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Seeding Experiments on Highway Backslopes

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Construction methods required to build modern highways lay bare extensive areas along the rights-of-way. These areas were previously left in an ungraded condition and no effort was made to establish a vegetative cover. Stands of soil-binding plants became established slowly by natural means; therefore these areas were unprotected and subject to costly and unsightly erosion. To prevent erosion and to facilitate the early establishment of a protective cover, present construction methods include grading and seeding these areas, mulching foreslopes and backslopes, and sodding of critical waterways.

Stand establishment on such areas is more difficult than on areas with topsoil in place. Little experimental work has been done with the seeding of areas denuded of topsoil, and there is an urgent need for technical information concerning methods of stand establishment on these areas. In recognition of this need, the Iowa Highway Commission and the Iowa State College are cooperating in a study of the problems involved. Experimental seedings of grass-legume mixtures on backslopes of new construction have been studied for three years by measuring the response of certain grasses and legumes to determine which serve best to stabilize these slopes at a reasonable cost.

Review of Literature

A survey of seeding practices and costs in several states (3) revealed that a total of 31 mixtures of two to seven kinds of seeds, and several species seeded singly at different rates were used. Seeding densities varied from 129.1 to 0.53 seeds per square inch. Costs were found to vary from over one hundred dollars to three dollars per acre.

A desirable vegetative cover for roadsides consists of a low-growing, closely knit turf of grasses and legumes that are drought tolerant, deep-rooted, resistant to weed invasion and able to grow well on soils with low fertility (2). Such species as alfalfa, alsike clover, lespedeza, sweet clover, red clover, Canada and Kentucky bluegrass, orchardgrass, redtop and timothy have been suggested (5).

In California, methods which reproduce conditions found on natural slopes are most successful in controlling erosion. The time required to attain complete control is shortened by artificially speeding up the stabilization process (6). That the stages of plant succession could be telescoped by introducing adapted plants into any stage was suggested by Warner and Aikman (9) in their study of secondary plant succession.

Grass-legume mixtures are recommended for highway seedings because grasses produce a fibrous root system that holds the soil in place, stems and leaves protect the soil surface, and legumes furnish nitrogen to stimulate grass growth (7). A bromegrass-alfalfa mixture is ranked high for erosion control and is suited for highway seedings in Iowa because it grows well on most Iowa soils (11).

Small equipment is most desirable from the standpoint of speed and economy because it is handled more easily on slopes (8). In Iowa, seedbed preparation consists of loosening the surface 3 to 4 inches of soil with a disk or spring-tooth harrow. Seed is broadcast or applied with some type of spreader and then rolled in. Specific dates for fall and spring seeding periods are observed (4, 7).

The question of whether high or low seeding rates are best in such work has been highly controversial. A complex grass-legume mixture seeded at 109 pounds per acre has been tested in Ohio and proved successful in stabilizing slopes (5). By contrast, southern states have found that low seeding rates of Bermuda grass with the addition of fertilizers have been efficient in producing a cover (1). Experiments with seeding rates for purposes other than slope erosion control show that rates greater than 20 pounds per acre waste seed (10).

Procedures

Five backslopes were selected five miles south of Ames on highway 69. Selection was based primarily on slope size, since it was desirable to have at least two replications on each slope and to measure the response on at least "A" and "B" soil horizons. A randomized block design was used. A block comprised one replication of eight treatments randomized on eight plots. Plots one rod wide, extending the full height of the slope, were laid out side by side horizontally on the slope. The height of the slope at the locus of a plot determined the plot's length. Each slope had two replications except one which had three, making a total of eleven.

Two mixtures seeded at four rates each were tested (Tables 1, 2). The symbols H and C are used to designate the two mixtures which have been named "highway" and "complete" and are shown in tables 1 and 2.

Table 1

Four Seeding Rates of the Highway Mixture Expressed in Quantities of Clean Viable Seeds

Species	Lbs. per acre	Computed No. of seeds per 1/16 millacre	Lbs. per acre	Computed No. of seeds per 1/16 millacre
	H-1		H-2	
Bromegrass	3.71	31.31	14.14	119.26
Alfalfa	1.18	16.61	4.71	66.71
Alsike clover	.47	19.88	1.89	80.33
Red clover	.71	11.98	2.83	47.65
Total	6.07	79.78	23.57	313.85
	H-3		H-4	
Bromegrass	56.56	477.34	113.10	954.68
Alfalfa	18.84	266.85	75.40	1067.69
Alsike clover	7.56	321.04	30.20	1282.81
Red clover	11.32	191.15	45.30	764.89
Total	94.28	1256.38	264.00	4070.07

