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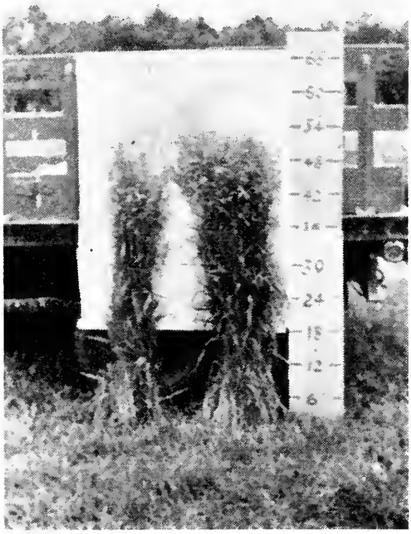

I. Yield and Persistency as Influenced by Nitrogen Rate and Time of Harvest.

by
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and Paul T. Blood,
Department of Agronomy

II. Nutritive Value.

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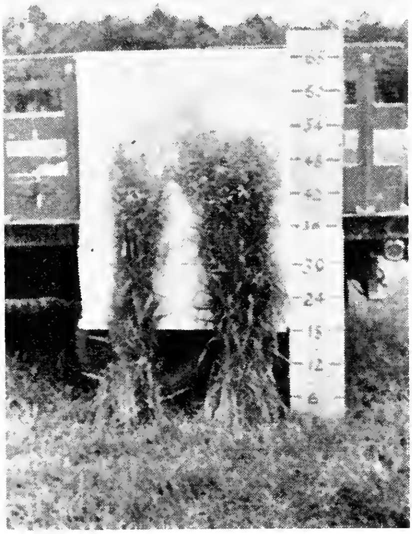

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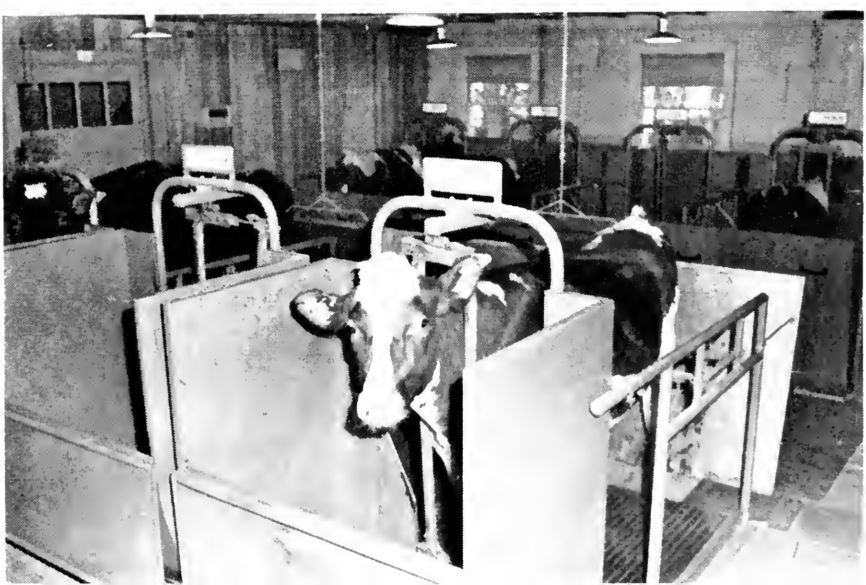

Bromegrass cut in the boot stage of maturity has a higher nutritive value and a lower yield than when cut in the soft-dough stage of maturity. A compromise between the maximum nutritive value and maximum yield can be obtained by harvesting the bromegrass in the flowering stage of maturity.

I. Yield and Persistency of Bromegrass Hay as Affected by Rate of Nitrogen Fertilization and Time of Harvest

Introduction

Under New England conditions, grass forages are easier to establish than legumes and with proper fertilization will have a comparable protein content. Bromegrass, rather than timothy, was selected for evaluation of yield and nutritive content as influenced by fertilization and stage of maturity because it appears to remain palatable for a longer period, generally yields more dry matter, and has a higher protein content.

Review of Literature

Considerable research on grassland fertilization has been conducted by New Hampshire Agricultural Experiment Station personnel (8, 9, 10). Work at Maine (6) and Pennsylvania (12), indicate that while early-cut hay has a high nutritive value, the yields of dry matter increase as the date of initial harvest is delayed. In a study of nitrate accumulation in plants, Gilbert et al. (4) found that conditions favoring high nitrates were: 1. high nitrogen in the soil, 2. young vegetation, 3. shady areas, 4. drought or low temperature, 5. form of nitrogen. Ramage et al. (11) reported that in a three year experiment in New Jersey, applications of nitrogen increased the crude protein and decreased the nitrogen free extract and ash of orchardgrass and reed canarygrass.

Experimental Procedure

To provide material for feeding trials by the Department of Dairy Science, plots of one hundred feet by seven hundred feet, located at Price Field, Northwood, New Hampshire were seeded to bromegrass in the early fall of 1956. All plots received the same rate of phosphorus and potassium (500 pounds of 0-25-25 per acre per year). There were variations in the amounts of nitrogen fertilizer and the dates of harvest. The nitrogen fertilizer used throughout the experiment was urea.

During the first year of the experiment, 1957, material from plots which had received total nitrogen applications of fifty and one hundred pounds of nitrogen per acre was available for study. The plots were harvested at three stages of maturity, early boot, flowering, and soft dough. In the subsequent years (1958 and 1959), the plots were fertilized at rates of 50, 100, 200, and 400 pounds of nitrogen per acre. The three highest rates of nitrogen were applied in a split application with half before the first cutting and half afterward. Limit of accuracy of the distributing equipment, prevented splitting the fifty pound rate of nitrogen, all of which was applied prior to the first cutting.

