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A Legume for Native Flood Meadows: I. Establishment and Maintenance of Stands of White-Tip Clover (*T. variegatum*) in Native Flood Meadows and its Effect Upon Yields, Vegetative and Chemical Composition of Hay[1]

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ONE of the most urgent needs of ranchers who rely on Northern Great Basin native flood meadows for their winter hay supply is a legume that will withstand the wild flood conditions. Such a legume would improve hay quality and increase the production of associated species through the fixation and release of nitrogen. Attempts to seed improved species such as alsike and strawberry clover have generally failed and attention has been centered on the possibilities of utilizing wild native legumes. Outstanding success has been achieved with annual white-tip clover (*Trifolium variegatum.*)

Preliminary data (2) have shown that phosphate fertilizer and delayed cutting to allow for seed dissemination increases the number and vigor of white-tip clover plants on areas to which it is indigenous. As a result, clover composition by weight in hay was increased from less than 1 to 50%. On meadows thus changed, yields of hay and crude protein have been more than doubled.

White-tip clover is an annual commonly found growing on native flood meadows in the Northern Great Basin. It withstands periods of flooding from 6 to 12 weeks on meadows where flooding depth is not more than 2 inches.

The seed germinates in the spring, producing a plant with a single stem, moderately branched and 8 to 30 inches in height. The root system is very shallow, and seldom penetrates the soil more than 4 inches.

Flowers are purple with white tips. The seed head is small with a diameter of less than one-half inch. It turns brown and resembles a bur when ripe. Seed pods shatter readily.

Seeds of white-tip clover are small (approximately 550,000 per pound). The germination content is usually 5 to 15% and the hard seed content 80 to 90%.

The plants are susceptible to a rust (*Uromyces trifolii*) which causes considerable leaf damage in some years. Control of the disease and the extent to which it may affect growth is unknown.

Because of the results of early trials with this legume and successful adaptation of these results to larger areas, intensive research has been conducted relative to its culture. This report presents data showing the influence of *(1)* seeding white-tip clover upon hay production, *(2)* seeding methods upon the establishment of white-tip clover in native flood meadows and *(3)* harvest management practices upon the maintenance of stands of white-tip clover.

GENERAL PROCEDURE

The studies were conducted on a meadow typical of the rush-sedge grass type (2). These meadows are flooded from early April until late June or early July. The vegetation consists principally of rush (*Juncus* spp.) and sedge (*Carex* spp.) with minor amounts of grass and native clover. The growing season of these species is concurrent with the flooding season.

At the end of the flooding period one cutting of hay is taken. Regrowth is negligible and is grazed with the aftermath of hay harvest by cattle returning from range in the fall of the year.

All experiments were conducted as factorials in randomized block designs of from 3 to 8 replicates with a plot size of 6 by 20 feet. Yield samples were obtained by harvesting a 38-inch strip through the length of each plot. Subsamples from the yield samples were used in determining oven dry matter and protein, calcium, and phosphorus content of hay. Crude protein was determined by the Kjeldahl method (1). The plant material used in determining calcium and phosphorus was wet digested by nitric, sulphuric, and perchloric acid (6). Calcium was then determined flame photometrically.[3] Phosphorus was determined colormetrically by a modified Fiske–Subbarow method as described by Toth et al. (6).

Seedling establishment was measured by the percentage stocked method (5). A 10 by 4-inch steel frame, subdivided into ten 2 by 2 inch units, was used in obtaining data. Ten frames at random were taken per plot for a total of one-hundred 2 by 2 inch units. A unit was considered stocked or occupied when one or more seedlings were present.

The clover composition of hay, by weight, was determined by the constituent differential method (4) and by hand separation.

More detailed procedure will be presented for each experiment in the subsequent section.

PROCEDURE AND RESULTS

Experiment 1

To evaluate the influence of seeding upon hay production white-tip clover was broadcast at 2 seeding rates in factorial combination with 2 phosphorus application rates in the spring of 1954. Rates of seeding were 0 and 35 pounds per acre and rates of phosphorus application were 0 and 80 pounds of P_2O_5 per acre. Plots receiving phosphorus in 1954 were fertilized at the same rate in 1955 and 1956. After the initial seeding of clover in 1954 clover stands were maintained by delaying cutting each year to allow for clover seed dissemination.

