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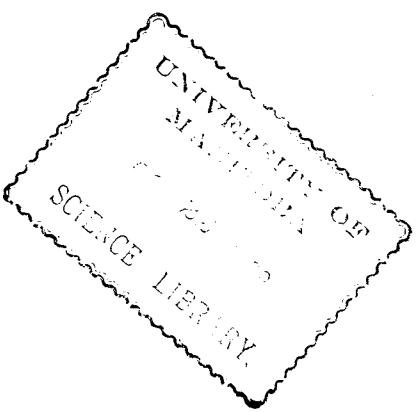
Survival of Several Alfalfa Varieties Seeded on Irrigated Land Infested With Bacterial Wilt

RALPH M. WEIHING, D. W. ROBERTSON, AND O. H. COLEMAN



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Survival of Several Alfalfa Varieties Seeded on Irrigated Land Infested With Bacterial Wilt

[*Phytomonas insidiosa* (McCulloch) Bergey, *et al.*]

RALPH M. WEIHING, D. W. ROBERTSON, and O. H. COLEMAN*

THE ORGANISM causing the bacterial wilt disease of alfalfa is probably present in most of the irrigated soils of Colorado. Due to this disease, all plants of some varieties of alfalfa are dead after 3 to 4 years of harvesting, while the plants of other varieties may survive for longer periods. Accordingly, the survival of several varieties seeded at and near Fort Collins was studied, as well as the number of quadrats per plot necessary to estimate stand.

Materials and Methods

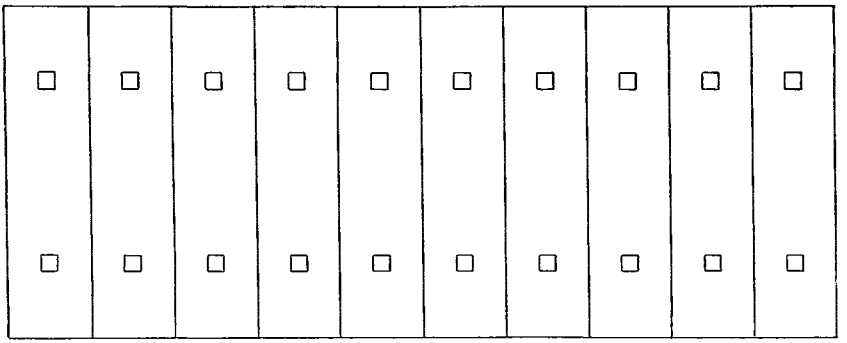
Five separate varietal trials with four to nine well-known varieties in each were seeded on the Colorado Experiment Station farm near Fort Collins. In addition to these, six varieties were seeded on the farm of the Colorado Potato Experiment Station, U. S. Department of Agriculture, at Greeley, Colo., and on four other farms: one near Greeley, one near Fort Collins and two near Longmont. The trials at the experiment stations were made with one-tenth acre plots, replicating the varieties two or three times, while the plots on the other farms were one-half acre in size with two replications. All were harvested for hay three times each year as long as they continued productive. So far as possible, the care of these plots was similar to field operations on a well-managed farm.

Two permanent quadrats, 1 meter square, were located on each plot for making spring and fall stand counts. The quadrats were placed several feet from each end of the plots and equidistant on two straight lines across the plots. The arrangement of quadrats is shown diagrammatically in the figure.

The number of plants per quadrat was counted in the fall of the first year of harvest, and thereafter in both spring and fall of each year until the plots were plowed due to thin stands. These counts were averaged to show the number of plants per quadrat in the spring and fall for each variety.

The data were analyzed further to determine if the two quadrats per plot used for the counts in these experiments were enough to estimate stand. This was done for each variety test

* G. W. Deming, Wayne Austin, and Dean C. Anderson, formerly assistant agronomists, assisted in collecting the data for varying periods of years during these experiments.