During the first two years of the study, the loose hay was chopped into a specially built drier. The dried hay was bagged and weighed. In the third year of the experiment, the hay was baled in the field, then placed in a commercial drier.

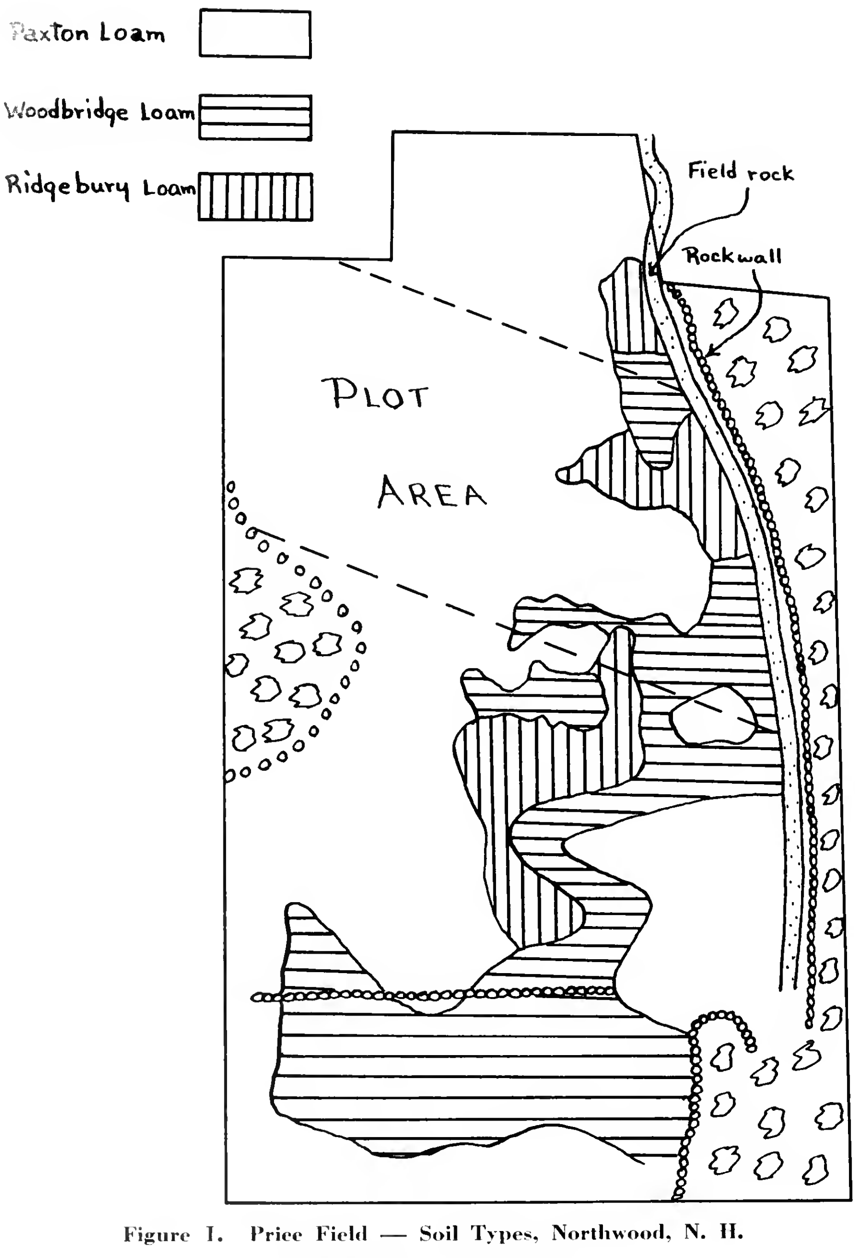

Figure I. Price Field — Soil Types, Northwood, N. H.

(Area of field — 20 acres)

Soils

The plot area of the experiment is shown in Figure 1. The soils of the Paxton series are well drained and their relief ranges from level to steep, with mild slopes predominating. They developed on deep, compact, platy till of Late Wisconsin age derived mainly from mica schist, gneiss, and granite. The Paxton soils, classified as Brown Padzolic, belong to the same catena as the moderately well-drained Woodbridge soils, the poorly-drained Leicester and Ridgebury soils, and the very poorly-drained Whitman soils. The Paxton soils range from strongly acid to medium acid. Surface runoff is generally medium to slow. A compact, platy substratum at 18 to 24 inch depth restricts the downward movement of water. When the upper layers of the soil are saturated, water moves laterally above the compact layer and seeps out along the lower slopes. Roots, water, and air penetrate the surface soil and subsoil readily. The soil has good tilth and responds to proper management and fertilization. Because of poorer drainage, production from the Woodbridge and Ridgebury loams is lower than from the Paxton.

