ness, and maintenance dollars are in short supply. To conserve maintenance dollars it is imperative that operation and maintenance of SRAs be accomplished in the most efficient way possible. Provision for good supervision, adequate (but not excessive) levels of staffing, proper personnel training, use of the best methods possible (including innovative alternatives), and proper control and use of materials will produce well-maintained SRAs that will provide satisfactory service to the motoring public at the lowest dollar value. Another result will be safer drivers.

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Fertilization and Legume Establishment on Highway Slopes

RUPERT F. STAFFORD

A fertilizer study illustrated the feasibility of discontinuing the use of loam in the construction of highway slopes in Maine. Protective grass sods can be established and maintained on subsoils devoid of organic matter through hydroseeding and subsequent top dressed fertilization. Spring and early summer seedings should be top-dressed in early fall, while late summer or early fall seedings may not require topdressing until the following spring. Research was also conducted to develop a practical way of establishing crown vetch on steep roadside slopes already in grass sod. Application of the transplanting method was limited to relatively small areas where the erosion hazard was great enough to justify the labor costs of hand planting. The crown vetch transplantings were successful at all highway sites studied and had vegetative spreading in excess of 122 cm within two years. A related study showed that, on slopes where equipment can be used, good establishment of both crown vetch and bird's-foot trefoil can be obtained by scarifying the surface of a grass sod prior to overseeding. The overseeding of bird's-foot trefoil (Empire) on relatively steep grassed slopes by using a herbicide (paraquat) was also studied. The herbicide reduced the competition from the initial ground cover and was advantageous in trefoil establishment.

Establishment and maintenance of the vegetative cover along highways is an expensive proposition. However, this must be done to prevent erosion and rutting of the roadsides. This is especially important along the steep backslopes of many highways in Maine. Also, the most practical and economical means available must be used. Answers are needed to such questions as

1. Do we need topsoil?
2. How much nitrogen do we need and how often?
3. How can legumes be introduced into a grass sod?

This study dealt with questions such as these, and enough data were collected to obtain some of the answers.

One objective of the study was to determine the fertilization requirements of grass sods on highway slopes constructed of subsoil materials without added topsoil loam. This was conducted on grass-covered embankments of the Back Cove Project of Interstate 295 in Portland, Maine.

A second objective was to determine the potential value of crown vetch and bird's-foot trefoil (Empire) as an indirect source of nitrogen for a legume and grass cover. These species were overseeded in 1972 on scarified grass-sod embankments in Old Town, Orland, and Portland.

A third objective of this study was to determine the transplanting and overseeding methods for legume establishment. One phase of the study concentrated on an evaluation of the effectiveness of the transplant method of establishing crown vetch in grassed highway slopes. This study was conducted over the period June 1973 to September 1975. Two principal sites were studied, one on US-1 at Orland and the other on ME-16 at Old Town. A supplementary study was carried out on an eroded highway off ME-201 in Caratunk and on embankments of I-295 in Portland. Another phase concentrated on overseeding bird's-foot trefoil (Empire) in grassed slopes by using a herbicide to reduce the grass competition and was conducted over the period October 1975 through November 1978. Studies were made at four principal sites in the towns of Orland, Old Town, Lincoln, and Dedham.

EXPERIMENTAL PROCEDURES

Fertilization of Grass Sod

The grass sod was seeded initially in August 1971 at the Back Cove site by the contractor, Leon E. Gordon, Inc. Standard hydroseeding practices were employed, including the equivalent of 1121-kg limestone/hm^2 and 1345-kg 10-10-10 fertilizer/hm^2. The typical roadside mixture of tall fescue, red fescue, K. bluegrass, redtop, and white clover was sown directly onto the unloamed embankments. The seeding was mulched with chopped hay at approximately 2242 kg/hm^2 and sprayed with emulsified asphalt.

A representative section of these grassed embankments was selected for fertilization studies in April 1972. Soil samples from this area were tested to determine their fertility level. Average values of pH were 6.8; medium phosphorus (P) and low potassium (K) were obtained.

Two experiments that used top-dressed fertilizers were established on April 26, each in a randomized complete-block design with four replications. One study involved a comparison of ammonium nitrate (AN) versus sulfur-coated urea (SCU) applied at several rates of nitrogen (N). The other study compared several rates of P and K. The N study received 672-kg 5-20-20/hm^2 to ensure unlimited phosphorus and potassium. The P-K study received two applications of 336-kg 33-0-0/hm^2 annually to ensure unlimited nitrogen. The experimental treatments are indicated in Tables 1 and 2.

