RESULTS AND DISCUSSIONS/MILESTONES

Energy Value of Current and Alternative Forages in the Northeast:

In field forage variety yield and quality evaluations:

Yield, quality, persistence, and insect damage were measured on 20 varieties of 4 perennial legume species across three cuttings in both 2018 and 2019. Throughout the 2018 season the weather was hotter and drier than normal with many parts of the state experiencing severe drought conditions as only approximately 60% of the typical accumulated rainfall was received. Extended periods of time without any rainfall occurred between the second and third harvests increasing the recovery period needed before harvest by eight days. By the third harvest some plots by this time had not regrown sufficiently to be picked up by the forage harvester and therefore would have required a recovery period likely greater than 50 days.

In 2019, cool wet spring conditions allowed the forages to grow considerably by the first harvest. However, due to the difficult season in 2018 and some additional winter damage, some plots experienced low density which allowed for weeds to establish. Weed biomass was measured in each plot at the first harvest to determine which plots were less persistent. Following that harvest the conditions continued to be cool but dry with both precipitation and growing degree day accumulation being below average for much of the summer. Excessively hot and dry weather in the middle of the season again slowed recovery of the forages and some of the species were quite damaged by the third harvest. Despite this challenging summer, the legumes continued to grow in the fall following some much needed rainfall and potentially could produce a fourth cutting if it were needed however this could further impact the persistence of the stand. Total dry matter yields for both seasons are summarized in the figure below.

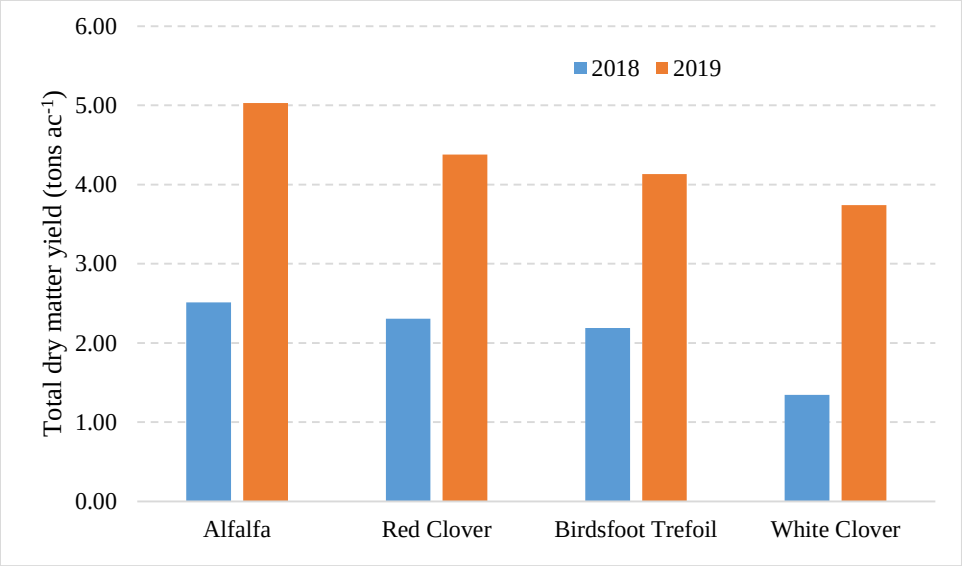

Figure 1. Dry matter yield by species across all cuttings, 2018 and 2019.

Alfalfa out yielded the other species in both years however this was much more pronounced in 2019. Despite the dry weather the shallower rooted species, birdsfoot trefoil and white clover, performed well. The birdsfoot trefoil produced yields close to that of red clover with the white clover yielding about 0.50 tons ac^{-1} less than the red clover. Overall these yields were significantly higher than in 2018. In terms of weed pressure the birdsfoot trefoil and white clover had higher proportions of grass and broadleaf weeds than the other species (Figure 2). This was expected as these species had shown the greatest signs of drought damage and stress the previous year.

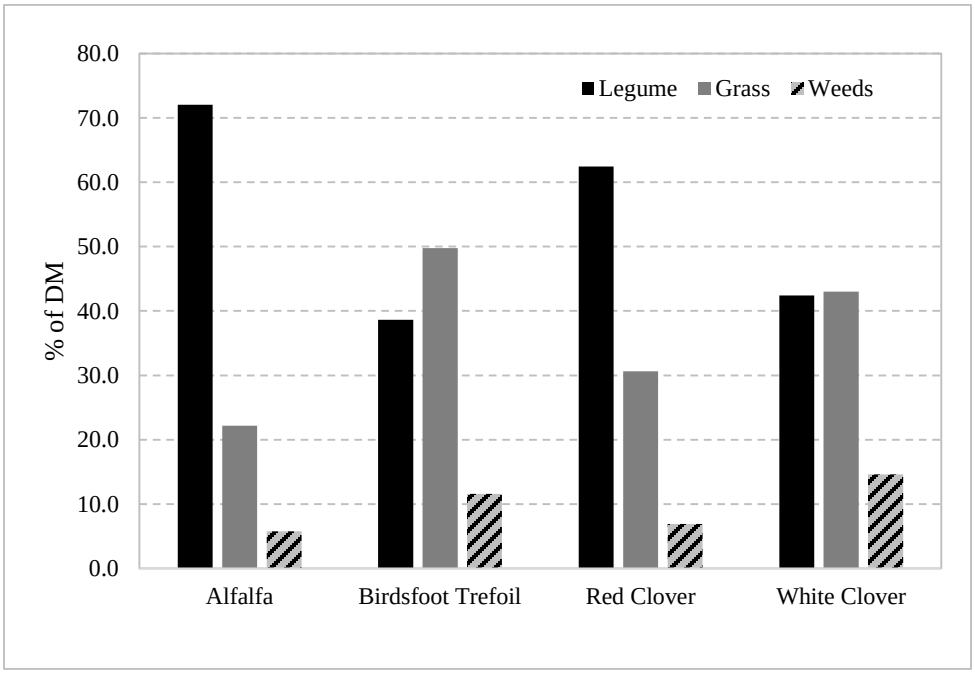

Figure 2. Dry matter composition by species at 1st cut 2019.

