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Forage Yield and Plant Stand Intensity of Nine Alfalfa Varieties in Relation to Nine Rates of Seeding and Bacterial Wilt Resistance

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FORAGE YIELD AND PLANT STAND INTENSITY OF NINE ALFALFA VARIETIES IN RELATION TO NINE RATES OF SEEDING AND BACTERIAL WILT RESISTANCE

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INTRODUCTION

In growing alfalfa it is important to obtain a good initial stand. However, it is difficult to predict the exact amount of seed necessary to insure a good stand.

There are about 220,000 seeds in 1 pound of alfalfa seed, or enough for four to five seeds per square foot at the rate of 1 pound of seed per acre. If every seed should grow, 2 to 3 pounds of seed per acre would be sufficient for a good stand.

However, there are many hazards. Some seeds are not viable, and others are planted too deep or too shallow to germinate. Many plants die in the seedling stage for one reason or another. The present planting equipment makes it possible to sow small quantities and distribute the seed uniformly; however, a good stand is directly dependent on the seedbed, and an ideal seedbed is seldom obtained. Therefore higher rates are recommended than would be necessary under ideal conditions.

Alfalfa is an important forage crop in the intermountain region of the United States. In Utah, alfalfa is often injured by severe winters, making the choice of a variety with a high degree of winter-hardiness important. Bacterial wilt, Corynebacterium insidiosum (McCull.) H. L. Jones, is closely associated with winter injury in alfalfa and hence disease resistance is of great value when selecting an alfalfa variety. Resistance to the alfalfa stem nematode, Ditylenchus dipsaci, is also a desired varietal characteristic.

The successful production of alfalfa is of prime importance to the farmer in Utah and many other states. This crop is an essential part of nearly all rotations and serious losses may result if it fails to produce satisfactory yields. For this reason the spread of bacterial wilt in Utah was of considerable concern.

The effect of bacterial wilt on alfalfa has been extensively studied in the United States. Usually disease development has been measured by determining the percentage stand or the degree of infection of the plants, and relatively little attention has been paid to forage yield. The purposes of the present study were (1) to obtain accurate information on the effect of the disease on alfalfa forage yield and root dry weight, (2) to evaluate the effect of nine rates of seeding on forage yield of nine alfalfa varieties, (3) to evaluate the extent to which these varieties resist bacterial wilt, and (4) to determine plant intensity.

REVIEW OF LITERATURE

Bacterial Wilt

General review

According to Jones and Williams (1940) bacterial wilt is one of the most destructive and widely occurring diseases of alfalfa. It is considered to be one of the principal factors causing thinning of alfalfa stands after the second crop year. The disease has been known since 1925, and reports indicate that it is present in most alfalfa growing areas of this country.

Jones (1930) pointed out that the bacteria causing wilt enter the plant through wounds. These wounds may be any exposure of the living active parenchymatous tissues of the plant to water in which bacteria are carried. The bacteria do not grow in dead tissue. The wounds to which natural infection have been traced thus far have always been in the root or crown close to the soil level. From point of first contact with living cells the bacteria grow between the larger, younger cells chiefly in the rays until they pass through the cambium and enter the vessels. When the bacteria have entered the vessels, they are easily carried in water currents a long way up into the stems and down into the taproot where they cause a plugging not only of the vessels which they have entered but of nearby cells.

Graber (1953) stated that when bacteria get into the inner tissues of the plant they plug up the vessels and water does not move up the stems to the leaves. The result is stunting and wilting even

though there is plenty of water in the soil. Such plants die in a week or so and the roots and the crown begin to rot. Weeds soon appear in the field when the stand of alfalfa has been thinned.

Peltier and Jensen (1930) reported that the diseased plants are characterized by a slow dwarfed growth of the stems, resulting from impaired water and possibly food conduction. Usually there is an excessive number of small and shortened stems, giving the plants a bunch-growth effect. The leaves are yellowish and much smaller than healthy ones; they are curled upward and appear cup-shaped.

Wilting of the plants is first recognized by the drooping over of the tips of the stems. Soon afterward a more or less complete wilting or drying up of the entire plant occurs. Wilting is usually observed during the growing season but plants may die without showing any sign of wilting, whereas dwarfing is always the most conspicuous symptom.

Tysdal and Kiesselback (1941) reported that when a diseased plant is dug and the root cut across, a yellow ring can be observed under the bark. The discoloration extends into the taproot, side roots, and rootlets, as contrasted with the discoloration caused by other rots that may often occur in the center of the roots.

Graber (1953) concluded that wilt is an insidious disease. A few wilt sick plants or several usually go unnoticed until the stand is badly thinned. The bacterial organisms causing wilt are invisible except under magnification. They live in the soil indefinitely and are always on hand to cause trouble. They are spread around by wind and dust and by water and at times by cultivation and mowing. Tysdal and Kiesselback (1941) pointed out that the disease is spread from infected to healthy plants by drainage water, and probably by other

agencies as well. They reported also that no seed infection has been found.

Jones (1928) stated that winter injury is correlated with bacterial infection. Graber (1953) reported that bacterial wilt is a "water disease." Generally, it appears first in the low areas where water accumulates and where winter weakening of alfalfa is more likely to occur. Infection can occur when alfalfa is cut and especially when it is cultivated. Sick plants may be alive in the fall but usually such wilt infected plants die through winter killing.

Stoker (1956) stated that three bacterial wilt resistant varieties, Buffalo, Ranger, and Vernal have been credited with saving the American farmer in excess of 100 million dollars annually. Burlison and others (1946) concluded that where bacterial wilt becomes conspicuous and widely distributed the field should be planted to some crop other than alfalfa the following year. Tysdal and Kiesselback (1941) in an experiment found out that 2 years after planting there was an average of 6 percent wilt where diseased alfalfa had preceded the experimental crop, and less than 1 percent in a field never before in alfalfa.

Resistance to bacterial wilt

Nature of resistance. Peltier and Schroeder (1932) reported that resistance in some alfalfa plants is associated with certain morphological features, particularly in the root, which inhibit rapid development and invasion of the vital tissues by the bacteria. These morphological differences in susceptible and resistant sorts are inherent, though not absolute, since any variety or strain of alfalfa is

made up of a widely diverse lot of individuals. They pointed out too that since resistance in alfalfa to wilt is associated with root structure, it is also true that inhibiting or accelerating the rate of growth of either susceptible or resistant sorts may modify the root structure to such an extent that susceptible sorts may become more resistant or resistant alfalfa more susceptible.

Jones (1934) indicated that resistance first finds expression in the failure of the bacteria to establish themselves rapidly and extensively in the parenchymatous tissue of the host, either at the portal of entry, or later from the invaded vessels.

He also reported that through the use of grafted plants bacteria can be introduced directly into unwounded and continuously functioning vessels of resistant tissue without having to pass through parenchymatous tissue which previous observation indicated they were unable to penetrate.