Diagrammatic arrangement of permanent quadrats in alfalfa plots.

by comparing the variance for error with that for quadrats within plots. The relationship of the two variances is given in the following analysis for a single test of six counts, two replications, and eight varieties:

Variation due to	D. F.
Spring and fall counts	5
Replications	1
Varieties	7
Counts x replications	5
Counts x varieties	35
Error	42
Total for plots	95
Quadrats within plots	96
Total for quadrats	191

However, before combining the spring and fall counts of a variety test into the above analysis, the errors (varieties x replications) for the single counts were analyzed for homogeneity by a modified form of the method described by Stevens (4). The method is as follows:

v = The observed variance
V = The theoretical variance
X^2 = Chi-square
N′ = Number of experiments (spring and fall counts)
N = D. F. between experiments (spring and fall counts minus 1)
M = D. F. within experiments (varieties x replications)
e = Sum of squares due to error (varieties x replications) in a single experiment

$$v = \frac{S(e)^2 - \frac{(Se)^2}{N'}}{N}$$

$$V = 2/M \left(\frac{Se}{N'} \right)^2$$

$$X^2 = N \frac{v}{V}$$

The P-values were obtained from Fisher's (1) table of chi-square. All counts of one variety test were combined into a single variance analysis when the chi-square test indicated that the set of variances were homogeneous.

EXPERIMENTAL RESULTS

SURVIVAL OF VARIETIES.—The varieties reported in table 1 were plowed in the spring of 1933, after 3 years of harvesting, due to thin stands. None of the varietal stands was thick enough at this time to leave for hay production. The data show distinct differences in survival at the end of the experiment. The average number of plants per quadrat in the spring of 1933 was 18.2 for Colorado Common, 12.2 for Meeker Baltic, 9.5 for Turkestan, 8.2 for Ladak, 5.8 for Cossack, 4.5 for Ontario Variegated, 3.2 for Grimm, and 2.2 for Hardigan. The data also indicate that the original stands (fall of 1930) were good for all varieties and did not greatly influence the final stands (spring of 1933), since the listing of varieties in order of magnitude of counts changes between these two dates. The average decrease for all varieties between the six consecutive counts was 7.9 plants per quadrat and seems to be quite consistent from spring to fall or fall to spring.

Field inspection indicated that death of plants was due largely to bacterial wilt.

Further information on some well-known varieties is given in table 2 for plots harvested in 1934, 1935, and 1936 and plowed in the spring of 1937. The variety Hardistan survived best in these plots, with 29.7 plants per quadrat in the fall of 1934 and 25.8 in the spring of 1937. The stand of this variety at the time of plowing was thick enough to leave for at least another year, while for all other varieties it was too thin for hay production. The final counts for the other varieties were 14.7 plants for

Nebraska Common, 12.7 for Ladak, 6.5 for Meeker Baltic, 6.0 for Cossack, 5.8 for Grimm and Ladak (50-50 mixture), 4.0 for Grimm, and 0.0 for Baltic. The average decrease in survival between successive counts was 4.6 plants for the period of this test.

TABLE 1.—*The average number of plants per quadrat in eight strains of alfalfa seeded in the spring of 1929 on the Agronomy Farm near Fort Collins, Colo.*

Variety	Source of seed	Number of plants per quadrat					
		1930	1931		1932		1933
		Fall	Spring	Fall	Spring	Fall	Spring
Colorado Common	Colorado	52.2	42.2	39.0	35.5	23.5	18.2
Meeker Baltic	Colorado	56.8	45.8	43.5	31.0	21.8	12.2
Turkestan	F. C. 15754	61.2	44.8	37.8	30.2	20.5	9.5
Ladak	F. C. 14135	39.0	32.8	27.2	17.2	12.2	8.2
Cossack	Montana	46.2	42.5	38.0	23.2	18.8	5.8
Ontario Variegated	Canada	47.2	40.2	31.8	21.5	13.8	4.5
Grimm	Colorado	37.5	32.8	31.8	21.0	14.0	3.2
Hardigan	Michigan	38.2	32.5	25.2	16.8	11.2	2.2
Average		47.3	39.2	34.3	24.6	17.0	8.0

Level of significance for variety averages (5 pct. point) = 13.22
Level of significance for spring and fall counts (5 pct. point) = 4.67

TABLE 2.—*The average number of plants per quadrat in seven strains of alfalfa seeded in the spring of 1933 on the Agronomy Farm near Fort Collins, Colo.*