Note that these studies were conducted with pure grass sods comprised mainly of red fescue and tall fescue. To avoid any significant contribution of fixed nitrogen, white clover and volunteer legumes

were kept at a low level throughout the study by repeated application of 2,4-D and dicamba. These two herbicides also served to keep the grass sods virtually free of all broad-leafed weeds.

The response of the grass sod to the experimental treatments was evaluated by harvesting and chemical analysis in 1972 and 1973. Dry matter yields and nitrogen uptake were determined in harvests made on July 6, 1972, and June 5, 1973. All harvested forage was removed from the plots on these two dates.

Following the June 1973 harvest, no further removal of forage occurred. The study was modified instead to permit recycling of any nitrogen subsequently taken up by the grasses. A rotary mower was used to leave the clippings in place on the respective subplots. The field experiments were mowed in this manner in late August 1973 and in mid-May and mid-June 1974. Fertilizer nitrogen for this recycling was applied to the N fertilization study at a uniform rate of 100-kg N/hm² on August 23, 1973, and again on April 29, 1974.

Observational notes and colored photographs were taken at periodic intervals throughout the three-year study. The field experiment at Portland was concluded in October 1974; samples were taken to determine the average depth of rooting of the grasses grown in the N fertilization study.

Two supplementary field studies were conducted at the Forage Research Center at Orono concurrent with the studies in Portland. In one of these studies, data were collected to determine the actual recirculation of nitrogen in clippings of repeatedly mowed grass sods. In the other study, a comparison was made between AN and SCU with regard to the seasonal pattern of nitrogen uptake by sod grasses over a three-year period.

Legume Establishment

Overseeding Crown Vetch and Bird's-foot Trefoil

Highway sites were picked at Portland, Orland, and Old Town. The Orland and Old Town sites were selected to be representative of relatively newly established slopes that had deteriorating grass cover. Soil conditions at the two sites were quite different; the relatively fine-textured material at Orland contrasted with the coarse, sandy material at Old Town.

The overseeding studies were initiated in 1972 at Portland and in 1973 at Old Town and Orland. These consisted of a direct broadcasting of crown vetch (Penngift) and bird's-foot trefoil (Empire) onto grass sod that had been lightly scarified by disking (Portland and Old Town) or by a hand-pulled harrow (Orland). Prior to scarification, these sods were top-dressed with 2242 kg/hm² of agricultural limestone and 672 kg/hm² of 5-20-20 fertilizer. All legume seed was heavily inoculated with the appropriate rhizobium inoculent prior to seeding and sown at the rate of 22 kg/hm². The seeding at Portland was made on May 10, at Orland on June 8, and at Old Town on July 19. No attempt was made to cover the seed either by mechanical means or by mulching.

Transplanting Crown Vetch

Crown vetch varieties (Penngift and Chemung) were used for transplantings made in 1973 and repeated in 1974. These were transplanted at three locations, as shown in the table below:

Location	Date	No. of Plants
Orland	June 12, 1973	92
	August 9, 1974	192
Old Town	July 20, 1973	180
	June 10, 1974	180
Caratunk	June 25, 1974	336

A greenhouse procedure was developed through which vigorous seedlings were grown from seed in 7.62x7.62-cm peat pots that could be planted directly in the field without root disturbance. The seedlings used ranged in age from two to nine months. Relatively simple transplanting procedures were followed to establish these seedlings at 1.8-m spacings in the field plots. Two pots that contained two seedlings each were planted close together in a shallow hole in which superphosphate fertilizer, equivalent to 224-kg P_2O_5/hm², had been mixed with the soil.

Maintenance practices for both the overseeding and transplanting studies were quite simple. The legume plots and transplants were left unmowed but were top-dressed with a borated high-potash fertilizer during the season following the year of establishment. Moderately high levels of soil fertility were maintained. Observational notes and photographs were obtained throughout the study.

Overseeding Bird's-foot Trefoil by Using a Herbicide

Four roadside sites were selected in eastern Maine during fall 1975 to represent soil textural condi-

Table 1. Dry matter yields and mineral content of harvested grass forage as influenced by levels of P-K fertilization top-dressed in April 1972 (Portland).