Yields.—The influence upon yields over a 3-year period from seeding clover or applying phosphorus, alone or in combination, is shown in table 1.

During the 3 years, clover plants were sparse on the unfertilized and unseeded plots. Unfertilized plots, seeded with clover, had good stands of clover in all years, but the clover contributed significantly to yield only in 1956. Yields were increased in all years on plots which had been fertilized with phosphorus, but not seeded. Clover plants were sparse on these plots during the first 2 years, but

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increased in density in the third year. The increase in clover density made phosphorus fertilization more effective in increasing yields. When plots were fertilized and seeded a highly significant interaction occurred. Yields were doubled in the first year and were substantially higher than the yields of other treatments in all years.

The response to treatment varied among years. Growing conditions within a year affect the establishment and growth of clover (experiment 2).

Clover composition.—In 1956 the composition of hay by weight was less than 5% clover on untreated plots and was 20, 24, and 57% clover respectively, for the clover seeded alone, phosphorus applied alone, and clover seeded with phosphorus, treatments. The percent of clover in the hay was in like proportion in the preceding years.

Crude protein.—The crude protein content of hay in 1954 and 1956 for all combinations of treatments is shown in table 1. Crude protein content of hay was in proportion to clover composition by weight. The crude protein content of clover in 1956 was 12.6% as compared to 8.2% for associated species.

Experiment 2

The influence of 2 seed treatments, 3 seeding rates, 3 levels of phosphorus application, and 2 levels of nitrogen application upon seedling establishment, first year yields, vegetative composition, and crude protein of the hay was studied in 1955 and 1956.

Seed treatments were *(1)* unscarified and *(2)* scarified by immersion in 78% sulphuric acid for 30 minutes. Seeding rates were based on the germination percentage of treated and untreated seed (15 and 33%, respectively) and were 1, 2, and 3 pounds of germinable seed per acre. Nitrogen levels, applied as ammonium nitrate were 0 and 60 pounds of N per acre and phosphorus levels, applied as treble superphosphate, were 40, 80, and 120 pounds of P_2O_5 per acre. Fertilizer was broadcast in the fall and clover seed was broadcast in the spring.

Seed scarification and seeding rate.—Treated and untreated seed was equally effective in obtaining stands of clover; however, stand densities were in direct proportion to seeding rate. Mean percentage occupancy was 35, 44, and 51% respectively, for rates of 1, 2, and 3 pounds of germinable seed per acre.

Seeding rate did not significantly affect yields, clover proportion, or crude protein of hay although proportion of clover and the crude protein content tended to increase with increased rates of seeding. Clover proportion, by weight, was 14, 17, and 20% and crude protein content was 8.9, 9.1, and 9.3% with seeding rates of 1, 2, and 3 pounds of germinable seed per acre.

Fertilization.—Nitrogen did not influence clover-stand density, but significantly increased hay yields from 1.91 to 2.47 tons per acre. The clover proportion decreased from 24 to 10% and crude protein content decreased from 9.5 to 8.7% with nitrogen fertilization. The decrease in clover proportion, which was mostly due to increased yields of associated species (3), was responsible for the decline in crude protein. The crude protein content of clover was 14.0% as compared to 8.1% for associated species.

The density of clover stands increased with increasing rates of phosphorus application. The percentage occupancy of clover seedlings was 40, 43, and 47% with phosphorus levels of 40, 80, and 120 pounds of P_2O_5 per acre. These differences in stand densities were significantly different at the 10% level.

Yields, clover component, and crude protein of hay increased significantly with increasing levels of phosphorus. Mean yields were 1.98, 2.16, and 2.43 tons per acre, clover proportion 5, 15, and 29%, and crude protein content 8.5, 9.0, and 9.8% respectively, with 40, 80, and 120 pounds of P_2O_5 per acre.

Seasons and site.—Seedling occupancy was 23% in 1955 as compared to 63% in 1956. In 1956 mean temperatures were 8° warmer in April and 5° warmer in May than in 1955. As a result of warmer temperatures in 1956 seeds germinated 3 weeks earlier and seedlings became better established prior to flooding. High mortality of seedlings occurred when they became completely submerged.

