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MANAGEMENT and PRODUCTIVITY of PERENNIAL GRASSES in the NORTHEAST
IV. TIMOTHY

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Management and Productivity of Perennial Grasses in the Northeast: IV. Timothy

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Contents

Preface

This publication describes experiments conducted by several experiment stations in the Northeastern Region of the United States, under the auspices of Northeastern Regional Technical Committee NE 29. C. S. Brown, Maine Agricultural Experiment Station; G. A. Jung, West Virginia Agricultural Experiment Station; K. E. Varney, Vermont Agricultural Experiment Station; R. C. Wakefield, Rhode Island Agricultural Experiment Station; and J. B. Washko, Pennsylvania Agricultural Experiment Station were responsible for the collection, statistical analyses, and interpretation of data. A manuscript was then prepared from these station summaries by C. S. Brown. Preparation and organization of the final manuscript was the responsibility of G. A. Jung.

The authors gratefully acknowledge the contributions of Prof. B. A. Brown, Connecticut, Storrs, Agricultural Experiment Station, and Drs. W. K. Kennedy and M. R. Teel, New York, Cornell University Agricultural Experiment Station, who assisted with the planning of the experiments; of Dr. V. G. Sprague, U. S. Regional Pasture Research Laboratory, who assembled the weather data; and of Dr. R. L. Reid, West Virginia Agricultural Experiment Station, who performed the nutritive evaluations.

Summary

Experiments were conducted in five Northeastern states to test the effects of harvesting at several stages of growth, fertilizing with nitrogen at two rates, and cutting the aftermath at two heights on yield, persistence, and forage quality of timothy.

1. Total yields exceeded 4 tons per acre of weed-free dry matter at every location during a relatively cool and wet season. Only under extreme drought did timothy yield less than 3 tons per acre when adequately fertilized. Total yields of dry matter were generally highest when the first crop was harvested at a late bloom stage.

2. Harvesting the crop at early head instead of at bloom stages of growth resulted in a sacrifice of 1 ton of dry matter in the first crop and there was little or no increase in aftermath production to compensate for this loss. First harvests at the early head stage of growth or later usually exceeded 2 tons per acre and represented approximately 75 per cent of the total yield. Maturation of timothy occurred at a relatively slow rate which resulted in the harvest of hay crops in late spring or early summer.

3. Aftermath yields rarely exceeded 1.5 tons per acre. Aftermath yields over three seasons averaged 1 ton per acre at the high rate of nitrogen and 0.5 ton per acre at the low rate of nitrogen.

4. Timothy was found to be relatively intolerant of harvesting during jointing (stem elongation). In one instance a stand was severely injured even when the first harvest was taken at the early head stage of growth. Partial recovery of severely injured timothy stands occurred following a lenient harvest schedule. Persistence was good when harvesting of the spring crop was delayed until full head or later.

5. Increasing the rate of nitrogen from 100-150 pounds per acre to 300-450 pounds per acre increased dry matter production an average of 25 per cent over the three-year period, but it also increased lodging and thinning of stands. Stand losses were greatest when a high rate of nitrogen fertilizer was coupled with early harvesting of the spring crop.

6. Consistent decreases in dry matter digestibility were associated with delayed harvesting of the spring crop. Average values ranged from 81 per cent digestible dry matter at a pre-joint stage of growth to 56 per cent at a past bloom stage.

7. Considering quantity and quality of forage and stand persistence, it is recommended that the spring crop of timothy should be harvested between the 50 per cent and full-head growth stages (5-10 days after early head emergence).

Management and Productivity of Perennial Grasses in the Northeast: IV. Timothy

REGIONAL RESEARCH STUDIES ON THE management of timothy (**Phleum pratense** L.) were initiated in the northeastern United States in 1949 and have continued during the intervening years. The first study (36) included an evaluation of the productivity of several varieties of timothy when grown alone as compared with their growth in association with ladino and red clover. In a subsequent experiment (37), the seeding year management of timothy-trefoil mixtures was studied cooperatively at six state agricultural experiment stations.

The investigations reported here represent the first management study of pure timothy stands on a regional basis in the Northeast. Cutting systems and nitrogen fertilizer levels were used to study the growth, energy reserves, and persistence of timothy. Increasing emphasis on earlier harvesting for improved forage quality, along with the general use of higher rates of fertilizer nitrogen, prompted this regional effort.

This bulletin presents experimental results from five state agricultural experiment stations (Maine, Pennsylvania, Rhode Island, Vermont, and West Virginia). At each station, pure stands of Climax timothy were subjected to nearly identical management treatments for either two or three years. Similar experiments were conducted simultaneously with reed canarygrass, bromegrass, and orchardgrass by the same regional technical committee (NE 29), and have been reported in regional publications (38-40).

LITERATURE REVIEW

Timothy (**Phleum pratense** L.) is a perennial, cool-season grass widely used throughout the northeastern United States. Surveys of seed usage during the past decade have documented the outstanding popularity of timothy (42). Currently, seed shipments of timothy in nearly every state of the Northeast greatly exceed the combined total of all other perennial forage grasses. Timothy has been relatively more popular in the northern half of the region because of its natural adaptation to cool, moist conditions. Its shallow root system (25) and sensitivity to high temperatures (3, 4, 60) have limited its productivity to some extent in southern areas of the region.

The literature concerning timothy management is voluminous. In this review, primary emphasis will be placed on the effects of cutting management and of nitrogen fertilization on yield, persistence, and nutritive value.

Growth Habit and Food Reserves

The spring crop of timothy passes successively through the typical stages of tillering, jointing, heading, flowering, and seed formation. Flowering heads are commonly produced in the summer aftermath, in contrast to most northern grasses in which heading and flowering are restricted to the primary tillers of the spring crop (57). Evans and Grover (13) concluded that rudimentary tillers of timothy develop vegetatively under short days, whereas they undergo reproductive development under long days. They also pointed out that flowering and seed maturation progress from the apex toward the base of the inflorescense, whereas tiller formation developed from the base towards the apex of the tiller.

Timothy is a typical hay-type plant, with relatively few basal leaves below normal grazing height. It is a shallow-rooted bunchgrass devoid of either rhizomes or stolons. Its unique structure is a haplocorm (12, 35) which forms at the base of the stem below ground, resulting from a bulbous enlargement of one or two basal internodes. The "corm," as it is commonly known, serves as the primary storage organ for organic food reserves which undergo cyclic accumulation and depletion during the growing season (17, 23, 35, 50, 54).

Vegetative reproduction of timothy occurs with the production of new shoots or tillers from buds commonly located at the basal node just below the corm (12). One or two tillers usually arise from a single corm, but exceptionally vigorous corms may support as many as four to six tillers (66). Individual tillers are relatively short-lived, rarely surviving longer than a single season. Detailed studies of tillering and leaf development of timothy have been undertaken by Langer (28-31), Peters (43), Lambert (26, 27), and Sheard (55).

The development and function of the corm have been studied for many years. In the early 1900's, Missouri studies (64, 66) showed that corms developed rapidly between heading and seed stages. Later studies by Evans **et al.** (14) and Knoblauch **et al.** (23) indicated that considerable (as much as 100 per cent) increase in the weight of timothy corms occurred between early head and full bloom.

The chemical nature of the food reserves of timothy corms has been extensively studied. In 1940 Archbold (2) published a review emphasizing the importance of the fructosans as reserve carbohydrates of grasses. Harper and Phillips (17) noted a large accumulation of fructosan in the corms of timothy, in contrast to its minor occurrence in other parts of the plant. In their studies, fructosan content increased rapidly with advancing maturity and constituted approximately 50 per cent of the dry weight of the corms at the blooming stage. Reserve carbohydrate content in the stem bases of timothy has been reported by Reynolds and Smith (50) at Wisconsin to reach a maximum content between the flowering and seed stage of growth. Smith and co-workers (16, 41, 58, 59, 61) also found fructosan to be the largest single reserve food, comprising over three-fourths of the total available carbohydrates in the stem bases. The fructosans of timothy were found to be relatively long-chained in comparison to those of bromegrass.

Harvest Management Effects on Yield and Persistence

Numerous experiments have shown timothy to be relatively intolerant of close, and/or frequent defoliation (5, 15, 20, 31, 43, 51, 53, 56). The consistently reduced yields, decreased size and number of corms, and declining vigor of stands support the general conclusion that timothy is not a good pasture species, **i. e.** it is intolerant of frequent grazing.

The effects of spring harvest timing on the yield and vigor of timothy have been studied repeatedly, but variable results have been reported. Relatively little research has been reported on the effects of harvesting timothy at a purely vegetative stage in the spring. Teel's study (63) with smooth bromegrass showed that a harvest made during the jointing stage was actually more injurious than a harvest made earlier in the season prior to stem elongation. Sheard and Winch (56) also reported timothy and bromegrass to be relatively tolerant of a pre-joint harvest in mid-May but adversely affected by harvesting at the jointing stage in early June. Studies in northern Wisconsin (53) indicated that timothy was less persistent than bromegrass or orchardgrass when these grasses were managed under conditions simulating pasturing. A detailed comparison of the effects of harvesting at the jointing and full head stages by Langer (31) showed that total yields for the season were sharply reduced by the earlier harvest, whereas aftermath tillering and growth rates were increased. He concluded that the delayed harvest resulted in more complete defoliation because the older basal leaves had become senescent by the time timothy reached the full head stage. On the other hand, Waters (66) and Evans **et al.** (14) found that harvesting at the early heading stage, instead of delaying harvesting until the bloom or seed stages, resulted in a reduction in plant vigor as well as crop yields. In a five-year study, Bird (5) found that harvesting at early head reduced first crop yields 25 per cent compared to harvesting at bloom stages; however, total yields for the season were reduced only 10 per cent. He noted that bromegrass was more adversely affected by harvesting at early head than was timothy. Similarly, Knoblauch **et al.** (23) noted that harvesting at early head for a period of four years severely reduced timothy yields and stands, compared with harvesting at either early or late bloom.

Nitrogen Fertilization Effects on Yield and Persistence

The yield response of timothy to nitrogen fertilization has been studied at various locations in the Northeast (1, 6, 11, 22, 34). Timothy has proven responsive to fertilizer nitrogen whenever the legume content of the sod has been at a low level. Split applications of 100 pounds of N annually have resulted in typical yield increases of 1.3 to 1.5 tons of dry matter per acre. In northern Wisconsin timothy yields were higher than those of bromegrass or orchardgrass without nitrogen fertilizer, whereas this was not so when the grasses were fertilized with nitrogen (53).

Studies by Langer (30), Lambert (26), and Ryle (52) have contributed to a more precise knowledge of the effect of nitrogen on shoot growth. Nitrogen fertilization resulted in increased leaf area, largely by means of increased tillering and increased leaf size. Rate of nitrogen fertilization had relatively little effect on the number of leaves per tiller.

The effect of nitrogen fertilization on stand persistence of timothy has not been as clearly defined. The desirable effects of a moderately high nitrogen supply on the stubble and root growth of timothy were noted by MacLeod (33) and Sheard (55). However, deleterious effects of excessive rates of nitrogen have been observed under conditions of plant stress. The adverse effects of close, frequent cutting were reported by Peters (43) to be more pronounced at higher levels of topdressed nitrogen. In addition, Smith and Jewiss (60) found that high nitrogen also intensified the undesirable effects of high temperature on aftermath recovery of timothy. Recent research with timothy (vegetative growth stage) at West Virginia (3, 4) has shown that a high level of nitrogen may reduce the storage of reserves and increase plant injury from high temperatures and drought.