Peltier and Schroeder (1932) found that wilt resistant varieties had smaller root xylem vessels than those susceptible to wilt. While Elling and Trosheirser (1960) and Jones (1934) found no evidence of morphological differences distinguishing resistant plants from the susceptible ones.

Peltier and Schroeder (1932) indicated that no direct evidence in physiological or mechanical studies showed any internal physiological function which made one variety more resistant than another, except insofar as morphological modifications may occur under different environmental conditions.

Walter (1960) reported that the susceptibility of Buffalo and Grimm varieties is definitely related to the level of potassium,

according to three tests conducted over a period of 3 years. Plant growth was poorest and bacterial wilt was most severe when the levels of nitrogen and phosphorous were high and the level of potassium was low. In contrast, bacterial wilt infection was lowest when the levels of nitrogen and phosphorous were low and the level of potassium was medium or high.

Genetics of resistance. Resistance to bacterial wilt is inherited. Peltier and Tysdal (1935) concluded that more than one factor, and possibly three, are involved in resistance to bacterial wilt. Brink et al. (1934) reported that resistance probably has a complex genetic basis. They found that resistant plants may differ greatly in composition with respect to the genes governing resistance and susceptibility.

Albrecht (1938) pointed out that the genetic factors involved are numerous and appear to be additive in their effect. He stated that resistance may be introduced by means of hybridization into any of the more commonly grown susceptible varieties of alfalfa. In his study the only group of F_1 plants tested for resistance was from crosses between susceptible plants and those of intermediate resistance. In this group, only two plants escaped with slight infection while the balance were infected. Jones and Williams (1947) agreed with Albrecht's (1938) results, and supported his conclusion that resistance may be introduced into the commonly grown susceptible varieties. In addition, they found that selection in the F_1 generation may lessen the labor involved.

Wilson (1947) found that resistance of alfalfa to bacterial wilt can be resolved into terms of separate genes. Three, and possibly

four, partially dominant genes differing in strength of resistance were isolated and designated P, R, T, and T'. P is the strongest and will give adequate protection against bacterial wilt and can be used to breed resistant varieties. R is intermediate between P and T. T and T' are both weak, behave similarly, and may be identical.

Donnelly (1952) and Stanford and Jones (1948) concluded that the results which they obtained were in agreement with the findings of Wilson (1947).

Effect of Bacterial Wilt on Forage Yield and Plant Intensity

Bacterial wilt markedly reduced the forage yield of Grimm alfalfa in the rotation plots (Peake and Cormack, 1955). They reported that the average yield reduction from the fourth to the sixth crop year was 57.7 percent as compared to 8.7 percent in the corresponding period before the disease became established. Although yields were generally higher in the fertilized than in the unfertilized plots, relatively the same losses were caused by bacterial wilt. A disease analysis showed that infection developed gradually until the third crop year, after which there was a rapid increase.

They also concluded that in a 6 year study of ten alfalfa varieties, the hay yields of Grimm, Canauto, Ferax, and Rhizoma were greatly reduced after the third crop year, and those of Ladak, Buffalo, Cossack, and Viking dropped off rapidly during the fifth and sixth year. The wilt-resistant varieties, Ranger and Hardistan, produced good yields during the entire period. In another experiment where conditions were particularly favorable for disease development, Hardistan, Orestan, and Wisconsin Synthetic C were seriously reduced

in stand and yield between the first and second crop year. Disease ratings showed that this damage was caused by bacterial wilt, and in the case of Buffalo and Ranger winter injury contributed to the stand reduction observed.

Graber and Jones (1935) compared winter hardy and wilt resistant Ladak and Turkistan alfalfas with winter hardy but susceptible Grimm, Canadian Variegated, and Cossack alfalfas and with regional strains of susceptible and moderately hardy Montana and South Dakota Common alfalfas. In a 1 year period the loss of plants was as follows: the population of the regional strains of Montana and South Dakota Common decreased 84 percent and 64 percent, respectively, Grimm 65 percent, Canadian Variegated 63 percent, Cossack 40 percent, Turkistan 16 percent, and Ladak 10 percent.

Peake and Cormack (1955) concluded that the early stages of infection in the 1 and 2 year old stands were detectable only in the roots. In the 3 year old stand over 20 percent of the plants were infected, with few showing top symptoms. The disease developed very rapidly in the older stands until nearly 90 percent of the plants were infected in the sixth year. Thinning of the stand through death of the plants appeared in the fourth year plot in which 12.1 percent of the plants were dead or dying. The increase of this damage to 63.8 percent in the sixth year explains the marked reduction in hay yield in the older stands.

Grandfield (1945) at Manhatten, Kansas compared the varieties Buffalo, Kansas Common, Grimm, Oklahoma Common, and Dakota Common. The stands ranged between 95 and 100 percent in 1939 but by 1942 had been reduced 6 to 25 percent for the wilt-susceptible varieties, while

that of Buffalo showed no reduction. The stand reduction was reflected in hay yield. Buffalo was not superior in yield in 1939 but by 1942 it yielded 3.26 tons per acre as compared to 2.52, 2.50, 2.46, and 2.85 tons per acre for the varieties listed in the order above. Hollowell (1945) reported that in the fourth year of a test at Ames, Iowa, Buffalo yielded 2.54, Ranger 2.34, Kansas Common 0.60, and Grimm 0.84 tons of hay per acre. In another test Ranger yielded 3.55, Grimm 2.47, Hardistan 3.47, Kansas Common 1.75, and Ladak 3.01 tons of hay per acre.

In regions in which the disease is prevalent it has been amply demonstrated that stands of susceptible varieties survive only 3 to 5 years (Jones and McCulloch, 1926; Grandfield, 1945), whereas prior to the advent of the disease longevity of stands was much greater. Speaking of the United States, Tysdal and Westover (1937) state that "bacterial wilt annually destroys hundreds of thousands of acres," and they point out that resistant strains which would extend the life of stands even 2 years would save millions of dollars.

Seeding Rates of Alfalfa

Early experiments conducted by Williams (1917) indicated no advantage for rates of seeding alfalfa over 10 pounds per acre. Cocke (1926) obtained 40 to 50 percent of weeds at 10 pounds per acre and only 3 to 5 percent at 30 pounds per acre. He recommended 20 to 30 pounds of seed per acre. Rather and others (1936) and Berg (1930) recommended seeding of 10 pounds or less.

At the Ohio Experiment Station, Williams (1917) secured the following yields from different rates of seeding: 5 pounds of seed,

9,013 pounds of hay to the acre; 10 pounds, 9,148 pounds; 15 pounds, 8,735 pounds; 20 pounds, 8,613 pounds; and 25 pounds, 7,722 pounds. He reported that 5 pounds of seed gave satisfactory results, but the weeds were a problem.

Burlison and others (1946) reported that the rate of seeding in Illinois varies from 10 to 20 pounds per acre. An average rate of 12 pounds has given good results. Oakley and Westover (1922) recommended 20 to 25 pounds per acre in the east, under irrigated conditions 15 to 20 pounds; and under dry land conditions 8 to 12 pounds per acre. McAllister (1957) pointed out that 10 to 12 pounds of seed one-half inch deep should be drilled to get a good stand. If a companion crop such as barley, wheat, or oats is used reduce the seeding rate of the small grain by half and manage the field to favor the alfalfa.

