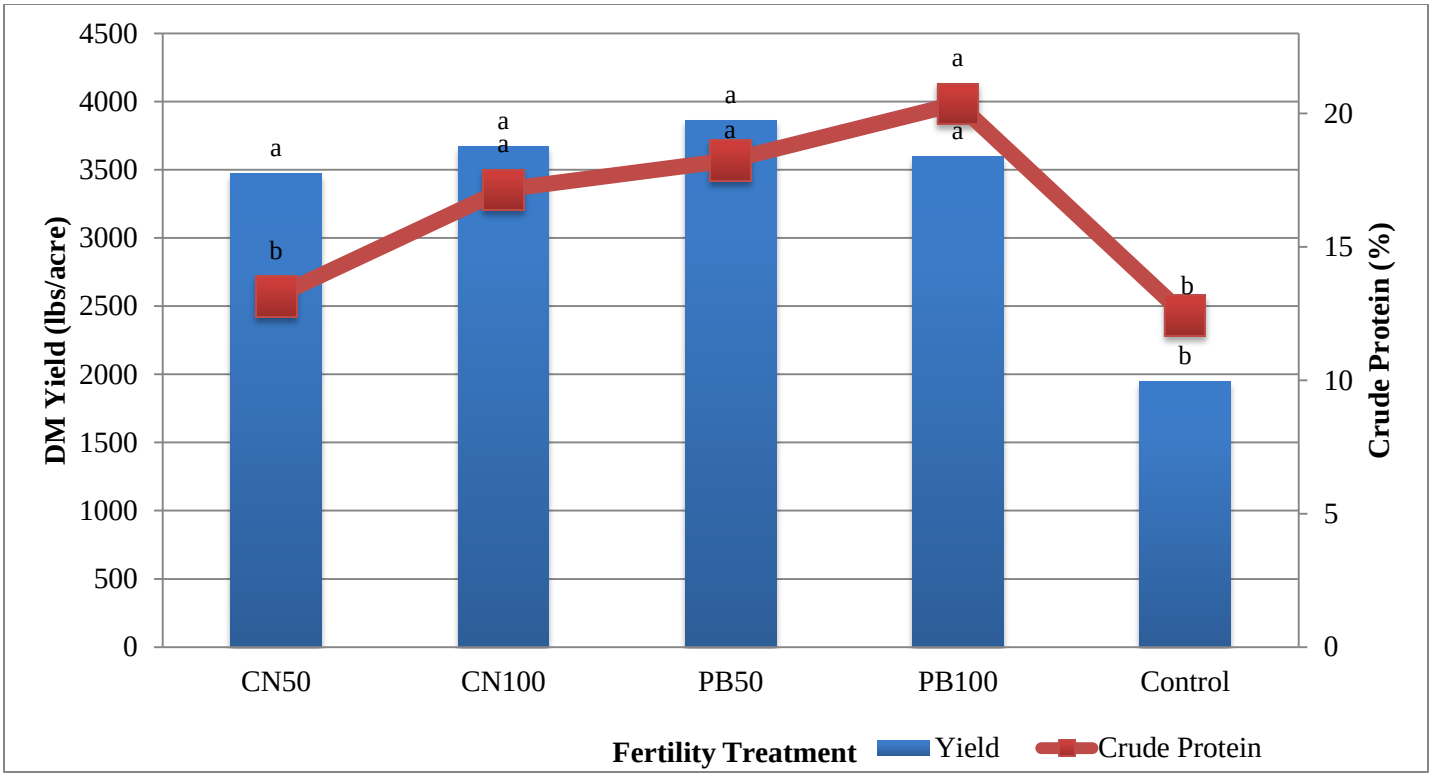


**Figure 6. Yield and crude protein at the boot stage of forage oats fertilized with Chilean Nitrate or Pro-Booster at 50 or 100 lbs. N acre$^{-1}$, Randolph Center, VT.**

## Milk Stage

In the milk stage, there was no statistical difference in yield from the fertility treatments (Table 7). Pro-Booster 100 had the highest crude protein levels of 12.7% (Figure 7). The control had the highest starch, NFC and NSC levels when the forage was harvested in the milk stage.