Nutritive Value

It is well recognized that the digestibility of forages by ruminant animals declines with advancing maturity. Coordinated studies of this relationship have been conducted during the past decade by animal nutritionists of a Northeast Regional Technical Committee (NE 24).

In New York studies, Reid **et al.** (47) concluded that the dry matter digestibility of first crop forages declined at a daily rate of approximately 0.5 per cent. Poulton **et. al.** (45) obtained similar results in a study of Climax timothy in Maine, with dry matter digestibility declining from 82 per cent on May 27 to 52 per cent on July 22. In a three-year New Hampshire study, Colovos **et al.** (9) found that the dry matter digestibility of common timothy declined from an average value of 73 per cent on June 1 to 60 per cent on June 30. Calder and MacLeod (7) reported similar decreases in the digestibility of forages as time of first harvest was delayed, but they also noted that the decline in digestibility of timothy was less than that of orchardgrass and greater than that of bromegrass. In an earlier study, Colovos **et al.** (8) made a comparison of the nutritive value of first crop timothy hay cut at several stages of maturity and fed to dairy heifers. The digestible energy of timothy cut at early head (June 21) was 64 per cent, as compared with 55 per cent for early bloom (July 5) and 50 per cent for the seed stage (July 25).

Numerous studies have been made of the chemical composition of first crop timothy at different stages of maturity (18, 44, 64, 65). A consistent decline in crude protein and a gradual increase in lignin content are usually associated with advancing maturity. Lloyd **et al.** (32) found the lignin content to increase from approximately 5 per cent of the dry matter at early bloom to 10 per cent at past bloom. During this same period, dry matter digestibility declined from 65 per cent to 48 per cent. Phillips **et al.** (44) studied eight northern grasses, including timothy, and noted rapid increases in lignin content in all species between the early head and seed stages. Steppler (62) made microscopic studies of the natural process of stem lignification occurring during the maturation of first crop timothy in Quebec. He found that lignification increased steadily from the early head stage to full bloom, and that the upper internodes became lignified more rapidly than the basal portion of the stem.

A rapid decline in leaf content with advancing maturity is closely associated with the decreasing digestibility of timothy hay. In Ohio studies, Hosterman and Hall (18) found that the leaf blades and sheaths combined constituted over 60 per cent of the total dry weight of timothy at full head but constituted only 36 per cent of the dry weight at full bloom. The lower protein content associated with delayed harvest resulted largely from changes in the leaf-stem ratio, rather than from large changes in protein content of either leaves or stems. In Scotland, Waite and Sastry (65) noted a similar decline in the leaf-stem ratio and protein content with advancing maturity. However, in their studies the protein content of both leaves and stems continued to decline through the flowering stages. In Canada, Pritchard **et al.** (46) conducted **in vitro** studies of the digestibility of timothy leaves and stems at several stages of growth, and observed a more rapid decline in the digestibility of the stem fraction. However, the stem was the most digestible part during the early growth stages.

The acceptability (voluntary intake) of forages by ruminant animals is considered to be very important in evaluating the nutritive value of forages (48). Moreover, it is widely accepted that the voluntary intake of first crop hay generally declines with advancing maturity (47). Colovos **et al.** (9) has noted the superior palatability of timothy hay cut at early head, in contrast to timothy hay harvested at the early bloom and seed stages. Dry matter intake of timothy by sheep was reported by Lloyd **et al.** (32) to decline 30 per cent between the early bloom and past bloom stages. However, the acceptability of timothy forage by sheep in West Virginia studies (49) was poorly correlated (+.57) with digestibility of dry matter.

The effect of nitrogen fertilization on the nutritive value of grass hays has been a subject of recent regional research in the Northeast. Woelfel and Poulton (67) found that abnormally high rates of nitrogen resulted in a small reduction in the digestibility of the nitrogen-free extract of aftermath timothy, but that the digestibility of crude protein was increased. In a three-year study of first crop timothy forage, Colovos **et al.** (9) also noted a significant increase in protein digestibility associated with higher levels of applied nitrogen. As one might predict, in virtually every study of this type, nitrogen fertization has resulted in significant increases in crude protein content of grass forage. In British studies, Jones **et al.** (19) reported that nitrogen depressed the soluble carbohydrate content in timothy, perennial ryegrass, and orchardgrass. The magnitude of the effect depended upon time of application, amount of fertilizer, and date of sampling. Several rates of nitrogen and potassium had no apparent effect on the **in vitro** digestibility of timothy, bromegrass, or orchardgrass according to Canadian investigators (7).

The literature reviewed here indicates an apparent conflict in optimum harvest stage for forage quality in contrast to yield and stand survival. Continued research is needed to elucidate the effects of climatic, nutritional, and genetic factors which may modify plant response to harvest management.

MATERIALS AND METHODS

Experiments were conducted simultaneously at five agricultural experiment stations—Maine, Pennsylvania, Rhode Island, Vermont, and West Virginia. At each station the experiment was located on a well-drained or moderately well-drained soil of medium to high fertility. Common soil treatment practices were followed at each location to promote vigorous grass growth and minimize weed competition. Suitable herbicides were used where needed to eradicate volunteer grasses in advance of seeding and to control broadleaf weeds annually throughout the study. Prior to seeding, the soil was limed to pH 6.5 or above and fertilizer applications of 80 pounds N, 70 pounds of P, and 133 pounds of K were made. During the subsequent harvest years (1960-1962) a high level of minerals was maintained by the application of 66 pounds of P and 240 pounds of K annually, with half applied in mid-summer and half after the last fall harvest.

Pure seedings of Climax timothy were made in early spring 1959 at all locations. Unusual spring drought necessitated reseeding or overseeding later in the season at four of the five locations (Table 1). Vigorous stands were obtained by spring 1960 at all locations other than Vermont, and defoliation and nitrogen fertilization treatments were initiated at that time. Experimental treatments were delayed until the 1961 season at Vermont.

TABLE 1

Site Description and Seeding Dates

Location	Elevation (ft.)	Latitude	Growing Degree Days*	Soil Type	Seeding Date (1959)
Orono, Maine	182	44° 52′	3657	Buxton silt loam	May 13 Reseeded July 8
Burlington, Vermont	331	44° 28′	3714	Hadley fine sandy loam	May 7 Reseeded Sept. 23
Kingston, Rhode Island	100	41° 29′	3849	Bridgehampton silt loam	May 7 Overseeded Sept. 2
Centre Hall, Pennsylvania	1175	40° 48′	4366	Hagerstown silt loam	April 23
Morgantown, West Virginia	1240	39° 39′	5060	Cavode silt loam	May 15 Overseeded Sept. 10

*March 1 to September 26 with base of 40°F. (10).

Stage at First Harvest

One objective of the experiment was to determine the response of timothy to early and deferred defoliation at specific maturity stages of the spring crop. The following four harvest stages were studied, using plants fertilized at the high rate of nitrogen as reference plants: (a) **pre-joint** — plants in an advanced tillering stage, with most stem primordia beginning to emerge but still below the 2 1/2-inch cutting height; (b) **early head** — heads beginning to emerge on not more than 10 per cent of the plant stems; (c) **early bloom** — anthers visible on not more than 10 per cent of the heads; (d) **past bloom** — two weeks after the early bloom harvest date. Dates of first and subsequent harvests at each location are given in Appendix Table 1.

Aftermath Management

Two stubble heights, 1 1/2 and 3 1/2 inches, were used in each of the four harvest stage treatments. These differential heights were left at the second harvest of all plots, except those first cut at the pre-joint stage. This latter group was differentially cut at the third harvest. The differential height cuttings were made when the growing points of most aftermath tillers were between 1 and 3 inches above the soil surface. Thus the 1 1/2-inch cut removed most growing points, whereas the 3 1/2-inch cut retained them for continued plant growth. All subsequent aftermath crops were cut to a stubble height of 2 1/2 inches and were cut when plants of the high nitrogen plots were at a late joint or retillering stage. Aftermath cutting was rarely delayed longer than six weeks, regardless of grass stage. The final seasonal harvests for all plots were taken on a common date in early fall, approximating the long-term average date of killing frost for the area.

Nitrogen Fertilization

Two rates of nitrogen fertilization were imposed on each of the harvest stage and stubble height treatments. A so-called "low" rate of nitrogen was established at 100 pounds of N per acre in split applications in 1960, and subsequently modified to 25 pounds of N per acre applied in the spring and after each cutting. The "high" rate of nitrogen supplied a total of 300 pounds of N per acre in split applications in 1960, but was modified in 1961 and 1962 to 75 pounds of N per acre applied in spring and after each harvest, except following the final fall harvest when only 25 pounds were applied.

The experimental design was a randomized complete block with three replications. Individual plot size was a minimum of 6 by 20 feet. Larger plots were utilized at Rhode Island to permit periodic sampling of subplot areas for dark chamber studies of regrowth potential.

Dry matter yields of weed-free timothy forage were determined for each harvest. Botanical separations were made by hand whenever necessitated by weed ingress. Stand survival was assessed each spring by visual estimates of the percentage of soil surface covered by basal plant area.

Residual effects of treatments, repeated for three harvest years, were measured by cutting all plots on a common first crop date in 1963. A uniform application of nitrogen was applied on all plots in early spring of this residual harvest year.

Supplementary studies were conducted at Rhode Island to evaluate food reserves and regrowth potential following differential management of the spring crop. Core samples of sod 4 inches in diameter were taken from sub-plot areas soon after first crop harvest, uniformly clipped and potted, and then placed in a dark chamber maintained at 70 F. These sod cores were supplied nitrogen in the form of NH_4NO_3 and maintained in a moistened state for approximately two months. Etiolated regrowth was measured by harvests repeated about every two weeks until recovery growth had ceased.

Supplementary studies of the apparent digestibility of selected forages were conducted at West Virginia, using samples from the 1961 harvests at West Virginia and from the 1962 harvests at Maine. An **in vitro** technique, described by Jung **et al.** (21), was used to determine digestible dry matter and digestible protein content.

Microclimatic records were maintained at each station. Continuous recordings of air temperatures at a 3-inch height and soil temperatures at a 4-inch depth were made. Rainfall was recorded and periodic readings of available soil moisture were made, using Bouyoucos blocks placed at several depths down to 12 inches.

Weather conditions were highly variable throughout the region during the three-year study. Each year one or more stations experienced moderate to severe drought by early summer, while at some other stations cool temperatures and above normal rainfall favored aftermath production. In general, it can be said that a representative sampling of expected long-term variations in weather was obtained by conducting the study at widely separated locations throughout the Northeast region.

EXPERIMENTAL RESULTS

First Harvest Yields

A comparison of spring harvest dates (Appendix Table 1) shows that the maturation of first crop timothy occurred over a narrow range of calendar dates throughout the Northeast region. As a three-year average, the early heading stage of growth ranged from June 7 at West Virginia to June 18 at Maine. The corresponding dates of early bloom were June 19 and July 4.

The pattern of dry matter accumulation with advancing maturity was quite similar at the several stations. A comparison of two-year means at five locations (Figure 1) shows that the yields at pre-joint and early head were approximately 20 and 70 per cent, respectively, of those at early bloom. The relatively high yields for the early head harvest at West Virginia were associated with stand injury (discussed later). Yields increased 10 to 15 per cent between early bloom and past bloom, except at Maine where lodging occurred with delayed harvest. The small year-to-year variation in relative dry matter production at the several growth stages is illustrated by Maine data in Table 2.