Table 2

Four Seeding Rates of the Complete Mixture Expressed in Quantities of Clean Viable Seeds

Species	Lbs. per acre	Computed No. of seeds per 1/16 millacre	Lbs. per acre	Computed No. of seeds per 1/16 millacre
	C-1		C-2	
Bromegrass	0.625	5.45	2.50	21.24
Ky. bluegrass	0.125	17.15	0.50	68.07
Alta fescue	0.250	3.54	1.00	14.16
Redtop	0.063	19.33	0.25	77.61
Alfalfa	0.938	13.34	3.75	53.10
Alsike clover	0.313	13.34	1.25	53.10
Red clover	0.375	6.26	1.50	24.32
Total	2.689	78.41	10.75	312.60
	C-3		C-4	
Bromegrass	10.00	84.95	40.00	339.28
Ky. bluegrass	2.00	272.30	8.00	1089.20
Alta fescue	4.00	56.64	16.00	226.55
Redtop	1.00	310.42	4.00	1241.69
Alfalfa	15.00	212.39	60.00	849.57
Alsike clover	5.00	212.39	20.00	849.57
Red clover	6.00	100.75	24.00	405.12
Total	43.00	1249.84	172.00	5000.98

The highway mixture is commonly sowed at 25 pounds per acre of straight run seed on Iowa highway rights-of-way. This seeding rate provides an average of 115.2 viable seeds per square foot. Rate 2 of both mixtures was set up to approximate this seeding rate. With this rate as a base the other rates were computed as follows: Rate 1 was a fourth of rate 2, rate 3 was four times rate 2, and rate 4 was sixteen times rate 2. The bromegrass was so excessive in H-4 that the seeding rate of this grass was reduced to half the computed rate for this treatment.

Seedings were made on slopes prepared by the contractor under the supervision of the highway commission. The seed was broadcast

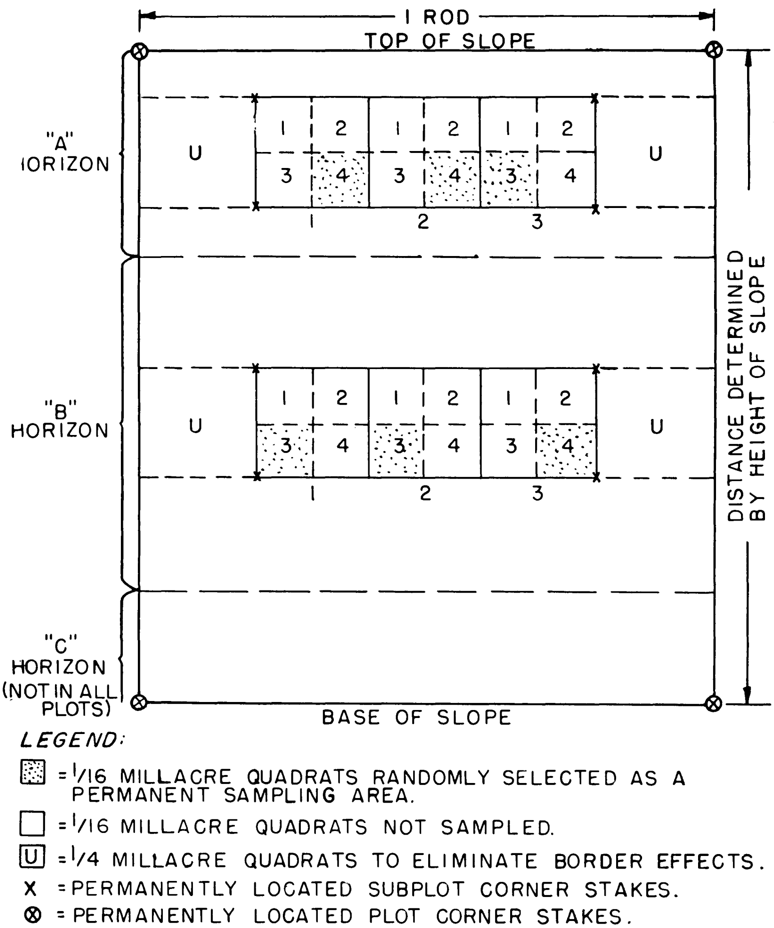

Figure 1. Diagram of plot No. 1 to illustrate the method of locating and numbering three 1/16 millacre quadrats to sample each of two soil horizons. This method was used for all plots.