Treatment No.	Fertilization (kg/hm²)		Dry Matter (kg/hm²)		Mineral Content of Dry Matter (%) (6/5/73)	
	P_2O_5	K_2O	7/6/72	6/5/73	P	K
1	0	0	5919	5551	0.42	2.36
2	0	112	5224	5112	0.43	2.42
3	112	112	5807	6166	0.53	2.75
4	112	224	5381	6502	0.53	2.36
5	112	336	5649	5583	0.51	2.54

Table 2. Dry matter yields, nitrogen uptake, and recovery of fertilizer nitrogen as influenced by rate, timing, and source of nitrogen top-dressed in April 1972 (Portland).

Treatment No.	Nitrogen (kg/hm²)		Dry Matter (kg/hm²)		Nitrogen Uptake (kg/hm²)		Nitrogen Recovery (%)
	AN	SCU	7/6/72	6/5/73	7/6/72	6/5/73	
1	0	0	3318	0	48	0	-
2	112	0	5426	67	90	1	38
3	224[a]	0	5157	2825	80	34	30
4	336[a]	0	5201	5605	84	88	37
5	0	224	5246	2264	91	27	31
6	0	336	5515	3453	112	54	36
7	112	112	5403	1457	103	17	32
8	112	224	5157	3363	107	43	31

[a]Split applications in increments of 100 kg N on April 26, July 18, and September 13 (all other N applications on April 26).

Table 3. Trefoil stand rankings based on visual observations.

Location	Treatment No.[a] 1	2	3	4	5	6
1976						
Orland	2.6	2.4	1.0	1.8	6.4	4.8
Dedham	1.6	1.8	1.0	2.0	3.4	4.0
Old Town	1.2	2.4	3.6	2.2	3.8	4.8
Lincoln	1.4	1.6	1.2	1.8	4.0	3.8
Mean	1.7	2.1	1.7	2.0	4.4	4.6
1977						
Orland	4.8	4.4	3.2	3.8	7.2	7.6
Dedham	3.0	3.4	3.4	2.8	6.2	6.8
Old Town	4.2	4.6	5.2	4.4	5.6	5.6
Lincoln	3.4	2.4	3.0	2.0	3.8	4.8
Mean	3.8	3.7	3.7	3.2	5.7	6.2
1978						
Orland	7.0	6.0	5.8	6.4	7.4	8.8
Dedham	4.4	6.0	5.0	5.8	7.8	8.6
Old Town	4.4	5.6	5.4	5.2	6.0	6.6
Lincoln	4.6	4.0	4.0	3.0	4.6	5.2
Mean	5.1	5.4	5.1	5.1	6.5	7.3

Note: Rank numbers are 1 = very poor through 9 = excellent.

[a]Figures within table are averages of five replications.

tions that ranged from gravel to clay. The sites with clay soils were at Lincoln and Orland, and the lighter sandy soils were at the Old Town and Dedham sites. At each location, a representative area of backslope sod was selected for legume overseedings to be made in early spring 1976. Each area was essentially a grass sod with variable amounts of herbaceous and woody weeds. Ground cover by the grass sod ranged from low to moderate density.

In October 1975 the following operations were carried out at each site. The experimental area was measured and staked out in preparation for the spring overseeding. Agricultural limestone was top-dressed over the entire area at a rate equivalent of 2242 kg/hm². The individual plot size was 2.4x9.1 m. There were six treatments replicated five times for a total of 30 plots/location. The individual treatments and seeding dates are shown in the table below:

Treatment No.	Seeding Date	Paraquat, 4.7 L/hm², May 11-12	K Application, 224-kg K_2O/hm², July 26
1	April 9	No	No
2	April 9	No	Yes
3	April 9	Yes	Yes
4	May 11-13	No	Yes
5	May 11-13	Yes	Yes
6	May 11-13	Yes	No

Soil pH levels prior to liming ranged from pH 5.9 at Old Town to pH 6.4 at Dedham. Phosphorus and potassium levels ranged from very low to medium, and there was considerable variability between replicates at the Lincoln and Old Town sites.

In spring 1976, the entire area at all locations was top-dressed with 112-kg P_2O_5/hm² prior to the April seeding. On April 9, treatments 1, 2, and 3 were seeded with bird's-foot trefoil (Empire) at the rate of 22 kg/hm². Treatments 4, 5, and 6 were seeded at the same rate on May 11 at Orland and Dedham, and May 13 at Old Town and Lincoln. Paraquat was applied at the rate of 4.7 L/hm² on treatments 3, 5, and 6 at all four sites immediately after the May seedings were completed. Potassium was applied annually on treatments 2, 3, 4, and 5 in July at the rate of 224-kg K_2O/hm².