Experiment 3

The normal practice for maintaining stands of white-tip clover has been delayed cutting to allow for seed dissemination. However, delayed cutting results in a sharp decline in the crude protein content of hay. Experiment 3 was initiated to determine if the hard seed (80 to 90%) present in the seed drop of one year would insure stands for one or more years and thus allow early cutting in those years. The study was conducted on a meadow on which the white-tip clover composition had been increased by phosphorus fertilization and delayed cutting in 1952 and 1953. Clover proportion by weight was 50% in 1953 and it was estimated that 200 pounds of seed per acre was disseminated. The experiment was initiated in 1954 and was conducted as a 2 × 2 × 2 factorial in which the 3 years, 1954, 1955, and 1956 were factors each at 2 levels of cutting (before and after seed dissemination). All plots were treated with a uniform application of 80 pounds of P_2O_5 each year.

First year effects.—In the initial year of the experiment (1954) density was not measured, but good stands of clover were observed on all plots. Delaying harvest to allow for seed dissemination resulted in a significant increase in hay yield from 2.65 to 3.08 tons per acre.

Crude protein content declined significantly from 11.6 to 9.3% and the yield of crude protein decreased from 613 to 575 pounds per acre with delayed cutting.

Table 1.—The influence of seeding clover and applying phosphorus, alone or in combination, upon the yields and crude protein content of flood meadow hay in 1954 and 1956.

Treatment	1954		1955*	1956		Average	
	Yield	Crude protein	Yield	Yield	Crude protein	Yield	Crude protein
	T/A.	%	T/A.	T/A.	%	T/A.	%
None	0.90	7.3	1.08	1.67	8.8	1.22	8.0
Clover seeded, 1954	0.97	7.4	1.14	2.00	10.2	1.37	8.8
P_2O_5 each year	1.20	8.3	1.25	2.36	10.4	1.60	9.4
Clover seeded, 1954 P_2O_5 each year	1.86	10.1	1.60	2.96	12.6	2.14	11.4
Average	1.23	—	1.27	2.23	—	—	—
5% LSD	0.23	0.9	0.22	0.31	2.4	—	—

* Crude protein not measured.

Regrowth occurred when plots were cut early. The yield of regrowth was 440 pounds per acre and consisted entirely of rush (*Juncus* spp.), sedge (*Carex* spp.), and grass species. The crude protein content of regrowth was 10.4%. Normally, little regrowth occurs on non-clover areas when cut at the same time as the early cutting date in this experiment. The regrowth herbage exhibited the dark green color associated with nitrogen fertilization. It appears that nitrogen was being released into the soil either by clover plants just prior to cutting or from rapid decomposition of annual clover roots following cutting. At the late date of cutting, soils were too dry to permit regrowth.

Second year effects.—In 1955 clover-stand density was not significantly different on plots which had been cut after, as compared to before, seed dissemination in 1954. The percentage occupancy of seedlings was 55 and 63% respectively, for plots which had been cut before and after seed dissemination in 1954.

Yields of hay in 1955 were not significantly affected by the cutting treatments of 1954, but were significantly different when cut early and late in 1955. The yield of hay increased from 2.26 to 2.51 tons per acre with delayed cutting. Increase in yield with delayed cutting was due to the continued growth of clover, but not of associated species (table 2). Regrowth on early cut plots in 1955 yielded 211 pounds per acre, which was considerably less than in 1954.

The proportion of clover, by weight, in hay in 1955 was significantly affected by previous cutting treatment in 1954 and by cutting treatment in 1955 (table 2). The difference in clover component as a result of previous cutting treatments was in proportion to the difference in seedling density. Clover proportion increased with delayed cutting in 1955 because the clover continued to grow after the first cutting date. The yield of clover was 0.45 ton per acre when cut early as compared to 0.80 ton per acre when cut late. In contrast, the yield of associated species was 1.81 tons per acre when cut early as compared to 1.71 tons per acre when cut late.