Tysdal (1953) found out that 6 to 8 pounds per acre provided a perfect stand under ideal conditions. However conditions are seldom ideal in the field.

Eastern growers and those who irrigate believe that a heavier rate of seeding is more preferred. The usual rate of seeding under these conditions is from 15 to 25 pounds per acre. In the corn belt from 12 to 15 pounds are used, and in the drier areas from 6 to 12 pounds. Graber (1953) stated that 20 to 25 pounds per acre of alfalfa seed were sown in the past. With new techniques for shallow sowing the rate may range from as little as 6 pounds per acre on sandy soils to a maximum of about 14 pounds of inoculated seed per acre on heavy soils. More seed is required on very rough cloddy soils than on those only moderately so.

Willard (1938) reported 5 years results from four seedings of Grimm and common alfalfa at nine rates ranging from 2½ to 50 pounds of seed per acre. He concluded that there was no significant increase in yield of hay per acre for rates of seeding above 7½ pounds per acre. The hay from the thick stand was considerably finer than that from the thin rates. In the thick stands there were many more stems on a given area, the stems were smaller in diameter, and each stem weighed less than in the thin stands.

Willard (1938) also pointed out that there were no significant differences in the percentage of leaves or in the percentage of protein in the hay from different rates of seeding. He found no significant increase in the weight of air-dry roots per acre for rates of seeding above 12½ pounds per acre. He concluded that the average standard rate of seeding alfalfa in Ohio is 10 to 12 pounds per acre. Seven pounds is sufficient under the best seeding conditions; if conditions are so poor that 15 pounds per acre will not give a satisfactory stand, something other than the rate of seeding needs correction.

Tysdal and Kiesselback (1941) reported that five and possibly three or four well established and evenly distributed plants per square foot may be as productive of forage as a thick stand. Thin stands, however, are invariably more or less uneven, more subject to weed growth, and usually produce a hay of lower quality. In general, therefore, 10 to 15 pounds of seed are sown per acre; the seeding of more than 15 pounds of seed per acre, however, seems inadvisable and unnecessary.

At the Arkansas Agricultural Experiment Station, Jacks (1955) found that 15-20 pounds of good quality alfalfa seed per acre appear

to be ample to insure a good productive stand. The 15 pound rate of seeding gave 20.9 plants per square foot, and was considered an excellent stand. Stand counts were made three times during the growing season in 1 foot squares placed at random in each plot. There was an average of 23.8 plants per square on all of the plots at the first count. The low count was 13.4 plants for the 10 pound seeding rate, and the high count was 30.8 plants for the 40 pound per acre rate.

He also concluded that there were no significant differences in yields between nine rates of seeding although the 10 pound rate gave lower yields than other rates. Yields from the 15, 20, 25, 30, and 40 pound rates were very similar. The average yield for all plots and all rates was 4.16 tons per acre. The 15 pound and 40 pound rates yielded 4.21 and 4.46 tons per acre, respectively.

METHODS AND PROCEDURES

Design and Plant Materials

The present study was undertaken to include a comparison of nine alfalfa varieties, and particularly to study the hay produced at the different rates of seeding. The rates of seeding are given in grams per plot or pounds per acre. The earlier data from this experiment have been provided by Dr. D. R. McAllister.

A level area of about one-fourth acre on F-Field of the Greenville Experimental Farm, North Logan, Utah, typical of much of the irrigated land in this valley, was chosen for the experiment. The soil is Millville silt loam with a water table at about 90 feet. It is a permeable soil and yields about 2 inches of water per foot depth. The surrounding areas were covered with grasses or alfalfa.

A 9 x 9 balanced lattice-design with 10 replications and a total of 810 plots was used in this study. Each plot was 20 feet long and had 4 rows 6 inches apart with 12 inches between plots (design furnished in 1955 by Dr. Rex Hurst).

Nine alfalfa varieties were used in this study. They were selected on the basis of different areas of adaptation and included:

Atlantic--a composite of many lines, developed by the New Jersey Agricultural Experiment Station through a program of material line selection in stocks tracing to more than 100 varieties and strains from North America, Europe, and Asia.

A-253--a Utah synthetic composed of seven clones selected for high seed production by Dr. M. W. Pedersen, U.S.D.A., Agricultural Research Service, Logan, Utah.

Buffalo--developed by U.S.D.A. and the Kansas Agricultural Experiment Station from selection of an old line of Kansas Common; although not inbred, it was close bred with attention being given to bacterial wilt resistance and forage productivity.

DuPuits--developed by Tourneur Freres of Coulommiers, France, and released to European farmers in 1937; first tested in the United States in 1947.

Ladak--introduced in 1910 from northern India by U.S.D.A., produces a heavy first crop.

Lahontan--a five-clone synthetic developed by U.S.D.A. and the Nevada Agricultural Experiment Station, parental clones selected from Nemastan which was originally Turkistan 19304; released for seed increase by the experiment stations of Nevada and California in 1954.

Ranger--developed by U.S.D.A. and Nebraska Agricultural Experiment Station, a multiple strain variety synthesized from five basic strains originating from Cossack, 45 percent; Turkistan, 45 percent; and Ladak, 10 percent.

Rhizoma--developed at the University of British Columbia, Vancouver, Canada, from a cross between a yellow-flowered variety, Don, and Grimm; used mostly for pasture and range improvement.

Vernal--a synthetic developed by Wisconsin Agricultural Experiment Station and U.S.D.A., released in 1953; 50 percent of the germ plasm in the variety was derived from six Cossack plants, the remainder from

crosses between selected plants of Ladak, Kansas Common, and diploid stock of Medicago falcata.

Plots were seeded in the spring of 1956, but the two north reps were reseeded in 1957. Nine rates of seeding, 1, 4, 7, 10, 13, 16, 19, 22, and 25 pounds per acre, were used. The desired amount of seed was previously weighed and drilled in each row with a V-belt seeder. The area was sprinkled for establishment but flooded through the rest of the time.

Disease Development

After final hay yield data had been obtained for the period 1958 to 1960 the 5 year old plots were sampled and rated for bacterial wilt in October 1960. Representative samples of each variety were obtained by plowing a strip 3 inches deep and 3 feet wide through every belt (figures 1, 2, and 3). Sample roots from every plot in all ten replicates were placed in individual sacks carrying the plot number.

All samples were moved to the store room for testing. Roots were tested by cutting diagonally about 2 inches below the crown and observing for a yellow ring under the bark. Diseased roots were counted and recorded for analysis.

Plant Intensity and Roots Dry Weight

Data on stands obtained from various rates of seeding were collected in 1960. Plant intensity was studied by counting the plants in each area plowed to obtain diseased samples. The number of roots was recorded to study the influence of the disease on the stand of every variety.