TABLE 2

First Crop Yields of Timothy at Maine

Stage at Harvest	Relative Yields (Per Cent) 1960	1961	1962	3-Year Average
Pre-joint	25	25	20	23
Early head	72	68	68	69
Early bloom[1]	100	100	100	100
Past bloom	99	95	95	96

[1]Dry matter yields at early bloom were 3.2, 3.5, 2.6 tons in 1960, 1961, 1962, respectively.

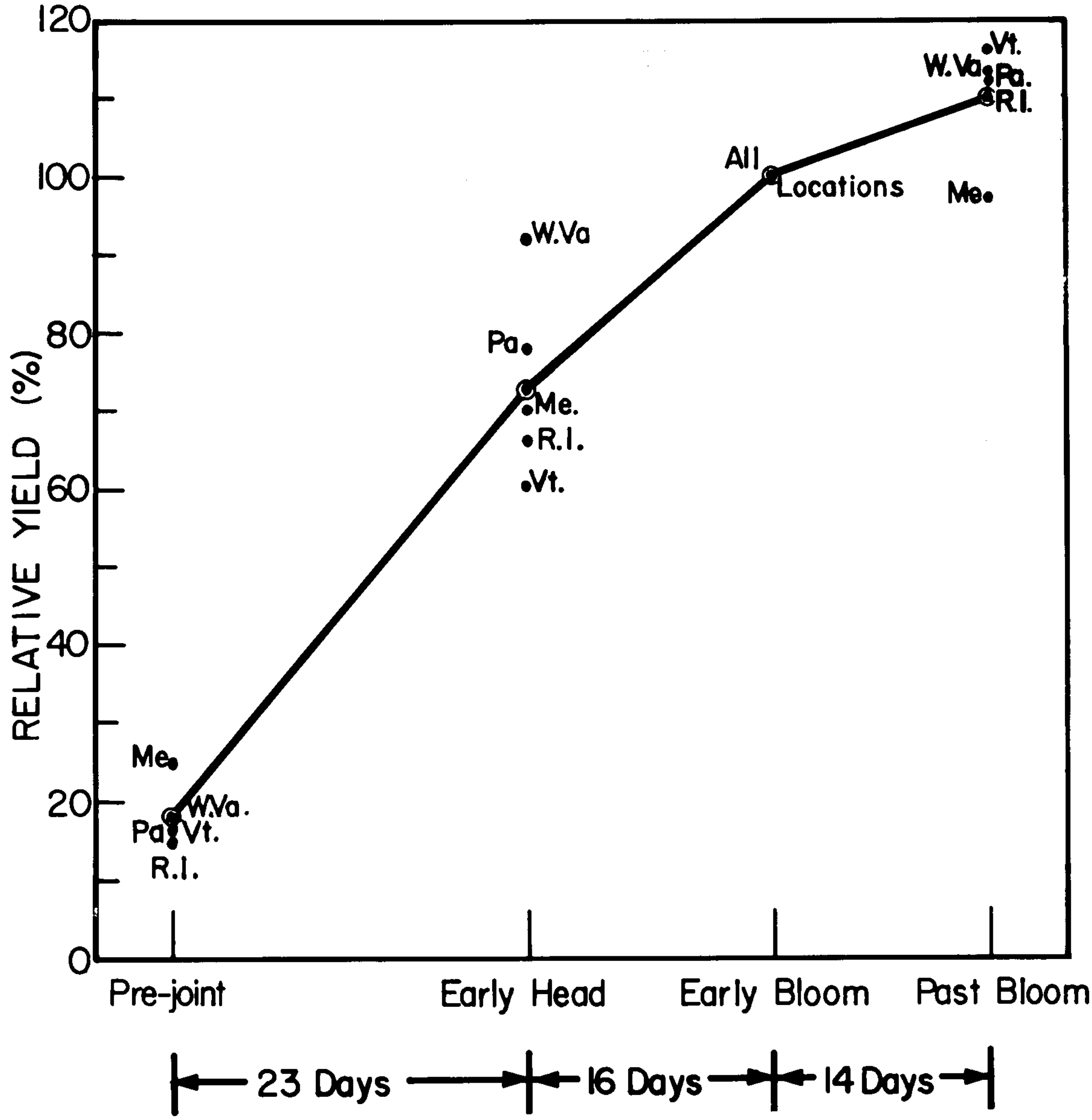


Figure 1. *Dry matter production of Climax timothy at four stages of growth during the spring and early summer of both* 1960 *and* 1961.

Total Seasonal Yields

Total yields of weed-free dry matter were generally highest whenever first harvests of timothy were made at early bloom or past bloom (Tables 3, 4, and 5). Harvesting at the past bloom stage of growth usually resulted in somewhat higher total yields than harvesting at early bloom, except at Maine where lodging of late-harvested first crop occurred. Seasonal yields of dry matter under the early bloom harvest system ranged from 1.4 to 5.4 tons per acre over the three years of study. The average yield under this schedule (Appendix Table 5) was 3.5 tons.

TABLE 3

Dry Matter Produced by Climax Timothy in the First Harvest Year*

Stage at First Harvest	N	Aftermath Cut	Total Yield T/A					Aftermath Yield T/A				
			Me.	Vt.	R.I.	Pa.	W.Va.	Me.	Vt.	R.I.	Pa.	W.Va.
Pre-joint	High	High	3.34a-d[1]	2.41f-i	1.42f	3.60cd	2.44a-d	0.59c-f	0.39cd	0.24bcd	1.10e	1.18a
	High	Low	3.62abc	2.57fg	1.37f	4.08bc	2.52a-d	0.62cde	0.49bc	0.31bcd	1.21cde	1.01abc
	Low	High	2.97cd	2.08i	0.87g	2.60ef	1.87de	0.37efg	0.40cd	0.12d	0.38g	0.88a-d
	Low	Low	2.90d	2.15hi	0.83g	2.81def	1.68e	0.41efg	0.33cd	0.12d	0.40g	0.68cd
Early head	High	High	3.38a-d	2.49fgh	2.77bc	3.49cd	2.36bcd	1.10a	0.15d	0.54abc	1.15de	1.06ab
	High	Low	3.36a-d	2.70f	2.93b	4.03bc	2.55abc	1.07ab	0.35cd	0.71a	1.44bcd	1.07ab
	Low	High	3.12bcd	2.49fgh	1.37f	2.05f	2.13b-e	0.78a-d	0.45bcd	0.13d	0.46fg	0.92abc
	Low	Low	2.98cd	2.25ghi	1.57f	2.51ef	1.96cde	0.76bcd	0.30cd	0.22cd	0.69fg	1.08ab
Early bloom	High	High	4.02a	4.02cd	3.95a	4.96a	2.79ab	0.81a-d	0.61abc	0.50a-d	1.77a	1.09ab
	High	Low	3.91a	4.54ab	3.99a	4.55ab	2.56abc	0.88abc	0.54abc	0.72a	1.59ab	1.00abc
	Low	High	3.72ab	3.62e	2.03e	2.87def	2.26b-e	0.52def	0.39cd	0.19cd	0.77f	1.00abc
	Low	Low	3.97a	3.72de	2.09de	2.89def	1.99cde	0.66cde	0.36cd	0.26bcd	0.61fg	0.88a-d
Past bloom	High	High	3.45a-d	4.73a	4.23a	5.14a	2.58abc	0.37efg	0.85a	0.70a	1.58ab	0.79bcd
	High	Low	3.40a-d	4.68a	4.23a	4.50ab	3.04a	0.52def	0.72ab	0.60ab	1.46bc	0.97abc
	Low	High	3.38a-d	4.36abc	2.55bcd	3.03def	2.14b-e	0.12g	0.56abc	0.18cd	0.40g	0.56d
	Low	Low	3.65abc	4.26bc	2.32cde	3.05de	2.22b-e	0.29fg	0.37cd	0.15d	0.50fg	0.87a-d
Averages:												
PJ			3.30s	2.30u	1.12u	3.27s	2.13s	0.50st	0.40st	0.20s	0.77t	0.94rs
EH			3.21s	3.48t	2.16t	3.02s	2.25rs	0.93r	0.31t	0.40r	0.94s	1.03r
EB			3.90r	3.97s	3.01s	3.82r	2.40rs	0.72rs	0.48s	0.42r	1.18r	0.99r
PB			3.47rs	4.51r	3.33r	3.93r	2.50r	0.32t	0.63r	0.41r	0.96s	0.80s
	High		3.56w	3.52w	3.11w	4.29w	2.61w	0.74w	0.51w	0.54w	1.27w	1.02w
	Low		3.34x	3.12x	1.70x	2.73x	2.03x	0.49x	0.39x	0.17x	0.66x	0.86x
		High	3.42y	3.27y	2.40y	3.47y	2.32y	0.58y	0.48y	0.32y	1.07y	0.94y
		Low	3.47y	3.36y	2.42y	3.55y	2.32y	0.52y	0.43y	0.39y	0.86y	0.95y
	C. V.%		10.5	5.6	11.3	13.0	14.4	26.7	34.8	56.6	17.6	18.9

*Vermont 1961, other stations 1960

[1]Values having the same letter are from the same statistical population at the 5 per cent level of significance. Comparisons may be made within each column. a-d includes a, b, c, and d.