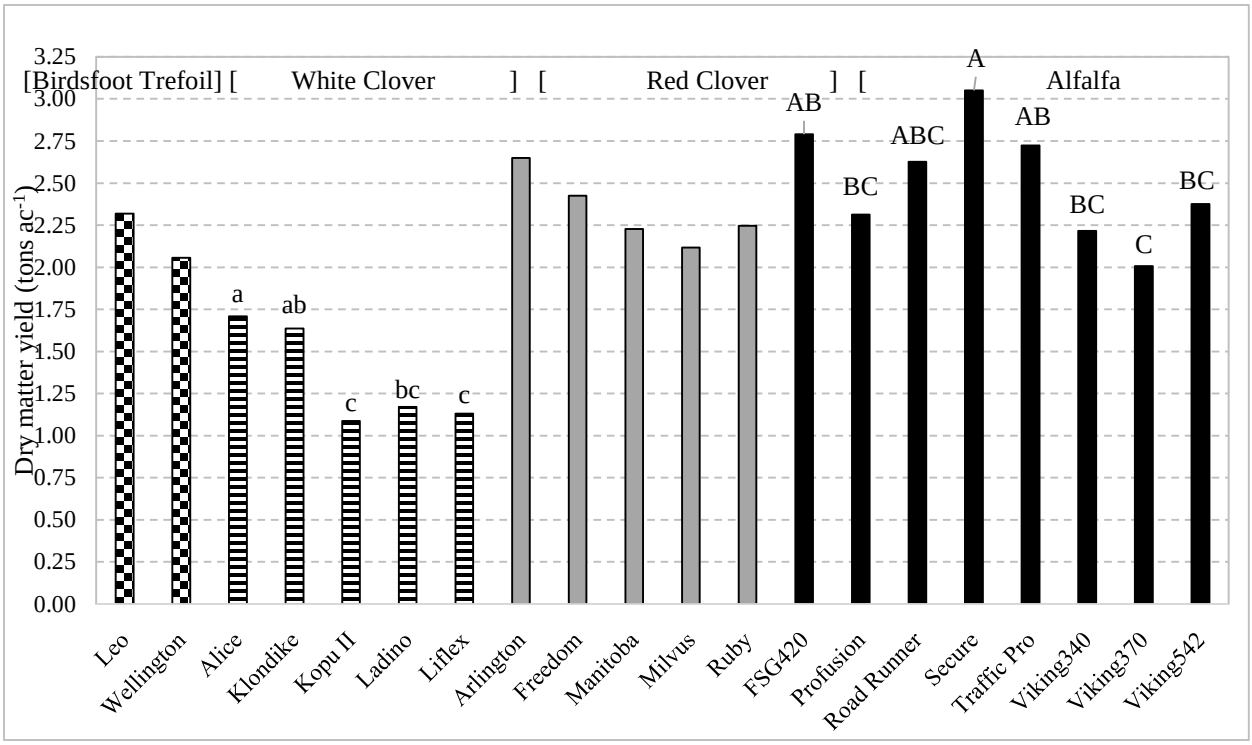

Figure 3. Total dry matter yield across varieties, 2018.

There were some statistically significant differences observed across all cuttings for white clover and alfalfa (Figure 3). At this time, forage quality analyses have only been completed for all the 2018 cuttings. In 2018, despite the droughty weather, the legumes still produced high quality forage. In terms of crude protein, levels ranged from approximately 20-24% with birdsfoot trefoil containing approximately 1.5% less protein than the white clover or alfalfa and there was some variation across varieties observed (Figure 4).

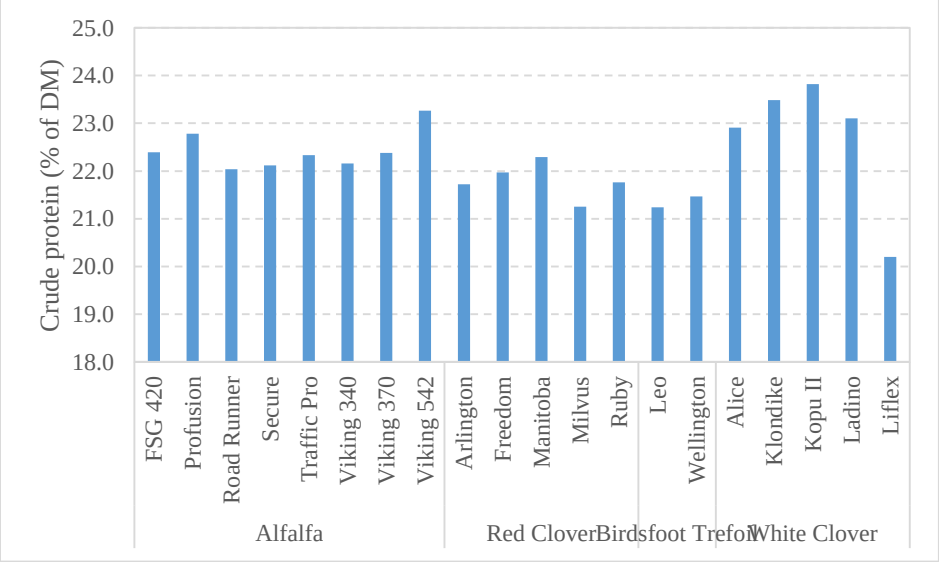

Figure 4. Crude protein content across varieties, 2018.

The species also differed in their NDF digestibility (Figure 5), however there was much less variation across the varieties. NDF digestibility is important to consider in addition to NDF content when comparing forages for quality as although a forage may have a higher NDF content, if a higher proportion of the fiber is

digestible, the animal may be able to utilize more of the nutrients from that forage. In 2018 we observed that white clover and birdsfoot trefoil had higher NDF digestibility than alfalfa and red clover. Generally, alfalfa and red clover have a more upright and stemmy growth habit which, under the drought conditions observed in 2018, can become more lignified and less digestible than the leafier and less fibrous white clover and birdsfoot trefoil.

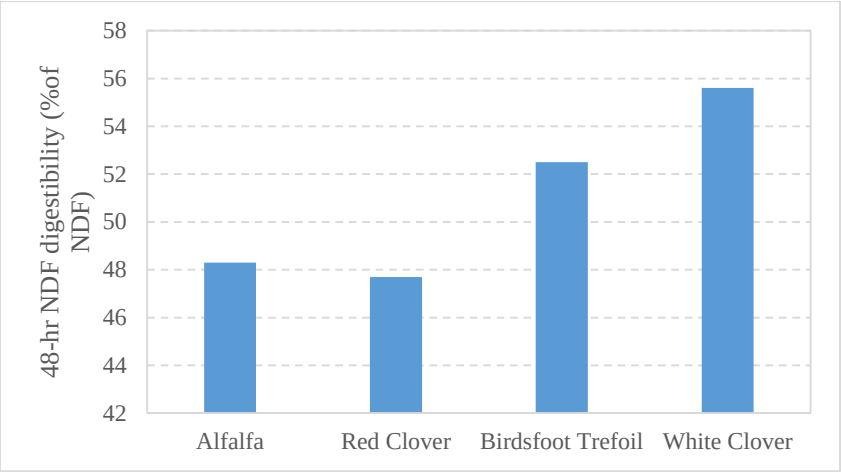

Figure 5. NDF digestibility by species, 2018.

