CHARACTERISTICS OF SEVERAL ALFALFA VARIETIES WITH EMPHASIS ON WINTERHARDINESS

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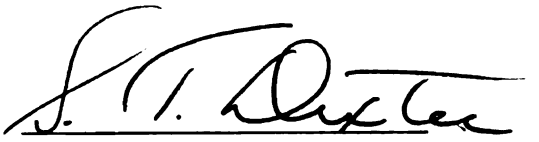

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CHARACTERISTICS OF SEVERAL ALFALFA VARIETIES WITH EMPHASIS ON WINTERHARDINESS

By

Durwood William Beatty

A THESIS

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INTRODUCTION

Alfalfa acreage in Michigan has averaged over 1,000,000 acres for approximately twenty years. With more than half of the total hay production being alfalfa this high quality forage has had a prominent part in the agriculture of the state.

Today there are many varieties and strains of alfalfa and more are being developed, particularly those which are resistant to bacterial wilt, have a high degree of winterhardiness, resistance to stem and leaf diseases, rapid recovery after cutting, and strong competitive ability. Choice of an alfalfa variety is thus an important factor for the most successful production.

The purpose of this study was to obtain information on several alfalfa varieties when grown under Michigan conditions. Emphasis was given to winterhardiness in relation to injury due to low temperatures.

REVIEW OF LITERATURE

The literature contains many theories on winterhardiness in relation to low temperatures. Such theories are concerned with the relationship between hardiness and structural characteristics, water content of the plant, cell sap concentration, and such protoplasmic factors as viscosity, hydrophillic properties, and membrane permeability. Harvey (11) has compiled an extensive bibliography on winterhardiness and Levitt (12) has written a comprehensive review of cold relations in plants.

Graber et al. (9) found that susceptibility to winter injury is increased by low percentages of dry matter and low concentrations of food reserves in the roots at winter dormancy. Dexter (5) showed that during the hardening process there occurs an accumulation of carbohydrates and other reserve foods. Salmon et al. (18), Graber (10) and Nelson (14) reported that frequent cutting of alfalfa resulted in rapid depletion of stand. Willard (20) found that cutting of alfalfa in Ohio in late September or early October was more injurious than cutting on November first when no exhaustive new growth could be initiated and after all root growth was complete. Silkett et al. (19) found that plants cut in September yielded less hay the following year although plants cut on normal dates and again during late October showed little effect from this removal of top growth. Willard (20) observed that in dry seasons frequent cutting did not exhaust the plots of alfalfa as it

does in normal seasons as the dry season favored storage of materials in roots.

Work of Dexter et al. (3) has indicated that injury from controlled freezing experiments may be conveniently determined by measurement of the degree of exosmosis of electrolytes. Dexter (4) and Megee (13) found that the electrical conductivity method was useful in determining susceptibility of plants to low temperatures and indicated the rate of hardening of alfalfa plants. Electrical conductivity determinations by Rather and Dorrance (17) showed that alfalfa plants cut or pastured in September were more susceptible to winter injury and evidenced by field observations the following spring.

Length of day is generally known to have profound effects on vegetative and reproductive growth of many plants. In a study of alfalfa seedlings under long and short days Oakley and Westover (15) found that varieties reacted to day length in accordance with their regional adaptation.

MATERIALS USED

Field Design

Field tests were conducted during the summer and fall of 1952 and 1953 on six varieties of alfalfa: Atlantic, Ranger, Rhizoma, Talent, Hardigan and Narragansett. Complete descriptions of the varieties are given in the appendix. The alfalfa was drilled in plots 14 by 48 feet in a double linear block design on Conover clay soil in July 1951. Varieties were replicated eight times with the exception of Narragansett which appeared only twice due to a small supply of seed.

A split plot design was used to give half of each plot a late fall clipping to induce winter injury. Notes were taken on varietal characteristics and yields were taken on areas 6 by 14 feet. Plots were cut with a six foot mower from East to West and from West to East on each plot. The alfalfa was left at the sides of the treatments as a source of root samples which were dug each fall for winterhardiness tests.

In the fall of 1953 one year old roots from an additional set of plots were obtained for testing.

EXPERIMENTAL RESULTS

Crop Yields

Hay Yields

In 1952 the plots were mowed May 28th to control weeds and no yield was recorded. A second cutting was taken on August 1, 1952 with a third taken on half of each plot on September 24th to induce winter injury. Yields are shown in Table I.

TABLE I

ALFALFA YIELDS IN 1952 EXPRESSED IN AVERAGE POUNDS OF GREEN WEIGHT PER 6 BY 14 FOOT PLOT

Variety	Second Cutting	Third Cutting	Total
Narragansett	9.6	9.9	19.5
Atlantic	8.5	9.8	18.3
Hardigan	8.4	9.9	18.3
Ranger	8.3	8.9	17.2
Rhizoma	7.9	8.7	16.6
Talent	6.6	8.2	14.8

Although Narragansett yielded the highest it appeared in only two plots and both were situated in the better areas of the experiment. However, Narragansett compared favorably with the other varieties in nearby plots and can be considered with Atlantic, Hardigan, and Ranger.

Rhizoma yielded slightly lower than the others while Talent yielded the least.

In 1953 two cuttings were taken. Approximately 62 per cent of the yield was recorded in the first cutting which was taken on the twenty-sixth of June. Yield was averaged for plots cut in two directions to be more comparable to harvest under farm conditions. Yields are shown in Table II. Treatment was not significant. Talent yielded less than other varieties and Ranger less than Hardigan at the one per cent level.