TABLE 4

Dry Matter Produced by Climax Timothy in the Second Harvest Year*

Stage at First Harvest	N	After-math Cut	Total Yield T/A					Aftermath Yield T/A				
			Me.	Vt.	R.I.	Pa.	W.Va.	Me.	Vt.	R.I.	Pa.	W.Va.
Pre-joint	High	High	3.67ab[1]	2.58f	2.07e	4.87ab	4.43abc	0.98ab	1.62abc	0.55b-f	1.69bc	0.71b
	High	Low	3.66ab	1.95g	1.98e	4.57bc	4.41abc	0.91abc	1.16d	0.69bcd	1.56bc	0.94a
	Low	High	2.40c	2.24fg	1.09f	3.29e	3.58c	0.44def	1.25cd	0.53b-f	0.90d	0.38def
	Low	Low	2.38c	2.31fg	1.05f	4.07cd	3.69c	0.54c-f[2]	1.27cd	0.29fg	1.07d	0.56bcd
Early head	High	High	3.73ab	2.73f	2.63d	4.55bc	4.03bc	1.22a	1.08d	0.49c-g	1.82b	0.62bc
	High	Low	3.65ab	2.25fg	3.30bc	4.85ab	4.11abc	1.16a	1.05d	0.55b-f	2.36a	0.73ab
	Low	High	2.83c	2.36fg	2.13e	3.39de	3.97bc	0.59b-f	0.50c	0.45d-g	0.94d	0.38def
	Low	Low	2.83c	1.82g	1.75e	3.19e	4.37abc	0.62b-e	0.65c	0.24g	1.08d	0.59bcd
Early bloom	High	High	4.10ab	4.34abc	4.65a	5.40a	3.85c	0.80a-d	1.71ab	1.06a	1.64bc	0.46c-f
	High	Low	4.25a	3.68de	4.39a	5.02ab	3.48c	0.50c-f	1.23cd	0.84ab	2.00ab	0.48cde
	Low	High	3.72ab	3.88cde	2.83cd	3.82cde	4.92ab	0.29ef	1.34bcd	0.20g	0.88d	0.38def
	Low	Low	3.71ab	3.46e	3.11bcd	3.87cde	4.40abc	0.32ef	1.12d	0.41d-g	0.96d	0.40c-f
Past bloom	High	High	3.68ab	4.82a	4.31a	5.38a	4.01bc	0.70b-e	1.76a	0.77bc	2.00ab	0.24f
	High	Low	3.50b	4.56ab	4.60a	5.39a	3.99bc	0.57b-f	1.70ab	0.77bc	1.80b	0.33ef
	Low	High	3.85ab	4.38abc	3.37b	5.00ab	4.89ab	0.18f	1.29cd	0.35efg	1.26cd	0.31ef
	Low	Low	3.77ab	4.12bcd	3.59b	4.36bc	5.04a	0.18f	1.21cd	0.39efg	0.99d	0.45c-f
Averages:												
PJ			3.03t	2.27t	1.55t	4.20st	4.03r	0.72r	1.32r	0.51rs	1.30s	0.65r
EH			3.26st	2.29t	2.45s	4.00t	4.12r	0.90r	0.82s	0.43s	1.55r	0.58r
EB			3.94r	3.84s	3.74r	4.53s	4.16r	0.48s	1.35r	0.63r	1.35rs	0.43s
PB			3.70rs	4.47r	3.97r	5.03r	4.48r	0.41s	1.49r	0.57r	1.51rs	0.33t
	High		3.78w	3.36w	3.49w	5.00w	4.04x	0.86w	1.41w	0.72w	1.85w	0.56w
	Low		3.19x	3.07x	2.36x	3.87x	4.36w	0.40x	1.08x	0.36x	1.01x	0.43x
		High	3.50y	3.42y	2.88y	4.46y	4.21y	0.65y	1.32y	0.55y	1.39y	0.43z
		Low	3.47y	3.02z	2.97y	4.42y	4.19y	0.60y	1.17z	0.52y	1.47y	0.56y
	C. V.%		10.3	9.2	9.7	9.2	11.9	34.0	16.7	29.8	18.1	22.9

*Vermont 1962, other stations 1961

[1]Values having the same letter are from the same statistical population at the 5 per cent level of significance. Comparisons may be made within each column.

[2]c-f includes c, d, e, and f

TABLE 5

Dry Matter Produced by Climax Timothy in the Third Harvest Year

Stage at First Harvest	N	After-math Cut	Total Yield T/A				Aftermath Yield T/A*		
			Me.	R.I.	Pa.	W.Va.	Me.	R.I.	W.Va.
Pre-joint	High	High	4.22a[1]	1.98c	1.26ab	1.49e	1.62a	0.77a	0.25a
	High	Low	3.55a-d[2]	1.97c	1.50ab	1.31e	1.27ab	0.81a	0.21a
	Low	High	3.07cde	0.88e	1.12b	1.64e	0.95bcd	0.23b	0.48a
	Low	Low	2.69efg	0.90e	1.24ab	1.53e	0.64cde	0.30b	0.39a
Early head	High	High	3.06cde	2.78b	1.62ab	0.06fg	1.32ab	0.79a	0.01a
	High	Low	3.06cde	2.73b	1.81a	0.00g	1.34ab	0.89a	0.00a
	Low	High	2.30fg	1.13e	1.36ab	0.58f	0.59de	0.36b	0.11a
	Low	Low	2.22g	1.27de	1.63ab	0.25fg	0.48e	0.36b	0.07a
Early bloom	High	High	4.10a	4.16a	1.67ab	3.08bc	1.52a	1.01a	0.38a
	High	Low	4.03ab	3.92a	1.51ab	2.25d	1.46a	0.77a	0.18a
	Low	High	3.26cde	1.75cd	1.49ab	3.29abc	0.76cde	0.37b	0.61a
	Low	Low	3.30b-e	1.42de	1.58ab	3.20abc	0.73cde	0.35b	0.51a
Past bloom	High	High	3.60a-d	4.23a	1.78a	3.10bc	0.99bc	0.77a	0.35a
	High	Low	3.75abc	4.18a	1.73ab	2.73cd	1.25ab	0.69a	0.30a
	Low	High	2.95def	1.74cd	1.84a	3.74a	0.59de	0.20b	0.64a
	Low	Low	2.66efg	1.81cd	1.58ab	3.61ab	0.46e	0.27b	0.62a
Averages:									
PJ			3.38rs	1.43t	1.28s	1.49t	1.12r	0.53r	0.33rs
EH			2.66t	1.98s	1.60r	0.22u	0.93rs	0.60r	0.05s
EB			3.67r	2.81r	1.56r	2.95s	1.12r	0.62r	0.42r
PB			3.24s	2.99r	1.73r	3.30r	0.82s	0.48r	0.48r
	High		3.67w	3.24w	1.61w	1.75x	1.35w	0.81w	0.21w
	Low		2.80x	1.36x	1.48x	2.23w	0.65x	0.30x	0.42w
		High	3.32y	2.33y	1.52y	2.12y	1.04y	0.56y	0.35y
		Low	3.15y	2.28y	1.57y	1.86z	0.95y	0.56y	0.29y
C.V.%			11.6	13.0	20.3	15.4	19.9	31.7	11.6

*No aftermath harvested at Pennsylvania in 1962 (drought)

[1]Values having the same letter are from the same statistical population at the 5 per cent level of significance. Comparisons may be made within each column.

[2]a-d includes a, b, c, and d

Early harvests at pre-joint or early head generally resulted in large sacrifices of potential yield. Average annual reductions in yield under the early head harvest system ranged from 0.7 ton at Pennsylvania to 2.1 tons at Vermont (Appendix Table 5). Little difference in yield was noted between the pre-joint and early head harvest systems during the first two years, except at Rhode Island where the pre-joint treatment proved inferior. In the third year, however, stand injury from harvesting at early head resulted in a drastic reduction of yields at West Virginia and a moderate reduction at Maine.

The higher rate of nitrogen fertilization increased total yields each year of the study except at West Virginia (Tables 3, 4, 5). Yield increases in response to high nitrogen were especially pronounced at Rhode Island and Pennsylvania, averaging 1.5 tons annually at Rhode Island over the three-year period, and 1.3 tons at Pennsylvania for 1960 and 1961. Yield reductions associated with the high rate of nitrogen at West Virginia were due to stand reductions (discussed later). Severe drought at Pennsylvania prevented any appreciable response to the higher level of nitrogen in 1962. At Rhode Island yield increases due to the extra nitrogen were always the highest when the first harvest was taken at early bloom, whereas delaying time of first harvest was not advantageous at other locations because lodging occurred when the high rate of nitrogen was used and moisture was plentiful.

Differential stubble height, imposed on the first aftermath crop, had relatively little effect on total seasonal yields. A beneficial effect of the higher stubble was noted in some individual management treatments, **i.e.** harvesting at early and past bloom with the high rate of nitrogen at West Virginia the third season, but no consistent pattern of response was noted. Any plant injury which may have occurred from a single, close cutting was apparently only temporary. In isolated cases, close cutting actually resulted in higher yields, apparently because of the sacrifice of unharvested forage in the 3 1/2-inch stubble.

Aftermath Yields

The yields of weed-free aftermath forage (Tables 3, 4, 5) represent all harvests following removal of the first hay crop. Thus, for the pre-joint harvest treatment the yields include only the third and subsequent harvests, while for the other three maturity stage treatments the second harvests are included. Aftermath yields over the three-year period varied from zero to 2.4 tons per acre and averaged only 0.7 ton per acre.

Stage of growth at the first harvest had no consistent effect on aftermath yields at most of the stations. The most pronounced effect was noted at Vermont where delayed harvesting until the bloom stages resulted in an appreciable increase in aftermath production relative to the early head treatment in the second harvest season. The Vermont results, plus the lack of any definite response to harvesting at early head at the other stations, indicate that the sacrifice in first crop yields from early harvest are not usually compensated by any appreciable increase in aftermath production.

Increasing the rate of nitrogen fertilization usually increased aftermath production. The higher rate of nitrogen increased yields as much as one ton per acre, although the average response was much less. In most cases there was little interaction with time of first harvest so that extra nitrogen was equally effective following either early or delayed harvest. The average aftermath increase in response to nitrogen over all years and locations was approximately 0.4 ton dry matter for each of the three hay treatments, early head to past bloom.

Mowing the first regrowth at a 3 1/2-inch stubble height rarely resulted in significant increases in aftermath yields. In some cases, increased yields were noted in the first regrowth following the higher clipping. However, these increases were usually too small to have a significant effect on total aftermath, or were offset by the sacrifice of unharvested forage in the higher stubble.

Aftermath yields as presented in Tables 3, 4, and 5 do not include the first regrowth following the pre-joint harvest in May. It is of significance to note that timothy exhibited rapid growth following this simulated pasture defoliation (Figure 2). Elongation of the primary culm and display of its associated leaves

A

B

Figure 2. Timothy clipped at a pre-joint stage on May 31, 1962, *(Maine) recovered rapidly, as this five-day regrowth on June* 5 *illustrates. Figure* 2-*A contrasts the unclipped timothy of the early bloom treatment with the regrowth of the pre-joint treatment. Figure* 2-*B shows in more detail the rapidity of recovery.*

proceeded in a normal pattern, apparently little affected by the defoliation. A hay harvest taken approximately one month after the pre-joint clipping produced yields ranging from about 1.5 to 2.0 tons dry matter per acre. In the Maine studies, the average daily growth rate during this period ranged from 106 pounds dry matter per acre in 1960 to 126 pounds in 1962, whereas average daily growth rates following harvests taken at the other growth stages were less than half of those following the pre-joint stage of growth. Similar observations of this growth response of timothy were noted in the Pennsylvania and Vermont experiments. A comparison of timothy and bromegrass was possible in the Maine and Vermont studies, and it was quite evident that timothy recovered much more rapidly than bromegrass following clipping at the pre-joint stage of growth.

Regrowth Potential

An indirect, biological measurement of the reserve energy status of timothy was obtained in dark chamber studies at Rhode Island. Etiolated growth from sod plugs provided a relative measure of the effect of harvest treatment on plant vigor. Sod samples were obtained each spring and each fall soon after the first and last harvests, respectively.

The spring data of Table 6 clearly illustrate the apparent accumulation of reserves with advancing maturity of the spring crop. Each year of the study, relatively little regrowth was ob-

TABLE 6

Etiolated Growth Produced in the Dark by Timothy at Rhode Island

Stage at First Harvest	N	Cutting Height	Dry Weight (mg) Produced Per 4-Inch Plug: 1960 Spring	1960 Fall	1961 Spring	1961 Fall	1962 Spring	1962 Fall
Pre-joint	High	High	107f[1]	170e	117f	243bc	33f	750b-e
	High	Low	170ef	330cde	147f	190bc	43f	787a-e
	Low	High	250def	423b-e[2]	323ef	557a	173ef	890a-e
	Low	Low	260def	420b-e	353ef	633a	167ef	727cde
Early head	High	High	630cde	237de	337ef	227bc	143ef	533e
	High	Low	870bc	353cde	240f	207bc	210def	697cde
	Low	High	737cd	543a-d	663cd	340b	437cde	1147abc
	Low	Low	1033abc	777a	613cd	337b	510bcd	783a-e
Early bloom	High	High	1313ab	360cde	640cd	240bc	1100a	940a-e
	High	Low	713cd	370cde	517de	197bc	1220a	947a-e
	Low	High	757cd	467b-e	997ab	513a	783b	1127a-d
	Low	Low	773cd	427b-e	1003ab	533a	797b	1180ab
Averages:								
PJ			197s	336t	235t	406r	104t	788s
EH			818r	478rs	463s	278s	325s	790s
EB			889r	406st	789r	370r	975r	1048r
	High		634w	303x	333x	217x	458w	776x
	Low		635w	510w	659w	486w	478w	976w
		High	632y	367z	513y	353y	445y	898y
		Low	636y	446y	479y	350y	491y	854y

[1]Values having the same letter are from the same statistical population at the 5 per cent level of significance. Comparisons may be made within each column.
[2]b-e includes b, c, d and e

tained immediately following the pre-joint harvest, while maximum regrowth occurred following harvest at early bloom. As a three-year average, the plants cut at early bloom produced approximately five times as much etiolated regrowth as that from plants cut at pre-joint.