These differences in NDF digestibility also impacts the amount of digestible energy available to an animal. One calculation that is often used to compare forages in energy content is net energy for lactation (Ne_L). This calculation is a better estimate of the portion of potentially digestible nutrients contained in the forage that the animal will actually be able to utilize for milk production once other losses are accounted for. Across species we observed the highest energy content in the white clover and birdsfoot trefoil (Figure 6). Alfalfa was not far behind the other two but the red clover was substantially lower. This makes sense as alfalfa and red clover were less digestible.

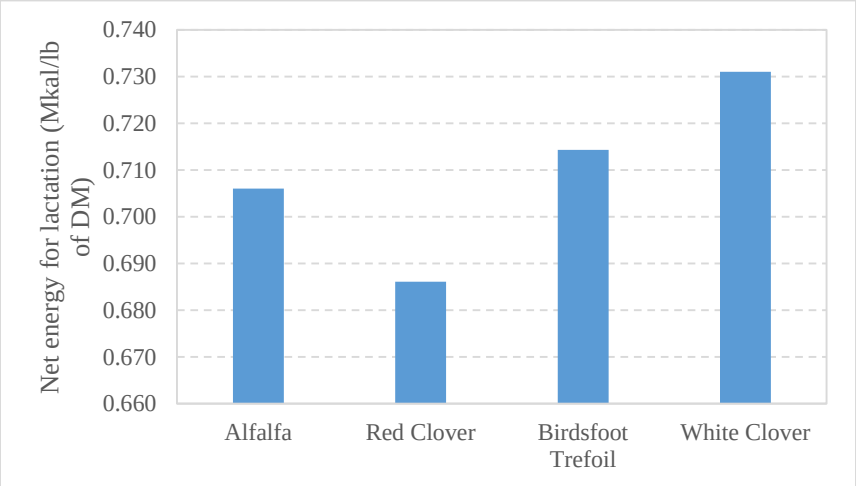

Figure 6. Net energy for lactation by species, 2018.

In addition to these differences in species, varietal differences were also observed (Figure 7). Some of the differences were quite substantial for example, Manitoba red clover had an Ne_L of 0.71 Mkal/lb while Freedom red clover, a very common and popular variety, contained only 0.68 Mkal/lb.

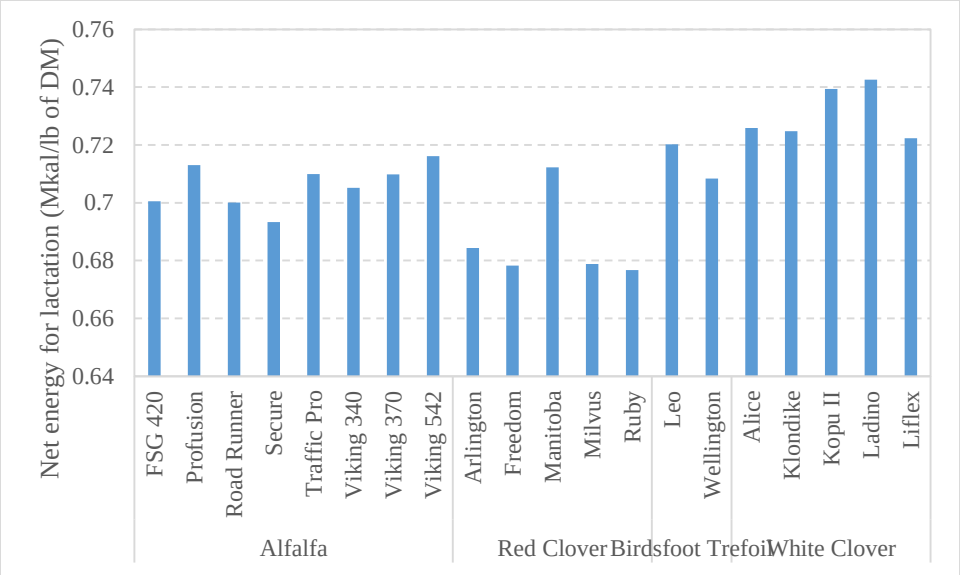

Figure 7. Net energy for lactation content by variety, 2018.

However, this energy content is per pound of dry matter. Therefore, the actual energy yield will depend on the dry matter yield potential of these species and varieties. There are several systems available that attempt to combine multiple quality parameters to better compare forages and some that also combine yield with quality parameters to better estimate the value of the forage. One such system is the milk per ton system developed by Dr. Understander at the University of Wisconsin. Using his method, we can better see which forages provide higher yield per acre, which provide higher quality and therefore milk yield, and which provide a better balance of both (Figure 8).