TABLE II

ALFALFA YIELDS IN 1953 EXPRESSED IN AVERAGE YIELD PER 6 x 14 FT. PLOT ON A GREEN WEIGHT BASIS

Variety	Not Clipped			September Clipped			Total Average
	Direction of Cutting			Direction of Cutting			
	E-W	N-S	Av.	E-W	N-S	Av.	
Ranger	49.2	39.5	44.4	44.2	41.9	43.0	43.7
Talent	42.1	33.7	37.9	39.6	33.9	36.7	37.3
Atlantic	52.8	40.4	46.6	47.7	41.8	44.7	45.6
Hardigan	54.6	41.8	48.2	49.7	43.4	46.5	47.3
Rhizoma	52.5	40.1	46.3	49.5	41.8	45.6	45.9
Narragansett*	52.5	41.2	46.8	51.3	43.1	47.2	47.0

* Only two replications, not included in analysis of variance.
L.S.D. between varieties: 5% = 2.4, 1% = 3.3.

TABLE III

ANALYSIS OF VARIANCE ON YIELD OF HAY FOR 1953

Source	DF	SS	MS	F
Total	79	1,875.7	23.7	
Variety	4	986.3	246.5	19.7**
Replication	7	230.9	32.9	
V x R = E_1	28	350.5	12.5	
Treatment	1	20.3	20.3	2.5
V x T	4	6.6	1.6	
Remainder = E_2	35	281.1	8.0	

** Significant at the one per cent level.

Seed Yield

A portion of the first cutting of 1953 was left for seed production. Strips three feet wide were cut through each plot and the harvested material threshed for seed. Seed set was extremely poor, the best yield approximating only about seven pounds per acre. Yields were higher from the plants clipped the previous September than from the plants unclipped.

TABLE IV

AVERAGE YIELD OF SEED PER 3 x 14 FOOT PLOT IN GRAMS

Variety	Clipped	Not Clipped
Hardigan	3.16	1.55
Ranger	3.11	.93
Narragansett	5.4	2.97
Talent	.93	.87
Atlantic	1.24	.61
Rhizoma	2.31	2.02

Winterhardiness

The procedure of Dexter et al. (4) was used for the winterhardiness tests. Plant roots approximately six inches long were dug at random from five plots. After being washed and rinsed in distilled water the roots were placed in cheesecloth to remove the surface water. The roots were then cut into one-half to three-quarter inch pieces and mixed thoroughly. Triplicate ten gram samples were weighed out and frozen for four hours in six-inch Pyrex test tubes placed in an alcohol-ice slush maintained

at -7° Centigrade. Fifty millimeters of water was added to each sample after removal from the freezer. The samples were then placed in a water bath held at 2° Centigrade for twenty hours to allow exosmosis of the electrolytes from the roots.

Resistance readings of the water extract were taken by means of a Wheatstone bridge and recorded as reciprocal ohms x 10^{-6} (mhos) per gram of root weight. Following these readings the roots and extracts were heated to 90° Centigrade to make the membranes fully permeable, and then held at 2° Centigrade for another twenty hours when the amount of total electrolytes was determined as above.

1952 Results

As shown in Tables V and VI, roots from the plants clipped in 1952 were more hardened in October than those from plants not clipped. The fall season was extremely dry with only 2.47 inches of rain during September and October. Plants which had been clipped made very little regrowth due to the dry conditions. This type of season was apparently more like Western Conditions where stands of alfalfa can be cut more frequently with less injury to stands as climate tends to prevent the exhaustion of root reserves. Some lowering of the food reserve did occur however as the roots from the clipped plants were slightly lower in dry matter as shown in Table VII.

The periods of dehardening as illustrated in Figures 1 and 2 were preceded by rainfall the week before the samples were taken. In November they were preceded by rainfall plus above average temperatures.

TABLE V

ELECTROLYTES, IN TERMS OF RECIPROCAL OHMS x 10^{-6} PER GRAM OF ROOT WEIGHT, OF EXTRACT OF ALFALFA ROOTS FOLLOWING FREEZING AT -7° CENTIGRADE. ROOTS FROM PLANTS NOT CLIPPED

Variety	Date of Sampling							
	October		November				December	
	22	29	5	12	19	26	3	10
Ranger	24.3	16.3	13.1	9.1	9.9	12.9	9.4	11.0
Narragansett	25.6	18.2	14.7	10.5	12.6	14.6	7.6	10.0
Rhizoma	27.1	18.2	19.1	13.3	8.8	18.3	7.7	11.8
Hardigan	18.8	18.5	15.8	11.1	8.6	14.2	7.5	10.3
Atlantic	22.3	18.5	19.4	13.2	11.9	16.2	8.5	12.6
Talent	34.2	30.8	26.6	21.1	14.5	24.8	15.0	18.0
Average	25.0	20.0	18.1	13.0	11.0	16.8	9.3	12.2

TABLE VI

ELECTROLYTES, IN TERMS OF RECIPROCAL OHMS x 10^{-6} PER GRAM OF ROOT WEIGHT, OF EXTRACT OF ALFALFA ROOTS FOLLOWING FREEZING AT -7°CENTIGRADE. ROOTS FROM PLOTS CLIPPED IN SEPTEMBER 1952

Variety	Date of Sampling					
	October		November			
	22	29	5	12	19	26
Ranger	11.5	10.7	11.1	10.9	13.4	13.8
Narragansett	12.3	11.6	11.9	10.9	14.1	13.6
Rhizoma	12.9	12.4	14.0	13.2	15.3	14.7
Hardigan	16.3	14.3	10.2	9.4	11.7	15.6
Atlantic	22.5	14.8	10.8	12.7	13.9	14.6
Talent	23.5	19.2	19.6	20.3	26.6	21.8
Average	16.5	13.8	12.9	12.9	15.8	15.6

TABLE VII

PER CENT DRY MATTER IN ROOTS DUG IN THE FALL OF 1952
AVERAGE OF ALL SIX VARIETIES

Sampling Date	Plants Not Clipped	Plants Clipped in September
October 22	41.1	37.2
October 29	42.5	37.1
November 5	42.7	36.7
November 12	40.8	36.5
November 19	38.8*	33.2
November 26	38.7	33.6
December 3	37.0*	
December 10	36.7	

* Averages of five varieties.