Regrowth data from the fall sampling indicate no consistent advantage of early or delayed spring harvest. Apparently, the large differences in amounts of reserves observed in the spring leveled out during summer and early fall. The fall data suggest, however, an adverse effect of the high rate of nitrogen, resulting in a general reduction in reserve food accumulation.

Persistence of Stands

Visual estimates of the density of timothy stands were made each year in early spring. The per cent of ground surface area occupied by timothy plants was used as a stand rating. The data obtained in 1961 (Table 7) revealed little effect of the different stage of maturity treatments employed the previous year, although at Rhode Island some thinning of stands from the

TABLE 7

Stand Ratings of Timothy in the Spring of the Second Harvest Year

Stage at First Harvest	N	After-math Cut	Stand Rating 1 = 10% 10 = 100% ground cover			
			Me.	R.I.	Pa.	W.Va.
Pre-joint	High	High	8.3a[1]	6.0b	7.3ab	8.5ab
	High	Low	7.7abc	4.7c	7.3ab	8.8ab
	Low	High	8.0ab	8.3a	7.0ab	8.9ab
	Low	Low	8.0ab	7.3ab	8.3a	9.1a
Early head	High	High	6.0def	7.3ab	7.6ab	8.6ab
	High	Low	6.7b-f[2]	7.0ab	8.0a	8.7ab
	Low	High	6.7b-f	9.0a	7.3ab	8.5ab
	Low	Low	6.7b-f	7.3ab	8.3a	8.9ab
Early bloom	High	High	5.3f	7.0ab	6.3b	8.3b
	High	Low	6.3c-f	7.7ab	8.3a	8.8ab
	Low	High	7.0a-e	7.0ab	7.3ab	8.6ab
	Low	Low	7.3a-d	8.7a	8.0a	9.1a
Past bloom	High	High	6.0def	8.3a	6.3b	8.6ab
	High	Low	5.7ef	7.3ab	8.0a	8.4ab
	Low	High	6.7b-f	8.0ab	7.3ab	9.1a
	Low	Low	7.0a-e	8.3a	8.3a	9.1a
Averages:						
PJ			8.0r	6.6s	7.5r	8.8r
EH			6.5s	7.7r	7.8r	8.7r
EB			6.5s	7.6r	7.5r	8.7r
PB			6.4s	8.0r	7.5r	8.8r
	High		6.5x	6.9x	7.1x	8.6x
	Low		7.2w	8.0w	8.1w	8.9w
		High	6.8y	7.6y	7.4y	8.6z
		Low	6.9y	7.3y	7.7y	8.9y
C.V.%			12.0	15.5	8.3	4.3

[1]Values having the same letter are from the same statistical population at the 5 per cent level of significance. Comparisons may be made within each column.

[2]b-f includes b, c, d, e, and f

pre-joint harvest was evident. However, by the spring of 1962 a drastic thinning of stands had occurred in the West Virginia study (Table 8). The loss of timothy plants was most severe when it was cut at the early head growth stage (Figure 3), although a significant decline occurred also in the high nitrogen treatments of the other harvest series. By the spring of 1963 (Table 9) the Maine station also had noted an accelerated loss of timothy stands cut when the plants were beginning to head. At Pennsylvania, stands had declined to a uniformly low level, apparently in response to the severe drought of the 1962 season. Nitrogen level proved to be the most consistent management factor associated with the decline of timothy stands. Each year, most if not all stations recorded a significant thinning of stands with high nitrogen fertilization.

A common harvest at the termination of the study in the spring of 1963 provided an excellent measure of the permanence of stand losses recorded in previous years. The data of Table 10 indicate a moderate residual loss of stand associated with early harvesting at Rhode Island and Vermont, and a pronounced carryover effect of the early head harvest at West Virginia. The Maine data, however, indicate a complete recovery from the injury previously observed with the early head treatment. It seems significant to point out that the residual harvest at Maine was delayed until a late bloom stage in mid-July, thereby permitting maximum recovery of previously weakened plants. Similarly, the surprising degree of recovery of the severely injured plants of the early head-high nitrogen treatments at West Virginia appears to be explained by the delayed common harvest in July 1963.

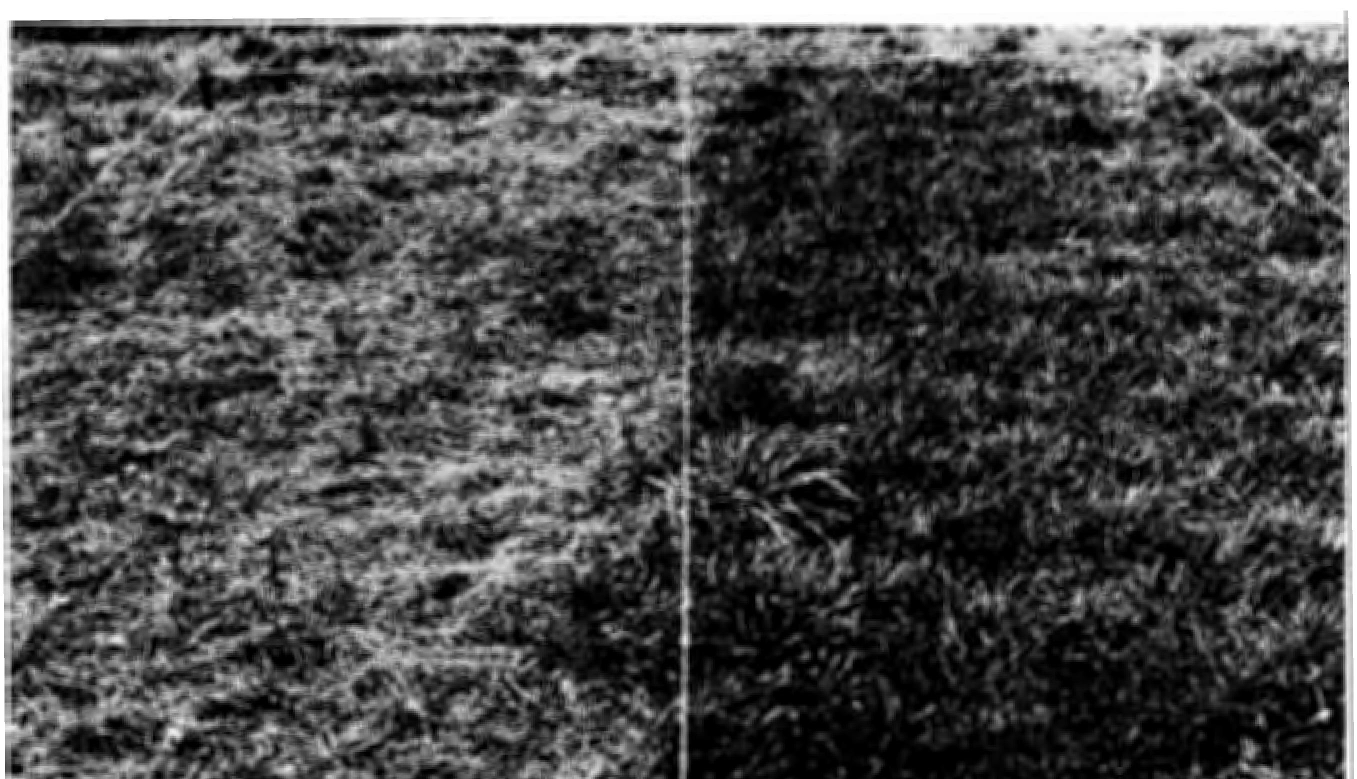
TABLE 8

Stand Ratings of Timothy in the Spring of the Third Harvest Year

Stage at First Harvest	N	Aftermath Cut	Stand Rating 1 = 10% 10 = 100% ground cover			
			Me.	R.I.	Pa.	W.Va.
Pre-joint	High	High	7.7ab[1]	5.7e	7.0ab	3.8b
	High	Low	7.0abc	6.3de	7.0ab	3.9b
	Low	High	7.7ab	7.3cd	7.7a	8.1a
	Low	Low	8.0a	8.7abc	7.0ab	7.2a
Early head	High	High	6.3bc	6.3de	6.7ab	0.9cd
	High	Low	6.3bc	5.7e	6.7ab	0.5d
	Low	High	7.7ab	8.7abc	6.7ab	1.2cd
	Low	Low	7.3abc	9.0ab	7.0ab	1.0cd
Early bloom	High	High	7.0abc	6.7de	7.0ab	4.2b
	High	Low	6.3bc	6.7de	6.3b	2.8bc
	Low	High	7.7ab	7.7bcd	7.3ab	9.2a
	Low	Low	7.7ab	8.7abc	6.3b	9.1a
Past bloom	High	High	6.0c	6.7de	7.0ab	4.7b
	High	Low	6.0c	7.3cd	7.0ab	4.7b
	Low	High	7.0abc	8.3abc	7.0ab	8.4a
	Low	Low	7.3abc	9.3a	7.3ab	8.7a
Averages:						
PJ			7.6r	7.0r	7.2r	5.7r
EH			6.9r	7.4r	6.8r	0.9s
EB			7.2r	7.4r	6.8r	6.3r
PB			6.6r	7.9r	7.1r	6.6r
	High		6.6x	6.4x	6.8w	3.2x
	Low		7.6w	8.5w	7.0w	6.6w
		High	7.1y	7.2y	7.0y	5.1y
		Low	7.0y	7.7y	6.8y	4.7y
C.V.%			9.9	11.6	7.7	23.5

[1]Values having the same letter are from the same statistical population at the 5 per cent level of significance. Comparisons may be made within each column.