Crude protein content of hay in 1955 declined significantly with delayed cutting (table 2). This decline was associated with a sharp decline in the crude protein of clover from 18.6 to 9.7% between cutting dates. In contrast, the crude protein content of associated species was 7.2 and 6.6% when cut early and late.

As in 1954, delayed cutting in 1955 reduced crude protein yields. Yields of crude protein in 1955 were 454 and 389 pounds per acre respectively, with early and late cutting. The carry-over influence of time of cutting in 1954 was equally apparent at each time of cutting in 1955 (table 2) and gave an average difference of 31 pounds of crude protein per acre in favor of late cutting the previous year.

The crude protein content of regrowth on plots cut early in 1955 was 9.6% and was less than in 1954.

The phosphorus content of hay cut in 1955 was not affected by the cutting treatments in 1954, but the early and late cutting treatments of 1955 were significantly different. Phosphorus content was 0.23 and 0.18% respectively for hay cut early and late in 1955. There was no significant difference in phosphorus content between clover and associated species at either cutting date.

Table 2.—The influence of cutting before and after seed dissemination in 1954 and 1955 upon clover proportion (by weight) and crude protein content of hay cut in 1955.

1955 cutting treatments	1954 cutting treatments					
	Early		Late		Average	
	Clover proportion	Crude protein	Clover proportion	Crude protein	Clover proportion	Crude protein
	%	%	%	%	%	%
Early	16	9.6	25	10.5	20	10.0
Late	27	7.5	37	8.1	32	7.8
Average	21	8.5	31	9.3		

5% LSD for comparing clover proportion means = 7%.
5% LSD for comparing crude protein content treatment means = 0.8%.

Calcium content of hay increased significantly from 0.65 to 0.84% with delayed cutting in 1955, and from 0.70 to 0.79% as a result of delayed cutting the previous year. Both increases were related to an increase in proportion of clover. Calcium content of clover was greater than that of associated species and was 1.73 and 1.35% when cut early and late. The calcium content of associated species increased with delayed cutting from 0.34 to 0.55%.

Third year effects.—In 1956 the average percentage occupancy of clover seedlings on all plots was over 90%, almost twice that of the preceding year. Because of the dense stands of seedlings, the occupancy method was inadequate for measuring density differences due to treatments. Plots which had been cut after seed dissemination in one or both of the preceding years appeared to have stands of higher density than those which had been cut before seed dissemination. However, all plots had more than an adequate number of seedlings.

Yields of hay (3.50 tons per acre when cut early and 3.55 when cut late) were not significantly different and were not affected by previous cutting treatment. They did not increase with delayed cutting as in other years because the clover had attained maximum dry matter production by the early cutting date.

The yield of regrowth on early cut plots was 414 pounds per acre. This was greater than in 1955 and comparable to 1954.

Clover proportion was 50%, by weight, at each time of cutting in 1956 and was not affected by previous cutting treatment.

Crude protein of hay decreased from 12.6 to 10.6% and crude protein of clover decreased from 16.9 to 11.3% with delayed cutting. Crude protein production per acre was much higher than in the preceding years due to larger yields and a higher clover proportion. The yield of crude protein was 884 and 756 pounds per acre when cut early and late. The crude protein content of regrowth was 14.2%.

Calcium content of hay cut early and late in 1956 was not significantly different and was 0.93 and 0.99%, respectively. These values were higher than those in 1955 because of the increased clover composition of hay.

DISCUSSION AND CONCLUSIONS

Experiments 1 and 2

White-tip clover can be used effectively as a legume for native flood meadows and, once established, has a profound influence upon hay yields and quality.

Stand density of clover may be increased through delayed harvest to allow for seed dissemination or through seeding. However, increases are more rapid through seeding if clover stands are initially sparse.

Clover seed may be scarified to increase the germinable seed content and decrease the amount of seed necessary to obtain stands. Seeding rates affect stand density but have little effect upon first year performance of clover. One pound of germinable seed per acre will insure a good stand of clover if phosphorus requirements are met.

Phosphorus fertilization influenced seedling establishment, and was a limiting factor in the growth of plants once established.

Applications of nitrogen do not benefit the growth of clover in any manner and result in a decrease in the clover proportion. It has been shown previously that such a decrease is a result of decreased clover yields due to competition from associated species and increased yields of associated species (3).

