

CONTROLLING EROSION ALONG HIGHWAYS

WITH VEGETATION

OR OTHER PROTECTIVE COVER

by

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## PREFACE

This research was conducted by personnel of the Agronomy Department of Virginia Polytechnic Institute and State University as part of the highway research program in cooperation with the Virginia Department of Highways and the Federal Highway Administration. Gratitude is expressed to personnel of the Virginia Highway Research Council for guidance, cooperation with experiments and suggestions made in the research work and to highway districts in the state that furnished some materials, supplies and help to facilitate the research pursuits. Their interest in search of knowledge to improve programs on erosion control in highway corridors has helped advance the accomplishments of this research project.

The services and quality of work of James Hammons, James Shaver, and Joyce Hile have added many fold to the research reported herein and are gratefully acknowledged.

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Names of some patented commercial material were used in this report because there were no other ways of distinguishing such products. Mentioning or using such patented commercial products in research does not imply that a state or federal agency endorses or condemns such products.

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ABSTRACT

Construction operations in highway corridors disturb the natural vegetation and land contours causing potential erosion sites if left denuded. Minimizing erosion on these areas is based on the principles of maximizing water infiltration and reducing water runoff obtainable with rough and stair-step grading to establish vegetative cover quickly. Rough grading is augmented temporarily by mulches until fast growing temporary canopies develop. Establishing and developing desirable vegetative covers depends on grading and soil preparation, soil amendments, mulches, and changing seed mixtures with seasons. Woodfiber @ 750 lbs/A as a tacking agent for straw has provided a persistent mulch for winter seedings that is equal to or better than asphalt @ 300 gal/A. The manipulation of these managements, through plant succession leads to the development of a near maintenance free vegetation that needs little mowing and little or no fertilizer as with crownvetch, flat pea, and sericea. Harsh environments often have partial vegetative covers and multi-step seeding and fertilization is required to develop protective vegetative canopies. Adequate soil amendments applied to a properly prepared seedbed eliminates the need for topsoil which is often of poor quality.

Sparsely vegetated grass slopes may be eliminated by overseeding with legumes, phosphorus, lime, and mulches in favorable seeding seasons.



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## I. INTRODUCTION AND RESEARCH APPROACH

The research findings reported herein were compiled from experiments conducted since initiation of the project entitled, "Controlling Erosion Along Highways With Vegetation or Other Protective Cover," in August of 1973. Experiments were planned and established in all regions of the state to determine grading methods, mulching practices, fertilizer mixtures, and seed mixtures that would best minimize erosion and avoid siltation where vegetation and natural contours of the soil are destroyed during construction operations. Good management of these factors enhances the rate of vegetative establishment. Erosion is minimized through a series of changes in plant cover from a quick cover of temporary species, shifting to semi-permanent grasses, and finally to a persistent leguminous cover and woody species. Several of the experiments reported herein can be followed for many years to determine plant succession resulting from treatment variables and different soil environments.

The specific objectives of this research project were as follows:

- A-1. To determine the effects of methods of grading cut slopes and constructing fill slopes on water and soil movement and the micro-environmental relationships on the speed of establishing persistent vegetation for controlling water movement and siltation.
- A-2. To ascertain the best rates and methods of applying mulching materials, with and without chemical binders, on erosion control per se and also on germination, seedling development and establishment of persistent vegetation. Comparisons will be made with direct sodding.
- A-3. To disclose the best adapted species and mixtures with various seeding methods for establishing turf during "off season seedings" while constructing highways.
- A-4. To impose seed treatments and coatings which maintain viability to delay germination until the favorable season(s) for germinating and establishing vegetative covers.
- A-5. To improve liming and fertilization practices (rates, combinations, chemical formulations when applied on the surface and incorporated) on widely varying soil materials for establishing a vegetative cover that will require

little lime and fertilizer for maintenance. Single and multi step applications with seed and with and without topsoiling will also be investigated.

- A-6. To determine the feasibility and best methods of establishing persistent vegetation in drainage ways where there is frequent and infrequent slow water movement.
- A-7. To investigate methods of obtaining woody vegetation by direct seeding into thin sods and variously graded bare slopes. Natural plant succession will also be characterized with grading methods.
- A-8. To find cultural methods to further improve the establishment of persistent perennial legumes (crownvetch and lespedeza) and to ascertain the adaptability and suitability of other legumes such as wild perennial pea. This will be investigated with new seedings and on slopes that now have thin grass cover.

Experimental sites were selected on slopes with uniform soil materials, aspect, steepness, and height. This was done so the imposed treatments for each experiment had as similar environments as possible.