Yield and Analytical Data

Yield and analytical data are given in Tables 1 and 2, and Figure 2. The variation in height and lodging of the third-stage bromegrass during the 1959 season is illustrated in Figures 3, 4, 5, 6, and 7. In the later

Table 1. Bromegrass Yields

First Cutting at Three Stages of Maturity			
	1957		
Treatment lbs. N per Acre	1st. Stage (5/30-31/57) lbs. dry matter/A	2nd. (6/9-10/57) lbs. dry matter/A	3rd. (6/20-21/57) lbs. dry matter/A
50	3,388	4,898	5,576
100	4,066	6,069	6,505
	1958		
	1st. Stage (6/4/58) lbs. dry matter/A	2nd. (6/13/58) lbs. dry matter/A	3rd. (6/23/58) lbs. dry matter/A
50	3,585	4,868	5,907
100	4,703	6,631	6,001
200	5,464	7,225	4,356*
400	4,670	4,860*	
	1959		
	1st. Stage (6/3/59) lbs. dry matter/A	2nd. (6/11/59) lbs. dry matter/A	3rd. (6/21/59) lbs. dry matter/A
50	1,787	2,364	2,463
100	2,261	2,971	3,210
200	4,731	4,949	4,183*
400	5,190	5,698	4,109*

* Severe lodging.

stages of maturity, the yields of plots that had received the higher rates of nitrogen were considerably reduced by lodging. The extent of lodging was also influenced by rainfall. In 1959, lodging occurred in the third stages of maturity after two and one-half inches of rain fell within a

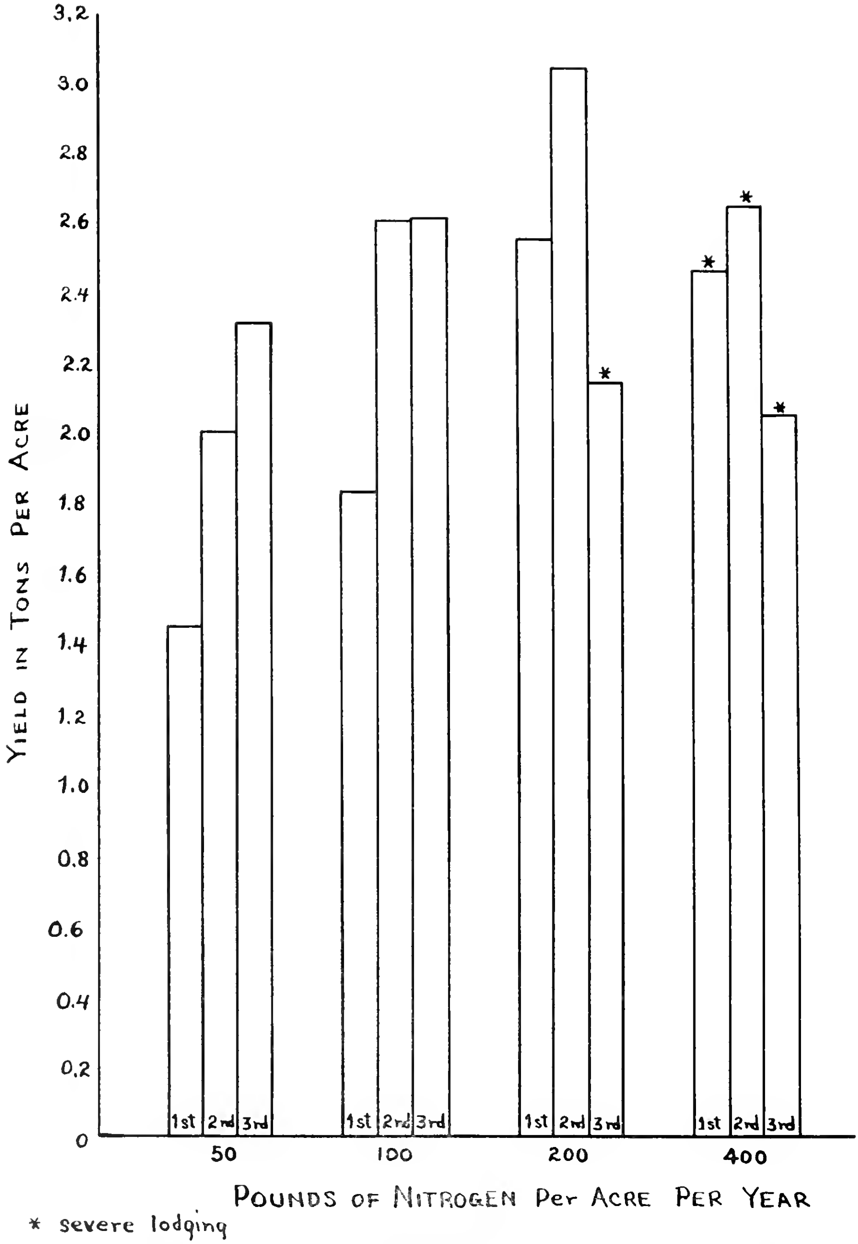

Figure 2.
Bromegrass Yields Averaged for 1957-59 at Three Stages of Maturity.

seven day period (see Table 3). The amount of phosphorus and potassium in the forage generally decreased as maturity increased (see Table 2). Calcium content was more variable and followed no consistent pattern.

Table 2. Three Year Comparison of P. K. Ca Content of Bromegrass

Forage Stage of Maturity and Nitrogen Rate Per Acre*	1957 Percent P	1957 Percent K	1957 Percent Ca	1958 Percent P	1958 Percent K	1958 Percent Ca	1959 Percent P	1959 Percent K	1959 Percent Ca
50 lb. nitrogen/acre									
Stage of maturity No. 1	.20	5.00	1.18	.26	4.23	1.18	.23	4.15	1.18
Stage of maturity No. 2	.14	3.90	1.19	.23	4.33	1.18	.20	3.98	1.32
Stage of maturity No. 3	.14	3.50	1.13	.25	4.88	1.30	.17	3.57	1.32
100 lb. nitrogen/acre									
Stage of maturity No. 1	.22	4.65	1.28	.23	4.73	1.30	.21	4.71	1.33
Stage of maturity No. 2	.15	4.20	1.20	.21	4.52	1.20	.18	3.93	1.33
Stage of maturity No. 3	.11	3.00	1.20	.16	3.80	1.25	.16	3.49	1.23
200 lb. nitrogen/acre									
Stage of maturity No. 1				.24	4.93	1.40	.19	4.83	1.26
Stage of maturity No. 2				.22	6.00	1.37	.18	4.00	1.32
Stage of maturity No. 3				.18	3.90	1.33	.13	3.20	1.14
400 lb. nitrogen/acre									
Stage of maturity No. 1				.28	5.90	1.23	.19	4.65	1.48

* Stage of maturity No. 1 cut about June 1.
Stage of maturity No. 2 cut about June 10.
Stage of maturity No. 3 cut about June 20.