Roots from the plots which received the clipping treatment seemed to deharden to a lesser extent from the moisture and temperature fluctuations. Due to adverse weather conditions roots from the plots clipped were not harvested in December. Talent showed the least amount of hardening of the unclipped plants on all dates and by December 10th had hardened only to the extent that the other varieties had hardened in late October. Rhizoma showed a sixty per cent decrease in electrolyte liberation from October 22nd to December 10th, while Atlantic and Talent decreased only 43 and 38 per cent respectively. By December 10th Narragansett was in the most hardened condition followed in order by Ranger, Rhizoma, Atlantic, and Talent. Narragansett, Hardigan, and Ranger appeared to deharden slower than Atlantic and Rhizoma.

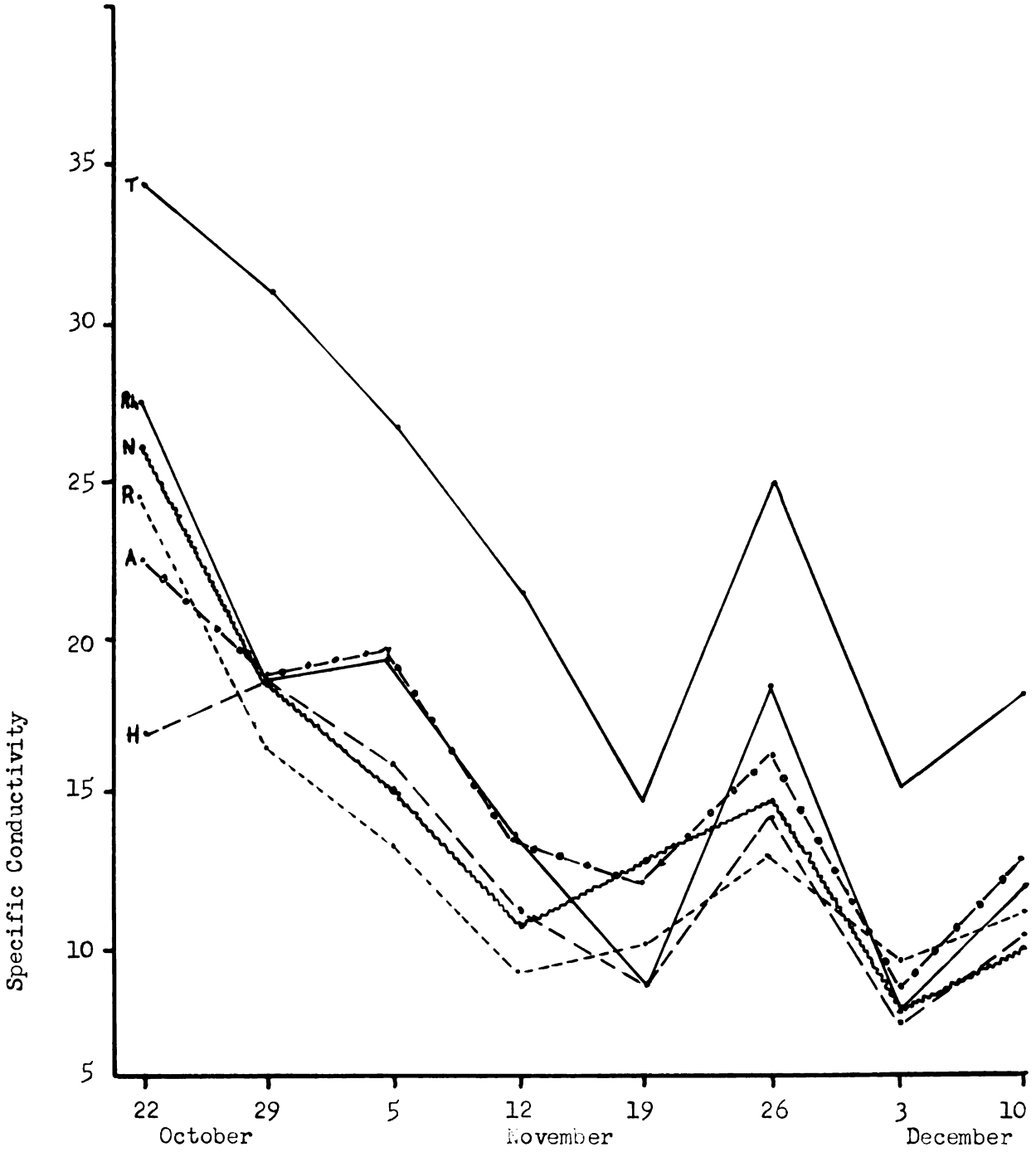


Figure 1. Curves presenting data of Table V in graphic form showing rate of hardening of alfalfa roots from the plants not fall clipped in 1952.