All experiments were designed in accordance with modern statistical methods to remove personal biases and obtain reliable data; e.g., the experimental treatment variables were randomly assigned and replicated two to four times to obtain measurements of statistical and biological significance for making valid interpretation of the data. Almost all of the experiments provided data for two or more objectives. The treatments were often in factorial combinations or in split-plot designs to evaluate interactions among various categories of treatment factors. The experimental lay-outs were generally randomized complete blocks or split-plot designs unless stated otherwise.

The experiments were established with conventional seeding and mulching equipment commonly used by contractors and highway departments. Seed mixtures, fertilizers, mulches, soil chemical binders, and certain straw tacking agents were usually applied with a hydro-seeder or a straw blower equipped with a pump for applying chemical fluids.

Data obtained from each experiment varied, pending the specific objectives, soil materials, moisture conditions, and rate of plant growth. Data generally obtained were: populations of plant species, plant heights, vegetative cover, components in vegetative

cover, general appearance of vegetation, persistence of mulches and binders, slope stability, and amount of erosion. Data on plant populations and vegetative cover are presented in terms of plants per square foot and percentages of soil cover, respectively. Many of the data based on estimates were made by two to four individuals making independent observations. The data were analyzed statistically with significant differences for individual or group means given at the 5% level. Means for a check (no treatment) were generally used as a standard for comparing treatments in an experiment.

The date of establishment of an experiment, its location and design, the slope characteristics and aspect, and soil chemical properties are given for each experiment. Diagrams of the original experimental lay-outs, with all treatments, replications, dates of establishing and exact highway stations are in a permanent file in the Agronomy Department at Blacksburg.

The treatments for each experiment are summarized in tables, usually presented as a part of the results and interpretations of each experiment.

## II. EXPERIMENTS WITH RESULTS AND INTERPRETATIONS

A. Experiments on Cut Slopes Using Grading Methods, Seed Mixtures, Fertilizers, Mulches, and Chemical Binders1. Route 718. Experiment near Lovington, established 5-14-74.

This split plot experiment was established on a 1:2 west facing cut slope. The chemical properties of the soil were: pH-5.1; CaO-L; MgO-L+; P<sub>2</sub>O<sub>5</sub>-L; and K<sub>2</sub>O-M. A 0-20-10 fertilizer @ 1000 and lime @ 1T/A was applied uniformly over the entire experimental area. The main plots of crownvetch @ 20 and flat pea @ 30 lbs were alternated from the top of one replication to the bottom of the other before the various mulch treatments as legume cover are given in Table 1.

## Results and Interpretation

Plant Populations: Legume plant stands were best for woodbark, woodfiber alone and woodfiber with Landlock on 9-5-74. Straw is usually an excellent mulch for most seeding purposes; however, this source of straw was obviously contaminated with crabgrass seed as only plots with straw mulch were covered with this weed. Petroset SRB, an experimental product, inhibited germination and later allowed few legume plants to grow.

Vegetative Cover: The weed and toxic problems still influenced the legume cover on 6-15-75 (Table 1). The surviving legumes on plots with the SRB binders grew and spread. On 6-10-76, the crabgrass competition continued to depress legume plants with straw mulch; the toxicity from the SRB chemical binder had not inhibited the spread of legumes.

Woodfiber or other weed and seed free mulches are vastly superior to weedy hay or straw that shade out desirable plants. It may require 10 or more years for legumes to completely cover slopes' under severe competition from weedy straw. Crownvetch or flat pea generally develop a total vegetative cover in 2 to 4 years. Woodbark is an excellent mulch and may be used where readily available.

Table 1. Effects of mulches on the establishment of flat pea (FP) and crownvetch (CV) on a rough slope.\* Route 718, near Lovington, established 5-14-74.

Mulches and binders Rates/Acre	Legume cover, %					
	9/5/74 plants/sq ft		6/15/75		6/10/75	
	FP	CV	FP	CV	FP	CV
Woodbark @ 35 yd <sup>3</sup>	16	29	100	100	100	100
WF @ 1500 lbs	23	26	100	100	100	100
WF @ 1500 + LL @ 80 gal	20	30	100	100	100	100
WF @ 1500 + Pet SRB @ 120 gal	9	3	50	39	100	100
Straw @ 2T + LL @ 80 gal	7	7	12	6	20	18
Straw @ 2T + Pet SRB @ 80 gal	5	1	14	15	22	24

\* Means in a vertical column with different letters are significantly different at the 5% level of probability. All plots received lime @ 1 T and 10-20-10 @ 1000.