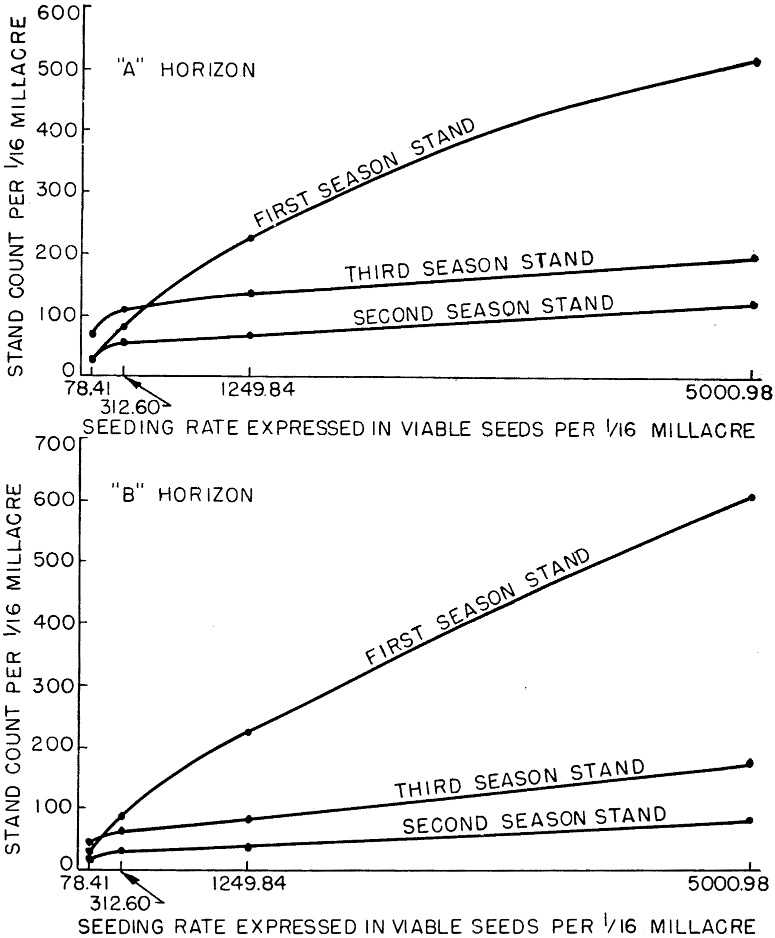

Figure 2. Stand count for each of the four seeding rates of the highway mixture. Points represent averages of all plots sampled each season.

by hand and raked in, taking care to distribute and cover the seed as evenly as possible. Legume seeds were inoculated prior to seeding. Slopes were then seeded with a rye nurse crop and mulched by the contractor. Seeding was begun May 28, 1949, and was completed two days later.

Three 1/16 millacre quadrats were randomly selected in each horizon from 12 possible quadrats (Figure 1). Stand counts were taken in the summer of 1949, 1950 and 1951 and weight yield data were taken the latter two years from these selected quadrats.

Results

Stand count data (Figure 2, 3) indicate that the largest stands generally occurred in the first season, that these stands were reduced the second season, and that they were increased in the third season. In each year, the highest stand count resulted from the highest seeding rate and the lowest stand count from the lowest seeding rate in both mixtures. The size of stands of intermediate rates followed the same order as the seeding rates. Stand count differ-

