# The Effect of Rate of Nitrogen Fertilization, Geographic Location, and Date of Harvest on Yield, Acceptability, and Nutritive Value of Timothy Hay

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## Summary

The effects of 50, 100 and 150 lb. nitrogen fertilization per acre and different dates of harvest on the yield, chemical composition, and nutritive value of the first cutting of two varieties of timothy, Commercial and Essex, grown at two different locations were studied for three consecutive years with ten animals.

Acceptability of some of the hays was determined using three Shropshire wethers. Complete energy balances of all the hays with all animals were determined by the use of two open-circuit indirect calorimeters. The nutritive evaluation of all the hays was done on the basis of total digestible nutrients, digestible energy, metabolizable energy, and net energy, all directly determined.

Delay of harvest affected the composition and nutritive value significantly. The crude protein decreased about 40-50 per cent and the crude fiber increased 20-25 per cent as the harvest was delayed from June 1 to June 30. The rate of decrease in total digestible nutrients, digestible protein and energy, metabolizable energy, and net energy was from 0.35 to 0.50 percentage units per day as the harvest was delayed after June 1. The order of voluntary intake of some of the hays fed to adult wethers followed that of the digestible and net energy.

The yield in the highest rate of nitrogen fertilization (150 lb. per acre) decreased considerably due to lodging. Also below-average temperatures decreased the yields of the forages in the June 1 and 14 harvests at both locations.


Personnel at the New Hampshire Agricultural Experiment Station conducted research on the nutritive value of timothy hay for a three-year period. The project was a cooperative effort of the members of the Departments of Animal Sciences, Agronomy and Biochemistry. The studies were related to the location, varieties, persistency, nitrogen fertilization, cutting dates and their effect on the nutritive value of timothy hay.

Research at many stations has clearly indicated that nitrogen fertilization increases the yield of feed per acre (3, 10, 13, 17). Date of cutting, or stage of growth when the forage is harvested, greatly influences its nutritive value and acceptability by the animals (6, 11, 12, 13, 14, 16). Recently it was reported that the aftermath of a forage is greatly

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This study was conducted as part of the contributing project of the New Hampshire Agricultural Experiment Station to the Northeast Regional Forage Evaluation Project (NE-24). 1500/4/65.

influenced by nitrogen fertilization and date of cutting in that both the nutrient yield and digestibility are enhanced (5, 15).

The purpose of this experiment was to study the effects of different nitrogen levels on the yield, chemical composition, and digestibility of the first cutting of two varieties of timothy, Commercial and Essex, grown under different climatic conditions and harvested at different dates. The yields of the second cuttings were recorded in order to determine total yield. The acceptability of some of the first cuttings was determined in feeding trials with sheep. The investigation also included the determination of complete energy balances of each hay by means of an open-circuit indirect calorimeter, direct determinations of the metabolizable and net energy, in addition to the conventional digestible energy and total digestible nutrients methods.

## Material and Methods

Pure stands of two varieties of timothy, one early-maturing Commercial and the other late-maturing Essex were grown in two different locations of the state, Groveton, New Hampshire which is in the northern part and Northwood, New Hampshire which is located in the southeastern part. The plots established at Northwood were on Paxton loam, a brown Podzolic soil which is one of the better agricultural soils in southern New Hampshire. While surface drainage is good, the soil has a slow internal drainage due to a compact layer which occurs at about 24 inches. The plots established at Groveton were on Hadley, very fine sandy loam, an alluvial soil with a higher-than-average fertility and good moisture-holding capacity. At Northwood the Commercial was grown under three levels of nitrogen, 50, 100 and 150 lb. per acre and the Essex under 100 lb. per acre only. At Groveton, both the Essex and Commercial were grown under 100 lb. nitrogen fertilization per acre. The nitrogen was applied in a split application with half before and half after the first harvest. All plots received the same rate of phosphorus and potassium.

The dates of cutting in both localities were June 1, 15 and 30. All resulting crops were artificially dried with heat for uniformity. The aftermath of each cutting was harvested two months after the initial cutting.

The animals used during the three-year study were as follows: one pair of twin Holstein steers H 509 and H 510 and two other unrelated Holstein steers H 906 and H 907 the first year, (1960-1961); the same four animals plus two males from a set of Holstein quadruplets H 559 and H 560 the second year, (1961-1962); and one pair of identical twin Ayrshire steers A 554 and A 556 and the set of Holstein quadruplets. H 559, H 560, H 557 and H 558, two male and two female, the third year, (1962-1963). Also three Shropshire wethers were used to determine the acceptability of some of the hays, and also the digestibility of three hays, the yields of which were not sufficient to carry the digestion balances with cattle. Table 1 shows the schedule of experiments.