Key

A = Atlantic Rh = Rhizoma
R = Ranger T = Talent
H = Hardigan N = Narragansett

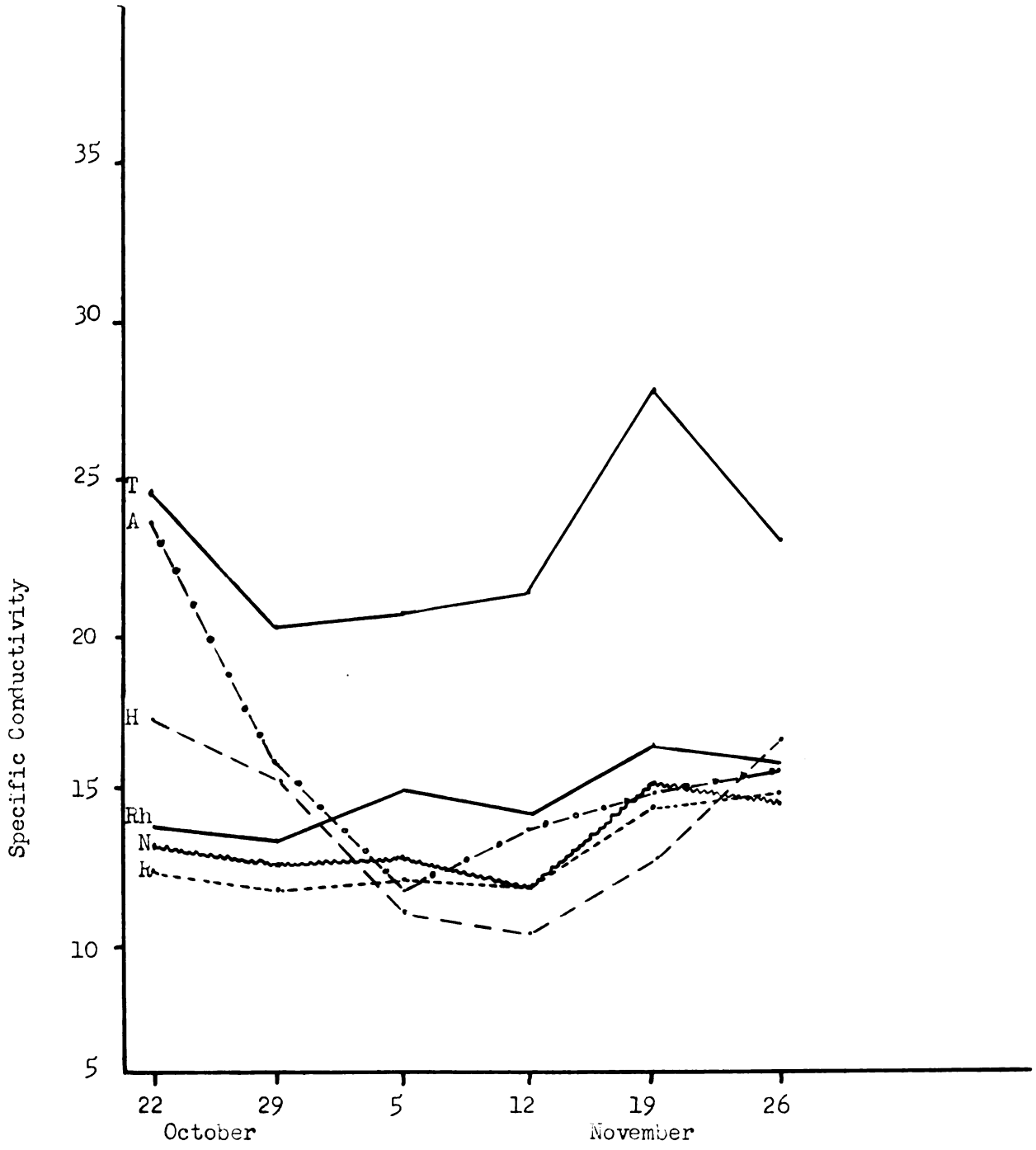


Figure 2. Curves presenting data of Table VI in graphic form showing rate of hardening of alfalfa roots from the plants fall clipped in 1952.

Key

A = Atlantic Rh = Rhizoma
R = Ranger T = Talent
H = Hardigan N = Narragansett

Total extractable salts are shown in Tables VIII and IX. Although variable they did not change the relationships of the various varieties or treatments to any great extent. The decrease in conductivity closely resembles Dexter's similar findings with winter wheat (6) and suggests Gorke's theory of winter hardening (8).

Results for 1953

In 1953 the varieties again received the same treatments of fall clipping and no fall clipping. The fall was exceptionally dry with 3.67 inches of rain for September, October and November compared with a mean rainfall of 7.63 inches during this period. As a result the clippings were short and no yields were taken. Temperatures during October, November, and December were below normal.

Healthy roots of wilt susceptible varieties were hard to obtain. Root samples were tested on November 3rd and December 10th. In the test on November 3rd on the unclipped plants, Narragansett was the most hardened with Hardigan, Atlantic, and Talent intermediate, and Ranger and Rhizoma least hardened. Results are shown in Table X. By December Narragansett was most hardened with Ranger, Hardigan, Rhizoma, Talent, and Atlantic following in that order. The Talent stand had been thinned the most by winter killing the two previous winters and the remaining roots were large and healthy when compared with the others. Working with two year old alfalfa plants, Peltier and Tysdal (16) concluded that natural selection enhanced chances for survival which served to explain the relatively better hardiness of Talent compared to its hardiness the previous year.