Figure 1. Sampling of alfalfa roots after plowing, F-Field, Greenville Farm, 1960. Sacks in foreground contain roots.

Figure 2. Sampling of alfalfa roots after plowing, F-Field, Greenville Farm, 1960. Sacks in foregound were placed over their respective plots.

Figure 3. Sampling of alfalfa roots after plowing, F-Field, Greenville Farm, 1960, showing method of root removal by use of pitchforks.

Samples were placed in the dryer for 5 days to obtain root dry weights. On the fifth day they were taken out and the dry weight recorded.

Yield

Hay yield data had been obtained for the period 1958 to 1960 on the basis of three crops a year except 1959 when only two crops were obtained. The harvesting procedure consisted of mowing the entire plot using a small power mower. Plot green weights were taken in the field using a 60 pound capacity Hanson Dairy Scale. Yields were recorded in pounds and then converted to tons of hay per acre dry weight by use of a calculated conversion factor. Considering an estimated 26-28 percent dry matter the formula used was as follows:

$$\frac{\text{plot green weight} \times .26 \times \frac{43,560}{\text{plot area in square feet}}}{2,000}$$

EXPERIMENTAL RESULTS

Rates of Seeding

Effect of rate

The Duncan's (1955) Multiple Range Test was applied to the annual forage yield data with results presented in tables 1, 2, and 3. The 1958 and 1959 comparisons (tables 1 and 2) showed that the 1 pound seeding rate produced significantly less hay than any other seeding rate. Greater differences occured in 1960 when the range test gave a three-way significance wherein the 1 pound rate gave one range, the 4 and 7 pound rates gave another, and the 10 through 25 pound rates gave a third significant range.

Response of varieties to rate of seeding

In table 4 the yields of nine alfalfa varieties at nine seeding rates are averaged separately for the 3 year period of production. Ranger outyielded the rest of the varieties and gave similar results at each rate of seeding except the 1 pound rate. A significant difference is not indicated for the most desirable rate of seeding for each variety. However, there was generally a progressive increase in yield for all varieties when more than 1 pound of seed was used. No variety showed a significant increase above the 10 pound seeding, although Atlantic, Ladak, Lahontan, and Vernal produced 23.09, 19.66, 22.31, and 21.46 total tons per acre, respectively, at the 25 pound seeding rate.

Table 1. Average yields of hay for nine rates of seeding during 1958, F-Field, Greenville Farm

Seeding rate lbs./acre	Mean yields of 3 crops tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test
19	8.58	a
25	8.57	a
22	8.52	a
10	8.48	a
16	8.43	a
13	8.41	a
7	8.29	a
4	8.10	a
1	6.79	b
$\bar{X}$	8.24	
F	44.93**	
$S\bar{X}$	.2591	

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 2. Average yields of hay for nine rates of seeding during 1959, F-Field, Greenville Farm

Seeding rate lbs./acre	Mean yields of 2 crops tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test
25	4.31	a
19	4.24	a
16	4.21	a
22	4.20	a
10	4.19	a
7	4.19	a
13	4.19	a
4	3.92	a
1	3.39	b
$\bar{X}$	4.09	
F	27.94**	
$S\bar{X}$	.1608	

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 3. Average yields of hay for nine rates of seeding during 1960, F-Field, Greenville Farm

Seeding rate lbs./acre	Mean yields of 3 crops tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
25	7.94	a		
22	7.70	a		
16	7.69	a		
19	7.68	a		
13	7.62	a		
10	7.61	a		
7	7.51	a	b	
4	7.00		b	
1	5.90			c
$\bar{X}$	7.40			
F	152.91			
$S\bar{X}$	.1502			

Note: Means within the table followed by the same letter are not significantly different.

Table 4. Total hay yields for nine alfalfa varieties at nine rates of seeding, 1958, 1959, and 1960, F-Field, Greenville Farm

Seeding rate lbs./acre	Total yield from 1958 to 1960 (8 crops) in tons/acre								
	Atlantic	A-253	Buffalo	DuPuits	Ladak	Lahontan	Ranger	Vernal	Rhizoma
1	16.08	17.85	17.11	13.55	16.13	17.76	19.22	15.85	12.15
4	20.67	21.86	19.62	15.93	16.89	20.24	21.12	19.36	15.56
7	21.24	20.89	21.73	17.07	18.85	21.15	22.27	19.54	17.27 ✓
10	21.92	22.09	21.58	17.14	17.98	21.19	21.67	20.19	16.96
13	21.88	22.85 ✓	21.35	16.83	18.32	21.86	22.96	20.00	15.96
16	22.06	22.28	21.20	17.83	18.37	21.37	22.45	20.53	16.48
19	22.26	21.88	22.12 ✓	17.37	19.39	21.20	22.81	20.23	17.08
22	22.00	22.00	21.73	16.84	19.26	21.61	23.29 ✓	20.19	16.95
25	23.09 ✓	22.70	21.76	18.03 ✓	19.66 ✓	22.31 ✓	21.82	21.46 ✓	16.67
$\bar{X}$	21.24	21.60	20.91	16.73	18.32	20.97	21.96	19.71	16.12

Yield data presented in tables 5, 6, and 7 represent the response of the varieties to the increase in rate of seeding for the years 1958, 1959, and 1960. In these three tables all varieties did not show an increase in yield after the 10 pound rate of seeding, from this rate and above the production was more or less uniform at each rate for each variety.

Atlantic, DuPuits, and Rhizoma produced less hay at all rates of seeding in 1960 compared to 1958. Lahontan and Ranger increased in yield at each rate of seeding in 1960.

Stand remaining

The multiple range test in table 8 showed that there was no significant difference in numbers of roots between Lahontan and the five varieties immediately after, although Lahontan ranked the highest. There were significant differences between Lahontan, Ladak, Rhizoma, and DuPuits. The variety DuPuits had the lowest number of roots and did not show significance from the five varieties immediately above.

The multiple range test for the number of roots found at the different rates of seeding is shown in table 9. The test showed no significant difference between the rates 19, 25, 22, 16, 13, 10, and 7 pounds per acre, but there was a significance between the seven first rates and the 1 and 4 pound rates. Rates 22, 16, 13, 10, 7, and 4 pounds had significantly higher numbers of roots than the 1 pound rate.