A



B

Figure 3. Timothy stands (West Virginia) were severely depleted by harvesting the spring crop at early head stage, as shown by these observations of ground cover in April 1962. *Figure* 3-*A contrasts the spotty condition of an early head plot (left) with the dense sod of an early bloom plot (right). Figure* 3-*B illustrates the further loss of the timothy stand (left) when the early head treatment was coupled with high N and low stubble height, in contrast to the early bloom plot (right) maintained at the lower level of N.*

TABLE 9

Stand Ratings of Timothy in the Spring of the Residual Harvest Year

Stage at First Harvest	N	After-math Cut	Stand Rating 1 = 10% 10 = 100% ground cover Me.	R.I.	Pa.	W.Va.
Pre-joint	High	High	7.3a[1]	5.7cd	3.7ab	5.5bcd
	High	Low	5.7bcd	5.0d	2.7abc	3.5de
	Low	High	6.3a-d[2]	5.7cd	4.7a	6.8abc
	Low	Low	6.3a-d	8.0ab	4.7a	8.8a
Early head	High	High	5.0d	6.7a-d	2.3abc	0.5f
	High	Low	5.7bcd	5.0d	4.0bc	0.1f
	Low	High	5.3cd	7.0a-d	2.0ab	3.5de
	Low	Low	6.0a-d	7.7abc	4.3ab	1.3ef
Early bloom	High	High	6.3a-d	6.3bcd	1.3c	6.5a-d
	High	Low	6.3a-d	6.7a-d	1.3c	4.2cde
	Low	High	7.0ab	7.3abc	3.3abc	9.2a
	Low	Low	7.3a	7.3abc	3.7ab	9.3a
Past bloom	High	High	6.3a-d	6.7a-d	1.3c	4.8cd
	High	Low	6.3a-d	8.7a	1.3c	6.7abc
	Low	High	6.7abc	8.0ab	4.3ab	8.4ab
	Low	Low	7.3a	7.0a-d	3.7ab	8.9a
Averages:						
PJ			6.4r	6.1s	3.9r	6.2r
EH			5.5s	6.6rs	3.2s	1.4s
EB			6.8r	6.9rs	2.4st	7.3r
PB			6.7r	7.6r	2.6st	7.2r
	High		6.1x	6.4x	2.2x	4.0x
	Low		6.5w	7.2w	3.8w	7.0w
		High	6.3y	6.7y	2.9y	5.7y
		Low	6.4y	6.9y	3.2y	5.3y
C.V.%			11.0	17.4	34.5	28.9

[1]Values having the same letter are from the same statistical population at the 5 per cent level of significance. Comparisons may be made within each column.
[2]a-d includes a, b, c, and d

Nutritive Value

The effect of stage of maturity on the digestibility of first crop timothy forage was not a primary objective of this agronomic study. However, the significance of nutritive value data in making a valid selection of desirable management treatments could not be disregarded. For this reason a limited number of **in vitro** digestibility analyses were made, using small samples of forage taken directly from the management plots. In addition, data from recent feeding studies with sheep, obtained by the Northeast Regional Technical Committee NE 24, have been utilized to further broaden the base of understanding.

The data of Table 11 present the results of **in vitro** laboratory tests conducted by the West Virginia station. A large decline in dry matter digestibility occurred at both Maine and West Virginia, with advancing maturity of the first crop. The forage produced at Maine showed a greater range in dry matter digestibility than that at West Virginia, but at both stations the

TABLE 10

Residual Harvest Yields of Dry Matter Produced by Timothy, Following Several Years of Differential Management

Previous Treatment*			Common Harvest (1963)			
Stage at First Harvest	N	After-math Cut	Me.	Vt.	R.I.	W.Va.
Pre-joint	High	High	3.55ab[1]	1.76abc	2.07bc	2.67ab
	High	Low	3.21bc	1.62bc	2.11bc	2.51abc
	Low	High	3.40ab	1.55c	1.80c	2.21abc
	Low	Low	3.20bc	1.73abc	1.74c	2.52ab
Early head	High	High	3.20bc	2.35abc	1.70c	1.05d
	High	Low	3.27bc	1.99abc	2.08bc	0.33e
	Low	High	3.51ab	1.95abc	1.84c	1.92abc
	Low	Low	3.46ab	1.80abc	2.09bc	1.68cd
Early bloom	High	High	3.51ab	2.63a	2.66ab	2.69a
	High	Low	3.64ab	2.23abc	2.54ab	1.95abc
	Low	High	3.60ab	1.91abc	2.12bc	1.94abc
	Low	Low	3.45ab	1.89abc	1.73c	2.30abc
Past bloom	High	High	3.15bc	2.40abc	2.07bc	2.72a
	High	Low	3.22bc	2.54ab	2.75a	1.84bc
	Low	High	3.46ab	2.28abc	2.09bc	2.15abc
	Low	Low	3.37ab	2.15abc	2.18abc	2.23abc
Averages:						
PJ			3.34rs	1.67s	1.93s	2.48r
EH			3.36rs	2.02rs	1.93s	1.24s
EB			3.55r	2.17r	2.27r	2.22r
PB			3.30rs	2.34r	2.27r	2.24r
	High		3.34w	2.19w	2.25w	1.97w
	Low		3.43w	1.91x	1.95x	2.12w
		High	3.42y	2.10y	2.04y	2.17y
		Low	3.35y	1.99y	2.15y	1.92y

*Two years at Vermont, three years at other stations

[1]Values having the same letter are from the same statistical population at the 5 per cent level of significance. Comparisons may be made within each column.

decline continued until the past bloom stage. A marked decline in protein digestibility occurred in the first crop, with similar protein digestibility levels observed at the two stations at any given stage of maturity.

The aftermath forage of timothy (Table 11) showed a relatively constant, high level of digestible dry matter and digestible protein. With the exception of the second harvest of the pre-joint plots, these samples were harvested at a vegetative stage of growth in which high levels of digestibility might be expected.

The results of **ad lib.** feeding trials with sheep (Figure 4) substantiate the continuous decline in dry matter digestibility noted in the **in vitro** tests. It is apparent that the rate of decline was somewhat greater at Maine (0.4 per cent per day) than at West Virginia (0.3 per cent per day). Relatively similar digestibility values were obtained in the two trials for each of the growth stages from the vegetative stage to full head. However, blooming and seed formation were delayed until mid-summer at Maine and this appears to explain the substantially lower digestibility of forage cut at the seed stage at that location.

In a general sense, the data suggest that the dry matter digestibility of first crop timothy hay will range from about 65 to 70 per cent for the early head stage down to 55 to 60 per cent for the late bloom stage. Possible differences between seasons, locations, and timothy varieties should be recognized.

TABLE 11

Digestibility of Timothy Forage*

Stage at First Harvest	Seasonal Harvest[+]	Digestible Dry Matter %		Digestible Protein %	
		Maine	W.Va.	Maine	W.Va.
Pre-joint	First	84.9	76.4	22.7	26.6
	Second	73.7	65.5	12.9	12.3
	Third	77.4	66.6	17.0	14.8
Early head	First	74.5	62.1	12.4	11.5
	Second	77.6	73.6	19.8	17.1
Early bloom	First	68.9	58.9	8.5	7.0
	Second	76.7	70.1	19.1	18.3
Past boom	First	56.3	55.3	4.5	4.7
	Second	78.8	73.4	16.3	20.4

***In vitro** tests by R. L. Reid, West Virginia Agr. Exp. Sta. (Sampled 1961 at West Virginia, 1962 at Maine). Nitrogen was applied at 75 pounds per acre after each harvest.
[+]Specific dates are given in Appendix Table 1.

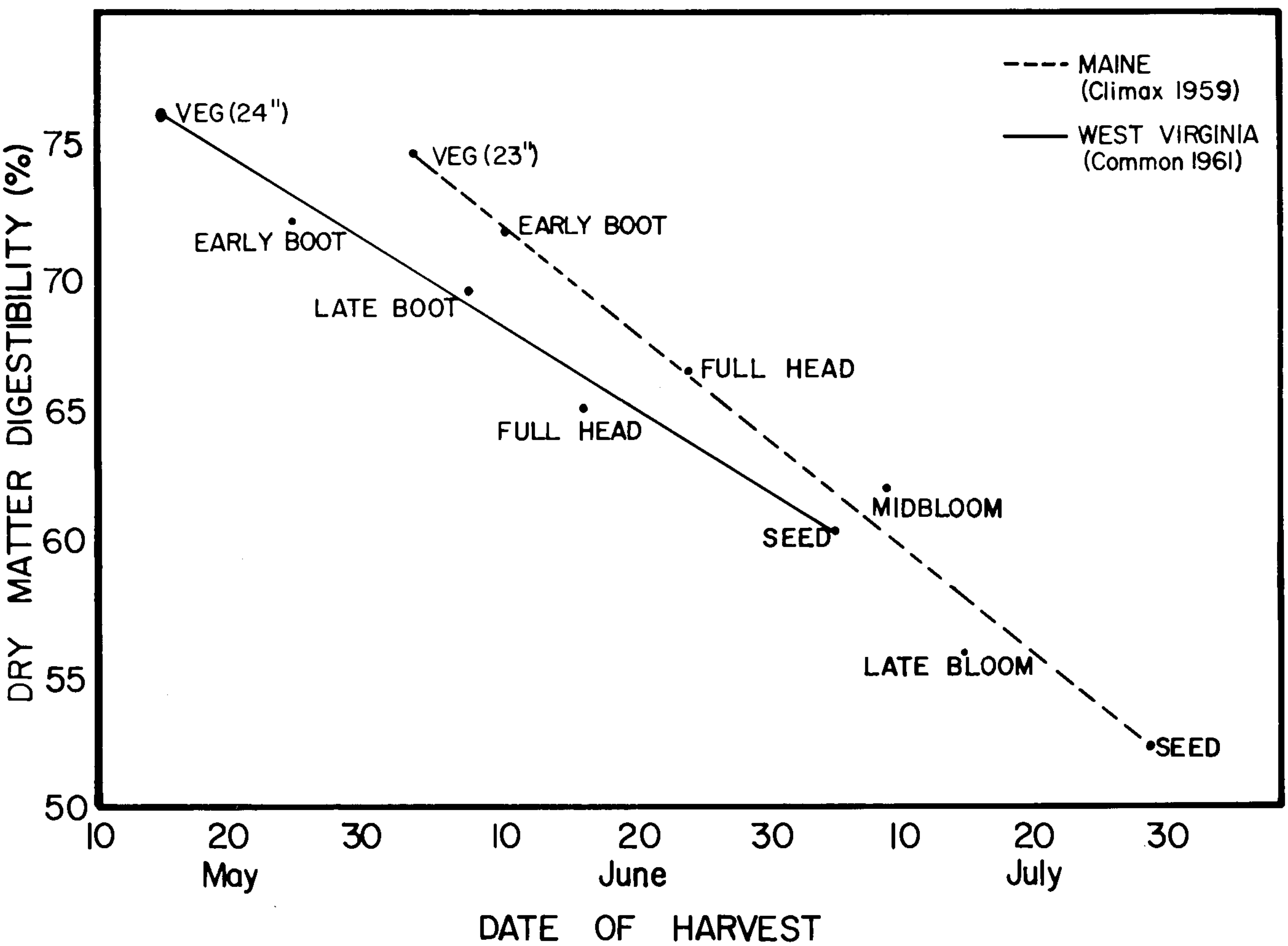


Figure 4. Effect of spring harvest date on the digestibility of first crop timothy fed to sheep. Data were obtained from cooperative studies with Regional Technical Committee NE 24 (The Nutritive Evaluation of Forages) conducted by R. L. Reid of West Virginia and B. R. Poulton of Maine.

DISCUSSION

An important consideration for every forage producer in the Northeast is that timothy is harvested as a hay crop in late spring or early summer. The advantages of a late harvest date is that inclement weather may be avoided, and harvesting of forages may be spread over a two-month period by using several species.

Forage yields, forage quality, and stand persistence, three major responses of timothy, should be considered in evaluating the effects of management. The relative importance of these in agricultural practice will depend, of course, upon the primary use for which a given crop of timothy is grown.