Visual observations were made at all sites during the season, and more detailed observations were made during October 1976, 1977, and 1978 (Table 3). These observations of trefoil stands were ranked on a number system that ranged from 1 (very poor) to 9 (excellent).

RESULTS AND DISCUSSION

Fertilization of Grass Sod

The P-K fertilization study indicated little response to additional phosphorus and potassium by the grass sod at the Back Cove site. Forage yields and chemical analyses from the spring harvests of 1972 and 1973 (Table 1), along with subsequent visual observations of the grasses, showed that there was adequate carry-over of minerals from the 1971 hydroseeding. However, chemical analyses of soil samples obtained in November 1972 and October 1973 indicate that the available potassium supply had declined with the removal of harvested forage. Without forage removal, the recirculation of potassium in grass clippings would probably be adequate to satisfy the long-term needs of a pure grass sod on this site. A legume and grass sod would have greater need for top-dressed potassium, since the critical concentration of K is considerably higher in legumes than in grasses.

The N fertilization study indicated the need for repeated nitrogen top-dressing during the year following hydroseeding. Nitrogen deficiency symptoms were clearly evidenced by the grasses in early October 1971 in spite of the liberal rate of N supplied with hydroseeding on August 9. Dry matter and nitrogen yields in the 1972 and 1973 harvests (Table 2) were greatly inferior in the unfertilized plots. These plots continued to decline in vegetative cover throughout the 1972 and 1973 seasons; bare spots of soil were increasingly evident. They showed dramatic recovery, however, when nitrogen top-dressing of the entire study area was initiated in August 1973.

The data in Table 2 also indicate that the heavy rates of SCU application in April 1972 were effective for continued release of nitrogen for grass growth into spring 1973. However, when compared with 335 kg/hm² of nitrogen from AN (split application), the amount of available nitrogen was too low to support a maximum growth rate in 1973. Delayed application of AN (September 1972) proved more effective in this regard than the use of SCU in 1972.

The supplemental study of SCU conducted at Orono showed results similar to those of the Portland study (Table 4). The SCU material that was rated as 20 percent rapid release (same material as used at Portland) gave good carry-over into the second year but little or none into the third year. Spring-applied AN released virtually all of its nitrogen during the year of application but resulted in a much higher rate of nitrogen recovery than that obtained with SCU.

The final year of study at Portland clearly illustrated the significance of nitrogen recirculation through clippings left in place by the rotary mower. The nitrogen top-dressed in April 1974 supported vigorous grass growth and rapid recovery after mowings made in mid-May and mid-June. However, grass growth slowed during the latter half of the 1974 season.

The supplemental study at Orono gave some quantitative measure of the amount of recirculation of nitrogen in grass clippings. A comparison of clippings removed versus clippings deposited on the sod showed that the equivalent of 36 percent of the

Table 4. Nitrogen uptake and recovery of fertilizer nitrogen as influenced by rate and source of nitrogen top-dressed in May 1972 (Orono).

Treatment No.	Nitrogen Source	Nitrogen Rate (kg/hm^2)	N Uptake (kg/hm^2) 1972 (3 cuts)	1973 (3 cuts)	1974 (1 cut)	Nitrogen Recovery (%)
1	None	0	32	39	20	-
2	AN	168	170	49	20	89
3	SCU[a]	336	164	70	19	48
4	SCU[b]	336	82	124	38	46
5	SCU[b]	672	139	185	58	44

[a]20 percent rapid release. [b]5 percent rapid release.

Table 5. Nitrogen uptake and recovery of fertilizer nitrogen applied July 6, 1971, as influenced by clippings returned and clippings removed (Orono).

N (kg/hm^2)	Method[a]	N Uptake (kg/hm^2) Aug. 5	Sept. 9	Oct. 15	Total	Recovery (%) Total	Cuts 2 and 3
0	C	47	11	13	71		
0	H	53	6	9	68		
75	C	98	28	26	152		36
75	H	99	15	13	127	70	

[a]C = clipped and returned, and H = harvested and removed.

fertilizer N applied in the spring was later reabsorbed by the grasses following rotary mowing (Table 5).