Figure 3. Fifty Pounds of Nitrogen Per Acre.

Table 3. Weather Data for 1957-1959 Growing Seasons at Northwood, N. H.

Month	1957	1958	1959
	Rainfall (inches)		
April	2.22	5.63	3.32
May	2.70	2.60	0.81
June	1.95	1.78	4.93
July	3.50	3.56	2.47
August	1.41	1.67	3.73
	Temperature °F. Max., Min., Avg.		
April	79:21:48	80:29:48	74:21:48
May	84:28:57	86:30:53	90:30:60
June	93:42:68	86:37:60	94:39:62
July	93:47:69	91:50:69	91:46:71
August	89:44:66	86:45:69	94:41:69

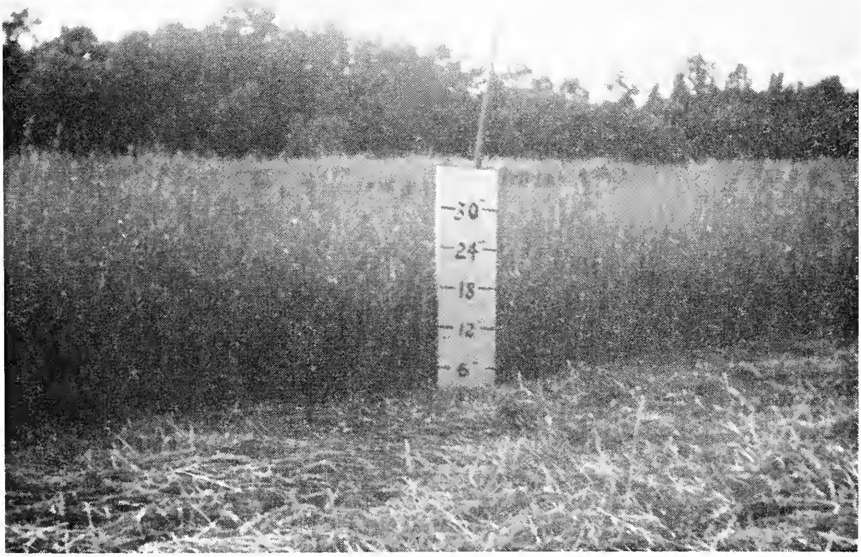

Figure 4. One Hundred Pounds of Nitrogen Per Acre.

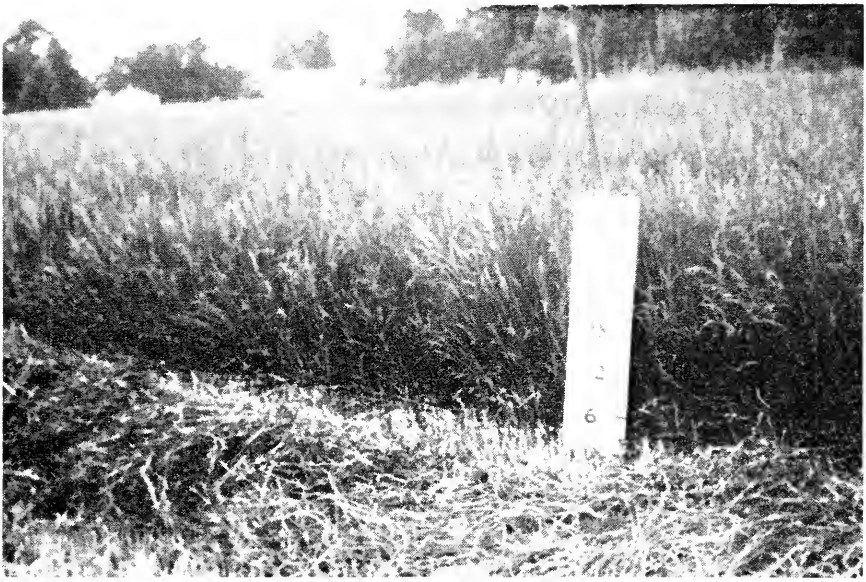

Figure 5. Two Hundred Pounds of Nitrogen Per Acre.

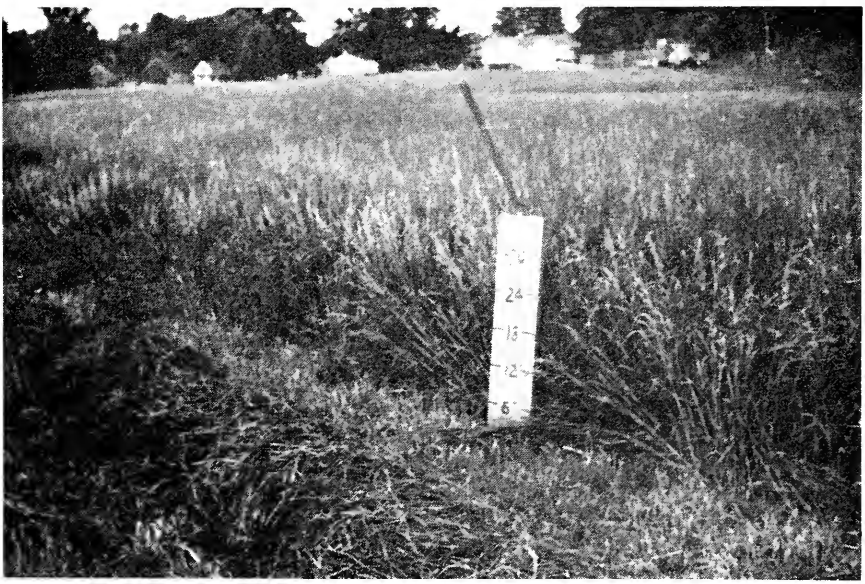

Figure 6. Four Hundred Pounds of Nitrogen Per Acre. Note Lodging.