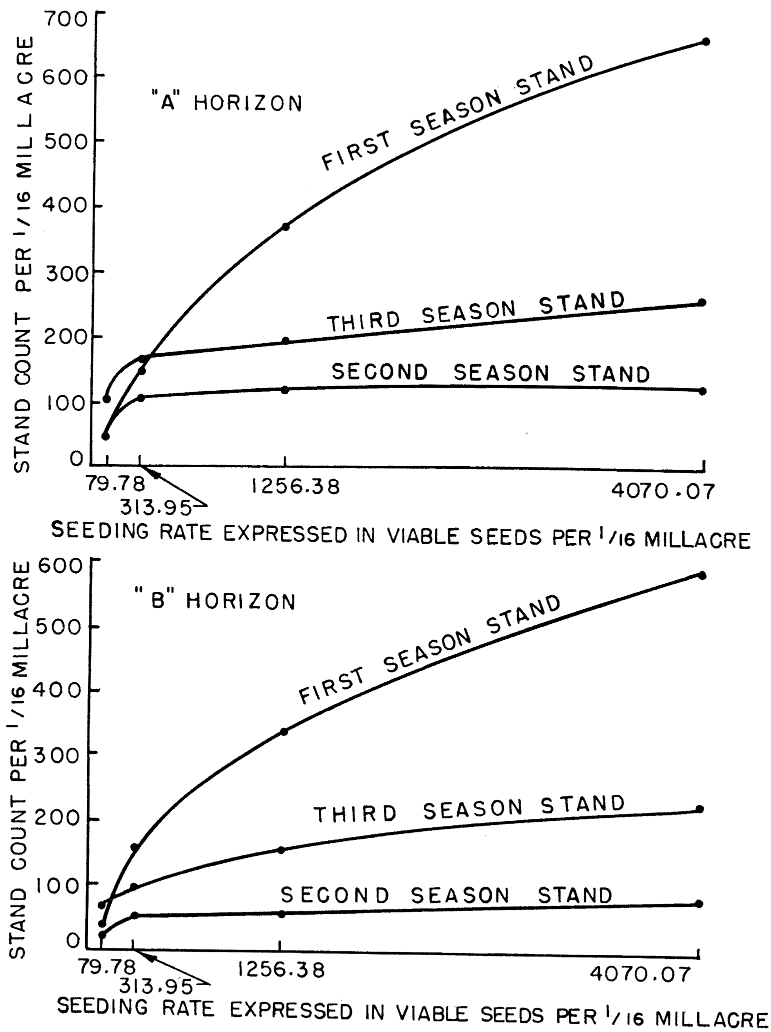

Figure 3. Stand count for each of the four seeding rates of the complete mixture. Points represent averages of all plots sampled each season.

ences between rates within each mixture were larger in the first season than in the two succeeding seasons.

Stand reductions between the first and second seasons were greatest in those plots where the stand counts were initially largest. These reductions were progressively smaller in plots where initial stands were smaller. From the second to the third seasons, increases were noted for all stands. The greatest increases appeared in stands that were greatest initially; however, the increases of various stands did not differ appreciably.

With few exceptions the highway mixture produced greater stands than the complete mixture, regardless of seeding rate, horizon or season. The stands on "A" horizons were generally greater than those on "B" horizons. Analyses of variance, with the data from slopes combined where possible, showed that differences between rates, between mixtures and among treatments were all highly significant. The differences between horizons were not significant.

Although stand increases resulted from every seeding rate increase, they were not proportional. The ratios of these increases (Table 3) show that more plants per additional unit of seed were obtained by increases from rate 1 to 2 than were obtained by any other rate increase. Highway mixture increases between these rates produced more additional plants per unit of seed than were produced by corresponding rate increases of the complete mixture.

The number of plants surviving per thousand viable seeds planted (Table 4) represents the efficiency of stand production, in which the highway mixture excelled. In the third season, the number of plants in the H-1 seeding exceeded the number of seeds originally planted on the "A" horizon.

The contribution made by each species and species group to the stand-producing efficiency is shown by the number of plants surviving per thousand seeds planted (Table 5). In the complete mixture, Kentucky bluegrass, alta fescue and redtop contributed least to the final stand. They not only had a low survival in the first season but showed little tendency to gain in succeeding seasons. Bromegrass exceeded the legumes in stand-producing efficiency with the exception of first season stands on the "B" horizon. This grass increased seasonally on all plots seeded with rates 1 and 2, except on the "B" horizon subplots and on "A" horizon subplots seeded with H-2. On these subplots and on all plots seeded with rates 3 and 4, bromegrass decreased in the second season and increased in the third.

No statement can be made concerning initial stands of the individual legumes, because they were treated as a group in the first year. Initial stands of legumes were more nearly alike on the two horizons than stands of bromegrass. In succeeding seasons there was a tendency for each legume to increase in the plots seeded with rate 1 and to decrease on plots seeded with rate 4. Stands of legumes

Table 3

Ratio of Differences Between Stands to Differences Between Corresponding Seeding Rates