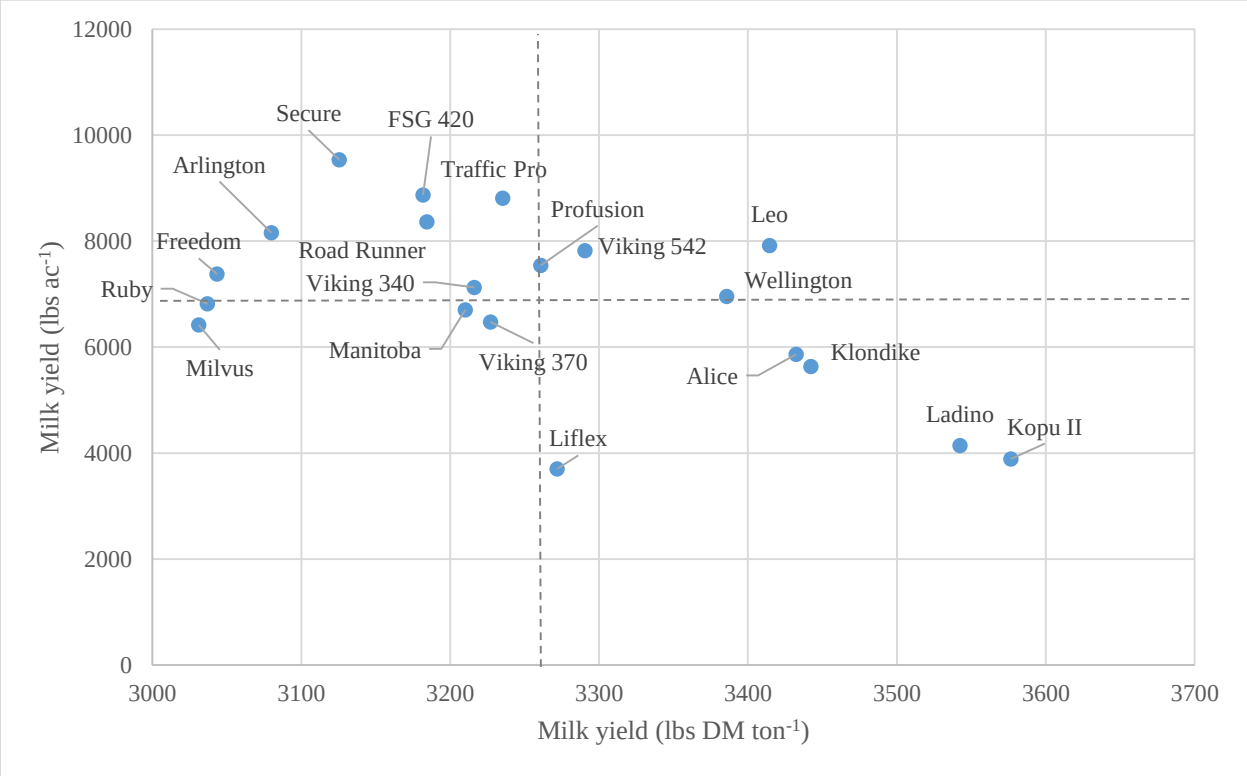

Figure 8. Forage quality and yield expressed in milk per ton and milk per acre by variety, 2018.

Varieties in the top left quadrant are those that expressed high yield but lower quality as they produce more milk per acre than average but lower than average milk per ton of dry matter. Conversely, varieties in the lower right quadrant had above average quality in terms of milk yield per ton of dry matter, but lower than average milk yield per acre due to low yield. The varieties that performed above average in both yield and quality fall into the top right quadrant. Surprisingly, only two alfalfa varieties and both birdsfoot trefoil varieties fall in this category. Furthermore, looking at the high quality but low yield quadrant we see only our white clover varieties and looking in the high yield but low quality quadrant we see mostly alfalfa and a few red clovers. Unfortunately, most of the red clover varieties and one alfalfa variety fell into the lower left quadrant which corresponds to below average yield and quality.

These data emphasize the importance of exploring both yield and quality potentials of forage varieties in addition to just species. Furthermore, although the 2019 quality analyses have yet to be fully completed, it is also important to conduct these experiments across different regions and years to identify species and varieties that are better suited to particular regions and can consistently produce high quality and yield across a variety of environmental conditions.

16 varieties of 4 perennial grasses were also evaluated in 2016 and 2017. The weather during these two years provides a good opportunity to identify species and varieties that maintain yield and quality potential across variable weather conditions. 2016 was largely drier than normal with extended periods without much precipitation. The winter was warmer than normal however 2017 was generally cooler and wetter than normal. These weather conditions influenced both yield and quality of the perennial grasses (Figure 9), however, some of the lower yields in 2016 can also be explained by the fact that it was the first full year of production for the new stand. Interestingly, under the dry conditions of 2016, meadow fescue struggled to produce over 2 tons of dry matter per acre while brome produced over 3 tons per acre. Yields were much higher in 2017 with the favorable forage growing conditions and increased stand establishment, however, under these conditions, all the species performed similarly.

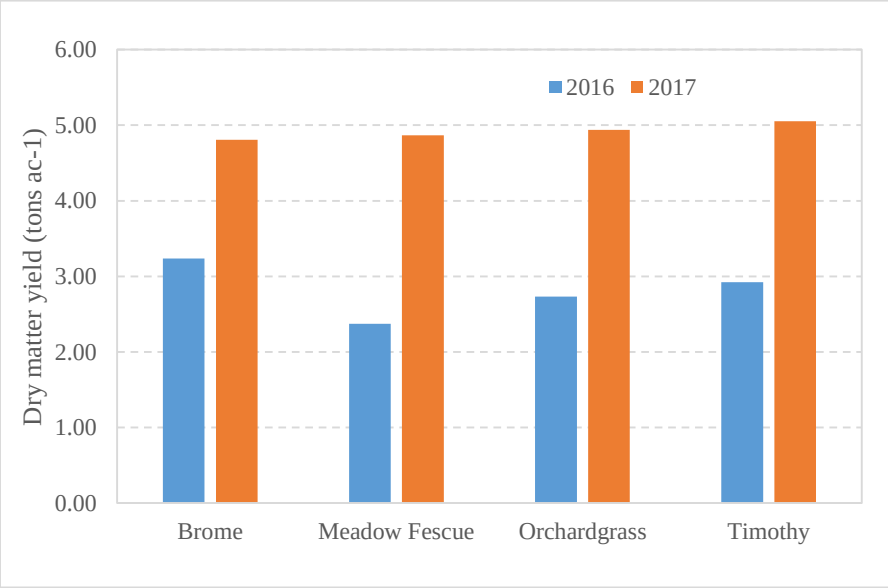

Figure 9. Total dry matter yield by species, 2016-2017.

In addition to these species differences, we also observed some interesting varietal differences (Figure 10). Both Timothy and brome showed some surprising varietal differences with some newer improved forage varieties, AC Success brome and Clair timothy, outperforming some of the older and very commonly selected varieties York Smooth brome and Climax timothy.

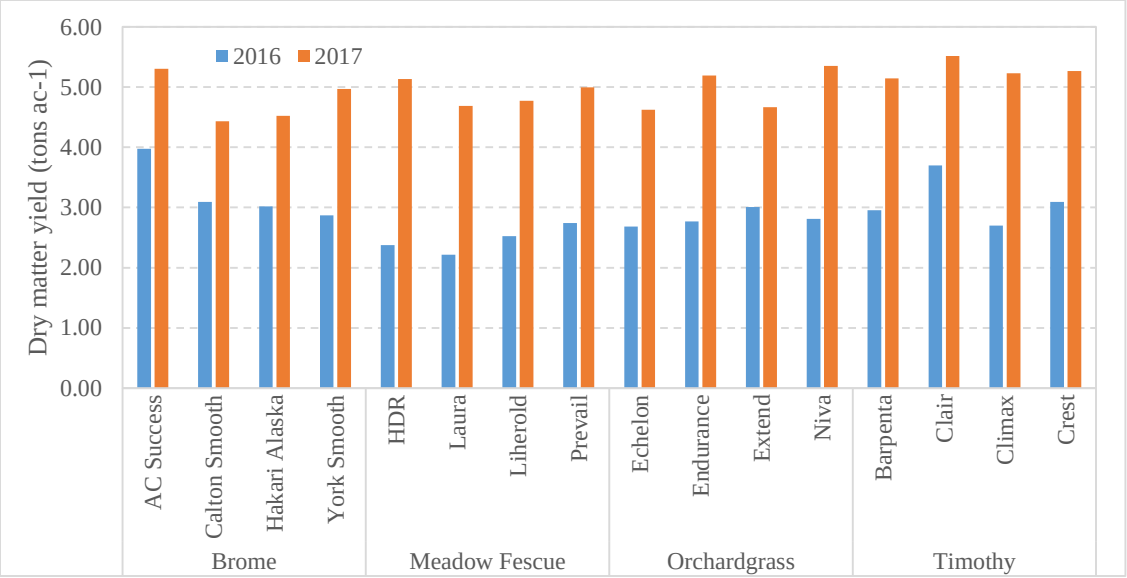

Figure 10. Total dry matter yield by variety, 2016-2017.