Dry weight per root

The weight per dry root and range test for nine varieties and nine rates of seeding are reported in tables 10 and 11, respectively. At the 5 percent level the varieties gave five significant ranges in

Table 5. Total hay yields for nine alfalfa varieties at nine rates of seeding, 1958, F-Field, Greenville Farm

Seeding rate lbs./acre	Total yield for three crops in tons/acre								
	Atlantic	A-253	Buffalo	DuPuits	Ladak	Lahontan	Ranger	Vernal	Rhizoma
1	7.06	6.98	6.56	7.29	6.77	6.60	7.50	6.46	5.91
4	9.17	8.92	7.91	8.66	7.31	7.49	8.44	7.76	7.25
7	8.94	8.17	8.62	8.73	8.20	7.94	8.62	7.99	7.40
10	9.26	9.25	8.82	8.92	8.18	8.18	8.39	7.72	7.62✓
13	9.37	8.97	8.24	9.48✓	7.60	8.40✓	8.99	7.80	6.82
16	9.11	9.35✓	8.37	9.17	7.57	8.05	8.79	7.99	5.51
19	9.28	8.84	8.99✓	9.34	8.01	8.12	8.96	8.10	7.49
22	9.26	9.23	8.28	8.94	8.21✓	8.30	9.17✓	7.78	7.56
25	9.68✓	9.19	8.67	9.29	8.01	8.40	8.45	8.39✓	7.01
$\bar{X}$	9.01	8.77	8.28	8.87	7.76	7.94	8.59	7.77	7.17

Table 6. Total hay yields for nine alfalfa varieties at nine rates of seeding, 1959, F-Field, Greenville Farm

Seeding rate lbs./acre	Total yield for two crops in tons/acre								
	Atlantic	A-252	Buffalo	DuPuits	Ladak	Lahontan	Ranger	Vernal	Rhizoma
1	3.55[a]	3.79	3.94	2.73	3.01	3.88	4.13	3.06	2.46
4	4.38	4.50	4.23	3.23	3.26	4.32	4.27	3.85	3.21
7	4.43	4.47	4.73	3.63	3.75	4.67	4.57	3.84	3.65 ✓
10	4.65	4.49	4.53	3.52	2.74	4.69	4.49	4.05	3.45
13	4.54	4.74 ✓	4.71	3.52	3.70	4.61	4.53	4.04	3.33
16	4.49	4.55	4.61	3.93 ✓	3.71	4.48	4.59	4.29	3.25
19	4.80 ✓	4.41	4.78 ✓	3.60	3.88	4.41	4.71	4.01	3.48
22	4.61	4.39	4.65	3.45	3.96 ✓	4.56	4.76 ✓	4.18	3.24
25	4.78	4.65	4.58	3.88	3.83	4.73 ✓	4.46	4.38 ✓	3.47
$\bar{X}$	4.47	4.44	4.53	3.50	3.54	4.48	4.50	3.97	3.28

[a] Each figure is a total for 2nd and 3rd crops.

Table 7. Total hay yields for nine alfalfa varieties at nine rates of seeding, 1960, F-Field, Greenville Farm

Seeding rate lbs./acre	Total yield for three crops in tons/acre								
	Atlantic	A-253	Buffalo	DuPuits	Ladak	Lahontan	Ranger	Vernal	Rhizoma
1	5.47	7.08	6.61	3.53	5.45	7.28	7.59	6.33	3.78
4	7.12	8.44	7.48	4.04	6.32	8.43	8.41	7.75	5.10
7	7.87	8.25	8.37	4.71	6.90	8.54	9.08	7.71	6.21
10	8.01	8.35	8.23	4.70	7.06	9.04	8.79	8.42	5.89
13	7.97	9.14	8.40	3.83	7.02	8.85	9.44	8.16	5.81
16	8.46	8.38	8.72	4.73	7.09	8.84	9.07	8.25	5.72
19	8.18	8.63	8.35	4.43	7.49	8.67	9.14	8.12	6.11
22	8.13	8.38	8.80	4.45	7.09	8.75	9.36	8.23	6.15
25	8.63	8.86	8.42	4.86	7.82	9.17	8.91	8.69	6.19
$\bar{X}$	7.76	8.39	8.15	4.37	6.92	8.62	8.86	7.96	5.66

Table 8. Average number of roots per square yard under nine alfalfa varieties, 1960, F-Field, Greenville Farm

Variety	Average number of roots per square yard	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
Lahontan	39.06	a		
Ranger	31.51	a	b	
A-253	29.24	a	b	
Buffalo	27.53	a	b	c
Vernal	27.04	a	b	c
Atlantic	24.84	a	b	c
Ladak	23.97		b	c
Rhizoma	23.04		b	c
DuPuits	14.28			c
$\overline{X}$	26.72			
F	20.80**			
$S\overline{X}$	4.40			

Note: Numbers within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 9. Average number of roots per square yard at nine rates of seeding, 1960, F-Field, Greenville Farm

Seeding rate lbs./acre	Average number of roots per square yard	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
19	33.76	a		
25	32.24	a		
22	30.38	a	b	
16	30.36	a	b	
13	28.58	a	b	
10	25.83	a	b	
7	25.09	a	b	
4	20.24		b	c
1	14.03			c
$\bar{X}$	26.72			
F	30.86**			
$S\bar{X}$	3.3952			

Note: Numbers within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 10. Average weight per dry alfalfa root for nine alfalfa varieties, 1960, F-Field, Greenville Farm

Variety	Average weight in pounds per dry alfalfa root	Least significant ranges at the 5 percent level Duncan's Multiple Range Test				
Atlantic	0.0477	a				
DuPuits	0.0450	a	b			
Vernal	0.0438	a	b			
Ladak	0.0434	a	b	c		
Rhizoma	0.0423	a	b	c	d	
Buffalo	0.0390		b	c	d	e
Ranger	0.0354			c	d	e
A-259	0.0351				d	e
Lahontan	0.0319					e
$\bar{X}$	0.0404					
F	4.67**					
$S\bar{X}$	0.0025					

Note: Numbers within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 11. Average weight per dry alfalfa root at nine rates of seeding, 1960, F-Field, Greenville Farm

Seeding rate lbs./acre	Average weight in pounds per dry alfalfa root	Least significant ranges at the 5 percent level Duncan's Multiple Range Test
1	0.0597	a
4	0.0558	a
10	0.0399	b
7	0.0394	b
13	0.0365	b
19	0.0339	b
22	0.0336	b
16	0.0332	b
25	0.0332	b
$\bar{X}$	0.0364	
F	8.58**	
$S\bar{X}$	0.0035	

Note: Numbers within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

table 10, while table 11 gave only two ranges. The varieties Atlantic and DuPuits ranked the highest while Lahontan ranked the lowest. In table 11 the 1 and 4 pound rates ranked highest while the 16 and 25 pound rates ranked lowest.

Bacterial Wilt Disease Counts

The varieties Lahontan and Vernal had the lowest mean number of diseased plants. The significant ranges in table 12 give the differences between the varieties. The results show there were great differences in diseased plant means separating the varieties. The greatest difference was between the first five varieties and the last four. The differences between A-253 through Vernal are not significant.

The multiple range test in table 13 shows the effect of different rates of seeding on diseased plants and gave two significant ranges. Seven pounds through 19 pounds gave the first range and 1 pound through 22 pounds gave the second range, The 7, 1, 4, and 19 pound rates are significantly different from the 13 through 22 pound rates of seeding.