TABLE VIII

TOTAL ELECTROLYTES, IN TERMS OF RECIPROCAL OHMS x 10^{-6} PER GRAM OF ROOT WEIGHT, OF ALFALFA ROOT EXTRACT FOLLOWING KILLING AT 90° C. ROOTS FROM PLOTS GIVEN NO CLIPPING TREATMENT IN 1952

Variety	October		November				December	
	22	29	5	12	19	26	3	10
Ranger	53.6	48.5	48.1	44.7	40.3	42.9	41.1	40.1
Narragansett	50.5	46.9	45.4	43.7	43.3	43.8	38.6	39.6
Rhizoma	54.4	47.1	49.8	45.2	41.1	43.3	39.9	38.7
Hardigan	52.1	50.4	46.3	45.5	40.9	43.6	41.8	42.6
Atlantic	51.1	47.2	47.0	46.6	40.5	44.4	41.7	42.9
Talent	55.2	50.6	47.2	48.4	40.3	43.5	42.1	38.5
Average	53.8	48.3	47.3	45.6	41.0	43.6	40.8	40.4

TABLE IX

TOTAL ELECTROLYTES, IN TERMS OF RECIPROCAL OHMS x 10^{-6} PER GRAM OF ROOT WEIGHT, OF ALFALFA ROOT EXTRACT FOLLOWING KILLING AT 90° C. ROOTS FROM PLANTS CLIPPED IN THE FALL OF 1952

Variety	October		November			
	22	29	5	12	19	26
Ranger	43.7	43.9	43.9	40.7	43.4	43.9
Narragansett	41.4	44.8	46.3	43.5	43.7	43.7
Rhizoma	45.4	48.6	43.2	45.3	42.7	42.7
Hardigan	45.9	45.8	43.5	40.1	39.8	43.8
Atlantic	53.8	44.5	41.6	44.1	39.4	42.1
Talent	54.7	48.2	52.2	44.7	47.9	48.5
Average	47.4	45.9	45.1	43.0	42.8	44.1

TABLE X

ELECTROLYTES, IN TERMS OF RECIPROCAL OHMS x 10^{-6} PER GRAM OF ROOT WEIGHT, OF EXTRACT OF ALFALFA ROOTS FOLLOWING FREEZING AT -7° CENTIGRADE. ROOTS TESTED IN 1953

Variety	Not Clipped		Fall Clipped 1952 and 1953	
	November 3	December 10	November 3	December 10
Narragansett	14.8	8.2	25.6	9.7
Hardigan	20.9	10.5	31.1	---
Atlantic	22.2	14.0	28.8	---
Talent	22.5	12.7	35.3	25.4
Ranger	29.3	9.0	21.3	11.1
Rhizoma	33.6	11.8	24.0	10.3
Average	23.8	11.0	27.6	14.1

Of the plots clipped in September of 1952 and 1953 Ranger was the most hardened on November 3rd with Rhizoma, Narragansett, Atlantic, Hardigan, and Talent following in that order. The Talent which had been clipped did not harden much in comparison with the Talent which had not been fall clipped indicating more injury from clipping for two years despite the dry fall weather. It was not possible to obtain a sufficient number of healthy roots for testing Atlantic and Hardigan on December 10th. Roots from the plants clipped were lower in dry matter than the roots from the unclipped plants.

Additional 1953 Tests

During the fall of 1953 one year old roots of the six varieties used in the previous tests plus Buffalo and DuPuits were obtained from an

additional set of plots which had been cut twice for hay in 1953. No fall clipping treatment was involved.

Narragansett was in the most hardened condition in November followed by Ranger, Rhizoma, Atlantic, Hardigan, Talent, and DuPuits. With the exception of Hardigan and Buffalo very little hardening had taken place in the varieties between the two dates. Results are shown in Table XI.

TABLE XI

ELECTROLYTES PER GRAM OF ROOT WEIGHT, FROM EXTRACT OF ONE YEAR OLD ALFALFA ROOTS FROZEN TO -7° CENTIGRADE IN THE FALL OF 1953

Variety	Date of Sampling	
	November 11	December 11
Narragansett	14.7	21.6
Ranger	16.5	22.3
Rhizoma	17.3	16.1
Atlantic	18.5	17.7
Hardigan	20.6	13.5
Buffalo	23.9	17.1
Talent	28.9	26.9
DuPuits	29.6	26.6
Average	21.2	20.7

Other Varietal Characteristics

Silage Quality

At the time of the first cutting in 1953 silage samples were taken from the six-variety test. The samples were chopped into one to one and one-half inch pieces with a paper cutter and triplicate five hundred

gram samples were packed into one quart Mason jars and later tested for pH at three levels in each jar. None of the silage produced bad odors and results in Table XII show no consistent differences.

TABLE XII

pH READINGS FROM SAMPLES TAKEN AT THREE LEVELS FROM QUART JARS OF SILAGE APPROXIMATELY FOUR AND A HALF MONTHS AFTER HARVEST

Variety	Replication	Top	Middle	Bottom
Ranger	1	4.80	4.96	4.85
	2	5.16	5.08	5.22
	3	5.47	5.70	5.54
Narragansett	1	5.10	5.33	5.38
	2	5.42	5.50	5.43
	3	5.18	5.58	5.43
Cardigan	1	4.95	4.60	4.95
	2	5.38	5.11	5.21
	3	5.46	5.53	5.30
Talent	1	5.89	5.62	5.53
	2	4.88	5.10	4.66
	3	5.13	5.13	5.16
Atlantic	1	5.40	5.80	5.99
	2	5.09	5.79	5.79
	3	5.08	5.22	5.03
Rhizoma	1	4.98	4.86	4.66
	2	5.21	5.31	5.49
	3	5.30	5.17	5.41

Foliage Color

Foliage color as affected by leafhopper. The first cutting of 1952 was made early to control an infestation of downy brome grass and

yield was not recorded. The following growth was attacked by leafhoppers especially along the south side next to plots of sugar beets. All varieties showed yellowing for approximately seven feet into the plots. However, beyond that point certain varieties stood out in marked contrast to the others. By July 20th, Hardigan and Rhizoma were still dark green and Narragansett showed only slight yellowing. Atlantic, Ranger, and Talent were increasingly yellow in that order.