We also observed some differences both by species and variety in terms of crude protein (Figure 11). In general crude protein was higher in the brome and meadow fescues but one variety of timothy, Climax, also produced similar protein levels. Overall, the orchardgrass protein levels were lower than the other species.

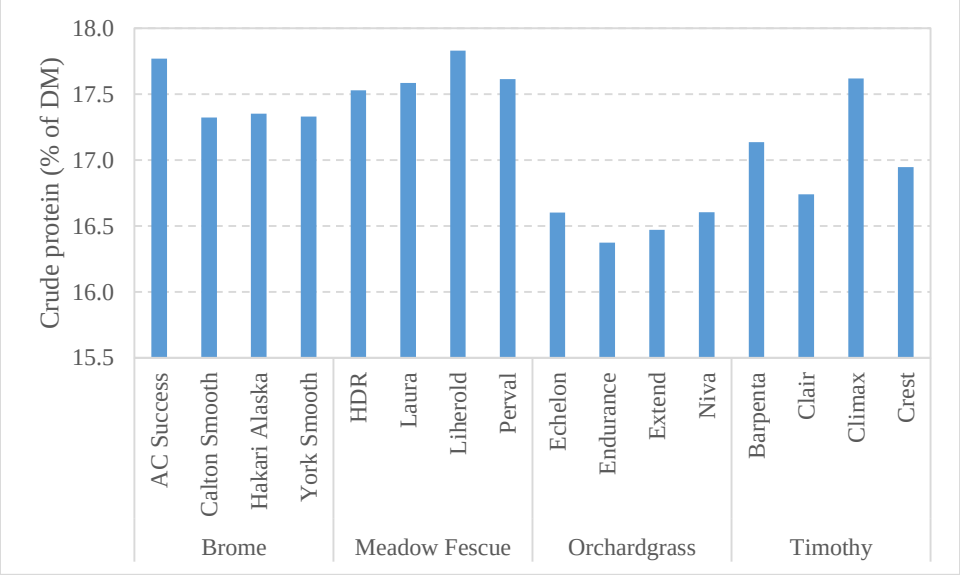

Figure 11. Crude protein content by variety averaged over 2016-2017.

There were also very interesting differences in NDF digestibility of these different grasses (Figure 12). Meadow fescue has increased in popularity in the last few years as it has been marketed on having higher quality including NDF digestibility and increase palatability compared to the more common tall fescue. Interestingly, the meadow fescues were only slightly more digestible than the orchardgrasses but much more digestible than the brome and timothy.

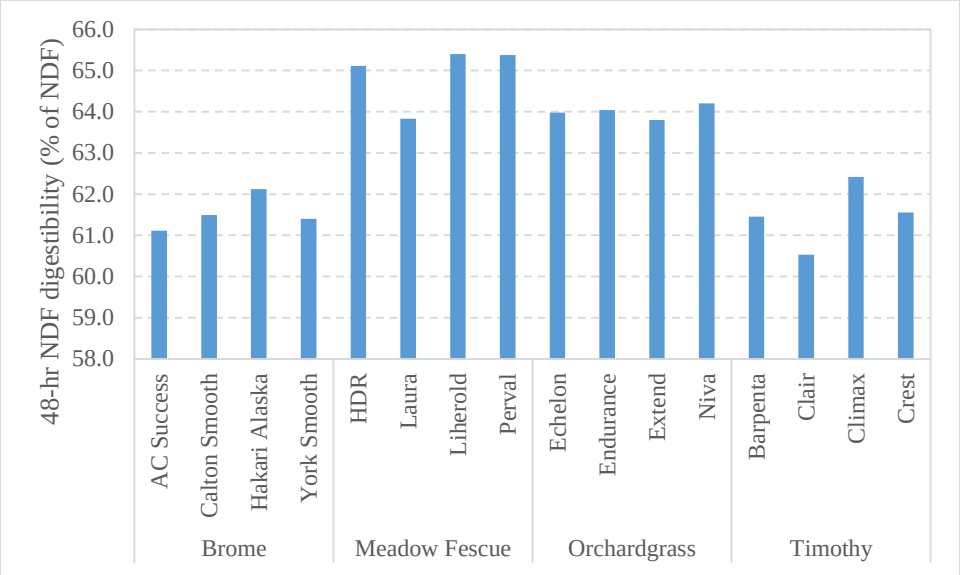

Figure 12. 48-hr NDF digestibility by variety averaged over 2016-2017.

Again, using the net energy calculation we can better predict how an animal will be able to utilize the nutrients in these forages for milk production once losses are accounted for. There was less variation in this measure for the grasses than the legumes, however, we did see slightly higher net energy in the meadow fescues and lower net energy in the orchardgrasses (Figure 13).

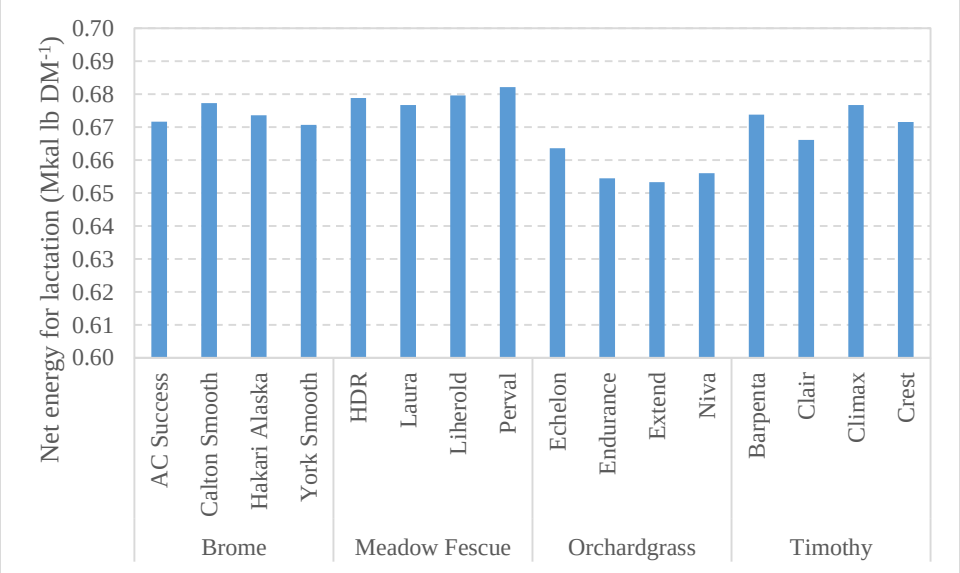

Figure 13. Net energy of lactation by variety averaged over 2016-2017.