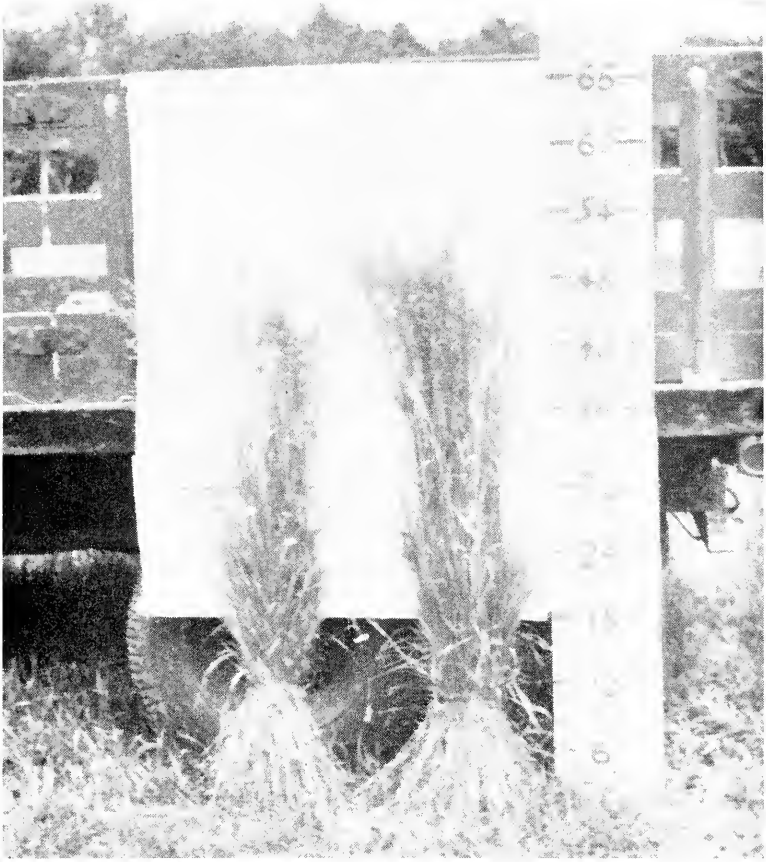

Figure 7. Fifty Pounds of Nitrogen Per Acre on the Left. One Hundred Pounds of Nitrogen on the Right.

Figure 8. Invasion of Red Clover in Bromegrass Plots Fertilized at the Rate of Fifty Pounds of Nitrogen Per Acre Per Year.

Conclusions

Yield: Bromegrass fertilized with high rates of nitrogen properly balanced with phosphorus and potassium produced the highest dry matter yield in the third stage of maturity. Nitrogen applied after the first cutting greatly increased the yield of the second cutting.

Fertilization: The best results were obtained where nitrogen was applied at the rate of seventy-five to one-hundred pounds per acre before the first cutting. After an early harvest (middle of June), fifty to seventy-five pounds of nitrogen per acre should be applied to encourage rapid growth of the second crop. Where the nitrogen carrier is acid and applied at a high rate, additional lime should be used. For, where a total of eight-hundred pounds of urea nitrogen was applied over a two year period the pH of the plots dropped from 6.2 to 5.5.

Persistency: Without sufficient phosphorus and potassium, high rates of nitrogen resulted in severe lodging and a reduction in persistency. At the low rates of nitrogen, the persistency of the stand was lowered by the invasion of red clover. Figure 8.

Protein: The protein content of bromegrass generally increased as the rate of nitrogen increased.

II. Effect of Different Levels of Nitrogen Fertilization and Dates of Harvest on Nutritive Value of Bromegrass Hay

Introduction

Economical milk production depends on maximum use of home-grown feeds. The northeast is mainly a forage-growing section and in order for dairying to remain profitable in this area it is necessary to continue to place more emphasis on maximum use of high quality forages grown in this section. In the last ten years the northeastern agricultural experiment stations have been concerned with extensive studies related to the breeding, persistency and nutritive evaluation of various forage crops adapted to this region. Because of the difficulty in holding stands of legumes in this area, the New Hampshire Agricultural Experiment Station has centered its attention on certain grasses which appear to have possibilities of yielding large crops of high quality feed, if fertilized sufficiently, managed properly and harvested at the right stage of maturity.

If a forage makes up a high percentage of the cow's ration, it must be high in feeding value, acceptable by the animal, and produce a high yield per acre.

Work done, at this station and elsewhere, clearly established that the early cutting of certain species of forage improves their nutritive value. The stage of growth in a forage greatly influences the acceptability of the forage by the animal. Early-cut forage is much more acceptable to the animal than late-cut. Protein content is also higher per unit weight when the forage is harvested early. Digestibilities of protein and energy, as determined by digestion experiments with dairy cattle, are significantly higher in early-cut forages as compared to the same forage when harvested at a later stage of maturity.

Recent research has also indicated that liberal use of fertilizer in the soil increases dry matter yield per acre. There is limited information on the effects of such practices on the nutritive value, yield per acre, and persistency of the species of forage.