Ratios	Soil Horizons A	B	A	B	A	B
Highway Mixture	First season stand		Second season stand		Third season stand	
Stand H-2 minus stand H1 / Seeding rate H-2 minus seeding rate H-1	.510	.561	.248	.146	.161	.143
Stand H-3 minus stand H-2 / Seeding rate H-3 minus seeding rate H-2	.210	.184	.014	.003	.050	.061
Stand H-4 minus stand H-3 / Seeding rate H-4 minus seeding rate H-3	.107	.090	.003	.010	.027	.025
Complete Mixture						
Stand C-2 minus stand C-1 / Seeding rate C-2 minus seeding rate C-1	.229	.263	.126	.084	.165	.083
Stand C-3 minus stand C-2 / Seeding rate C-3 minus seeding rate C-2	.143	.146	.011	.0003	.038	.012
Stand C-4 minus stand C-3 / Seeding rate C-4 minus seeding rate C-3	.081	.103	.017	.013	.016	.028

Table 4

Average number of plants surviving per thousand viable seeds of all species planted

Mixture and Rate of Seeding	Soil Horizons "A"	"B"	"A"	"B"	"A"	"B"
Highway mixture	First season stand		Second season stand		Third season stand	
H-1	600.5	395.0	584.9	271.6	1237.1	818.4
H-2	533.0	518.9	333.9	177.8	457.6	314.5
H-3	290.9	268.1	94.3	46.7	149.8	124.4
H-4	163.9	144.8	31.3	21.5	65.6	55.4
Complete mixture						
C-1	335.4	301.0	333.7	180.7	829.9	510.1
C-2	255.6	272.4	178.1	108.2	331.6	189.8
C-3	171.5	177.5	53.0	27.3	111.2	56.2
C-4	103.7	121.7	25.9	16.6	40.0	35.3

Table 5

Average Number of Plants Surviving Per Thousand Viable Seeds Planted According to Grass and Legume Groupings

Species or Group	Mixture and Rate of Seeding	Soil Horizons					
		A	B	A	B	A	B
Grasses	Highway Mixture	First season stand		Second season stand		Third season stand	
Bromegrass	H-1	680.4	338.7	870.3	271.5	2163.8	1249.6
	H-2	695.2	654.0	672.2	225.7	956.6	582.4
	H-3	357.7	312.5	139.3	66.0	320.0	255.0
	H-4	266.8	213.1	75.2	48.0	236.0	196.8
Legumes							
Alfalfa	C-1	548.9*	431.4*	647.2	401.4	657.2	534.3
	C-2	433.6*	436.1*	182.4	228.6	196.7	217.4
	C-3	249.9*	240.9*	129.3	74.6	95.7	81.2
	C-4	132.4*	123.8*	40.7	29.6	31.9	23.6
Alsike Clover	1			92.2	62.9	153.0	129.9
	2			28.0	24.9	14.5	8.3
	3			11.2	2.9	7.7	1.3
	4			1.5	0.3	0.2	0.4
Red clover	1			570.4	438.2	2017.3	1227.7
	2			215.1	244.8	320.9	296.4
	3			72.1	33.1	45.6	65.6
	4			13.3	12.7	10.0	15.7
Grasses	Complete Mixture						
Bromegrass	1	822.9	489.3	963.3	825.7	6307.3	2859.3
	2	583.5	438.0	796.5	514.0	2730.7	1414.4
	3	363.8	230.1	183.4	74.6	1144.8	420.3
	4	259.3	289.2	189.1	109.1	457.1	368.1
Kentucky bluegrass alta fescue, and redtop	1	57.5	41.6	39.3	22.9	80.1	43.7
	2	42.1	48.7	107.9	8.9	24.8	11.2
	3	36.4	29.3	5.7	0.3	0.6	0.3
	4	45.3	36.8	4.0	0.9	3.7	3.6
Legumes							
Alfalfa	1	582.4*	585.1*	618.4	449.8	727.8	468.5
	2	462.2*	517.5*	246.4	246.4	270.7	238.5
	3	304.7*	349.1*	131.0	76.5	122.4	74.9
	4	149.5*	197.7*	55.9	34.0	33.9	32.9
Alsike clover	1			206.1	68.7	271.7	259.2
	2			28.2	59.6	75.3	75.3
	3			14.5	5.9	0.8	3.3
	4			0.4	0.9	0.2	0.7
Red clover	1			1331.2	292.9	2263.0	2070.0
	2			273.2	207.3	921.5	406.5
	3			159.6	100.1	237.4	311.8
	4			17.3	33.9	14.6	34.4

*No attempt was made in 1949 to distinguish between the three legume species.

on plots seeded with rates 1 and 2 were intermediate between these extremes. Alsike clover was more adversely affected by high seeding rates than any other legume. Actual counts of this species showed that stands from the highest rates were generally smallest.