When these data are used to calculate milk yield per ton and per acre, we only see one variety, Perval meadow fescue, having both above average milk yield on a per acre and per ton of dry matter basis (Figure 14). The other meadow fescues were similar but slightly lower in quality than Perval. Interestingly, all the brome varieties except for AC Success performed below average in both yield and quality.

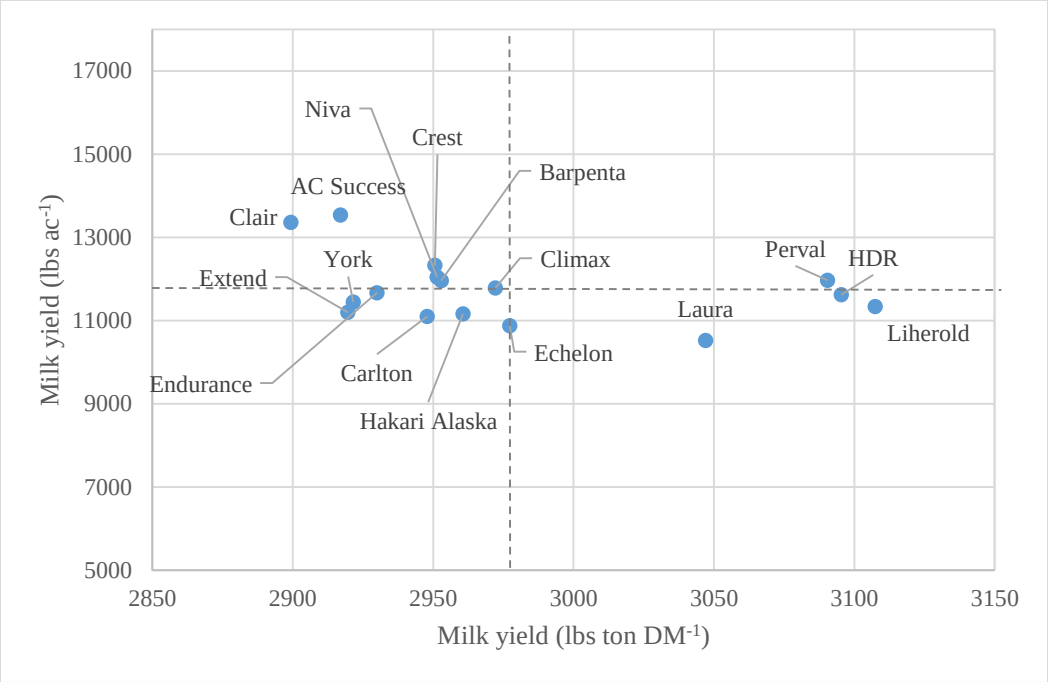

Figure 14. Milk yield per ton of dry matter and per acre by variety averaged over 2016-2017.

Laboratory forage species digestion kinetics evaluations:

Material from the legume trial second harvest in 2018 and other existing forage trials in Alburgh, VT were collected for analysis via an in situ nylon bag study to examine digestion kinetics of various forage nutrient components.

Observations to note from the following graphs (Figures 15-23) are that slightly higher dry matter disappearance was observed for both the sudangrass and the orchardgrass compared to the other forages, indicating a higher nutrient availability in the rumen (Figure 3).

In terms of nutrient content, white clover had the highest % CP and % WSC content in the initial (time 0) samples, and the lowest aNDF content as a % of DM.

More divergence in the ADF, aNDF, CP and WSC disappearance (as a % of initial) was apparent. Both ADF and aNDF demonstrate sample enrichment with an increase in hours of incubation, indicating that they are the more slowly degraded fraction and represent a higher proportion of the remaining dry matter as incubation length increases, as is expected. Orchardgrass, sudangrass, meadow fescue and millet performed more similarly to each other, while white clover had a much smaller aNDF and ADF disappearance compared to these other 4 forages. Orchardgrass was again the forage with some of the higher disappearance rates for these cellulose-containing components.

For both CP and WSC, meadow fescue had the lower % disappearance as a % of initial, and had lower disappearance compared to the white clover while the other forages (orchargrass, sudangrass, and millet) had approximately the same extent of disappearance or slightly higher disappearance compared to the white clover.

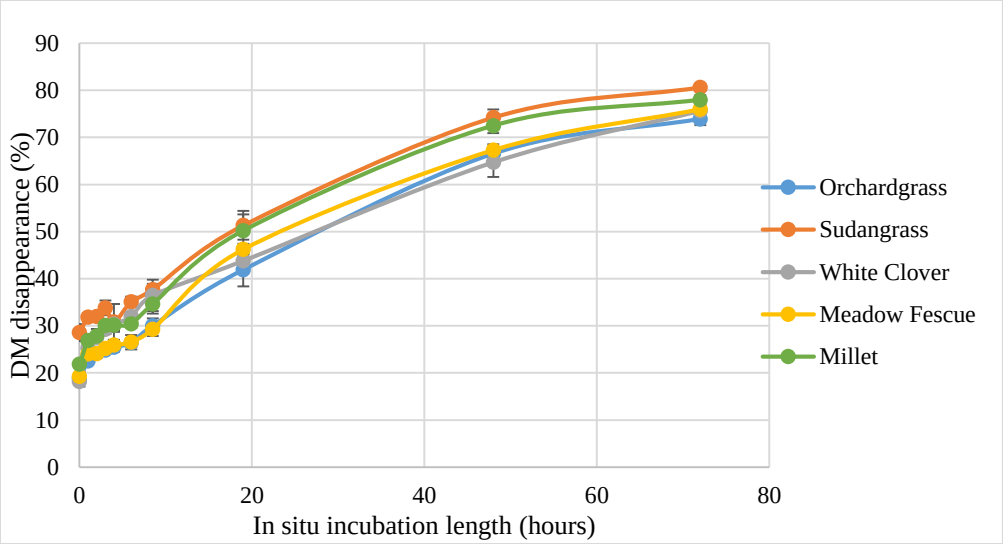

Figure 15. Dry matter disappearance of forages using in situ technique.