In some years clover in native meadows has been much more plentiful than in other years. From observations during this study it would appear that density of clover stands is largely dependent upon early spring temperatures and flood conditions. The mortality of seedlings is high whenever they become completely submerged. If germination is delayed because of cold spring temperatures, seedlings attain little growth prior to flooding and may become submerged even on areas where flooding is only 1 to 2 inches deep. On meadows where flooding depth is more than 2 inches, seedlings seldom attain enough growth prior to flooding to keep from being submerged. These areas should not be considered for clover establishment.

Experiment 3

Yields of hay averaged 500 pounds per acre less when cut early as compared to late; however, cutting early allowed an average regrowth of 355 pounds per acre. The slight loss in yield from early cutting was more than compensated for by increased yields (119 pounds) of crude protein from early cutting and regrowth.

The increase in crude protein production is of particular importance because it is a common practice to feed protein supplement with wild meadow hay which normally contains about 7% crude protein. Of further importance is the regrowth which occurred with early cutting. Cattle returning from range in the fall normally rely on the aftermath of hay harvest until winter feeding begins. The aftermath consists mainly of poor quality dry stubble and animals frequently lose weight during the fall grazing period. Regrowth, of the quality exhibited in this experiment, would contribute considerably to livestock nutrition.

These results provide information of the cultural practices necessary to maintain white-tip clover in native meadows. In this experiment cutting was delayed for two years prior to initiation to allow for clover seed dissemination. This seed source provided enough hard seed to insure good stands of clover during each of the 3 years of the study. Differences in seedling density were observed in 1955 following one year of differential cutting treatment and in 1956 following 2 years of differential cutting treatment. These differences in seedling density were not significant at the 5% level with the measuring method used and affected clover proportion only in 1955, an unusually poor year.

It appears that a system of harvest management which will allow for early cutting of mixed white-tip clover hay may be practiced without impairment of clover stands if cutting is delayed periodically to allow for seed dissemination. Hard seed from this seed crop will insure stands of clover for several years and thus allow for early cutting. As a general practice, delayed harvest every third year should provide an adequate seed source. However, an operator may adjust his harvest management to the appearance of the clover stand. In this case, whenever the stand of clover begins to thin, cutting should be delayed to restock the hard seed reserve.

SUMMARY

A description of annual white-tip clover *(Trifolium variegatum)*, a native legume which can withstand the wetland conditions of native flood meadows, is presented.

Influence of *(1)* seeding white-tip clover upon meadow hay production, *(2)* seeding methods upon establishment of white-tip clover in native flood meadows, and *(3)* harvest management practices upon the maintenance of stands of white-tip clover were evaluated. Measurements were made of seedling establishment, vegetative composition, hay yields, crude protein, calcium, and phosphorus contents of hay.

Seeding white-tip clover with an application of phosphorus substantially increased yields of hay and crude protein. Scarified and unscarified seed were equally effective in establishing clover. Seedling stand densities increased with seeding rate and with phosphorus levels, but were not significantly affected by nitrogen fertilization. Seedling establishment was related to spring temperatures and flood conditions among years. The mortality of seedlings was high when they became completely submerged. Nitrogen increased hay yields and decreased clover composition and crude protein of hay. Phosphorus increased hay yields and the clover proportion. The increase in clover component was accompanied by an increase in the crude protein content of hay.

Delayed cutting to allow for seed dissemination in 2 years provided enough hard seed to insure good stands of clover in each of 3 following years. During those 3 years early cutting each year resulted in higher crude protein content of hay, higher yields of crude protein per acre, and allowed for regrowth. The decline in crude protein content of hay with delayed cutting was associated with a sharp decline in crude protein content of clover and a slight decline in the crude protein content of associated species. Regrowth was attributed to the release of nitrogen by clover. Yields of hay increased with delayed cutting in 2 of 3 years. The yield increase was associated with an increase in proportion of clover. The clover continued to grow during the period cutting was delayed, whereas associated species did not.

It was concluded that if cutting is periodically delayed to allow for seed dissemination, early cutting may be practiced in some years without impairment of clover stands.

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