Variety	Source of seed	Number of plants per quadrat					
		1934	1935		1936		1937
		Fall	Spring	Fall	Spring	Fall	Spring
Hardistan	Nebraska	29.7	31.2	24.8	21.8	25.8	25.8
Nebraska Common	Nebraska	33.0	27.5	25.8	23.7	19.5	14.7
Ladak	Colorado	26.8	27.8	22.3	21.5	15.3	12.7
Meeker Baltic	Colorado	39.3	37.0	28.8	23.3	15.8	6.5
Cossack	Colorado	32.8	30.0	23.7	21.7	15.0	6.0
Grimm and Ladak	Colorado	33.3	27.3	23.7	19.7	13.8	5.8
Grimm	Colorado	41.2	33.3	25.8	20.2	16.2	4.0
Baltic	F. C. 19001	21.3	19.7	15.5	12.8	5.5	0.0
Average		32.2	29.2	23.8	20.6	15.9	9.4

Level of significance for variety averages (5 pct. point) = 9.88
Level of significance for spring and fall counts (5 pct. point) = 3.49

Four varieties seeded in 1930 (table 3) were harvested 4 years for hay, except Hardistan which remained productive for 5 years. The average number of plants per quadrat in the falls of 1931 and 1934, respectively, was 49.0 and 38.0 for Hardistan, 45.2 and 10.0 for Utah Common, 52.8 and 8.5 for Grimm, and 46.5 and 8.5 for Meeker Baltic. The greater survival of Hardistan was marked.

The stands of the nine varieties reported in table 4 decreased on the average from 44.3 plants per quadrat in the fall of 1930 to 11.3 in the spring of 1933. Although Colorado Common, Idaho Common, New Mexico Common, and Montana Common averaged 19.2, 19.0, 16.8, and 15.2 plants per quadrat, respectively, in the spring of 1933, none of the stands of these varieties was thick enough for hay production in 1933. The plots of Utah Common, Kansas Common, Dakota 12, and Argentine had fewer plants, averaging, respectively, 9.5, 6.8, 4.5, and 2.2 plants per quadrat in the spring of 1933. For all varieties the average decrease between successive counts was 6.6 plants per quadrat.

The Turkestan strain shown in table 5 survived better than most of the varieties tested on the Agronomy Farm near Fort Collins. After 3 years of harvesting, it had 30.2 plants per quadrat and could have been left for hay production for at least another year. The stands of all other varieties in the test were too thin for hay production. The final counts in the spring of 1937 were 14.8 for Nebraska Common, 9.5 for Kansas Common, 8.8 for Colorado Common, 4.0 for New Mexico Common, 4.0 for Chilean, and 0.7 for Arizona Common. The average decrease be-

TABLE 3.—*The average number of plants per quadrat in four strains of alfalfa seeded in the spring of 1930 on the Agronomy Farm near Fort Collins, Colo.*

Variety	Source of seed	Number of plants per quadrat						
		1931	1932		1933		1934	1935
		Fall	Spring	Fall	Spring	Fall	Fall	Spring
Hardistan	Nebraska	49.0	39.8	37.5	42.5	43.5	38.0	34.0
Utah Common	Utah	45.2	37.2	40.5	36.5	24.2	10.0	
Grimm	Colorado	52.8	41.5	42.0	33.2	26.0	8.5	
Meeker Baltic	Colorado	46.5	37.5	40.0	31.5	22.0	8.5	
Average		48.4	39.0	40.0	35.9	28.9	16.2	

Level of significance for variety averages (5 pct. point) = 9.52
Level of significance for spring and fall counts (5 pct. point) = 4.76

TABLE 4.—*The average number of plants per quadrat in nine strains of alfalfa seeded in the spring of 1929 on the Agronomy Farm near Fort Collins, Colo.*

Variety	Source of seed	Number of plants per quadrat					
		1930	1931		1932		1933
		Fall	Spring	Fall	Spring	Fall	Spring
Colorado Common	Colorado	55.0	44.8	41.8	33.8	26.2	19.2
Idaho Common	Idaho	48.5	42.2	34.5	31.2	20.5	19.0
New Mexico Common	New Mexico	61.5	50.0	41.0	33.2	23.0	16.8
Montana Common	Montana	45.2	42.8	35.8	31.8	22.5	15.2
Utah Common	Utah	53.2	45.8	39.5	31.0	19.0	9.5
Blended	Colorado	34.5	27.5	26.2	21.5	16.0	8.2
Kansas Common	Kansas	33.0	31.8	23.0	18.5	14.0	6.8
Dakota 12	Wyoming	25.0	23.8	20.2	15.8	12.5	4.5
Argentine	Colorado	33.2	35.0	29.8	13.0	14.8	2.2
Average		44.3	38.2	32.4	25.5	18.7	11.3