Analyses of variance were constructed to assess the importance of the various factors (location, variety, date of cut, and fertilizers) on the nutritive value of the hay. Since the data were not balanced, the method

Table 1. Schedule of Experiments.

1960-1961 4 Animals

| Series | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Animal No. | | | | | | (Hays) | | | | | | |
| H 509 | 4 | 1 | 2 | 6 | 11 | 7 | 12 | 9 | 10 | 8 | 3 | 0 |
| H 510 | 7 | 12 | 4 | 9 | 1 | 8 | 5 | 3 | 6 | 0 | 2 | 11 |
| H 906 | 6 | 10 | 9 | 5 | 8 | 12 | 3 | 1 | 2 | 0 | 11 | 0 |
| H 907 | 1 | 7 | 4 | 11 | 10 | 9 | 2 | 12 | 3 | 6 | 5 | 0 |

1961-1962 6 Animals

| Series | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Animal No. | | | (Hays) | | | | |
| H 510 | 5 | 17 | 3 | 18 | 9 | 11 | 0 |
| H 559 | 3 | 14 | 2 | 10 | 8 | 18 | 15 |
| H 509 | 8 | 12 | 7 | 14 | 5 | 0 | 6 |
| H 907 | 9 | 18 | 8 | 11 | 2 | 17 | 12 |
| H 906 | 6 | 10 | 9 | 17 | 3 | 15 | 7 |
| H 560 | 2 | 11 | 5 | 15 | 6 | 14 | 12 |

1962-1963 6 Dairy Animals + 3 Sheep

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Animal No. | | | (Hays) | | | | |
| A 554 | 5 | 17 | 3 | 4 | 9 | 11 | 0 |
| A 556 | 3 | 14 | 2 | 10 | 8 | 0 | 0 |
| H 557 | 8 | 12 | 7 | 14 | 5 | 10 | 6 |
| H 558 | 9 | 4 | 8 | 11 | 2 | 17 | 12 |
| H 559 | 6 | 10 | 9 | 17 | 3 | 1 | 7 |
| H 560 | 2 | 11 | 5 | 1 | 6 | 14 | 12 |
| Sheep No. | | | | | | | |
| 20 | 13 | 15 | 18 | | | | |
| 22 | 13 | 15 | 18 | | | | |
| 44 | 13 | 15 | 18 | | | | |

Key:

| | | | | |
|---|---|---|---|---|
| 1 = | Northwood, | Commercial, | Early-cut, | 50 lb. Nitrogen* |
| 2 = | Northwood, | Commercial, | Medium-cut, | 50 lb. Nitrogen |
| 3 = | Northwood, | Commercial, | Late-cut, | 50 lb. Nitrogen |
| 4 = | Northwood, | Commercial, | Early-cut, | 100 lb. Nitrogen* |
| 5 = | Northwood, | Commercial, | Medium-cut, | 100 lb. Nitrogen |
| 6 = | Northwood, | Commercial, | Late-cut, | 100 lb. Nitrogen |
| 7 = | Northwood, | Commercial, | Early-cut, | 150 lb. Nitrogen |
| 8 = | Northwood, | Commercial, | Medium-cut, | 150 lb. Nitrogen |
| 9 = | Northwood, | Commercial, | Late-cut, | 150 lb. Nitrogen |
| 10 = | Northwood, | Essex, | Early-cut, | 100 lb. Nitrogen |
| 11 = | Northwood, | Essex, | Medium-cut, | 100 lb. Nitrogen |
| 12 = | Northwood, | Essex, | Late-cut, | 100 lb. Nitrogen |
| 13 = | Groveton, | Commercial, | Early-cut, | 100 lb. Nitrogen* |
| 14 = | Groveton, | Commercial, | Medium-cut, | 100 lb. Nitrogen |
| 15 = | Groveton, | Commercial, | Late-cut, | 100 lb. Nitrogen |
| 16 = | Groveton, | Essex, | Early-cut, | 100 lb. Nitrogen |
| 17 = | Groveton, | Essex, | Medium-cut, | 100 lb. Nitrogen |
| 18 = | Groveton, | Essex, | Late-cut, | 100 lb. Nitrogen |

* None in 1961-1962

of least squares was used to obtain estimates for each major factor and one estimate of all interaction.