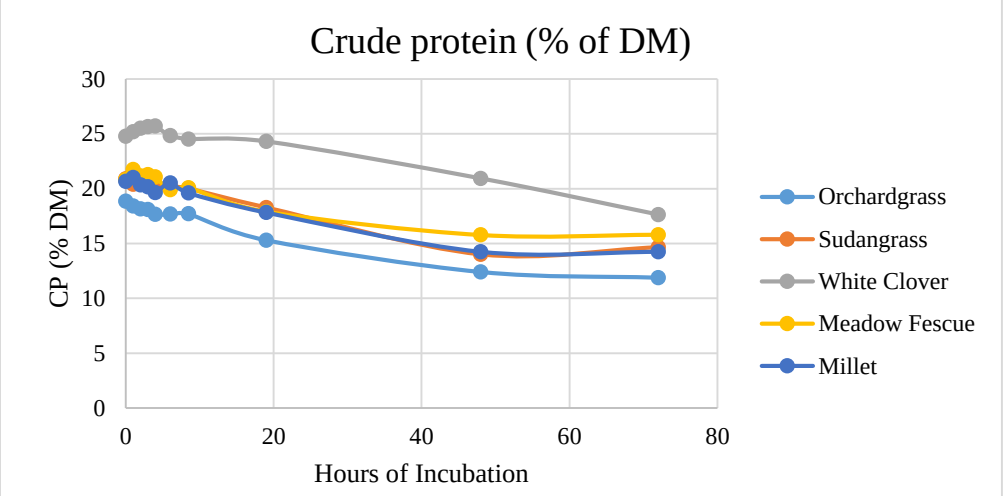

Figure 16. Crude protein content of forages as a percentage of dry matter.

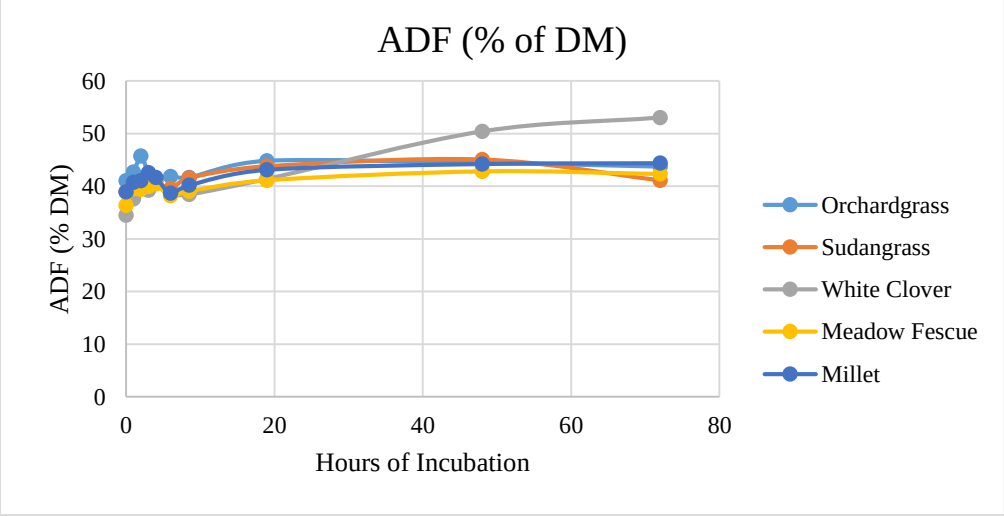

Figure 17. Acid Detergent Fiber content of forages as percentage of dry matter.

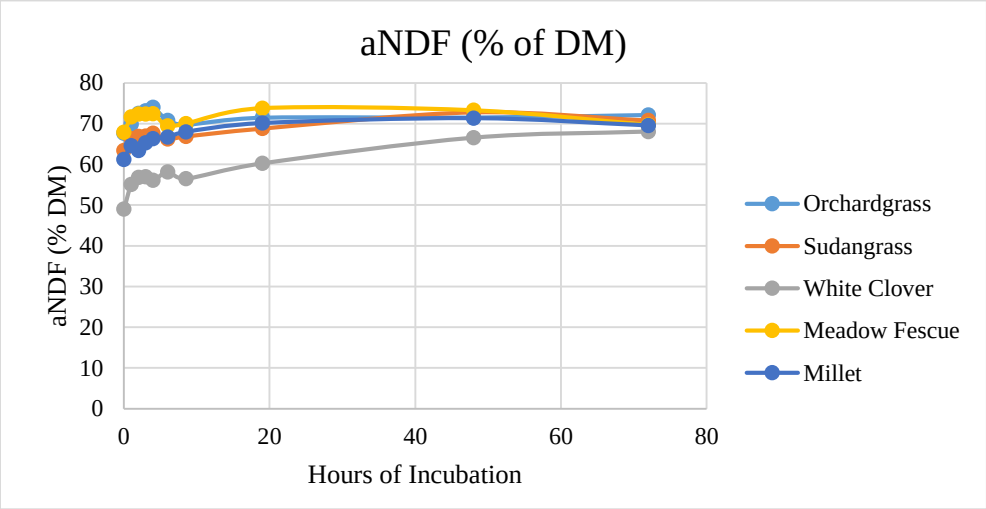

Figure 18. Neutral Detergent Fiber content of forages as percentage of dry matter.

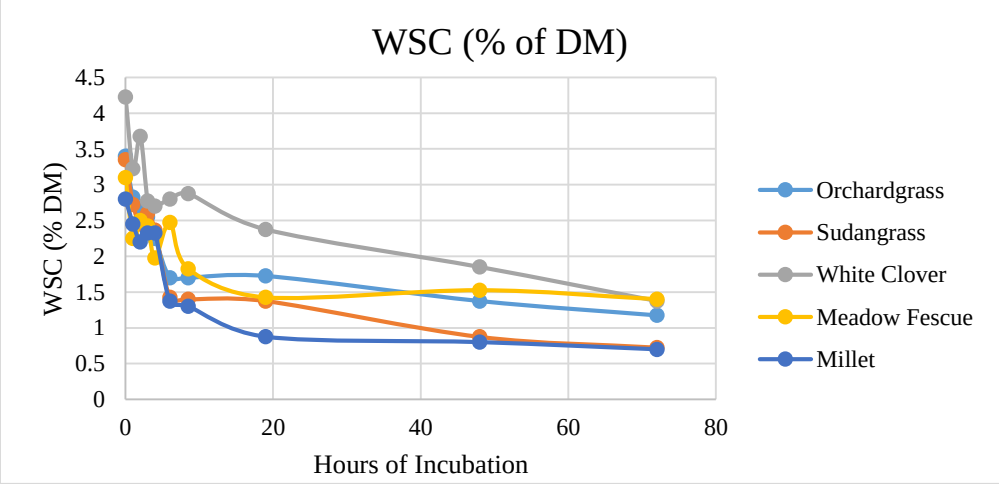

Figure 19. Water soluble carbohydrate content of forages as a percentage of dry matter.