The percentage of grass in the stand indicates that the highway mixture, which contained the lowest percentage of grass seed, produced stands with the highest percentage of grass plants (Figure 4). In general, the percentage of grass in stands from this mixture was greater than the percentage of grass seed in the seeding mixture. These percentages show that grass gained in all stands each season.

The number of plants established per dollar cost indicates the stand-producing economy of the seeding rate and mixture (Table 6). The H-2 and the C-3 seedings ranked highest in this respect in the first season and rate two of both mixtures excelled in the second season. The C-2 remained highest for the complete mixture and the H-1 became highest for the highway mixture in the third season. A comparison of the optimum rates of each mixture indicates that the

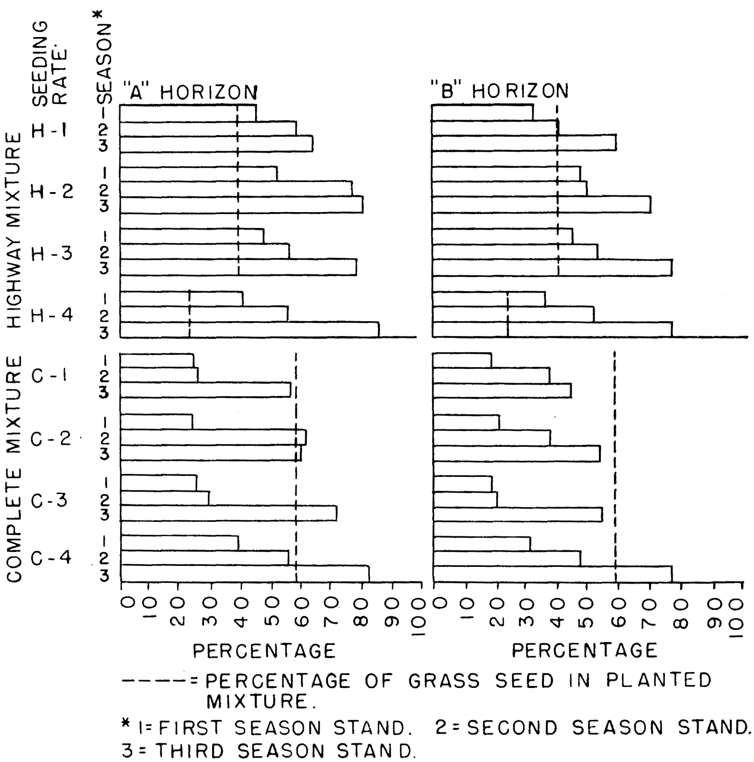

Figure 4. Percentage of grass in total stand for each of the four seeding rates of the two mixtures. Bars represent average percentages for each season.