It was apparent from this regional study that Climax timothy continued to accumulate dry matter yield through the full bloom stage of the spring crop. Harvesting at early head resulted in a sacrifice of one-third of the potential first crop yield, although this loss was actually reduced to about 20 per cent when expressed as digestible dry matter.

Total yields for the season were likewise reduced by an early first crop harvest. Relatively little increase in aftermath production occurred to offset the lower yields of an early first crop. In general, aftermath yields of timothy were quite low, rarely exceeding one ton of dry matter per acre. Prolonged drought and associated high temperatures explain, in part, the generally poor aftermath performance of timothy throughout the region. Aftermath yields as high as 2.4 tons were produced at Pennsylvania under favorable environmental conditions in 1961. In contrast, no harvestable aftermath was produced at that location during the prolonged drought of the 1962 season.

The importance of forage quality in modern livestock feeding will usually justify the loss in yield associated with a pre-bloom harvest of timothy. The improved digestibility of early-cut timothy has been repeatedly shown in previous animal studies, and was further illustrated by the **in vitro** tests conducted with small samples from the present management study. Improved palatability and animal intake of hay is another factor of great economic significance which will justify the sacrifice in yield which occurs when the spring crop of timothy is harvested before flowering has begun.

Stand persistence is probably the most significant criterion of desirable practice in timothy management. Timothy is most widely used in long-term sods throughout the Northeast, and is well adapted to cool, moist conditions. It was apparent from the study that harvesting at early head often resulted in a significant thinning of stands. Supplemental studies at Rhode Island in 1961 and 1962, however, showed that harvesting timothy at full head (7-10 days after early head) maintained vigorous stands and high yields. Other supplemental studies revealed timothy to be least tolerant of spring harvests made during the jointing stage, prior to head emergence.

The combined effects of early harvest and intensive nitrogen fertilization were especially deleterious. The studies with etiolated regrowth suggest that the two practices together apparently depleted energy reserves and delayed restorage of reserves in the timothy corms.

The apparent ability of timothy stands to recover from the injurious effects of early harvest is considered a very significant observation in this management study. Residual yields obtained in a delayed July harvest in the fourth year of the Maine experiment indicated nearly complete recovery of stands. Even at West Virginia, where the most severe injury of timothy stands had previously occurred, a surprising degree of recovery was noted. This revitalization of timothy appears analogous to the well-known recovery of winter-weakened alfalfa following a delayed harvest of the spring crop.

Other management practices, not tested in the present study, might also enhance the ability of timothy to tolerate early harvesting of the spring crop. It would be desirable to identify the optimum rate and time of nitrogen fertilization in terms of yield and stand persistence. Lenient fall management to assure more continuous photosynthetic activity and reserve food storage would seem a promising area for future study. Compensating effects of a longer interval between harvests might also prove beneficial. It should be noted that the aftermath schedule in this study was more intensive than that commonly employed on Northeast farms.

The overall impression gained from this study is that cutting between the mid- and full head stages appears to be a desirable compromise at which reasonably high yields of quality timothy forage may be obtained without permanent stand losses. Harvesting before head emergence in the spring may be expected to result in significant injury.

Special note should be made concerning timothy's apparent tolerance of the pre-joint defoliation treatment. In view of the low etiolated growth values associated with the pre-joint harvest, the vigorous recovery observed following defoliation in early May (prior to stem elongation) is difficult to understand. However, some investigators have found that when cutting prior to stem elongation, only a small amount of the reserves in timothy are needed to initiate new growth (24, 55). Comparisons of timothy and bromegrass at Maine and Vermont showed timothy to be distinctly superior in its rate of regrowth following this simulated pasture treatment. In large-plot animal trials with timothy, conducted subsequently in cooperative NE 24—NE 29 studies, pre-joint defoliation had only a small direct effect on the forage quality of the subsequent hay crop. Defoliation at a pasture (pre-joint) stage appears to be of some practical value in minimizing the clogging of sickle-bar mowers during the harvesting of late-cut grass hay.

In conclusion, it seems obvious from this regional study that timothy management becomes more complex whenever an intensive cultural system is employed. Ultra-early harvest for maximum quality, plus high nitrogen fertilization for maximum yield, may prove disastrous to stand survival in an unfavorable season. One must be aware of this in practical farm management, and be prepared to make adjustments when necessary in the defoliation schedule which will permit adequate renewal of timothy stands. It is apparent that some sacrifice of both quality and yield will often be necessary to achieve the longevity of timothy stands so often desired in fields unadapted to frequent tillage.

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Appendix

TABLE 1

Schedule of Harvest Dates

Location and Year	Stage at First Harvest	Harvest Number 1st	2nd	3rd	4th	5th	Total Harvests
		First Harvest Year (1960)					
Maine	Pre-joint	5-23	6-29	8-5	9-24		4
	Early head	6-13	7-18	8-17	9-24		4
	Early bloom	6-29	8-5	9-24	--		3
	Past bloom	7-18	8-29	9-24	--		3
Vermont[1]	Pre-joint	5-12	6-7	7-11	9-7		4
	Early head	6-7	7-11	9-7	--		3
	Early bloom	6-27	7-11	9-7	--		3
	Past bloom	7-11	8-23	10-11	--		3
Rhode Island	Pre-joint	5-16	6-17	7-25	8-30		4
	Early head	6-16	7-25	8-30	--		3
	Early bloom	6-27	8-3	9-7	--		3
	Past bloom	7-11	8-17	9-23	--		3
Pennsylvania	Pre-joint	5-13	6-17	7-21	10-13		4
	Early head	6-9	7-21	10-13	--		3
	Early bloom	6-24	8-12	10-13	--		3
	Past bloom	7-8	8-15	10-13	--		3
West Virginia	Pre-joint	5-21	6-21	7-28	8-19	9-14	5
	Early head	6-6	7-11	8-12	9-14	--	4
	Early bloom	6-21	7-28	8-19	9-14	--	4
	Past bloom	7-5	8-15	9-14	--	--	3
		Second Harvest Year (1961)					
Maine	Pre-joint	5-31	6-30	7-31	8-29	9-28	5
	Early head	6-21	7-31	8-29	9-28	--	4
	Early bloom	7-7	8-11	9-28	--	--	3
	Past bloom	7-21	8-23	9-28	--	--	3
Vermont[1]	Pre-joint	5-22	6-15	7-12	8-20	10-16	5
	Early head	6-7	7-17	8-30	10-16	--	4
	Early bloom	6-25	7-26	9-7	10-16	--	4
	Past bloom	7-11	8-13	10-16	--	--	3
Rhode Island	Pre-joint	5-19	6-15	7-26	9-5		4
	Early head	6-15	7-26	9-5	--		3
	Early bloom	6-29	8-8	9-8	--		3
	Past bloom	7-13	8-25	10-6	--		3
Pennsylvania	Pre-joint	5-11	6-28	8-15	10-24		4
	Early head	6-12	8-15	10-24	--		3
	Early bloom	6-28	8-15	10-24	--		3
	Past bloom	7-10	8-15	10-24	--		3
West Virginia	Pre-joint	4-26	6-14	7-26	9-13		4
	Early head	6-12	7-17	8-15	9-13		4
	Early bloom	6-26	7-28	9-13	--		3
	Past bloom	7-13	8-7	9-13	--		3

[1]First harvest year 1961; second harvest year 1962

(Continued on next page)

TABLE 1 (Continued)

Location and Year	Stage at First Harvest	Harvest Number 1st	2nd	3rd	4th	5th	Total Harvests
		Third Harvest Year (1962)					
Maine	Pre-joint	5-31	7-2	8-22	10-9		4
	Early head	6-20	8-8	9-7	10-9		4
	Early bloom	7-5	8-17	10-9	--		3
	Past bloom	7-19	8-31	10-9	--		3
Rhode Island	Pre-joint	5-25	6-22	8-3	9-7		4
	Early head	6-15	7-25	9-5	--		3
	Early bloom	7-2	8-20	10-2	--		3
	Past bloom	7-13	8-30	10-2	--		3
Pennsylvania	Pre-joint	5-9	6-14				2
	Early head	6-18	--				1
	Early bloom	6-25	--				1
	Past bloom	7-5	--				1
West Virginia	Pre-joint	5-15	6-15	7-23	8-24	10-10	5
	Early head	6-2	7-13	10-10	--	--	3
	Early bloom	6-11	7-23	8-24	10-10	--	4
	Past bloom	6-25	8-7	10-10	--	--	3

Residual Harvest Year (1963)

A common harvest of all treatments was made on the following dates:

Maine	July 16	West Virginia	July 1
Vermont	June 27	Pennsylvania	--[2]
Rhode Island	June 26		

[2]No common harvest, experiment continued into 1964

TABLE 2A

Bi-Weekly Precipitation

INCHES TOTAL RAINFALL

State	April		May		June		July		August		September		Total Season	Deviation + above N* — below N
	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30		
							1959							
Maine[1]	2.2	0.3	0.1	0.5	3.3	3.7	2.7	0.3	1.8	3.4	2.0	0.7	21.1	+1.5
Vermont	1.3	0.3	0.4	1.1	2.7	0.8	1.3	0.5	1.6	2.7	1.5	0.6	14.7	—5.0
Rhode Island	1.7	1.3	0.9	2.0	3.7	3.2	4.1	0.1	1.5	2.4	0.8	0.1	21.8	+0.3
Pennsylvania	2.0	2.2	1.4	1.6	1.9	0.5	3.0	2.7	1.0	4.9	0.6	0.2	22.0	+0.6
West Virginia	2.7	1.6	1.7	0.9	0.5	0.7	1.4	2.1	1.1	2.1	0.1	1.0	15.8	—7.3
							1960							
Maine	2.3	0.5	2.7	0.7	1.6	0.9	1.2	1.4	0.0	0.6	2.2	0.9	15.0	—4.6[1]
Vermont	1.2	1.4	2.0	1.6	0.8	2.8	1.0	2.4	0.9	0.6	3.7	1.2	19.6	—0.4
Rhode Island	2.7	0.5	2.4	1.6	1.3	0.5	3.5	0.8	1.3	0.5	1.8	5.5	22.2	+0.7
Pennsylvania	1.4	0.6	3.4	3.9	1.3[2]	1.1[2]	3.0	0.6	0.7	0.2	3.8	1.2	21.2	—0.2
West Virginia	1.2	0.6	2.8	2.1	1.4	0.6	2.6	2.7	2.9	0.6	2.1	0.9	20.5	—2.6
							1961							
Maine	1.8	1.8	0.6	4.7	1.1	1.0	0.7	1.0	0.2	0.6	0.6	2.3	16.4	—3.2[1]
Vermont	1.7	2.2	1.2	1.5	2.0	1.7	3.6	1.3	1.4	1.8	2.7	0.0	21.1	+1.5
Rhode Island	3.8	4.2	1.7	4.3	1.1	1.6	0.2	0.9	1.6	4.8	2.0	8.6	34.8	+3.3
Pennsylvania	2.4	1.8	1.2	1.1	2.5	0.6	2.4	2.7	3.4	1.5	1.9	0.0	21.5	+0.1
West Virginia	2.1	2.0	1.4	1.4	3.8	3.0	3.3	2.3	3.1	0.8	1.2	3.2	27.6	+4.5
							1962							
Maine	3.2	1.0	0.4	0.6	0.8	0.9	1.6	1.6	0.3	2.7	1.1	2.1	16.3	—3.3[1]
Vermont	1.8	0.8	1.1	1.1	0.4	2.7	2.1	3.9	2.8	0.7	2.4	1.1	21.5	+2.1
Rhode Island	3.0	0.1	1.1	0.8	3.4	2.1	1.4	0.4	1.8	2.3	0.2	3.6	20.2	—1.3
Pennsylvania	4.3[2]	0.2[2]	0.9[2]	0.3[2]	1.7	1.0	0.4	0.3	0.4	1.2	1.6	2.3	14.7	—6.7
West Virginia	3.4	1.4	0.5	1.4	2.1	0.1	2.0	0.7	3.3	0.1	1.8[3]	2.3[3]	19.1	—4.0