Level of significance for variety averages (5 pct. point) = 13.64
Level of significance for spring and fall counts (5 pct. point) = 4.55

TABLE 5.—*The average number of plants per quadrat in seven strains of alfalfa seeded in the spring of 1933 on the Agronomy Farm near Fort Collins, Colo.*

Variety	Source of seed	Number of plants per quadrat					
		1934	1935		1936		1937
		Fall	Spring	Fall	Spring	Fall	Spring
Turkestan	Commercial 2674	44.5	41.8	33.7	29.3	29.8	30.2
Nebraska Common	Nebraska	37.7	29.2	27.5	23.5	22.0	14.8
Kansas Common	Kansas	33.7	30.7	26.7	23.3	15.8	9.5
Colorado Common	Colorado	33.0	28.2	20.7	21.0	17.2	8.8
New Mexico Common	New Mexico	29.7	23.0	20.2	18.5	13.8	4.0
Chilean	California	29.7	21.5	20.8	14.3	16.2	4.0
Arizona Common	Arizona	36.7	28.8	19.3	18.5	15.0	0.7
Average		35.0	29.0	24.1	21.2	18.5	10.3

Level of significance for variety averages (5 pct. point) = 11.67
Level of significance for spring and fall counts (5 pct. point) = 4.41

tween successive counts was 4.9 plants per quadrat in this test.

In table 6, data are summarized for six varieties seeded in 1929 at five locations: one near Fort Collins, two near Greeley,

TABLE 6.—*The average number of plants per quadrat in six strains of alfalfa seeded on five farms in* 1929.

Variety	Source of seed	Number of plants per quadrat										
		1930	1931		1932		1933		1934		1935	
		Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Two farms near Greeley and Longmont, and Greeley Potato Station												
Ladak	Colorado	52.8	48.5	41.9	38.0	35.7						
Cossack	Montana	52.7	48.9	39.3	34.3	31.0	Level of significance for variety averages					
Common	Colorado	48.1	41.0	35.2	30.5	20.1	(5 pct. point) = 10.92					
Hardigan	Michigan	49.0	42.7	35.7	28.2	19.2	Level of significance for spring and fall					
Grimm	Colorado	46.8	45.3	33.6	24.2	13.5	counts (5 pct. point) = 4.46					
Canadian Variegated	Canada	44.7	37.4	30.7	21.5	12.7						
Average		49.0	44.0	36.1	29.4	22.0						
Two farms near Longmont and Fort Collins												
Ladak	Colorado	53.0	53.5	48.1	42.5	38.0	35.7	37.1	31.1	31.2	25.4	22.8
Cossack	Montana	58.4	60.6	50.9	47.8	39.8	30.3	29.6	24.1	28.4	16.4	17.4
Common	Colorado	49.4	50.2	47.6	40.5	39.0	28.9	26.0	23.4	22.1	14.6	11.8
Canadian Variegated	Canada	56.6	51.9	44.0	40.0	35.1	21.9	20.2	18.8	22.4	10.5	7.8
Hardigan	Michigan	58.4	55.9	47.8	44.8	37.4	21.5	22.6	16.9	17.8	8.0	5.2
Grimm	Colorado	54.6	50.0	42.4	36.0	26.8	15.5	13.0	12.0	10.8	6.8	4.2
Average		55.1	53.7	46.8	41.9	36.0	25.6	24.8	21.1	22.1	13.6	11.5

Level of significance for variety averages (5 pct. point) = 13.00
Level of significance for spring and fall counts (5 pct. point) = 5.31

and two near Longmont. Stand counts, in the fall of 1930, averaged over 50 plants per quadrat for the five tests. Three of the tests were plowed, after 3 years of harvesting, due to thin stands which averaged 22.0 plants per quadrat in the fall of 1932. These three tests were analyzed as one unit. The survival in the other two tests was much better, and these plots were harvested for 6 years, although the yield was low and the stand thin for Grimm after the third year, for Hardigan and Canadian Variegated after the fourth year, and for Cossack and Common after the fifth year. Ladak survived quite well for the 6 years, after which the plots were plowed. For the two-farm average, the rank of varieties according to final counts was Ladak, Cossack, Colorado Common, Canadian Variegated, Hardigan, and Grimm. This rank of varieties agrees quite well with the three-farm average.