Legume Establishment

Overseeded Crown Vetch and Bird's-foot Trefoil

Observations in 1974 of the legume overseeding study at Portland that was seeded in spring 1972 showed growth of crown vetch and Empire trefoil to be very vigorous. The legume overseeding at Orland on June 8 proved to be highly successful. Essentially complete ground cover was obtained with each of the legume species sown--bird's-foot trefoil (Empire) and crown vetch (Penngift and Chemung). The stands of trefoil and crown vetch have persisted throughout the study.

In contrast, the overseeding at Old Town proved to be relatively ineffective. Initial germination in 1973 appeared adequate but subsequent seedling survival was poor. It appears that the delayed seeding date (July 19) did not permit adequate plant growth before winter. In addition, the native vegetative cover at the Old Town site contained a considerable amount of red clover and was therefore more competitive than that at Orland. However, spots of trefoil and crown vetch that were evident in 1975 had grown considerably larger during 1976 and 1977, which suggests that delayed germination of hard seed may provide improved stands in future years. Recent observations made in 1981 showed that nearly complete ground cover had been obtained.

Crown Vetch Transplants

The crown vetch transplantings were universally successful at all the highway sites studied. Detailed notes of the extent of vegetative spreading were obtained in September 1975 and July 1976 and are presented in Tables 6, 7, and 8. The delayed 1974 transplantings at Caratunk and Orland were not sufficiently developed for detailed measurement of rhizome spread, so only general observations were possible. It is apparent from the older (1973) plantings that vegetative spreading in excess of 122 cm was generally obtained within two years. The Chemung variety proved somewhat more rapid spreading than Penngift. Seedling age at the time of transplanting appeared to have relatively little effect on subsequent plant growth.

Observations of the crown vetch transplanting sites in 1977 showed excellent plant survival and spreading. At Orland the slopes were completely covered. Caratunk did not have complete cover; however, the plants were spreading and should give good cover and minimize a serious erosion problem in the future. The Old Town site was affected by drought in 1976, but observations made in 1981 showed the site to have complete cover.

Overseeding Bird's-foot Trefoil by Using a Herbicide

Observations made in 1976 showed variations in stand densities between replications, and observations ranged from very poor to good; thus, the treatment means in Table 5 were never higher than a rating of fair in 1976. However, some individual replications at all sites received ratings of good. Treatments 5 and 6 had the best stands of trefoil, and treatments 1 and 3 were the poorest (Table 3). Treatment 3 was best at the Old Town site with a rating of fair compared with very poor at the other sites. This may be explained in part by the heavy ground cover at the Old Town site that formed a protective canopy prior to application of the herbicide paraquat. It appeared that there was some injurious effect from use of paraquat in treatment 3, which was seeded on April 9. The four-week interval between seeding date and time of paraquat application could have allowed the seed coat to become more permeable to the herbicide. This seemed to be evident at Dedham and Orland. Overall, the May seeding was best, regardless of the herbicide application. The trefoil stands obtained in treatments 5 and 6 indicate a definite advantage in the use of a herbicide such as paraquat to reduce competition, especially where the density of the initial ground cover is quite high (Table 3).

Observations made in 1978 still showed treatments 5 and 6 to be the best with ground cover rated excellent at Orland (Table 3). All treatments at all locations improved over ratings given in 1977.

The differential potassium treatments showed no visible effects on plant stands until 1978, when differences began to show between treatments 5 and 6.

CONCLUSIONS AND RECOMMENDATIONS

Fertilization of Grass Sod

The results obtained in this study support certain

Table 6. Vegetative spreading of crown vetch seedlings transplanted June 1973 (Orland).

Variety	Age of Seedling (months)	Maximum Lateral Spread of Rhizome (cm)			
				All Plants (avg)	
		Poorest	Best	Sept. 1975	Sept. 1976
Penngift	2	75	114	92	cc
Chemung	2	93	150	124	cc
	6	91	154	126	cc

Note: cc = complete cover.

Table 7. Vegetative spreading of crown vetch seedlings transplanted July 1973 (Old Town).

Variety	Age of Seedling (months)	Maximum Lateral Spread of Rhizome (cm)			
				All Plants (avg)	
		Poorest	Best	Sept. 1975	July 1976
Penngift	2	30	81	56	79
	3	17	56	34	66
Chemung	2	53	124	85	112
	3	30	85	55	74
	7	38	102	70	102

Table 8. Vegetative spreading of crown vetch seedlings transplanted June 1974 (Old Town).