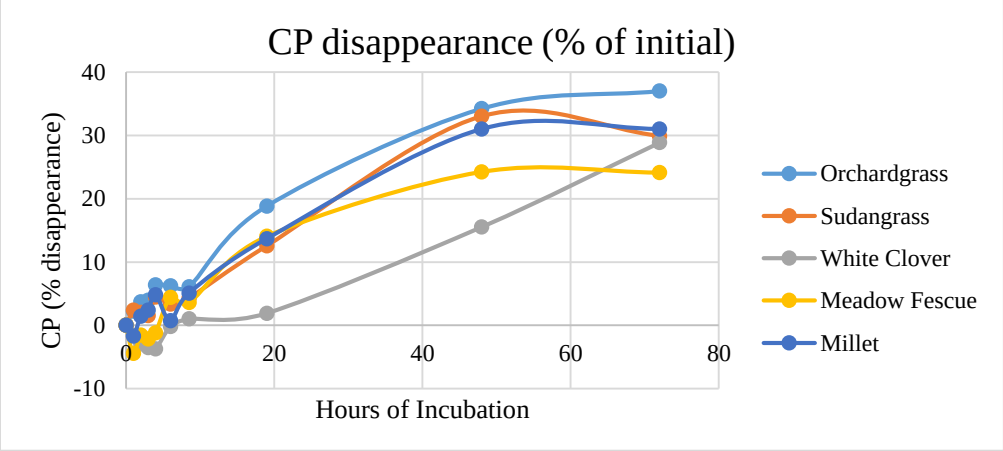

Figure 20. Crude protein disappearance of forages as percentage of initial.

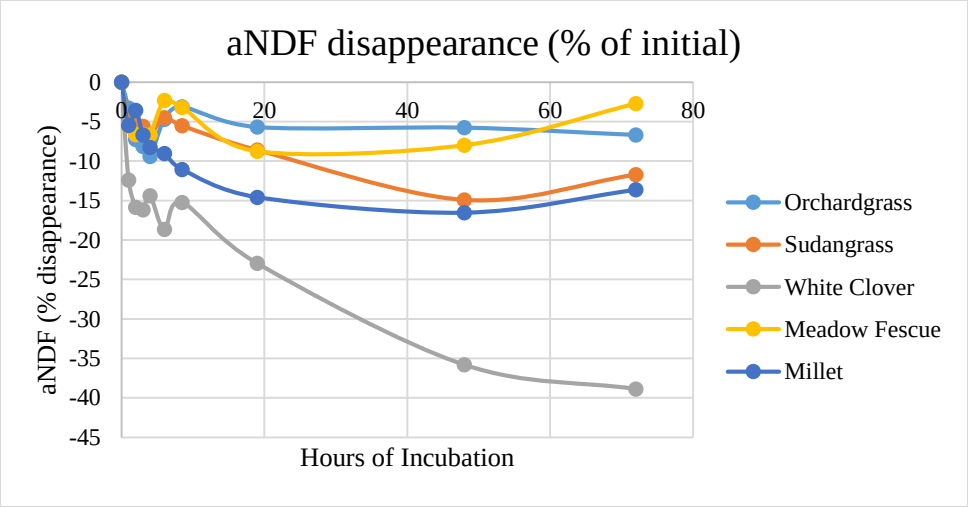

Figure 21. Neutral Detergent Fiber disappearance of forages as percentage of initial.

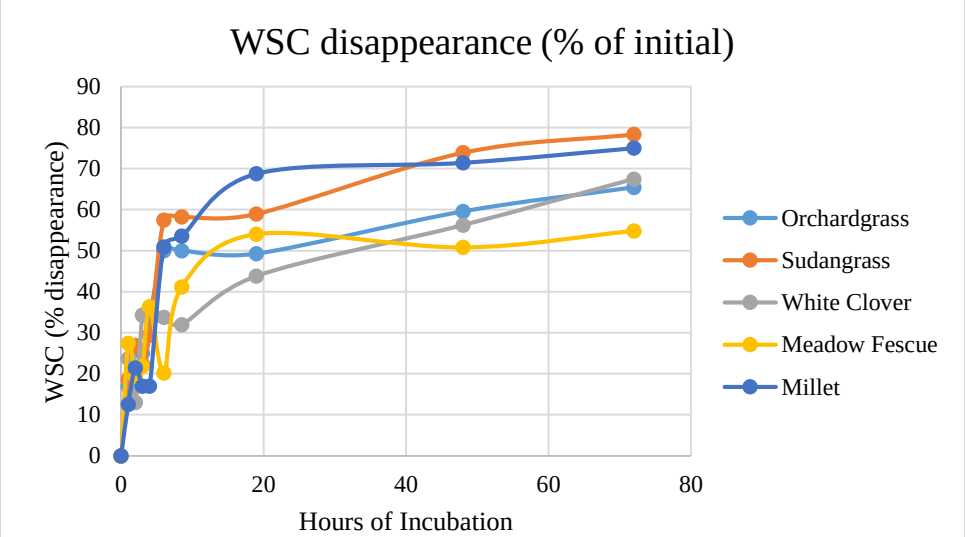

Figure 22. Water soluble carbohydrate disappearance of forages as percentage of initial.

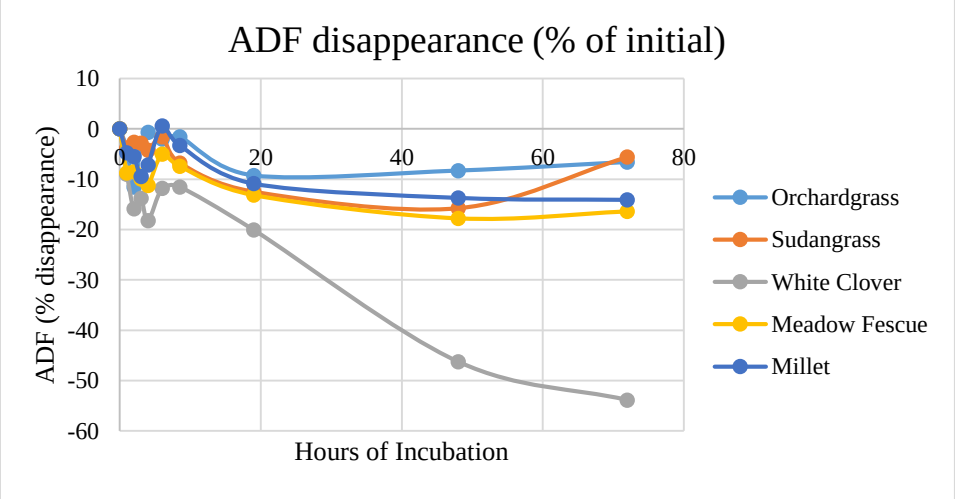

Figure 23. Acid Detergent Fiber disappearance of forages as percentage of initial.