The hays were chopped, sampled and fed twice a day at 7 a.m. and 5 p.m. in equal amounts, at a level slightly above maintenance. A preliminary period of 15 days preceded an eight-day collection. Total separate collection of feces and urine was made with both female and male animals by means of collection devices described previously (8). The solid and liquid excreta were weighed, sampled daily at 9 a.m. and each composited. The composite feces was frozen solid and the composite urine kept in a refrigerator just above freezing until each was analyzed.

Heat production measurements of at least 24-hour duration on each feed were made at the end of the collection periods by means of an open-circuit, indirect calorimeter (2) to complete the energy balance of the ration. This was followed by a 24-hour measurement in the post-absorptive state to determine the heat increment of the ration, according to the method used by Colovos et al. (6). On a maintenance-plus level of feeding the forage, the post absorptive state, as indicated by the absence of respired methane and a respiratory quotient of about 0.7, was reached after 48 hours of fasting.

The chemical composition for dry matter, ash, crude protein, ether extract, crude fiber and nitrogen-free extract were made using the methods in the A. O. A. C. Manual (1). Gross energy determinations were made using an adiabatic bomb calorimeter.

The digestibility of energy, dry matter, protein, ether extract, fiber and nitrogen-free extract was calculated. Methane, carbon dioxide and oxygen determinations of samples of outdoor air and respiration chamber air were carried out using Carpenter's modification of the Haldane gas analysis apparatus (4) with slight changes made at New Hampshire (8).

## Results and Discussion

The forages harvested in 1960, 1961 and 1962 at both Northwood and Groveton differed only slightly in chemical composition from year to year, where the timothy had received the same rate of nitrogen and had been harvested on the same dates.

Figure 1 shows the comparative yields of Commercial timothy grown under three levels of nitrogen, 50, 100 and 150 lb. per acre and cut at three different dates, June 1, 15 and 30 and also the yield of the late-maturing Essex variety grown under 100 lb. nitrogen per acre in Northwood, N. H. The yields of the same two varieties grown under 100 lb. nitrogen fertilization and cut in Groveton, N. H. on the same dates as above are also shown. There was not enough growth of the Essex timothy to harvest on June 1 in Groveton.

Table 2 shows the total yields for each year, first cutting and aftermath, and the mean for the three-year period. The study did not include Groveton in 1960. There was not enough growth of Essex at Groveton to harvest on June 1 in either 1961 or 1962.

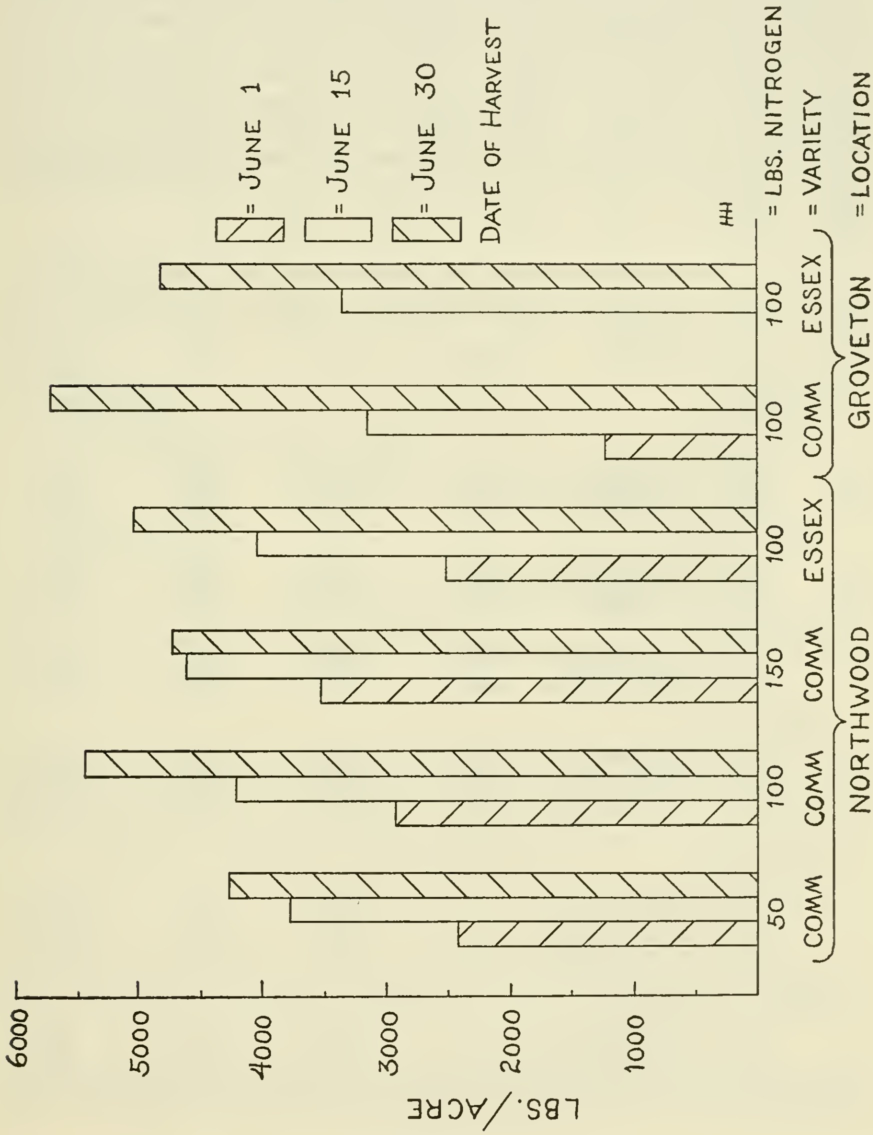
Table 3 shows the average composition of the forages.