To obtain answers to some of these questions, a cooperative study between the Dairy Science, Agronomy, and Biochemistry departments was undertaken. The over-all objectives of this cooperative effort were:

1. To study the effect of different levels of nitrogen fertilization and date of cutting on the nutritive value of forage.

2. To study the effect of the above conditions on the yield of nutrients per acre and also on the persistency of the species of the forage.

3. To determine the nutritive value of the forage crops on the basis of digestible dry matter, total digestible nutrients, digestible protein and digestible energy.

Review of Literature

Prince et al. (8) reported digestion experiments conducted in 1931 by Ritzman and associates to compare the nutritive value of timothy hay cut June 20 and July 20. The digestibility of protein decreased 15 per cent, the digestibility of energy decreased 12 per cent and the daily balance of energy decreased from 5510 Calories to 1280 Calories in the late cut hay. Each of the four animals received about 20 pounds of hay daily as the sole ration. Observations after each feeding revealed that the animals accepted the earlier-cut hay much more readily than they did the hay that was cut July 20. Hay cut about August 7 from another portion of the same field, showed a digestibility of 32 per cent in the protein, 49 per cent of energy, and the daily balance of energy about 1000 Calories which was an additional 17 percent decrease of the digestibility of the protein and a 6 per cent decrease in the energy balance.

Colovos et al. (3) 1949 compared the nutritive value and acceptability of timothy hay cut at different stages of maturity with clover hay. The results of this experiment showed a decrease in nutritive value similar to that in the experiment with timothy hay in 1931 at this Station. (8).

Poulton et al. (7) 1957 reported the effect of nitrogen fertilization at levels of 100, 200, and 400 lb. per acre on the nutritive evaluation of orchardgrass hay. The hays thus grown were compared to alfalfa hay. The conclusion was that the total digestible nutrients of the three orchardgrass hays were higher than the values found for alfalfa.

Nellin et al. (6) 1960 studied the effects of date of harvest on the nutritive value of timothy. Climax timothy grown under 100 pounds per acre of 10-10-10 fertilizer was harvested at eleven stages of maturity beginning May 27 and ending August 5. Delayed harvest decreased the digestible energy and total digestible nutrients of the forage materially until the first week in July after which the decrease was not as pronounced.

Browning et al. (1) 1960 reported that liberal nitrogen fertilization of Coastal Bermuda and Johnsongrass improved the feeding value and yield of the resulting hays.

Spahr et al. (12) 1960, noted that advancing stage of maturity of the forages tested resulted in lower daily milk production per cow and lower body weight gains when the forages were fed ad libitum as the only source of roughage.

Chalupa et al. (2) 1961, studied the nutritive value of reed canary grass hays grown with 0 lb., 100 lb., and 200 lb. nitrogen per acre and compared them to alfalfa.

Lloyd et al. (5) 1961, determined the effect of nutrient digestibility of timothy hay harvested at four stages of maturity and compared the nutritive value index of the hays. In general there was a decrease in the apparent digestibility of all fractions of timothy hay with increasing maturity.

Experimental

The nutritive evaluation of bromegrass hay grown under different levels of nitrogen fertilization was carried out over a three-year period.

1957 - 1958

The first hays. grown under two levels of nitrogen fertilization. 50 and 200 pounds per acre. were harvested at three stages of maturity during the Spring of 1957. The digestion balance experiments were run during the period of October 1957 and May 1958.

The animals used in this experiment were identical twin Holstein steers. These same animals were used throughout the three years' experimental period.

1958 - 1959

The bromegrass hays for this year's experiments were grown under four levels of nitrogen fertilization. 50 lb.. 100 lb.. 200 lb.. and 400 lb. per acre. and harvested at three stages of maturity June 4. June 13. and June 23. 1958. Due to severe lodging in the 400 lb. N acre. digestion balance experiments were run only on the June 4 cutting. The nutritive value of ten hays was determined during this year. Digestion balances were run during the period of September 1958 and June 1959.

A second cutting of the crop on all fertilizations was made on July 20. 1958 on representative plots to determine the total crop on each treatment but no digestion balances were obtained with the animals.

1959 - 1960

The experiment was repeated with the ten hays grown and harvested as in the previous years. A second cutting crop estimate was made on all fertilizations from representative plots harvested on July 20 as in the previous year. Digestion balances were run during the period of September 1959 and June 1960.

Procedures

The procedure and methods followed in this experiment differed very little from those used in previous research reported from this laboratory except in the method of the excreta collection. A brief description of the procedure and methods is presented below together with the changes made.

Feed

The hays were chopped and mixed thoroughly before they were transported into the laboratory in large burlap bags. The hays were fed to the animals twice a day at which time an aliquot sample was taken to composite it for analysis. A salt block was kept in front of each animal at all times. A preliminary period of 15-18 days was allowed before each digestion balance collection.

Collection periods were of 8 days duration. During the collection periods any refuse was carefully recovered. dried and compounded for analysis.