*Normal (1931-1960) means obtained from most nearby available source.
[1]U.S.W.B. Old Town, Maine (other data from Orono, Maine)
[2]Data for Centre Hall were not available, therefore data taken at State College were used.
[3]U.S.W.B. Airport Station

TABLE 2B

Bi-Weekly Air Temperature

State	April 1-15	April 16-30	May 1-15	May 16-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15	August 16-31	September 1-15	September 16-30	Total Season	Deviation + above N* — below N
	MEAN DAILY AIR TEMPERATURE													
							1959							
Maine[1]	40	43	53	58	58	58	67	72	67	67	62	56	58.4	—0.3
Vermont	41	48	54	54	64	65	69	74	69	71	66	60	61.2	+0.6
Rhode Island	47	50	55	62	64	64	69	73	70	74	70	61	63.3	+2.2
Pennsylvania	47	53	60	66	68	71	70	75	72	75	68	65	65.9	+2.2
West Virginia	50[2]	58[2]	63	64[3]	69	69[3]	73	76	74	78	71	67	67.9	+0.9
							1960							
Maine	38	44	56	59	60	66	66	68	65	66	60	53	58.4	—0.3[1]
Vermont	41	49	61	63	63	68	68	69	67	67	61	57	61.2	—0.4
Rhode Island	44	52	53	59	63	67	67	68	68	70	65	58	61.2	+0.1
Pennsylvania	44	60	51	61	65[4]	68[4]	65	69	71	70	65	61	62.6	—1.1
West Virginia	51	64	54	66	69	70	70	74	75	74	70	66	66.9	0.0
							1961							
Maine	35	40	49	52	59	64	62	69	65	66	67	58	57.2	—1.5[1]
Vermont	36	44	51[3]	50[3]	62	65	65	71	69	66	71	60	59.2	—1.6
Rhode Island	42	48	53	56	65	64	68	73	68	71	74	63	62.1	+1.0
Pennsylvania	37	48	56	55	68	65	71	76	73	73	75	63	63.3	—0.4
West Virginia	41	51	60	54	68	65	69	75	71	73	76	63	63.8	—3.1
							1962							
Maine	39	41	44	47	58	63	60	62	64	63	57	49	53.3	—5.4[1]
Vermont	40	47	50	63	63	65[3]	63	65	65	66	61	50	58.2	—2.6
Rhode Island	44	50	49	60	62	67	66	66	68	66	63	56	59.8	+1.3
Pennsylvania	42[4]	58[4]	59[4]	70[4]	68	71	70	71	70	71	64	53	64.2	+0.5
West Virginia	44	56	63	72	70	72	73	69	72	73	68[2]	57[2]	65.8	—1.1

*Normal (1931-1960) means obtained from most nearby available source
[1]U.S.W.B. Old Town, Maine (other data from Orono, Maine)
[2]U.S.W.B. Airport Station
[3]Estimated value 2-6 days missing
[4]Data from Centre Hall were not available, therefore data taken at State College were used.

TABLE 3A

Analysis of Variance (F Values) of Timothy Yields Produced in the First Harvest Year

State	Stage	Nitrogen	Cutting Height	SxN	SxCH	NxCH	SxNxCH
			Total Yield				
Maine	9.8**	4.6**	< 1	1.7	< 1	< 1	< 1
Vermont	407.2**	54.8**	2.5	2.1	2.5	5.4*	< 1
Rhode Island	159.7**	322.8**	< 1	15.8**	< 1	< 1	< 1
Pennsylvania	11.0**	141.9**	< 1	1.6	2.3	< 1	< 1
West Virginia	3.2*	34.8**	1.1	< 1	1.2	< 1	< 1
			Aftermath Yield				
Maine	29.7**	28.7**	2.0	< 1	1.4	< 1	< 1
Vermont	8.6**	6.9**	< 1	4.4	< 1	2.2	< 1
Rhode Island	3.3*	40.3**	< 1	1.6	< 1	< 1	< 1
Pennsylvania	11.8**	322.1**	< 1	3.0*	3.4*	< 1	< 1
West Virginia	3.9*	10.3**	< 1	1.2	3.6*	< 1	< 1

* .05 level of probability
** .01 level of probability

TABLE 3B

Analysis of Variance (F Values) of Timothy Yields Produced in the Second Harvest Year

State	Stage	Nitrogen	Cutting Height	SxN	SxCH	NxCH	SxNxCH
			Total Yield				
Maine	16.0**	32.6**	< 1	9.4**	< 1	< 1	< 1
Vermont	169.2**	11.8**	21.6**	1.5	< 1	1.6	< 1
Rhode Island	190.8**	188.1**	1.1	3.0*	< 1	< 1	4.0*
Pennsylvania	14.8**	91.1**	< 1	2.0	1.0	< 1	3.0
West Virginia	1.2	6.0*	< 1	9.2**	< 1	< 1	< 1
			Aftermath Yield				
Maine	13.2**	55.3**	< 1	< 1	< 1	2.2	< 1
Vermont	23.7**	31.2**	6.0*	2.2	2.2	3.5	< 1
Rhode Island	3.5*	63.3**	< 1	5.1**	< 1	< 1	3.4*
Pennsylvania	2.5	127.4**	1.4	1.6	2.8	< 1	1.0
West Virginia	19.3**	17.1**	14.9**	8.6**	1.5	< 1	< 1

* .05 level of probability
** .01 level of probability

TABLE 3C

Analysis of Variance (F Values) of Timothy Yields Produced in the Third Harvest Year

State	Stage	Nitrogen	Cutting Height	SxN	SxCH	NxCH	SxNxCH
			Total Yield				
Maine	15.7**	64.0**	2.3	< 1	1.2	< 1	< 1
Rhode Island	70.8*	473.0**	< 1	15.1*	< 1	< 1	< 1
Pennsylvania	4.5*	1.9	< 1	< 1	1.0	< 1	< 1
West Virginia	257.2**	29.3**	8.9**	2.0	< 1	1.2	1.4
			Aftermath Yield				
Maine	6.5**	147.4**	2.3	< 1	2.1	< 1	< 1
Rhode Island	1.6	98.1**	< 1	< 1	< 1	< 1	< 1
West Virginia	3.2*	4.2*	< 1	< 1	< 1	< 1	< 1

* .05 level of probability
** .01 level of probability

TABLE 4

Analysis of Variance (F Values) of Timothy Spring Stand Ratings

State	Stage	Nitrogen	Cutting Height	SxN	SxCH	NxCH	SxNxCH
			Spring of Second Harvest Year				
Maine	10.9**	8.0**	< 1	1.7	< 1	< 1	< 1
Rhode Island	3.3*	10.5**	< 1	2.2	2.5	< 1	< 1
Pennsylvania	< 1	30.5**	3.4	< 1	< 1	< 1	2.8
West Virginia	< 1	9.0**	3.7	1.1	1.4	< 1	< 1
			Spring of Third Harvest Year				
Maine	4.4*	22.7**	< 1	< 1	< 1	1.1	< 1
Rhode Island	2.3	67.8**	4.8*	1.3	1.1	2.3	< 1
Pennsylvania	2.0	1.8	1.8	< 1	2.3	< 1	< 1
West Virginia	65.7**	105.2**	< 1	11.1**	< 1	< 1	< 1
			Spring of Residual Harvest Year				
Maine	8.1**	6.2*	< 1	< 1	2.6	2.7	< 1
Rhode Island	3.4	7.2	< 1	1.3	< 1	< 1	4.0*
Pennsylvania	4.9**	48.7**	< 1	< 1	< 1	< 1	< 1
West Virginia	37.5**	44.5**	< 1	< 1	1.6	< 1	2.4

* .05 level of probability
** .01 level of probability

TABLE 5

Average Annual Dry Matter Produced by Timothy (1960-62)*

Stage at First Harvest	N	Aftermath Cut	Total Yield T/A Me.	Vt.	R.I.	Pa.	W.Va.	Aftermath Yield T/A Me.	Vt.	R.I.	Pa.	W.Va.
Pre-joint	High	High	3.74	2.50	1.82	3.23	2.78	1.06	1.01	0.52	1.39	0.71
	High	Low	3.60	2.26	1.77	3.38	2.75	0.93	0.83	0.60	1.38	0.72
	Low	High	2.81	2.16	0.95	2.33	2.37	0.59	0.83	0.29	0.64	0.58
	Low	Low	2.66	2.23	0.93	2.71	2.30	0.53	0.80	0.24	0.74	0.54
Early head	High	High	3.39	2.61	2.73	3.22	2.15	1.21	0.62	0.61	1.49	0.57
	High	Low	3.36	2.48	2.99	3.56	2.22	1.19	0.70	0.72	1.90	0.60
	Low	High	2.75	2.43	1.54	2.26	2.22	0.65	0.48	0.31	0.70	0.47
	Low	Low	2.67	2.04	1.53	2.44	2.19	0.62	0.48	0.27	0.89	0.58
Early bloom	High	High	4.07	4.18	4.25	4.01	3.24	1.04	1.16	0.86	1.70	0.64
	High	Low	4.06	4.11	4.10	3.71	2.77	0.95	0.89	0.78	1.79	0.56
	Low	High	3.56	3.75	2.20	2.73	3.49	0.52	0.87	0.25	0.82	0.66
	Low	Low	3.66	3.59	2.21	2.78	3.20	0.57	0.74	0.34	0.79	0.59
Past bloom	High	High	3.58	4.78	4.26	4.10	3.23	0.69	1.31	0.75	1.79	0.46
	High	Low	3.55	4.62	4.34	3.88	3.25	0.78	1.21	0.69	1.63	0.53
	Low	High	3.39	4.37	2.55	3.30	3.59	0.30	0.93	0.24	0.83	0.50
	Low	Low	3.36	4.19	2.57	3.00	3.62	0.31	0.79	0.27	0.75	0.65
Averages:												
PJ			3.20	2.29	1.37	2.91	2.55	0.78	0.86	0.41	1.04	0.64
EH			3.04	2.39	2.20	2.87	2.20	0.92	0.57	0.48	1.24	0.55
EB			3.84	3.91	3.19	3.31	3.17	0.77	0.92	0.56	1.28	0.61
PB			3.47	4.49	3.42	3.55	3.42	0.52	1.06	0.49	1.25	0.54
	High		3.67	3.44	3.28	3.64	2.80	0.98	0.96	0.69	1.63	0.60
	Low		3.11	3.10	1.81	2.69	2.87	0.51	0.74	0.28	0.77	0.57
		High	3.41	3.35	2.54	3.15	2.88	0.76	0.90	0.48	1.17	0.57
		Low	3.36	3.19	2.56	3.18	2.79	0.74	0.80	0.49	1.23	0.60

*Two years at Vermont, three years at other locations