Studies on Alfalfa Varieties

Forage yields for 1958 and 1960 for the nine varieties are shown in figure 4. Only three varieties, Lahontan, Vernal, and Ranger, showed no reduction in yield, but they increased in yield in 1960. All other varieties showed a marked reduction. DuPuits was the second highest variety in 1958 and dropped off to the lowest yielding variety in 1960. Atlantic was first in 1958 and reduced in yield to sixth in 1960. Rhizoma was the lowest yielding variety in 1958 and the eighth

Table 12. Percentage of bacterial wilt (Corynebacterium insidiosum) infected roots in nine alfalfa varieties, F-Field, Greenville Farm, 1960

Varieties	Percentage of diseased roots	Least significant ranges at the 5 percent level Duncan's Multiple Range Test
DuPuits	22.58	a
Rhizoma	21.99	a b
Atlantic	18.00	a b c
A-253	16.96	a b c d
Ladak	16.39	a b c d
Buffalo	15.91	b c d
Ranger	14.30	c d
Lahontan	11.81	c d
Vernal	11.10	d
$\bar{X}$	16.55	
F	3.96**	
$S\bar{X}$	1.994	

Note: Numbers within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 13. Percentage of bacterial wilt (Corynebacterium insidiosum) infected roots found in plots seeded at nine seeding rates, F-Field, Greenville Farm, 1960

Seeding rate lbs./acre	Percentage of diseased roots	Least significant ranges at the 5 percent level Duncan's Multiple Range Test	
7	19.54	a	
1	18.09	a	b
4	18.00	a	b
19	16.97	a	b
13	14.51		b
25	14.40		b
10	14.37		b
16	14.36		b
22	14.23		b
$\bar{X}$	16.05		
F	3.32**		
$S\bar{X}$	1.31		

Note: Numbers within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

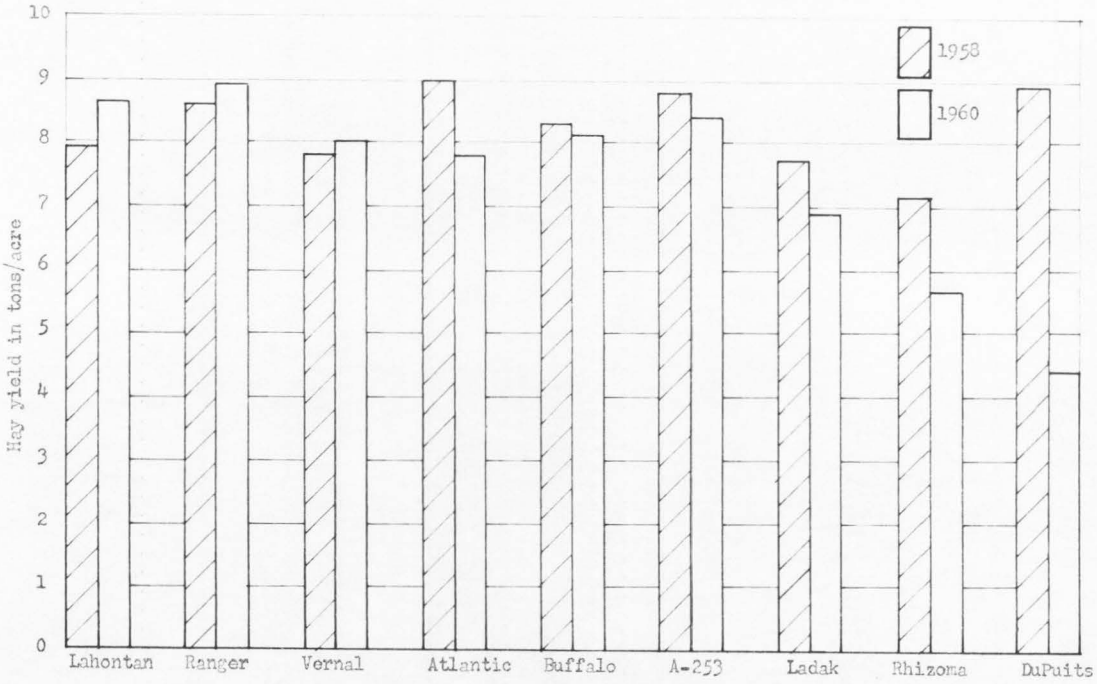

Figure 4. Influence of bacterial wilt on yield of three crops a year in alfalfa stand for the period 1958 and 1960.

in 1960. Buffalo, A-253, and Ladak had a slight drop in yield in 1960.

The multiple range tests for first, second, and third crops of 1958 are presented in tables 14, 15, and 16. The first and third crop comparisons (tables 14 and 16) show that Atlantic ranked the highest in yield and was significantly different from Lahontan, Vernal, Ladak, and Rhizoma. Atlantic ranked the second highest in table 16 but was not significantly different from Lahontan in tables 14 and 15. Lahontan was eighth in first crop and sixth in second and third crops, respectively. DuPuits ranked third, first, and second in tables 14, 15, and 16, respectively. Rhizoma was the poorest yielding variety in the three crops. Ranger was fourth in first and second crop and fifth in the third crop.

Ranked varietal means of the three crops combined for 1958 are presented in table 17. Atlantic and DuPuits were the highest yielding varieties and were significantly better than Lahontan, Vernal, Ladak, and Rhizoma, but not from A-253, Ranger, and Buffalo. Varieties Ranger through Ladak were significantly different from Rhizoma. The varieties Rhizoma and Ladak were the lowest yielding varieties. It was noted that A-253, Ranger, Buffalo, and Lahontan ranked third, fourth, fifth, and sixth, respectively.

The multiple range test and the ranked varietal means of the second and third crops for 1959 are reported in tables 18 and 19. Ranger was the highest yielding variety in table 18 and fourth in table 19. Atlantic and Lahontan ranked second and third, respectively in the third crop. Varieties Ranger through Ladak are significantly different from Rhizoma and DuPuits in table 18 while Vernal, Ladak,

Table 14. First crop forage yields for nine alfalfa varieties, 1958, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test	
Atlantic	3.33	a	
A-253	3.29	a	
DuPuits	3.22	a	b
Ranger	3.20	a	b
Buffalo	2.97	a	b
Ladak	2.91	a	b
Vernal	2.89	a	b
Lahontan	2.87	a	b
Rhizoma	2.82		b
$\bar{X}$	3.06		
F	18.15**		
$S\bar{X}$	.1421		

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 15. Second crop forage yields for nine alfalfa varieties, 1958, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
DuPuits	3.53	a		
Atlantic	3.50	a		
A-253	3.38	a		
Ranger	3.33	a	b	
Buffalo	3.23	a	b	
Lahontan	3.14	a	b	
Ladak	3.07		b	c
Vernal	3.03		b	c
Rhizoma	2.82			c
$\bar{X}$	3.22			
F	34.92**			
$S\bar{X}$	.1139			

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 16. Third crop forage yields for nine alfalfa varieties, 1958, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test				
Atlantic	2.18	a				
DuPuits	2.11	a	b			
A-253	2.08	a	b	c		
Buffalo	2.07	a	b	c		
Ranger	2.04	a	b	c		
Lahontan	1.92		b	c	d	
Vernal	1.84			c	d	
Ladak	1.77				d	
Rhizoma	1.54					e
$\bar{X}$	1.95					
F	62.73**					
$s\bar{X}$	.0766					