**Table 7. Spring oat forage yield and quality when harvested in the milk stage, 18-Jul 2012.**

| Milk Stage | DM Yield lbs ac$^{-1}$ | CP % | ADF % | NDF % | dNDF % | Starch % | TDN % | NEL Mcal lb$^{-1}$ | NFC % | NSC % |
|---|---|---|---|---|---|---|---|---|---|---|
| CN50 | 5367 | 9.4 | 40.2 | 61.3 | 44.3 | 7.05 | 60.5 | 0.620 | 22.3 | 14.1* |
| CN100 | 5789 | 11.0* | 40.2 | 60.7 | 42.9 | 6.63 | 59.9 | 0.618 | 20.7 | 13.2 |
| PB50 | 6285 | 9.5 | 40.4 | 61.1 | 43.5 | 7.00 | 59.9 | 0.615 | 21.9 | 13.9 |
| PB100 | 7070 | **12.7*** | 39.0 | 59.6 | 45.0 | 5.75 | 60.8 | 0.628 | 20.2 | 12.5 |
| Control | 3581 | 8.0 | 40.3 | 61.4 | 44.7 | **8.45** | 61.6 | 0.638 | **24.5*** | **15.5*** |
| Stage Mean | 5618 | 10.1 | 40.0 | 60.8 | 44.1 | 6.98 | 60.5 | 0.624 | 21.9 | 13.8 |
| LSD (p<0.10) | NS | 1.81 | NS | NS | NS | 1.34 | NS | NS | 1.69 | 1.49 |

* 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.