2. Route 617 near Floyd; established 5-22-74.

This split plot experiment was established on a 2:1 east facing cut slope. Kentucky 31 fescue @ 40 and 10-20-10 fertilizer @ 1000 and lime @ 3000 lbs/A were applied uniformly to the entire experimental area by use of a hydroseeder. Straw was applied on half of each replication versus no mulch as the main plots after the split plot seed treatments were applied. The treatments, plant stands and vegetative cover are shown in Table 2.

#### Results and Interpretations

Plant population: The legume stands were better with straw mulch for both sweet pea and crownvetch than without mulch. With straw mulch, the crownvetch stands were generally best with the check treatment, but the results were variable. Perennial sweet pea was best with the low lovegrass rate and millet depressed stands. German millet and lovegrass are very aggressive toward legumes during the summer season but cause little competition to the developing cool season legumes during autumn and the late winter-early spring season. Conversely, tall fescue (check treatment) is not aggressively competitive with summer seedlings. The no mulch plots generally had a poorer stands than the straw mulch plots.

Vegetative Cover: Vegetative cover was about 10% better for straw mulching as compared to no mulch one year after establishing the experiment. Lovegrass cover gave the best vegetative cover because fescue alone or fescue with millet died during the first season. Vegetative cover was best with no mulch for the 2 low rates of lovegrass and dropped sharply with the high seeding rate. This trend is not explainable at present.

Legume cover on 6-23-76 was excellent with straw as shown in Table 2. The slower rate of spread of sweet pea than crownvetch is attributed to more proliferating roots for the latter. Even with no mulch, both sweet pea and crownvetch gave nearly a two thirds vegetative cover, except for sweet pea with the low rate of lovegrass. German millet is excellent for obtaining stands of Ky 31 fescue and legumes. Millet dies the first season after a frost, leaving an in situ mulch and no competition, allowing rapid growth of legumes and perennial grasses. It is estimated that these legumes will completely cover this slope area in another year.

Table 2. Effects of mulch and companion grasses on establishing crownvetch (CV) and perennial sweet pea (PSP). Route 617 near Floyd, established 5/22/74.

Grasses Lbs/acre*	9/10/74				5/23/75		6/23/76			
	No. plants/sq ft**				% total vegetative cover		% legume cover			
	straw		0 mulch		straw	0 mulch	straw		0 mulch	
	CV	PSP	CV	PSP			CV	PSP	CV	PSP
Lovegrass @ 5	3b	9a	3b	2c	82	86	87	78	75	38
Lovegrass @ 10	6a	5c	5a	5b	83	82	85	57	70	75
Lovegrass @ 15	4b	--	3b	--	92	62	97	--	52	--
Check	6a	6b	2b	6a	66	61	95	77	60	62
G. millet @ 10	3b	5c	2b	5b	79	60	97	75	58	68
G. millet @ 20	4b	4c	3b	5b	73	64	75	78	80	72
Avg	4.3	5.8	3	4.6	79.2	69.2				

\* All plots had Kentucky 31 fescue @ 40 with either crownvetch at 15 or flat pea at 30 lb/A; lime was applied @ 1-1/2 tons, 10-20-10 @ 1000/A and straw @ 1-1/2 tons/A.

\*\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

### 3. Route 291 - 460 Interchange near Lynchburg; established 4/2/75.

This randomized block experiment was established on a northeast facing 1:1 cut slope. A slurry of 10-20-10 fertilizer @ 1000, lime @ 2 T and woodfiber @ 1500 lbs/A was applied with a hydroseeder uniformly over the entire experimental area after seed treatments were applied. The treatments (Table 3) were designed to determine grass species that allow fast encroachment and good survival of legumes.

#### Results and Interpretation

Plant Populations: About 4 months after seeding on 4/24/75, the legume populations were best when seeded with grasses. Legumes grew better when seeded with Kentucky 31 fescue alone and with creeping red fescue than when seeded with annual ryegrass - fescue mixture (Table 3). This is

attributed to rapid germination and competition from vigorous ryegrass seedlings. Legume heights (Table 3) were better with no companion grass as compared with annual ryegrass where there was competition for light, water, and nutrients. However, by 6/24/76 legume cover was best when seeded with Kentucky 31 - fescue and annual ryegrass and poorest with Kentucky 31 fescue alone. This is attributed to most of the fast growing annual ryegrass dying out during summer of 1975, leaving more open canopies for the surviving legumes to spread into. Fescue in pure stands often forms dense sods that allow little encroachment by any species. When seeding legumes a companion grass should be used in seed mixture with Kentucky 31 fescue. However, low seeding rate of tall fescue should be used to avoid dense stands of annual ryegrass that may be lethal to developing legumes.

Table 3. Effects of grass mixtures and species on the establishment of flat pea (FP), perennial sweet pea (PSP) and crownvetch (CV).\*  
Route 291 - 460 Interchange, near Lynchburg, established 4/2/75.