1. Protein content of the forage increased as the level of nitrogen fertilization increased.

2. Delay of cutting after June 1st decreased the protein content of the forage and increased the crude fiber content. This confirms results previously published by this Station on this forage specie (6).

3. The temperature differences at Groveton and Northwood, favored an earlier growth at the latter location as evidenced by greater yields for the first two cutting dates. Growth of both varieties of forage lagged by about 10 days in Groveton as compared to Northwood. Consequently,

**Figure 1. The Effect of Location, Nitrogen Fertilization and Date of Harvest on the Yields of First Cutting Commercial and Essex Timothy Hay.**



the protein content of the forages grown in Groveton was higher and the crude fiber lower than the counterparts grown and harvested at Northwood. This indicated that plants were less mature in Groveton than those cut on the same date at Northwood. In neither 1961 or 1962 was there enough growth of Essex timothy at Groveton to warrant taking a harvest on June 1st. By June 30, the growth of the Commercial timothy at Groveton was such that yields averaged higher than at Northwood for plots receiving the same rate of nitrogen. The yields at Northwood, in 1960, were reduced by lodging on the plots receiving 100 and 150 pounds of nitrogen per acre. The most lodging was noted on the plots receiving 150 pounds of nitrogen harvested on June 30, 1960. The low residual levels of phosphorus and potassium may have been partly responsible. In 1961, the yields of June 1 and 15 were lowered because of the below-average temperatures at both locations. In most cases the total yield for the year was highest for the plots receiving 150 pounds of nitrogen (see Table 2). The influence of climate in relation to day length and temperature has been expressed in terms of "Growing Degree Days" (11). The "Growing Degree Days" were greater in Northwood than Groveton.

Table 2. Total Yield of Timothy for 1960 through 1962 for Two Cuttings.

| Location, variety, treatment and cutting dates | 1960 | 1961 | 1962 | Three year mean |
|---|---|---|---|---|
| NORTHWOOD | | | | |
| *Commercial* | | | | |
| 50 lb. N/Acre | | Yield in pounds per acre | | |
| June 1 and August 1 | 4,182 | 3,604 | 5,419 | 4,402 |
| June 15 and August 15 | 4,954 | 4,733 | 4,008 | 4,565 |
| June 30 and August 30 | 4,912 | 3,687 | 5,990 | 4,863 |
| 100 lb. N/Acre | | | | |
| June 1 and August 1 | 5,852 | 4,965 | 6,373 | 5,730 |
| June 15 and August 15 | 6,392 | 7,045 | 5,652 | 6,363 |
| June 30 and August 30 | 7,899 | 6,382 | 7,871 | 7,381 |
| 150 lb. N/Acre | | | | |
| June 1 and August 1 | 8,110 | 5,692 | 7,609 | 7,137 |
| June 15 and August 15 | 7,590 | 8,265 | 7,490 | 7,782 |
| June 30 and August 30 | 6,199 | 7,267 | 9,139 | 7,535 |
| *Essex* | | | | |
| 100 lb. N/Acre | | | | |
| June 1 and August 1 | 4,920 | 4,699 | 5,000 | 4,873 |
| June 15 and August 15 | 6,841 | 5,359 | 5,005 | 5,735 |
| June 30 and August 30 | 6,912 | 6,420 | 6,667 | 6,666 |
| GROVETON | | | | |
| *Commercial* | | | | |
| 100 lb. N/Acre | | | | |
| June 1 and August 1 | —— | 9,789* | 3,281 | 6,535 |
| June 15 and August 15 | —— | 5,703 | 7,657 | 6,680 |
| June 30 and August 30 | —— | 8,616 | 7,895 | 8,255 |
| *Essex* | | | | |
| 100 lb. N/Acre | | | | |
| June 1 and August 1 | —— | —— | —— | —— |
| June 15 and August 15 | —— | 5,623 | 5,478 | 5,550 |
| June 30 and August 30 | —— | 7,470 | 7,067 | 7,268 |