The second cutting was made on August first and by September the following color ratings were made:

Talent and Ranger - very yellow
Atlantic - moderately yellow
Narragansett - slightly yellow
Hardigan and Rhizoma - very little yellowing

In 1953 each plot was given a color rating of one to ten with ten being dark green. Averages of these ratings are given in Table XIII. Narragansett, Hardigan, and Rhizoma seemed definitely superior to the other varieties in relation to damage by leafhopper.

TABLE XIII

FOLIAGE COLOR RATINGS FOR JUNE 21 AND AUGUST 1, 1953, WITH TEN REPRESENTING DARK GREEN

Variety	June 21	August 1
Narragansett	8.7	7.5
Rhizoma	8.2	7.3
Hardigan	7.6	8.3
Atlantic	6.7	6.2
Ranger	6.3	6.7
Talent	5.6	6.0

Foliage color as affected by fall frosts. The first killing fall frosts in 1952 occurred during the first week of October. The Talent foliage was killed, with the exception of the young crown shoots, and appeared very light in color with some leaves falling. Ranger foliage was also killed. Hardigan and Atlantic were damaged but showed some green color. Rhizoma and Narragansett were still quite green and did not appear to be very damaged.

Bloom

Following the first cutting of 1952, removed before blossoming for weed control, Talent produced the greatest amount of bloom with Ranger second. Hardigan, Narragansett, Atlantic, and Rhizoma followed in that order.

In 1953 Rhizoma was the first to bloom with the purple flowers appearing to bloom first, early in June. Narragansett, Hardigan, and Atlantic followed in that order. By June 14th all varieties were in bloom and the varieties were rated one to ten for bloom with ten being the greatest amount of bloom. Ratings were also given on June 22nd previous to harvest of the first cutting.

TABLE XIV

RELATIVE AMOUNT OF BLOOM OF ALFALFA VARIETIES IN 1953 WITH TEN REPRESENTING THE GREATEST AMOUNT OF BLOOM

Variety	Date of Bloom Rating	
	June 14	June 22
Narragansett	6.0	8.5
Rhizoma	4.0	7.5
Hardigan	3.5	8.0
Atlantic	2.3	6.9
Ranger	1.8	6.8
Talent	1.8	6.1

Wilt

The soil in which the plots were located was known to be heavily infested with bacterial wilt. During the second harvest year wilt symptoms began appearing in the plots, but not consistently in all plots of one variety.

Talent and Hardigan showed the most symptoms while Rhizoma was intermediate and Atlantic showed slight symptoms. By fall Talent showed the most wilt infected plants. Hardigan, Rhizoma and Atlantic were next in order while Ranger showed few symptoms and Narragansett showed none.

Lodging

Following the first cutting of 1953 observations were made on the aftermath left after cutting to determine the amount of lodging. Rhizoma and Narragansett showed the greatest amount of lodging when cut East to West, while the other varieties showed very little. When cut West to East Rhizoma again showed the most lodging with Atlantic slightly more lodged than the remaining varieties.

Recovery After Cutting

Talent exhibited extremely vigorous recovery after cutting. Atlantic was somewhat quicker to recover than Ranger but both recovered faster than Hardigan and Narragansett. Narragansett recovered slightly slower than Hardigan, while Rhizoma had very slow recovery.

Response to Photoperiod

In the fall of 1953 eight varieties of alfalfa were planted in the greenhouse in six inch clay pots filled with sand. They were watered

daily and given nutrient solution weekly. After the first true leaves appeared they were thinned to four plants per pot and given photoperiods of eight and twelve hours. The cultures replicated five times were placed under fluorescent lighting to extend the normal daylight period.

At the end of eight weeks the plants were harvested by washing the sand from the roots. Green weights were recorded for top growth and total plant growth of ten representative plants and are shown in Table XV.

TABLE XV

GRAMS OF TOTAL GREEN WEIGHT OF TEN ALFALFA PLANTS GIVEN LONG (LD) AND SHORT (SD) PHOTOPERIODS

Variety	Top Growth		Total Plant Growth	
	LD	SD	LD	SD
Buffalo	4.46	2.31	6.19	3.61
Talent	4.44	3.31	5.97	4.81
Narragansett	3.76	2.96	5.22	4.15
Atlantic	3.66	3.26	4.87	4.67
DuPuits	3.40	3.40	4.67	4.68
Ranger	3.22	3.01	4.75	4.40
Rhizoma	3.15	2.59	4.76	3.60
Hardigan	3.00	2.35	4.44	3.49
Sevelra	2.21	2.01	2.65	2.80

All varieties except DuPuits gave more top growth on long days. The more vigorous varieties tended to produce a higher yield under either photoperiod.