Gross energy determinations of the feed and refuse were made by the use of an adiabatic bomb calorimeter. Proximate analyses were made on both feed and refuse. The nitrogen and the energy in the refuse were sub-

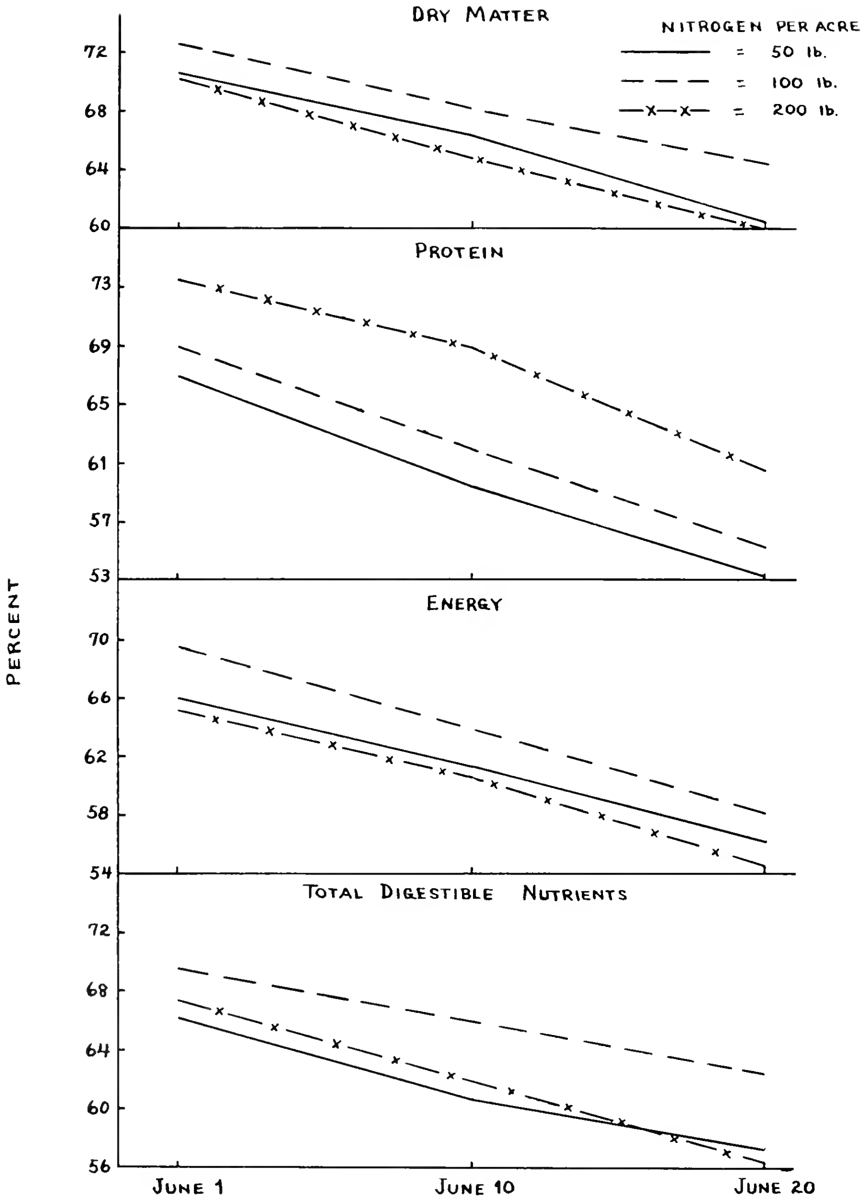

Figure 1.

Effect of Nitrogen Fertilization and Stage of Maturity on Digestibilities.

tracted from the amount fed in order to determine the protein and energy consumed by the animal and also obtain some of the data for the determination of the total digestible nutrients.

Excreta

Feces and urine from the steers were collected separately by means of collection devices developed at this laboratory (3). These consist of metal containers placed in the opening under the floor and directly in back of the metabolism stall to receive the feces when the animals defecate. Urine goes into stainless steel funnels which are in the center of each stall and covered by a grid, and is directed into a bottle in the basement. Both urine and feces are collected in the basement where the temperature is kept much cooler than the rest of the building.

Feces and urine were weighed and sampled daily. Composite samples of feces were kept at a temperature of approximately —16° C. while the composite samples of urine were stored at a temperature slightly above freezing. At these temperatures no preservative is necessary. At the end of the collection period, the feces samples were thawed, mixed thoroughly and an aliquot was taken for moisture, nitrogen and gross energy determinations. The remainder of the sample was spread in a shallow pan and dried in a forced hot air oven at a temperature of 55° C. and then ground in a Wiley mill. Gross energy was determined on the dry feces as well to check for any loss due to volatilization during the process of drying (8).

Urine samples were allowed to come to a temperature of about 20° C., and their specific gravity determined; they were analyzed for both nitrogen and gross energy. The urine samples used for the gross energy determinations were dried in the combustion capsules under vacuum.

Results and Discussion

The composition of the bromegrass hays grown under the levels of nitrogen fertilization of the experiment and harvested at the three stages of maturity are shown in Table 1. The letters E, M, and L before the numbers under the forage column denote early, medium, and late cuttings, or about June 1, 10, and 20 respectively. The number after each letter denotes the weight in pounds of nitrogen fertilization per acre.

The proximate analyses of the three years' crops differed little when compared on the basis of date of harvest. The protein, ether extract, and ash percentage composition decreased while the crude fiber and nitrogen-free extract increased as the harvest was delayed.

The protein content in the early-cut hays of the two higher fertilizations, 400 lb. and 200 lb. nitrogen per acre, ranged between 16 and 23 per cent. This is in agreement with other investigators (2) who found protein values in grasses as high as in legumes.

Digestibilities of dry matter, protein and energy, as well as the total digestible nutrients for the three years are shown in Table 2 and for comparison in Figure 1. Digestibilities decreased as the date of cutting was delayed. The decrease in the digestibilities of dry matter, protein, energy, and total digestible nutrients averaged about one half of one per cent per day of delay after the first of June.

The effect of nitrogen fertilization and date of cutting on the yield of digestible nutrients of bromegrass hay per acre is shown in Table 3. Yields of digestible protein and digestible energy per acre were higher in the early-cut hays when the comparison is made on the total yield, except in the case of digestible energy in the 1959-1960 hays. The reason for this is obviously the severe drought experienced during the growing season in 1959 that reduced the yield considerably.