* Three cuttings: June 1, July 10 and August 30.

Table 3. 3-Year Mean Composition of Commercial and Essex Varieties of Timothy Fertilized With Different Levels of Nitrogen and Harvested on Different Dates.

| Forage | Ash | Crude Protein | Ether extract | Crude fiber | Nitrogen-free extract | Gross energy |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | kcal/g |
| NORTHWOOD | | | | | | |
| *Commercial* | | | | | | |
| 50 lb. N/Acre | | | | | | |
| Cut June 1 | 7.83 | 13.81 | 3.18 | 31.59 | 43.59 | 4.395 |
| 15 | 5.91 | 8.99 | 2.64 | 36.44 | 45.80 | 4.400 |
| 30 | 4.97 | 6.94 | 2.25 | 38.79 | 46.69 | 4.454 |
| 100 lb. N/Acre | | | | | | |
| Cut June 1 | 8.14 | 15.52 | 3.19 | 32.50 | 40.67 | 4.411 |
| 15 | 6.03 | 9.83 | 2.67 | 37.91 | 44.50 | 4.405 |
| 30 | 5.04 | 7.61 | 2.11 | 39.64 | 45.42 | 4.431 |
| 150 lb. N/Acre | | | | | | |
| Cut June 1 | 8.37 | 17.10 | 3.44 | 30.77 | 40.01 | 4.427 |
| 15 | 6.21 | 11.93 | 2.82 | 37.21 | 41.63 | 4.435 |
| 30 | 4.96 | 9.30 | 2.17 | 39.34 | 44.82 | 4.474 |
| *Essex* | | | | | | |
| 100 lb. N/Acre | | | | | | |
| Cut June 1 | 7.50 | 15.95 | 3.52 | 29.01 | 43.44 | 4.436 |
| 15 | 6.67 | 10.82 | 2.95 | 36.49 | 42.29 | 4.414 |
| 30 | 5.46 | 9.23 | 2.26 | 38.62 | 44.93 | 4.439 |
| GROVETON | | | | | | |
| *Commercial* | | | | | | |
| 100 lb. N/Acre | | | | | | |
| Cut June 1 | 6.88 | 20.25 | 3.06 | 30.03 | 39.26 | 4.564 |
| 15 | 5.77 | 15.35 | 3.08 | 33.96 | 40.66 | 4.447 |
| 30 | 6.75 | 13.15 | 2.26 | 38.33 | 40.75 | 4.475 |
| *Essex* | | | | | | |
| 100 lb. N/Acre | | | | | | |
| Cut June 1* | —— | —— | —— | —— | —— | —— |
| 15 | 6.65 | 15.70 | 3.50 | 32.13 | 41.66 | 4.504 |
| 30 | 5.70 | 11.17 | 2.57 | 37.15 | 43.44 | 4.486 |

* There was not enough yield of forage to cut for digestion and utilization experiment.

Table 4 shows the average digestibilities of the chemical components of the forages over the three-year period of the experiment. Delay of harvest decreased the digestibility of all components, the decrease in protein and fiber being most pronounced.

Table 5 contains data on the average nutritive values of the timothy cuttings:

1. The percentage of total digestible nutrients decreased between 0.35 and 0.50 percentage units with each day's delay in harvesting the forage after June 1st, thus confirming previous results (6).

2. Rate of nitrogen fertilization did not materially influence the energy utilization. Date of cutting, however, greatly affected the digestible, metabolizable and net energy of each hay.