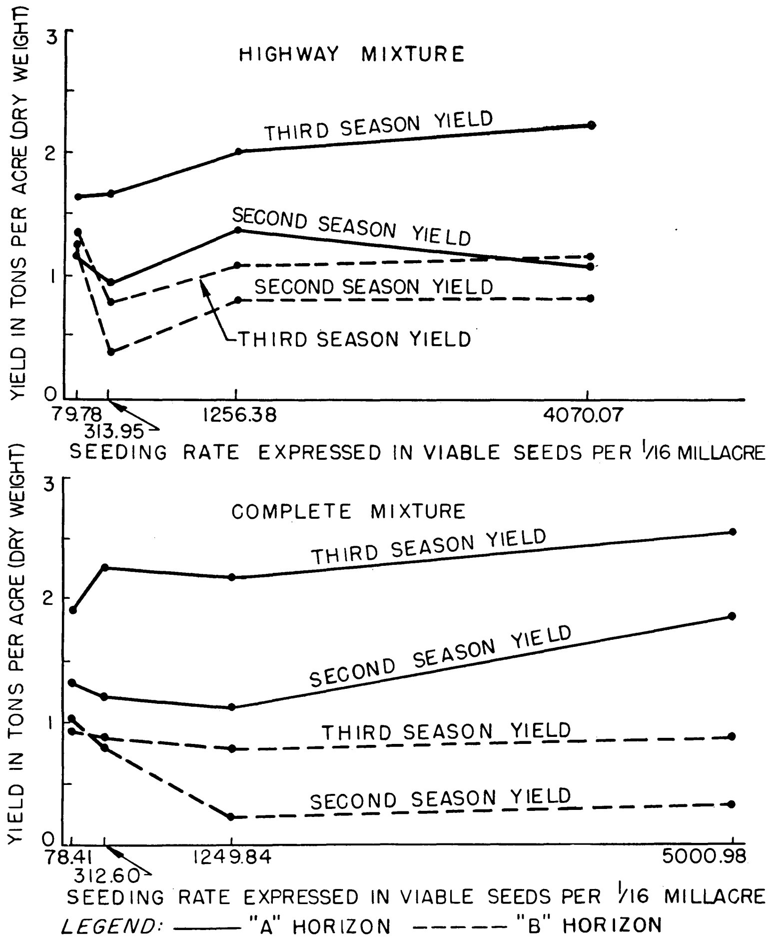

Figure 5. Yield each season for each of the four seeding rates of the two mixtures. Points represent averages of all plots sampled.

highway mixture was the most economical stand-producing mixture.

The weight yield data (Figure 5) compiled in the second and third seasons indicate a tendency for all stands to show an increase in yield in the third season. The H-2 and C-3 appeared to produce the lowest yielding stands. In general, "A" horizon subplots had greater yields than "B" horizon subplots. Any further interpretation was difficult because the data were so variable.

Analyses of variance, with the data from all slopes combined within seasons, showed that yield differences between rates, between mixtures and among treatments were not significant. The difference between horizon subplots was also not significant.

Table 6

Number* of Plants Established Per Dollar Total Cost

Mixture and Rate of Seeding	First Season Stand	Second Season Stand	Third Season Stand
Highway mixture			
H-1	30.73	26.44	66.22
H-2	88.51	43.06	64.97
H-3	84.43	21.29	41.72
H-4	62.32	10.65	24.44
Complete mixture			
C-1	20.76	16.78	43.72
C-2	54.91	29.76	54.19
C-3	80.44	18.50	38.64
C-4	74.74	14.08	24.95

*Figures given in thousands of plants, soil horizons A and B considered together.

Separation of grasses and legumes in twenty randomly selected samples of the clippings taken each year made possible estimates of the stand composition. In 1950, 8 per cent of the yield was grass, the balance legumes, and in 1951, 60 per cent was grass.

Discussion

Stand count and weight yield data were obtained from stands resulting from selected seedings made on highway backslopes. These data have provided information concerning the treatment responses on the two soil horizons as well as the annual trend of stands. Stand data have been used in combination with the seeding cost and seeding rate information, to compute costs and efficiencies of stand production. This information was used as a basis for selecting the rate and mixture that produced the greatest stand at the most reasonable cost.

Stand reductions between 1949 and 1950 were largely the result of competition for space and growth factors. This conclusion is supported by the fact that stands which were dense initially, were reduced more than stands which were sparse initially.

Stand increases between 1950 and 1951 were the result of reproduction by seed from original plants of the seeding and by rhizomes in the case of bromegrass.

In spite of competitive effects, stands from the highest seeding rates were greatest throughout the three seasons. If cost is not to be considered as a factor, the highest seeding rate is best. It should be used when soil and slope conditions are such that early establishment of a stand is imperative.

Since cost is a factor, however, the seeding combination that produced the greatest stand per dollar cost would be best. The H-2 qualifies above all others in this respect. One exception to this general statement is found in the third season results, where the H-1 stand had a few more plants per dollar cost than the H-2. There is justification, however, for disregarding this exception in that the H-2 stand was greater.

Survival figures for the stand as a whole show that a thousand seeds of the highway mixture produced more plants than did a thousand seeds of the complete mixture. The reverse relationship between mixtures is noted when stands of the individual species common to both mixtures are compared. This reversal was due to these facts: (1) the seeding rates of these species were lower in the complete mixture; (2) the three grasses contained only in the complete mixture responded poorly. As a result of these two facts, competition was less in complete mixture seedings and more seeds of the species common to both mixtures were able to produce plants. Species composition of the stands must be considered when a comparison of mixtures is made. The results of such a comparison indicate that the highway mixture produced more plants per thousand seeds planted.

In view of the poor response of Kentucky bluegrass, alta fescue and redtop, these grasses should not be sowed where conditions parallel those encountered in this experiment. This may be true only for seeding combinations approximating the complete mixture, however, and for this reason they should not be completely discarded. Since the presence of these grasses in the complete mixture constitutes the greatest difference between the two mixtures, all mixture differences may be explained on this basis.