Table 1. Effect of Nitrogen Fertilization and Stage of Maturity on the Chemical Composition of the Bromegrass Hays*

Stage of Maturity and Nitrogen Rate Per Acre	Ash	Protein	Ether Extract	Crude Fiber	Nitrogen-Free Extract
	Percent	Percent	Percent	Percent	Percent
50 lb. nitrogen/acre					
Stage of maturity No. 1	6.73	11.58	2.67	33.75	42.53
Stage of maturity No. 2	5.69	8.49	2.30	35.01	45.34
Stage of maturity No. 3	5.08	6.95	1.98	36.34	46.44
100 lb. nitrogen/acre					
Stage of maturity No. 1	6.05	11.71	2.95	34.38	44.36
Stage of maturity No. 2	6.39	9.28	2.47	37.49	43.97
Stage of maturity No. 3	4.81	7.49	2.02	36.86	49.38
200 lb. nitrogen/acre					
Stage of maturity No. 1	6.97	16.89	2.94	32.44	38.04
Stage of maturity No. 2	5.67	11.86	2.45	34.46	42.02
Stage of maturity No. 3	5.55	10.00	2.30	36.60	41.41
400 lb. nitrogen/acre					
Stage of maturity No. 1	7.02	21.12	3.37	30.25	37.51

* Percentages are expressed on dry basis.

Table 2. Effect of Nitrogen Fertilization and Stage of Maturity on the Digestibilities and Total Digestible Nutrients

Stage of Maturity and Nitrogen Rate Per Acre	Dry Matter	Protein	Energy	Total Digestible Nutrients
	Percent	Percent	Percent	Percent
50 lb. nitrogen/acre				
Stage of maturity No. 1	70.73	66.99	65.98	66.18
Stage of maturity No. 2	66.34	58.81	61.45	60.84
Stage of maturity No. 3	60.61	53.39	56.20	57.30
100 lb. nitrogen/acre				
Stage of maturity No. 1	72.60	69.05	69.55	69.58
Stage of maturity No. 2	68.23	61.93	64.04	65.84
Stage of maturity No. 3	64.63	55.55	60.30	62.60
200 lb. nitrogen/acre				
Stage of maturity No. 1	70.34	73.67	65.40	67.42
Stage of maturity No. 2	64.98	68.91	60.75	61.75
Stage of maturity No. 3	59.80	60.81	54.74	56.48
400 lb. nitrogen/acre				
Stage of maturity No. 1	71.67	76.78	68.83	69.24

Summary and Conclusions

Nutritive values of bromegrass hays grown under four levels of nitrogen fertilization and harvested at three stages of maturity were determined with identical twin steers.

Nutritive evaluation was made on the basis of digestible dry matter, digestible protein, total digestible nutrients, and digestible energy.

The experiment was repeated for three years to study the uniformity and persistency of the crop on the basis of nutrient yield per acre.

The level of nitrogen fertilization did not affect the digestibilities of the dry matter, the carbohydrate portion, nor the energy of the forage to a great extent. The digestibility of the protein, however, increased with the level of nitrogen fertilization. There was no appreciable effect on the total digestible nutrient content of the hays due to the level of nitrogen fertilization.

Advancing stage of maturity decreased the digestibilities of all the ingredients of the bromegrass hays, confirming previous results at this Station with timothy hay.

The results showed that early-cut bromegrass hay grown under a 200 pound nitrogen fertilization per acre was as good a protein source as legume hay.

The results further showed that while the late-cut bromegrass hay increased the yield of dry matter per acre, and consequently the digestible energy by about 10 per cent, the digestible protein content decreased by more than 30 per cent.

Table 3. Effect of Nitrogen Fertilization and Date of Cutting on Yield of Digestible Nutrients Per Acre of Bromegrass Hay

Stage of Maturity and Nitrogen Rate Per Acre	Digestible Dry Matter			Digestible Protein			Digestible Energy			T D N		
	1957-58	1958-59	1959-60	1957-58	1958-59	1959-60	1957-58	1958-59	1959-60	1957-58	1958-59	1959-60
	lb.	lb.	lb.	lb.	lb.	lb.	Therms.	Therms.	Therms.	lb.	lb.	lb.
50 lb. N/acre												
Stage No. 1	2399‡	2418	1321	315‡	263	136	4423‡	4572	2706	2130‡	2248	1275
		1163†	1151†		127†	119†		2209†	2353†		1082†	1111†
Stage No. 2	3164	3207	1620	302	241	121	5709	6091	3212	2755	3075	1493
Stage No. 3	3173	3659	1611	274	218	98	7410	7151	3206	2680	3625	1553
100 lb. N/acre												
Stage No. 1		3218	1736		381	182		6288	3584		3029	1682
		1598†	2424†		189†	254†		3120†	5018†		1504†	2348†
Stage No. 2		4420	2074		394	164		8356	4246		4183	2021
Stage No. 3		3758	2139		241	138		7206	4254		3621	2070
200 lb. N/acre												
Stage No. 1	2911‡	3641	3444	552‡	734	529	5571‡	6889	6830	2606‡	3488	3293
		1895†	2788†		381†	429†		2345†	5514†		1815†	2665†
Stage No. 2	3830	4753	3266	508	443	393	7097	9070	6733	3348	4517	3345
Stage No. 3	3727	2699*	2516*	392	345	213	6887	5553	5147	3128	2554	2464
400 lb. N/acre												
Stage No. 1		3330*	3738		824	767		6330	7511		3180	3653
		4073†	2380†		1005†	592†		7768†	5800†		3890†	2816†

* Severe lodging.
† Aftermath cutting.
‡ No record of aftermath.

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