Table 4. 3-Year Mean Digestibility of Ingredients of Commercial Essex Varieties of Timothy.

| Forage | Dry matter | Crude Protein | Ether extract | Crude fiber | Nitrogen-free extract |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| NORTHWOOD | | | | | |
| *Commercial* | | | | | |
| 50 lb. N/Acre | | | | | |
| Cut June 1 | 73.25 | 68.21 | 53.67 | 80.92 | 73.04 |
| 15 | 67.59 | 61.28 | 53.69 | 71.98 | 68.54 |
| 30 | 60.73 | 48.18 | 53.39 | 61.60 | 61.83 |
| 100 lb. N/Acre | | | | | |
| Cut June 1 | 72.49 | 69.53 | 56.06 | 80.46 | 70.37 |
| 15 | 67.31 | 62.43 | 59.04 | 71.32 | 66.83 |
| 30 | 59.11 | 52.97 | 45.76 | 62.08 | 59.52 |
| 150 lb. N/Acre | | | | | |
| Cut June 1 | 72.66 | 72.78 | 57.56 | 80.86 | 71.43 |
| 15 | 67.23 | 67.81 | 55.26 | 73.56 | 64.56 |
| 30 | 59.35 | 59.59 | 45.45 | 61.78 | 58.95 |
| *Essex* | | | | | |
| 100 lb. N/Acre | | | | | |
| Cut June 1 | 73.72 | 72.14 | 55.38 | 80.56 | 74.54 |
| 15 | 69.93 | 65.27 | 53.09 | 76.21 | 67.29 |
| 30 | 61.71 | 54.64 | 45.80 | 64.81 | 60.58 |
| GROVETON | | | | | |
| *Commercial* | | | | | |
| 100 lb. N/Acre | | | | | |
| Cut June 1 | 69.08 | 69.84 | 50.59 | 78.30 | 67.12 |
| 15 | 70.82 | 71.29 | 57.93 | 77.30 | 67.97 |
| 30 | 59.97 | 70.06 | 45.15 | 60.46 | 58.78 |
| *Essex* | | | | | |
| 100 lb. N/Acre | | | | | |
| Cut June 1 | —— | —— | —— | —— | —— |
| 15 | 73.55 | 71.58 | 56.68 | 80.75 | 73.38 |
| 30 | 63.05 | 60.95 | 43.47 | 68.40 | 60.20 |

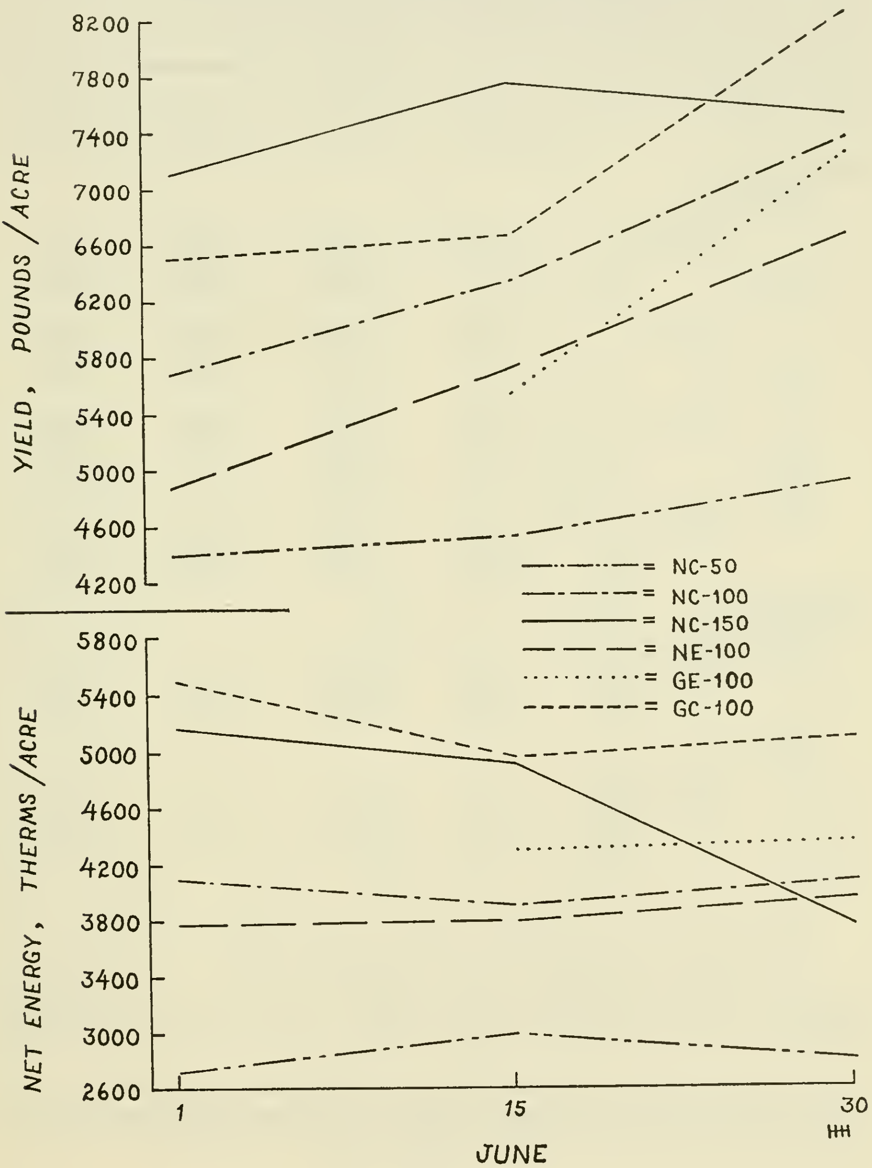
3. On a percentage basis, the net energy seemed to be the most sentitive basis of comparison.