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 17. Total forage yield for nine alfalfa varieties, 1958, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test			
Atlantic	9.01	a			
DuPuits	8.86	a	b		
A-253	8.76	a	b		
Ranger	8.59	a	b	c	
Buffalo	8.28	a	b	c	
Lahontan	7.94		b	c	d
Vernal	7.77			c	d
Ladak	7.76			c	d
Rhizoma	7.18				d
$\bar{X}$	8.24				
F	41.46**				
$S\bar{X}$	.2870				

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 18. Second crop forage yield for nine alfalfa varieties, 1959, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test	
Ranger	2.86	a	
Lahontan	2.84	a	
A-253	2.83	a	
Atlantic	2.81	a	
Buffalo	2.80	a	
Vernal	2.57	a	b
Ladak	2.39	a	b
Rhizoma	2.18		b
DuPuits	2.13		b
$\bar{X}$	2.60		
F	22.14**		
$S\bar{X}$	0.191		

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 19. Third crop forage yield for nine alfalfa varieties, 1959, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
Buffalo	1.72	a		
Atlantic	1.66	a	b	
Lahontan	1.65	a	b	
Ranger	1.64	a	b	
A-253	1.61	a	b	
Vernal	1.40	a	b	c
DuPuits	1.37	a	b	c
Ladak	1.27		b	c
Rhizoma	1.11			c
$\bar{X}$	1.49			
F	24.74**			
$s\bar{X}$	0.128			

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

DuPuits, and Rhizoma produced similarly in second and third crop. Buffalo ranked the highest and did not show significant difference from the next six varieties immediately after it in table 19.

The two crops combined data and multiple range test for 1959 are reported in table 20. The variety Buffalo produced the highest mean yield while Rhizoma produced the poorest yield. Ranger and Lahontan were second and third, respectively, and were significantly different from DuPuits and Rhizoma. The varieties A-253, Vernal, Ladak, and DuPuits were not significantly different at the 5 percent level.

The multiple range test was applied to the data of first, second, and third forage crop yields for 1960 and presented in tables 21, 22, and 23. In comparing first and third crops (tables 21 and 23) Ranger, A-253, and Lahontan ranked first, second, and third, respectively, in first crop while Lahontan ranked second and A-253 fourth in the third crop. Lahontan was the highest yielding variety in table 22 and showed a significant difference from Rhizoma and DuPuits. The varieties DuPuits, Rhizoma, and Ladak were the lowest yielding varieties through the entire year. Buffalo was fifth, fourth, and third in tables 21, 22, and 23, respectively. Atlantic was the fifth in tables 22 and 23 and the sixth in table 21.

Ranked varietal means for the three crops combined for 1960 are presented in table 24. Ranger with a mean of 8.86 tons and Lahontan with 8.62 tons per acre had significantly higher yields than Rhizoma and DuPuits. The yields for Ladak, Rhizoma, and DuPuits were not significantly different. DuPuits with a mean of 4.37 tons per acre was the poorest variety in production.

Table 20. Total forage yields for nine alfalfa varieties, 1959, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
Buffalo	4.53	a		
Ranger	4.50	a		
Lahontan	4.48	a		
Atlantic	4.47	a		
A-253	4.44	a	b	
Vernal	3.97	a	b	c
Ladak	3.66	a	b	c
DuPuits	3.50		b	c
Rhizoma	3.28			c
$\bar{X}$	4.09			
F	24.25**			
$S\bar{X}$	0.304			

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 21. First crop forage yields for nine alfalfa varieties, 1960, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
Ranger	3.69	a		
A-253	3.54	a		
Lahontan	3.43	a		
Vernal	3.38	a	b	
Buffalo	3.35	a	b	
Atlantic	3.04	a	b	
Ladak	2.80	a	b	
Rhizoma	2.31		b	c
DuPuits	1.65			c
$\bar{X}$	3.02			
F	34.77**			
$S\bar{X}$	.0392			

Notes: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 22. Second crop forage yields for nine alfalfa varieties, 1960, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
Lahontan	2.81	a		
Ranger	2.77	a		
A-253	2.62	a		
Buffalo	2.54	a		
Atlantic	2.53	a		
Vernal	2.46	a	b	
Ladak	2.21	a	b	
Rhizoma	1.83		b	c
DuPuits	1.33			c
$\bar{X}$	2.35			
F	43.98**			
$S\bar{X}$	.2177			

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 23. Third crop forage yields for nine alfalfa varieties, 1960, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
Ranger	2.40	a		
Lahontan	2.37	a	b	
Buffalo	2.26	a	b	
A-253	2.23	a	b	c
Atlantic	2.18	a	b	c
Vernal	2.12	a	b	c
Ladak	1.90	a	b	c
Rhizoma	1.51		b	c
DuPuits	1.37			c
$\bar{X}$	2.04			
F	17.04**			
$S\bar{X}$	.2687			

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

Table 24. Total forage yield for nine alfalfa varieties, 1960, F-Field, Greenville Farm

Variety	Mean yields tons/acre	Least significant ranges at the 5 percent level Duncan's Multiple Range Test		
Ranger	8.86	a		
Lahontan	8.62	a	b	
A-253	8.39	a	b	
Buffalo	8.15	a	b	
Vernal	7.96	a	b	
Atlantic	7.76	a	b	
Ladak	6.92	a	b	c
Rhizoma	5.66		b	c
DuPuits	4.37			c
$\bar{X}$	7.41			
F	23.87**			
$S\bar{X}$	.9235			

Note: Means within the table followed by the same letter are not significantly different.

** Significant at 1 percent level.

DISCUSSION

Effects of Rates of Seeding on Forage Yield

There was no significant difference in yield due to rate of seeding except the 1 pound rate differed significantly from any other, although the yield from the 4 pound rate was slightly lower than the other rates in most years and would probably be significantly so in a longer experiment. Yields from the 10, 13, 16, 19, 22, and 25 pound rates were similar. The 10 and 25 pound rates yielded, in 3 years of production, 20.28 and 20.82 tons per acre, respectively.

According to the above results it seems that a 10 pound rate of seeding can be expected to do about as well as a 22 pound rate or even a 25 pound rate. These results were in agreement with those reported by Williams (1917) and indicated no advantage for rates of seeding alfalfa over 10 pounds per acre.

Some publications state that alfalfa varieties respond differently to different rates of seeding. From this study, although Ranger, Atlantic, A-252, Lahontan, and Buffalo outyielded the rest of the varieties, they did so rather uniformly at each rate of seeding except the 1 pound rate and there was no appreciable difference in the most desirable rate of seeding for any variety.