Variety	Age of Seedling (months)	Maximum Lateral Spread of Rhizome (cm)			
				All Plants (avg)	
		Poorest	Best	Sept. 1975	July 1976
Penngift	3	16	61	36	48
	9	0	52	22	36
Chemung	3	41	90	63	71
	9	25	72	47	53

conclusions and recommendations regarding the fertilization requirements for successful establishment and maintenance of grass sods on highway slopes constructed on unloamed subsoil materials. Current hydroseeding specifications should be followed with regard to lime and fertilizer rates and mulching practice. Seedings should be made during the cooler parts of the growing season. The risk of poor germination and inadequate cover is relatively serious from early July through mid-August. All seedings should be completed by early October to ensure adequate cover before winter.

The phosphorus fertilization needs can be satisfied largely or wholly at the time of the initial seeding, and there is little need for top-dressed phosphorus for several years after seeding. Soil samples should be obtained from the roadside slope prior to seeding and chemically analyzed for available phosphorus content. Based on previous work, fertilization rates at the time of hydroseeding should range from the equivalent of 112- to 224-kg P_2O_5/hm^2, depending on soil test results. All hydroseeding should receive at least 112-kg P_2O_5/hm^2 to ensure rapid seedling growth and protective cover of the slope.

The potassium fertilization needs for sod maintenance are less readily satisfied by a single application of fertilizer in the initial hydroseeding. Fertilizer rates in excess of 112- to 168-kg K_2O/hm^2 may result in salt injury to germinating seeds during prolonged dry weather. Soil sites that test very low in available potassium may require a supplemental top-dressing of fertilizer potassium within a year or two following the initial seeding. This top-dressing is especially important whenever a legume is desired in mixture with grasses. Rates up to 224-kg K_2O/hm^2 may be top-dressed without any concern for injury to the established grass or legume-grass sod.

The nitrogen needs of grasses on subsoil embankments cannot be satisfied by heavy rates of fertilization at the time of seeding. Rates in excess of 100-kg N/hm^2 should rarely be used in the initial hydroseeding. These rates result in significant losses of nitrogen through leaching and denitrification and in dry weather may result in seed injury and reduced seedling populations. Excessive nitrogen may also suppress the establishment of an associated legume through unusually rapid growth of the competing grasses.

In general, grass sods on unloamed slopes should receive top-dressed nitrogen within 2-4 months after the initial hydroseedings. Spring and early summer seedings should be top-dressed in early fall, while late summer or early fall may not require top-dressing until the following spring. The rate of fertilization should rarely exceed about 100-kg N/hm^2. A second top-dressing will often prove necessary within 3-6 months after the first. Top-dressed nitrogen should be scheduled for the cooler periods of the growing season and avoid mid-June through mid-August when grass roots are largely inactivated by heat and drought.

Nitrogen top-dressing may be terminated 1-2 years after the initial hydroseeding. By this time, grass roots will be deep enough and sufficiently extensive to ensure efficient absorption of nitrogen recycled back to the soil by dying vegetation. The period of time in which nitrogen fertilization may be omitted is presently unknown but is estimated to be as much as five years or longer. At some point, however, grass sods grown on subsoils with little or no organic matter will run out of recycled nitrogen and will require one or more applications of fertilizer nitrogen to recharge the nitrogen cycle.

Based on the results of this study, there does not appear to be any clear-cut advantage to the use of SCU in dry matter yields or nitrogen uptake. The more protracted release of nitrogen appears to be offset by lower rates of recovery by the grass sod. However, the high rate of SCU did maintain good cover and needed only one application compared with three for AN. More research is needed to define the economic role of slow-release nitrogen fertilizers for highway sods.

Legume Establishment

Legume Overseeding and Crown Vetch Transplants

The results obtained in this portion of the study justify certain conclusions regarding management practices for the successful establishment of legumes in grass sods on Maine roadsides. In particular, practices for the establishment of crown vetch transplants appear well defined. Less-definitive results were obtained in regard to direct overseeding.

The results of a direct overseeding of crown vetch and trefoil on untreated grass sods appear to be quite unpredictable. The low seedling vigor of these legumes species may often result in their suppression below the spring growth of established grasses. However, legume stands may develop in subsequent years from delayed germination of hard seeds or from natural reseeding. Good establishment of crown vetch and bird's-foot trefoil was obtained, however, by scarification of the grass sod prior to overseeding.