The value of alsike clover in seedings on these slopes is questionable in view of its limited response. Casual observations of the occurrence of this legume on the plots indicated that in certain areas it became established satisfactorily where conditions limited the response of other legumes.

Weight yield data furnish no basis for the selection of a rate or mixture since significant differences were not shown. Yield increases from season to season resulted from increased stands and from the fact that the stands were one year older and thus better established and more vigorous. Yields were also greater because grasses were stimulated by nitrogen produced by legume root nodules.

Grass contributed little to the protective cover until the third season as shown by estimates of percentage of grass in the yield. The number of grass plants in relation to the total stand gained steadily throughout the three years as shown by the percentage of grass in the stand. These two facts suggest that as a move toward economy, grass might be seeded at a lower rate in the mixture without seriously affecting the protective value of the stand. Even at a reduced rate, grass would gain dominance eventually through succession.

Summary

1. The response of two grass-legume mixtures seeded at four rates each on backslopes of a newly constructed highway near Ames were studied by taking plant count and weight yield data. The purpose was to determine the best mixture and planting rate for seeding highway backslopes.

2. Stands were generally greatest the first year. They were reduced in the second year as a result of competition and increased in the third year as a result of reproduction. Stands which were greatest the first year showed the greatest reduction. In the third year, only the stands from the lowest seeding rates became greater than they were in the first season.

3. The size of the stands from the various rates were significantly different within each season. The stands from the highest rates were greatest and those from the lowest rates were smallest.

4. Low seeding rates produced more plants per thousand seeds planted than high rates. Increases in the low rates of seeding produced more additional plants per additional unit of seed applied than did increases in the high rates of seeding.

5. The "highway" mixture produced stands significantly greater than those of the "complete" mixture in the first season and these remained greater in the second and third seasons. This mixture also produced more plants per thousand seeds than did the "complete" mixture.

6. The H-2 treatment produced more plants per dollar total cost and thus appeared to be the best mixture and rate of those tested for highway backslopes.

7. No significant difference appeared between plant responses on the "A" and "B" soil horizons.

8. No significant weight yield differences were found between mixtures, rates and horizons. Yields in the third season were greater than yields in the second season.

9. Percentage of grass in the stands increased each season. Stands of the "highway" mixture had the highest percentage of grass plants.

10. Bromegrass generally exceeded legumes in stand producing efficiency.

11. Alsike clover was more adversely affected by high rates of seeding than the other legumes. Red clover was the most efficient stand-producing species at low seeding rates.

12. Stand counts per thousand seeds planted were lower for Kentucky bluegrass, alta fescue and redtop than for all other species tested except alsike clover in the high seeding rates.

Literature Cited

1. Aust, Franz A. Report of subcommittee on slope erosion. Reports at the 18th annual meeting by the joint committee on roadside development. Highway Research Board and American Association of State Highway Officials. pp. 2-9. 1939.
2. Brant, H. B. and Ferguson, M. H. Safety and beauty for highways. U. S. Dept. Agr. Yearbook of Agr. 1838:315-318. 1938.
3. Chittenden, Dudley B. Comparison of seed mixtures, rate of seeding and costs of seed used in several states. (Unpublished data.) Iowa Highway Commission, Ames, Iowa.
4. Chittenden, Dudley B. Out-of-season seeding in Iowa. Better Roads. 17:23. Dec. 1947.
5. Dreibelbis, F. R. and Kohnke, H. Stabilization of roadside banks. Soil Conservation. 3:38-40. 1937.
6. Erosion control on California state highways. Highway Res. Abst. 21:1. Feb. 1951.
7. Heath, Maurice E., Carey, Sheldon W. and Hughes, H. D. Sow down the highways. Farm Science Reporter. 6:7-10. Ames, Iowa. 1949.
8. Small rigs speed roadside projects. Contractors and Engineers Monthly. 47:57-59. Nov. 1950.
9. Warner, Robert M. and Aikman, J. M. The relation of secondary plant succession to soil and water conservation. Iowa State College Jour. Sci. 17:175-189. 1943.
10. Wiggans, R. C. Studies of various factors influencing the yield and the duration of life of meadow and pasture plants. N. Y. (Ithaca) Agr. Exp. Sta. Bul. 424. 1923.
11. Wilsie, C. P., Peterson, M. L. and Hughes, H. D. Bromegrass in Iowa. Iowa Agr. Exp. Sta. Bul. p. 75. 1945.