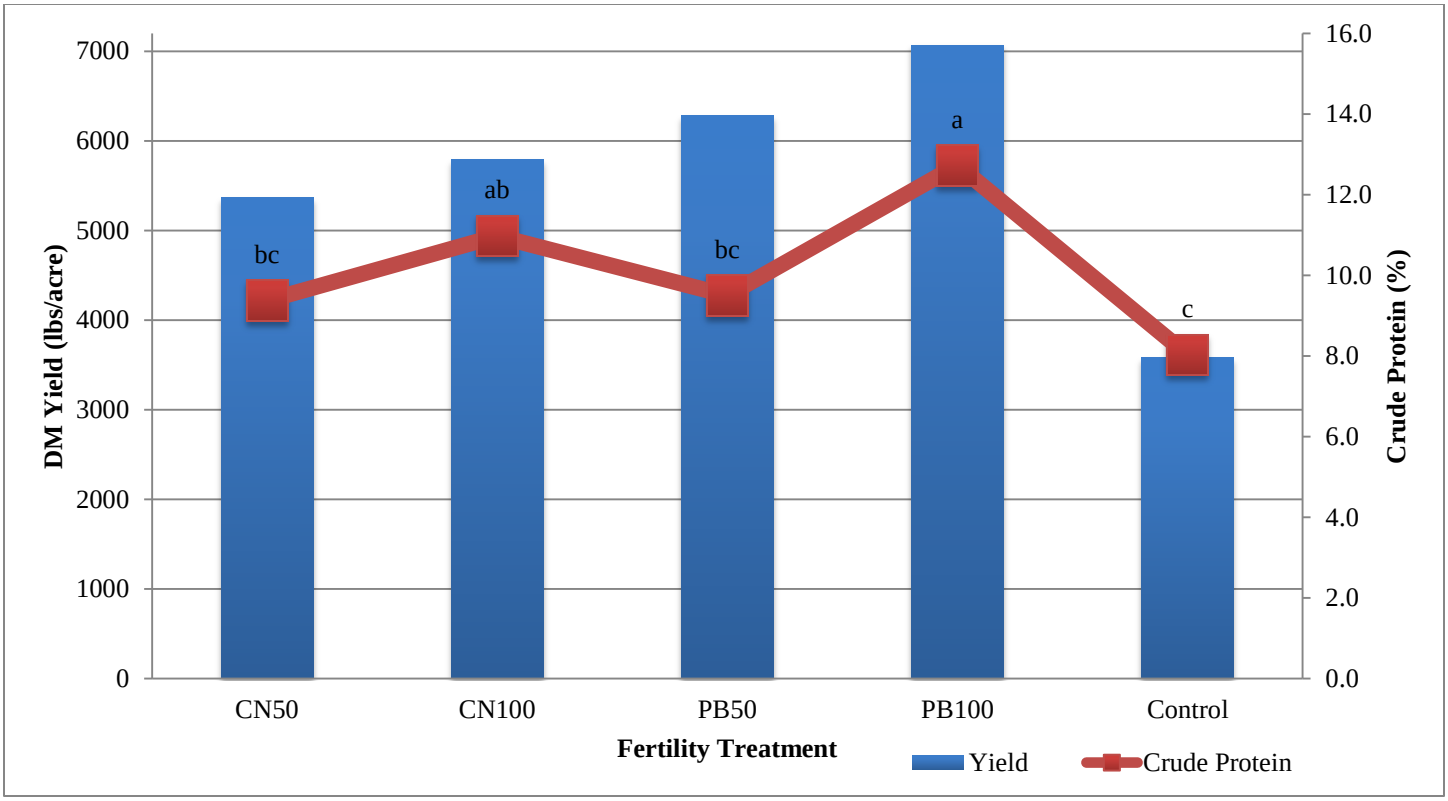


**Figure 7. Yield and crude protein at the milk stage of forage oats fertilized with Chilean Nitrate or Pro-Booster at 50 or 100 lbs. N acre$^{-1}$, Randolph Center, VT.**

## Soft Dough Stage

All of the fertility treatments resulted in higher yields than the control when the oat forage was harvested in the soft dough stage (Table 8). Pro-Booster100 had the highest crude protein of any treatment in the soft dough stage, 11.1% (Figure 8). Pro-Booster 100 had the lowest ADF, highest TDN and NEL.

**Table 8. Spring oat forage yield and quality when harvested in the soft dough stage, 24-Jul 2012.**

| Soft Dough Stage | DM Yield lbs ac$^{-1}$ | CP % | ADF % | NDF % | dNDF % | Starch % | TDN % | NEL Mcal lb$^{-1}$ | NFC % | NSC % |
|---|---|---|---|---|---|---|---|---|---|---|
| CN50 | **8234*** | 8.1 | 38.8 | 58.5 | 42.6 | 9.95 | 61.5 | 0.635 | 26.3 | 17.2 |
| CN100 | 6521* | 8.8 | 37.1* | 56.4 | 42.3 | 12.83* | 63.7 | 0.660 | 28.0 | 19.4 |
| PB50 | 7469* | 9.6 | 35.4* | 54.3 | 43.1 | 14.50* | 65.6* | 0.680* | 29.4 | 20.7 |
| PB100 | 7903* | **11.1** | **34.3** | 53.0 | 43.4 | 14.40* | **66.5*** | **0.693*** | 29.4 | 20.3 |
| Control | 3951 | 8.3 | 35.0* | 53.8 | 44.3 | **16.03*** | **66.5*** | **0.693*** | 31.3 | 22.3 |
| Stage Mean | 6816 | 9.2 | 36.1 | 55.2 | 43.1 | 13.54 | 64.7 | 0.672 | 28.8 | 20.0 |
| LSD (p<0.10) | 2234 | 1.41 | 2.93 | NS | NS | 3.32 | 2.79 | 0.032 | 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.