4. The total decrease in net energy associated with the later harvest date was greatest in timothy plots receiving nitrogen at the 150 pound per acre rate. This may have been due to the more stemmy condition of the hay. However, where severe lodging had occurred, the growth was reduced.

5. At Northwood, the Essex timothy had higher net energy value than the Commercial timothy produced with the same rate of nitrogen fertilization. This was undoubtedly due to the more advanced growth of the Commercial timothy.

Figure 2 shows the comparative effect of location, variety of timothy. level of nitrogen fertilization and date of cutting had on the combined yield of the first cutting and aftermath of each hay. The lower part of the graph shows the effect of these factors on the net energy of the first cutting in each hay. The hay grown under the 150 lb. nitrogen fertilization had the greatest decrease in net energy as the harvest was delayed. Also the total yield of this hay did not increase at the rate the other hays did because of lodging. The 100 lb. per acre nitrogen fertilization produced a high total yield and a fairly steady net energy content.

**Figure 2. Effect of Geographic Location, Variety, Level of Nitrogen Fertilization and Cutting Date upon Seasonal Yield and Yield of Net Energy of Timothy Hay When Fed to Non-lactating Cattle.**



6. Acceptability trials of a limited number of hays determined using mature wethers indicated that the order of acceptability followed that of the digestibility and net energy content. Of the three hays fed, June 1 harvest Commercial, June 30 Commercial and June 30 Essex all grown at Groveton under 100 lb. nitrogen per acre, the intakes per 100 lb. live weight were 0.96, 0.62 and 0.62 lb., respectively.

Table 5. 3-Year Mean Nutritive Values of Commercial and Essex Varieties of Timothy Grown Under Different Climatic Conditions, Levels of Nitrogen and Dates of Harvest.

| Forage | TDN | Digestible energy | Metabolizable energy | Net energy |
|---|---|---|---|---|
| | % | kcal/g | kcal/g | kcal/g |
| NORTHWOOD | | | | |
| *Commercial* | | | | |
| 50 lb. N/Acre | | | | |
| Cut June 1 | 70.89 | 2.938 | 2.352 | 1.350 |
| 15 | 66.40 | 2.792 | 2.258 | 1.440 |
| 30 | 59.47 | 2.464 | 2.032 | 1.226 |
| 100 lb. N/Acre | | | | |
| Cut June 1 | 69.64 | 2.863 | 2.283 | 1.583 |
| 15 | 65.35 | 2.666 | 2.155 | 1.354 |
| 30 | 57.67 | 2.331 | 1.899 | 1.214 |
| 150 lb. N/Acre | | | | |
| Cut June 1 | 71.06 | 2.947 | 2.386 | 1.594 |
| 15 | 65.97 | 2.703 | 2.198 | 1.388 |
| 30 | 58.57 | 2.321 | 1.872 | 1.102 |
| *Essex* | | | | |
| 100 lb. N/Acre | | | | |
| Cut June 1 | 71.69 | 3.084 | 2.483 | 1.707 |
| 15 | 66.99 | 2.801 | 2.237 | 1.458 |
| 30 | 59.27 | 2.480 | 2.014 | 1.314 |
| GROVETON | | | | |
| *Commercial* | | | | |
| 100 lb. N/Acre | | | | |
| Cut June 1 | 67.47* | 3.044* | 2.579* | 1.858* |
| 15 | 70.66 | 3.079 | 2.516 | 1.624 |
| 30 | 61.52 | 2.641 | 2.161 | 1.361 |
| *Essex* | | | | |
| 100 lb. N/Acre | | | | |
| Cut June 1 | —— | —— | —— | —— |
| 15 | 70.70 | 3.070 | 2.499 | 1.702 |
| 30 | 58.35 | 2.540 | 2.067 | 1.316 |