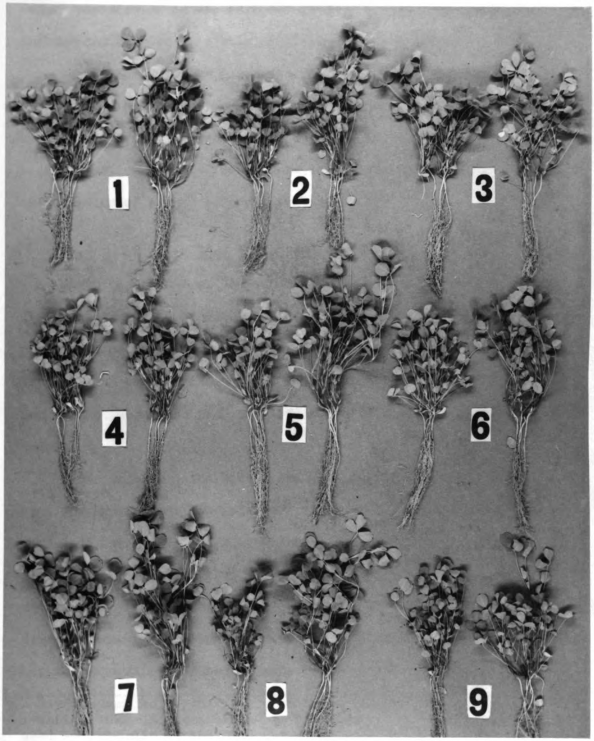
Six plants of each variety and treatment were photographed and are shown in Figure 3. All plants showed more elongation when grown under long day conditions. Narragansett, Buffalo, DuPuits, Atlantic, and

Figure 3. Alfalfa plants given short (left) and long (right) photoperiods.

Varieties are:

1. Narragansett
2. Nardigan
3. Talent
4. Rhizoma
5. Buffalo
6. DuPuits
7. Atlantic
8. Ranger
9. Sevelra

Scale = one-third actual size.


1
2
3
4
5
6
7
8
9

Ranger appeared to be the most elongated under long day conditions. Rhizoma and Sevelra were only slightly taller on long days.

Temperatures in the greenhouse were not controlled and often were higher than the temperatures used by Oakley and Westover (15) which may explain why the seedlings did not separate so completely into categories such as they observed. Temperature relations are closely related to the behavior of plants to photoperiods.

Seed Weight and Germination

Eight replicates of one hundred seeds were counted out from twenty different varieties or sources of seed and the weights recorded in milligrams per one hundred seeds. There was considerable variability. Buffalo seed was the largest and would amount to about 191,000 seeds per pound. Nomad was much smaller and would approach 249,000 seeds per pound.

After weighing, the seeds were dusted with Arasan and planted in sand one hundred per row in wooden flats in the greenhouse. Stand counts were made one week after they were planted. California Common seedlings were noticeably taller than all others. Talent, Atlantic, and Buffalo were slightly more vigorous than the other seedlings. Nomad, Utah Common, Sevelra, Ranger 7 and the Ladaks were the slowest in growth. Seedling height was again estimated 22 days after planting. California Common,[1]

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1 Several samples of the seed were grown in California at the various locations and altitudes listed below. Some of the samples were not 1952 seed and are also listed.

Certified Ranger 4, Tehachapi, California, elevation 3958 feet.
Certified Ranger 12, Anza, California, elevation 4,000 feet.
Certified Atlantic, Tehachapi, California, elevation 3958 feet.

(continued)

TABLE XVI

WEIGHT IN MILLIGRAMS PER ONE HUNDRED SEEDS AND PER CENT GERMINATION AFTER ONE WEEK. (AVERAGE OF EIGHT REPLICATIONS)

Variety	Average Weight	Per Cent Germination
Buffalo	237	78
Atlantic	223	58*
Talent	220	77
Ranger 4	215	83
Narragansett	212	88
Ranger 12	210	86
Ranger 6	210	94
DuPuits	209	43
Ranger 2	207	81
Ladak	206	62
California Common	204	91
Ladak	201	71
Rhizoma	198	62
Grimm	195	71
Hardigan	188	63
Cossack	187	81
Nomad	182	61
Utah Common	181	49
Ranger Nebr.	176	67
Sevelra	172	53

* Average of seven replicates.

DuPuits, Talent, and Buffalo were the most vigorous as shown in Table XVII. Nomad, Sevelra, Utah Common, Ladak, and Hardigan were the slowest growing.

(Footnote 1 continued)

California Common, Antelope Valley, elevation 2600 feet.
Buffalo, California grown.

Ranger 6, California Certified, 1951 seed.
Ranger 2, California Certified, 1950 seed.
Ranger 7, Nebraska Certified, 1945 seed.

TABLE XVII

SEEDLING HEIGHT OF PLANTS GROWN IN SAND WITH NORMAL DAY LENGTH HEIGHTS MEASURED 22 DAYS AFTER PLANTING IN RELATIVE VALUES ONE TO TEN, WITH TEN BEING THE TALLEST

Variety	Height
California Common	7.5
DuPuits	7.5
Talent	7.4
Buffalo	7.1
Ranger 2	6.8
Narragansett	6.8
Atlantic	6.7
Ranger 6	6.5
Ranger 4	6.5
Ranger 12	6.4
Cossack	6.4
Grimm	6.4
Ranger Nebraska	6.2
Rhizoma	6.2
Ladak Idaho	6.1
Hardigan	5.8
Ladak	5.8
Utah Common	5.4
Sevelra	5.3
Nomad	5.1

Rate of Germination

Four replicates of one hundred seeds each were placed in a germinator at 28° C. and daily counts were made of the number of seeds sprouting and beginning to grow. In general considerable variability existed in the rate of germination as shown in Table XVIII. The Ranger alfalfas, California Common, Talent, and Atlantic (California) contained relatively few hard seeds as compared with Nomad, Hardigan, Rhizoma, Vernal, Ladak, and Grimm. The latter varieties were also slower to germinate.