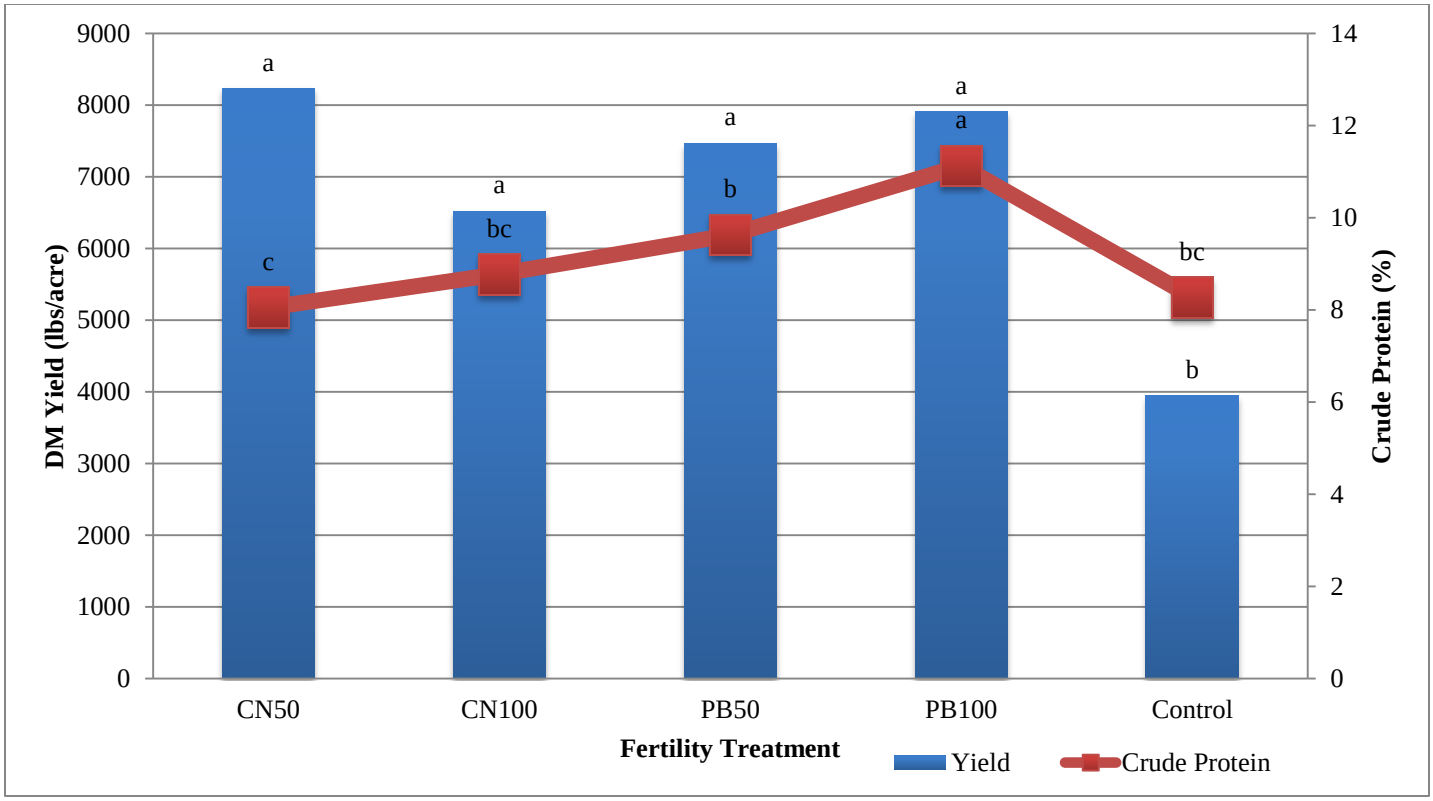


**Figure 8. Yield and crude protein at the soft dough stage of forage oats fertilized with Chilean Nitrate or Pro-Booster at 50 or 100 lbs. N acre$^{-1}$, Randolph Center, VT.**

## ACKNOWLEDGEMENTS

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