* Sheep

Table 6 shows the statistical analysis of the data.

1. The effect of date of cutting on the digestibility of the protein, total digestible nutrients, digestible energy and net energy was significant.

2. Rate of nitrogen fertilization affected the digestibility of the protein, significantly but had no effect on the total digestible nutrients, digestible energy or net energy of the forage.

3. Location affected the digestible energy of the forage but not the net energy, while an effect on the digestibility of protein and total digestible nutrients was demonstrable only in 1961-1962.

4. The difference between varieties significantly affected the digestible energy and total digestible nutrients.

5. There was no substantial evidence of important interactions among the factors.

From the results of the experiment, it is concluded that Commercial timothy grown under 100 lb. per acre at both Northwood and Groveton gave the highest total yield per acre and also the highest net energy. Essex, the late-maturing variety, is entirely unsuitable for the northern locations where the "growing degree days" are shorter. The recommended date of the first cutting at these locations should be the second week of June and the aftermath about two months later.

**Table 6. Analyses of Variance by Variable and Year.**

| Source of variation | 1960-1961 | | 1961-1962 | | 1962-1963 | |
|---|---|---|---|---|---|---|
| *Digestible Protein* | d.f. | Mean Square | d.f. | Mean Square | d.f. | Mean Square |
| Locations | – | —— | 1 | 997.46† | 1 | 8.85 |
| Varieties | 1 | 21.54 | 1 | 37.48 | 1 | 33.82† |
| Date of cut | 2 | 622.47† | 2 | 727.44† | 2 | 834.92† |
| Fertilizers | 2 | 189.61† | 2 | 101.42† | 2 | 146.84† |
| Interactions | 6 | 0 | 7 | 57.18† | 7 | 46.14† |
| Error | 28 | 10.04 | 27 | 3.36 | 25 | 3.68 |
| *Digestible Energy* | | | | | | |
| Locations | – | —— | 1 | .4382† | 1 | .1247† |
| Varieties | 1 | .4162* | 1 | .1727† | 1 | .0868* |
| Date of cut | 2 | .5703† | 2 | 1.4937† | 2 | .8045† |
| Fertilizers | 2 | 25.25* | 2 | .0071 | 2 | .0254 |
| Interactions | 6 | .0479 | 7 | .0371 | 7 | .0345* |
| Error | 28 | .0548 | 27 | .0213 | 25 | .0120 |
| *Net Energy* | | | | | | |
| Locations | – | —— | 1 | .1106 | 1 | .0403 |
| Varieties | 1 | .1158 | 1 | .0415 | 1 | .0439 |
| Date of cut | 2 | .2758* | 2 | .7261† | 2 | .2887† |
| Fertilizers | 2 | .1116 | 2 | .0094 | 2 | .0022 |
| Interactions | 6 | .0574 | 7 | .0405 | 7 | .0370 |
| Error | 28 | .0632 | 27 | .0307 | 25 | .0387 |
| *Total Digestible Nutrients* | | | | | | |
| Locations | – | | 1 | 111.18† | 1 | 21.09 |
| Varieties | 1 | 23.45* | 1 | 59.65† | 1 | 32.84* |
| Date of cut | 2 | 327.43† | 2 | 567.83† | 2 | 301.13† |
| Fertilizers | 2 | 6.89 | 2 | 3.48 | 2 | 17.62 |
| Interactions | 6 | 8.94 | 7 | 9.57 | 7 | 17.18* |
| Error | 28 | 4.27 | 27 | 7.57 | 25 | 5.34 |

* Significant at the 5 per cent level
† Significant at the 1 per cent level

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