TABLE XVIII

RATE OF GERMINATION AS SHOWN BY NUMBER OF SEEDS REMOVED FROM THE GERMINATION BLOTTER AT THE FIRST SIGNS OF SPROUTING (SEEDS REMOVED ON DATE INDICATED)

Variety	Number of Days After Seeds Placed in Germinator					Hard Seed	Total Germination
	2	3	4	5	6		
Ranger 12	35	51	8	2	1	2	96
Ranger 4	49	34	7	1	1	5	92
Ranger 2	45	39	6	1	1	-	92
Ranger 6	30	45	16	1	-	1	92
California Common	30	47	17	1	2	3	96
Talent	32	36	6	1	1	1	75
Sevelra	22	25	9	2	2	1	59
Atlantic	19	39	11	3	2	-	72
Narragansett	20	45	22	6	3	1	95
Ranger 7	14	41	7	3	1	1	66
DuPuits	17	45	26	3	3	3	93
Buffalo	18	40	22	3	1	5	83
Cossack	8	26	13	4	2	5	52
Ladak, Idaho	27	46	8	4	3	7	87
Grimm	10	34	19	3	2	10	67
Ladak	11	36	9	2	3	11	60
Utah Common	6	27	17	4	7	4	60
Vernal	9	44	15	11	1	14	79
Rhizoma	4	20	23	5	6	17	57
Hardigan	9	34	19	3	6	21	70
Nomad	2	17	28	5	5	29	56

Summary

Several alfalfa varieties were harvested for hay yield during the summers of 1952 and 1953. Observations were made on varietal characteristics such as lodging, bloom, foliage color, wilt and recovery after cutting. In 1953 silage samples were made from the various varieties and tested for pH. Each fall root samples were tested for degree of winter hardening by means of controlled freezing experiments in the laboratory.

The response of alfalfa seedlings to photoperiodic treatments was studied in the greenhouse.

Various lots of seed were studied with respect to size and rate of germination.

CONCLUSIONS

1. September clipping in the fall of 1952 did not reduce total hay yields the following year.
2. September clipping for two seasons lowered the per cent dry matter in the roots and caused root injury.
3. All varieties showed considerable root injury at the end of the second harvest year due to winter injury or wilt.
4. Talent appeared to be inferior to other varieties in Michigan because of poor winterhardiness and susceptibility to wilt and leafhopper attacks.
5. Electrical conductivity determinations for winterhardiness were more reliable when used in a series of dates with only healthy roots than when used on older diseased roots.
6. Temperature and moisture were important in relation to hardening of alfalfa plants.
7. Seed size and germination of samples from various locations varied considerably.
8. Alfalfa plants varied in response to photoperiod giving more growth on long days.

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APPENDIX

Description of Varieties

Hardigan

Hardigan alfalfa is a selection from Baltic made at Michigan State College. Flowers are variegated but largely purple in color. The plants are uniform, blossom freely, and are reported to produce exceptionally good seed yields when conditions are favorable. The leaf color is dark green and the variety is fairly resistant to leaf diseases and leafhopper yellowing. Recovery after cutting is medium. Although very winterhardy it is susceptible to bacterial wilt.

Narragansett

Narragansett was developed at Rhode Island through mass selection from several strains of yellow blossomed alfalfa and from variegated stocks such as Grimm, Hardigan, Cossack, and Ladak. It has more variegation than Hardigan or Ranger, and dark green foliage and is about equal to Hardigan with respect to leaf diseases and winterhardiness, but seems less susceptible to bacterial wilt.

Rhizoma

Rhizoma was developed at the University of British Columbia from a cross between a yellow flowered alfalfa and Grimm. It exhibits a high proportion of yellow flowers and a decumbent type of growth with a low

spreading crown. The foliage is dark green. It is susceptible to bacterial wilt and in Wisconsin (6) and Michigan stands are thinned in short order. It is winterhardy and recovers slowly after cutting.

Atlantic

This variety is composed of selections from many different strains. It was developed at New Jersey for high forage yield. The flowers show some variegation and the plant type is variable. It is fairly winterhardy but susceptible to bacterial wilt, leadhopper yellowing and leaf diseases.

Ranger

Ranger is a multiple strain variety developed at the University of Nebraska from wilt resistant selections of Cossack, Turkestan, and Ladak. It exhibits variability in plant growth. Although wilt resistant it does not produce more forage in Iowa (20), Michigan (7), Ohio (2), than the other tested varieties unless the stand of such varieties was reduced by wilt.

Talent

Talent alfalfa was developed by the Oregon Agricultural Station from seed obtained from Provence, France. For twenty years it has undergone natural selection in Oregon. There it is a high yielding variety which recovers quickly after cutting and grows late in the fall. Flower color is light blue to reddish purple and can be classified as a common alfalfa. It is susceptible to injury by leadhoppers and to bacterial

wilt. Winterhardiness has not been fully determined but in the field here seems poor.

Buffalo

Buffalo is a selection from Kansas Common. It is resistant to bacterial wilt and not quite as winterhardy as Hardigan.

Sevelra

Sevelra is the result of crossing between strains of Siberian alfalfa and other alfalfa and subsequent natural selection in Idaho for over forty years (1).

DuPuits

DuPuits is a vigorous type of alfalfa from France.

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