NUMBER OF QUADRATS FOR STAND COUNTS.—The P-values for the homogeneity test of the errors (varieties x replications) for the spring and fall counts within each variety test were computed. For each of the 10 tests, P exceeded 0.05, indicating that the errors were sufficiently alike to allow combining the data of each test into one variance analysis.

The mean square for error in seven of the 10 varietal trials (table 7) was larger than that for quadrats within plots. It was significantly larger for the combined value of the 10 trials, indicating that two quadrats per plot were sufficient for stand counts in these experiments.

TABLE 7.—*The mean squares of error and of quadrats within plots for 10 varietal trials of alfalfa.*

Test reported in table	Number of varieties	Number of replications	Number of counts	Error		Quadrats within plots		F(3)
				D. F.	Mean square	D. F.	Mean square	
1	8	2	6	42	43.72	96	63.10	1.44
2	8	3	6	84	36.62	144	24.60	1.49*
3	4	2	6	18	22.69	48	32.10	1.41
4	9	2	6	48	46.50	108	37.02	1.26
5	7	3	6	72	51.12	126	21.69	2.36**
6	6	2	5	25	120.69	60	132.66	1.10
6	6	2	5	25	96.80	60	86.02	1.12
6	6	2	5	25	50.80	60	36.17	1.40
6	6	2	11	55	66.88	132	55.29	1.21
6	6	2	11	55	102.14	132	63.75	1.60*
Combined values				449	60.66	966	50.60	1.20*

* Exceeds 5 pct. point.
** Exceeds 1 pct. point.

SUMMARY

The survival of varieties of alfalfa in 10 varietal trials seeded at or near Fort Collins, Colo., was studied. For six tests the plots were one-tenth acre in size, and one-half acre in size for four. All varieties were replicated either two or three times. The plants were counted in the spring and fall in each of two permanent quadrats, 1 square meter in size, per plot. These values were averaged to show the number of plants for each variety per quadrat and for all varieties at successive counts. Decrease in the number of plants during the period of the tests was due mainly to bacterial wilt.

The first stand counts for all tests were made in the fall of the first year of harvesting; and in all experiments the stands were thick enough for excellent hay yields, averaging 46.4 plants per quadrat for the 10 tests.

After 3 years of harvesting, the stands in seven tests were too thin for further hay production. For these tests the initial counts averaged 43.7 plants per quadrat; whereas the fall counts of the third harvest year averaged 19.4. The following spring, stand counts in four of these tests averaged 9.8 plants per quadrat. For the seven tests there was a rather consistent decrease of 6.1 plants per quadrat between successive spring-and-fall or fall-and-spring counts. One of the 10 tests with four varieties was productive for 4 years, averaging 48.4 and 16.2 plants per quadrat for the initial and fourth fall counts, respectively; while two tests were productive for 5 years, averaging 55.1 and 22.1 plants per quadrat for the initial and fifth fall counts, respectively.

These trials show that the stands of most varieties of alfalfa were too thin for hay production at or near Fort Collins after the third or fourth year of harvesting. Hardistan was an exception, as it survived and remained productive for 1 and possibly 2 or more additional years. The commercial strain No. 2674 of Turkestan seemed to rank next to Hardistan in survival. The rank of survival from high to low counts of variegated strains was Ladak, Meeker Baltic, Cossack, Ontario Variegated, Grimm, and Hardigan; while for the Commons it was Nebraska, Colorado, Idaho, Montana, Utah, New Mexico, Kansas, and Arizona. The survival of Chilean and Argentine was as low as that of any of the varieties. For the varieties tested there seemed to be little difference in the average survival of variegated and common strains of alfalfa grown on wilt-infested land.

Statistical analysis indicated that stand counts on two quadrats per plot were sufficient for good information on the survival of varieties under the conditions of these experiments.

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23	*The Survival of Several Alfalfa Varieties Seeded on Irrigated Land Infested With Bacterial Wilt*	Ralph M. Weihing, D. W. Robertson, O. H. Coleman