The transplant method can be readily employed for ensured establishment of crown vetch on steep slopes or on other difficult areas where erosion effects make direct overseeding of dubious value. Virtually 100 percent survival was obtained during the initial establishment period at all three locations, including the badly eroded site of Caratunk. In addition, transplant seedlings are easily maintained until the actual planting date, which is in contrast to the short storage life of rhizome cuttings.

Seedling transplants of crown vetch suitable for field use can be readily produced in greenhouse flats within 2-3 months after seeding. Key factors in rapid seedling growth are adequate watering and supplemental fertilization. The soil used in the peat pots should be well fertilized and limed prior to seeding. In some cases, it may be desirable to top-dress a high-potash fertilizer over the flats of seedlings a month or two after seedling emergence.

The desired spacing of crown vetch transplants will vary with soil conditions (moisture and fertility), slope exposure, and other factors. Vegetative spreading by rhizome elongation (below ground) generally did not begin until early spring of the year following the year of transplanting. Further spreading then occurred during the cooler parts of each growing season; there was little or no rhizome extension during midsummer. By fall of the second year after the planting year, the more vigorous plants had spread laterally 122-152 cm under conditions of adequate fertilization and reasonably good soil moisture supply (Orland). Under more droughty conditions (Old Town), spreading was more limited. For all sites it appeared that supplemental fertilization was highly important to vigorous rhizome growth. Potassium was the key nutrient element in this regard, and it is recommended that crown vetch transplantings should be top-dressed with a high-potash fertilizer (e.g., 0-10-40) sometime during the year following the year of planting.

Winter survival of both crown vetch and bird's-foot trefoil was very good during the period of study (1976-1978). It appeared that these two legume species would prove to be long-lived on highway slopes in Maine. However, in 1979, 1980, and 1981, visual observations indicated that trefoil stands were beginning to thin at all locations but may improve from natural reseeding. Potential heaving problems were minimized by the natural surface drainage of these slopes. Low-temperature injury was minimized by the protected position of rhizome buds of crown vetch and the deep set crown of trefoil. Natural mulching by dead vegetation on these overwintering slopes was also an important factor that contributed to legume survival.

Overseeding of Bird's-foot Trefoil by Using a Herbicide

The overseeding of bird's-foot trefoil (Empire) in grassed slopes justifies certain conclusions regarding management practices for the successful establishment of bird's-foot trefoil in grass sods on Maine roadsides. They are summarized as follows:

1. Fewer established plants were obtained from the April 9 seeding; however, good stands may develop in subsequent years from delayed germination of hard seeds or from natural reseeding;
2. There is a definite advantage to using a herbicide such as paraquat to reduce competition, especially where the density of the initial ground cover is high;
3. Observations made during the growing season indicate that some initial ground cover is beneficial in protecting the seed from the herbicide and helps prevent the seed from being washed downslope during heavy spring rains;
4. Differences due to fertility treatments were not observed until the 1978 season;
5. No observed differences in trefoil stands could be attributed to the different clay and sandy soil types; and
6. The observations made in 1978 indicate that treatments 5 and 6, both of which had a May seeding and received paraquat, gave the best ground cover.

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Abridgment

Environmentalism, Pesticide Use, and Rights-of-Way

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A spectrum of organized environmental groups is attempting to stop the use of pesticides that are vital to rights-of-way maintenance. Managers must supplement their scientific training with an understanding of social and political dynamics in order to preserve chemical programs. Affluence and occupational shift to the service sector are among the primary forces that gave rise to the environmental movement of the 1960s and shaped new laws and regulations. Five types of antipesticide groups are discussed, and differences in their internal dynamics and tactics are examined. The campaign to ban 2,4,5-T is a typical case that shows how antipesticide groups use sympathetic media coverage and political pressure on government agencies to obtain their purposes. The development of this campaign is outlined by using expert witness testimony at Administrative Law Hearings of the U.S. Environmental Protection Agency (EPA) to show how pressure tactics appear to have changed EPA policy from its original position that scientific opinion found no causal link between 2,4,5-T forestry spraying and miscarriages near Alsea, Oregon, to the position that statistical data showed a danger sufficient to ban 2,4,5-T for certain uses.