The data in this test justify the conclusion that no variety showed a high increase in yield with an increase in seeding rate above 10 pounds although there was a slight increase in forage yield for all varieties when more than 1 pound of seed was used. This test

showed that all varieties responded equally to the increase of seeding rate

Effect of Rate of Seeding on Plant Intensity and Root Dry Weights

The effect of rates of seeding on plant intensity and root dry weights were statistically highly significant.

The differences in stands between the plots seeded at different rates of seeding showed that generally thicker stands were obtained from higher rates of seeding. Lahontan, Ranger, and A-253 maintained thicker stands which may be attributed to the particular rate of seeding instead of to varietal difference. However, it is important to note in studying the effect of rate of seeding on plant intensity an even seeding should be insured to obtain accurate results.

The average weight of roots from different plots was reported to study a measure of the effect of seeding rate on the individual plants; the heavier rates of seeding resulted in smaller plants. The individual roots of Lahontan were smaller than those of the other varieties. This suggests that the differences in yield of roots between Lahontan and the other varieties were due to the higher average stand of Lahontan retained after 4 years. This study agreed with the results obtained by Willard (1938).

On the basis of this experiment seeding rates from 10 to 13 pounds of good quality seed per acre would appear to be sufficient to insure a good productive stand. It is believed that 10 to 12 well established plants per square foot will give a good yield. Ten to 13 pounds of seed gave 27.4 average number of roots per square yard.

However, a word of caution is in order. This low rate of seeding should not be used unless sufficient care is taken to prepare an ideal seedbed. The final stand is directly dependent on the condition of the seedbed and the viability of the seed.

Bacterial Wilt Study

Importance of bacterial wilt

Invasion of an alfalfa stand by bacterial wilt is usually a gradual process and yield reductions are seldom marked before the third and probably the fourth year. However, under conditions that are particularly favorable for the advance of the disease, yield reduction may occur earlier and in much more severe form. Peake and Cormack (1955) stated that in the early stages of infection in the 3 year old stand over 20 percent of the plants were infected with nearly 90 percent of the plants infected by the sixth year. Other writers agreed on the advance of the disease under suitable conditions. Tysdal and Kiesselback (1941) reported that 2 years after planting there was an average of 6 percent wilt where favorable conditions were present and 1 percent in the field where conditions were not suitable for the invasion of disease.

The results of this study emphasize the importance of bacterial wilt as a major limiting factor in the production of alfalfa. Before this disease became established in Utah alfalfa production from most varieties was usually satisfactory and the stand could be maintained for many years longer than at the present time. As indicated by the forage yield data presented, more than half of the varieties used in this test showed serious reduction in their yield and maintained a

poor stand in the third year of the test. These results indicate that planting wilt-resistant varieties should be more profitable in irrigated areas.

Varietal resistance to bacterial wilt

The data from this variety test were in agreement with those reported by Hollowell (1945) and Grandfield (1945). From this test the varieties DuPuits, Rhizoma, and Atlantic proved susceptible to the wilt disease; they showed a marked reduction in yield in the third year. DuPuits reduced by half in 1960. Atlantic produced 1.2 tons per acre less in 1960 than in 1958, while Rhizoma produced 7.2 tons per acre in 1958 compared to 5.7 tons per acre in 1960. Besides the yield reduction, these varieties gave very poor stands and maintained the lowest number of roots in comparison to the rest. This study and the observations agreed with other reports, Peake and Cormack (1955), that the reduction in yield of these varieties is obviously due to their high susceptability to the bacterial wilt disease.

The varieties A-253, Buffalo, and Ladak ranked together and showed slight reductions in yields. They were moderately resistant to bacterial wilt disease. Buffalo and A-253 produced more than Ladak and had very small drops in yield. That may be due to the climatic conditions rather than a disease effect. Buffalo was developed by the U.S.D.A. and the Kansas Agricultural Experiment Station with attention being given to bacterial wilt resistance. In this test Buffalo did not drop off rapidly in the third year but probably would in a longer time. Peake and Cormack (1955) stated that Buffalo dropped off rapidly during the fifth and sixth years. A-253 with less resistance

background to wilt disease dropped off more than Buffalo during the same period of production. Ladak with somewhat less susceptability to bacterial wilt than Atlantic showed more decrease in yield than Buffalo and A-253. This may be due to the weakening of the resistance character as a result of crossing with other alfalfas.

The varieties Lahontan, Ranger, and Vernal were highly resistant to bacterial wilt and maintained the best stands during this study. These varieties in respective order were least infected with wilt disease and had a lower percentage of infected plants.

Lahontan produced significantly better during 1960 than any other variety except Ranger. This was due to the resistance which this variety has for wilt disease and its adaptation to the environment and length of season. The data indicate that Lahontan ranked sixth during the first year and second during the third year. This was probably due to the fact that Lahontan was more persistant in keeping a good stand than the rest of the varieties. The data showed also that Lahontan produced higher in the second and third crops of every year. This may be attributed to its quick recovery and fast growth following cutting. Ranger showed resistance to the wilt disease and ranked the highest in production for the three years of the study. This variety is commonly recommended for Utah because of its resistance and high yielding ability.

The variety Vernal ranked sixth in total production for three years. It had the least amount of disease among the nine varieties, however, it did not produce as high as Lahontan and Ranger, but it was significantly different from five other varieties in the percentage of diseased plants. This variety did not drop off in the third year, but

showed a slight increase in production. This probably is a result of its high level of winter hardiness and wilt resistance. This variety showed promise but did not give high yields during the period of this test.

SUMMARY AND CONCLUSIONS

Three year's results from seeding nine alfalfa varieties at nine rates of seeding, ranging from 1 to 25 pounds per acre, were studied. This experiment was used to determine the effect of rates of seeding and bacterial wilt disease (Corynebacterium insidiosum) on forage yield and plant intensity.

The forage yield test indicated that there was no significant increase in yield for rates of seeding above 10 pounds per acre, although there were small yield increases when seeding rates were increased. The response of all varieties was similar and there were no significant yield differences favoring the most desirable rate of seeding alfalfa. Ranger outyielded the rest by very similar increases at all rates.

Significant differences in number of roots and root dry weights for the varieties and rates of seeding were found. There was a progressive increase in the number of roots and a significant decrease in root dry weight as the seeding rate increased. Lahontan ranked the highest in the number of roots and lowest in root dry weight, while Atlantic ranked the lowest in number of roots but the highest in root dry weight. This was due to the fact that heavier rates resulted in thicker stands and smaller roots.

Root symptoms of bacterial wilt were evident in most varieties in the experiment. Lahontan had the least mean number of infected roots and DuPuits was the most severely infected variety. Evidence was

found that Lahontan, Ranger, and Vernal produced higher forage yields in the third year due to their resistance to bacterial wilt disease.

The forage yield of Ranger was higher than all other varieties in this experiment. Lahontan ranked fourth and appeared to be well adapted to the length of season in this area. Varietal yields of Rhizoma and DuPuits were similar during the study and both were highly susceptible to wilt. Buffalo, A-253, and Ladak ranked fifth, second, and seventh in their total yields, respectively. They were moderately resistant to bacterial wilt.

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