Grass associates	7/24/75**					6/24/76			
	legumes/sq ft			leg. ft <sup>2</sup>	Average ht/plant, in.	Legume cover, % cover			
	FP	PSP	CV			FP	PSP	CV	%
a. no grass	8.0	7.0	17.5	9.2a	8.2a	33	7	25	22b
b. Ky 31 @ 20 A. ryegr @ 20	6.7	4.5	5.0	5.3c	4.5c	20	22	43	28a
c. Ky 31 @ 20 CRF @ 20	6.5	5.5	8.0	6.7b	6.8b	40	7	20	23B
d. Ky 31 @ 40	7.5	4.0	8.0	6.5b	5.3b	7	5	5	9c

\* The legumes were seeded @ 30 lbs/A.

\*\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

4. I-95 South, one-half mile north of Dumphries; established 4/17/75.

This randomized block experiment was established on a 1:1 east facing cut slope. A 10-20-10 fertilizer @ 1000 and lime @ 2 T/A were applied uniformly over the entire slope; the seed treatments along with woodfiber @ 750 lbs/A were then applied with a hydroseeder (Table 4). Several grass species were seeded with crownvetch and flat pea to determine their compatibility.

#### Results and Interpretation

Vegetative Cover: The best initial legume cover was obtained with lovegrass @ 10 lbs/A and the poorest by deertongue, creeping red fescue, and Ky 31 fescue, each seeded alone. Deertongue gave an excellent, healthy looking vegetative cover when seeded alone or in combination with other grasses. Further research is needed to verify its adaptability. It is thought to be best adapted for droughty, acid areas. It is very desirable to seed mixtures of grasses when seeding on difficult slope environments and one of the grasses should develop quickly to stabilize the slope, while the more persistent, slow growing grass or legume becomes established.

Plant Populations: Flat pea stands were not significantly different with any grass species but were good with deertongue alone. Crownvetch stands were best when seeded with deertongue alone. This is attributed to little competition with the open canopy from deertongue that was over 3 months old on 7/29/75 when data was collected. Lovegrass @ 10 and creeping red fescue @ 30 created much competition, possibly for moisture, for the developing crownvetch plants, causing poor stands.

Subsequent Vegetation: Crownvetch and flat pea encroached over all grass species, flat pea providing more cover than crownvetch, except where they were seeded with creeping red fescue @ 30 and redtop @ 3 lbs/A. Grass cover was best on 7/7/76 where deertongue was seeded @ 30 and where Kentucky 31 fescue and lovegrass were seeded together (Table 4). The crownvetch cover with these grasses was poor because of the aggressive grass growth. Flat pea seems to persist under aggressive competition and appears destined to become the dominant species. Deertongue appears to be a fast growing, aggressive grass that may be seeded with an aggressive legume as flat pea. A mixture of Kentucky 31 fescue and lovegrass provides an excellent protective vegetative cover the second year when fescue becomes dominant.

Table 4. Effects of grass species and mixtures on the establishment of flat pea (FP) and crownvetch (CV). Route I-95 south of Dumfries; established 4/17/75.

Grasses, lbs/A	7/29/75		Total vegetative cover, %	7/7/76		Grass cover %
	Legume/ft <sup>2</sup>			Legume cover, %		
	FP	CV <sup>1/</sup>		FP	CV	
A. Lovegrass @ 10	2	.5c	100a	27	2	65ab
B. Deertongue @ 20 + LG @ 5	2	1.5b	92b	20	5	55b
C. Deertongue @ 20	2.5	6.5a	87b	15	5	75a
D. Deertongue @ 20 + Redtop @ 3	2	2.0b	93b	25	15	60b
E. Ky 31 @ 40 + LG @ 5	1.5	1.5b	94b	20	5	75a
F. Ky 31 @ 40	2	1.5b	73c	12	7	30c
G. Ky 31 @ 40 + Redtop @ 3	3	3.5b	91b	23	25	40c
H. CRF @ 30 + LG @ 5	1.5	1.5b	94b	20	17	45c
I. CRF @ 30	2	1.0c	82c	13	7	55b
J. CRF @ 30 + Redtop @ 3	2	3.5b	93b	25	42	25c

<sup>1/</sup> Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

5. I-95 South, one-fourth mile from Quantico Marine Base exit; established 4/29/75.

This split plot experiment with two replications was established on a 1.5:1 east facing cut slope. The chemical characteristics of this subsoil material were: pH - 2.9, CaO - L, MgO - M, P<sub>2</sub>O<sub>5</sub> - H+, and K<sub>2</sub>O - L. This and other similar surrounding areas have not developed vegetative covers because of the low pH. Plant species with a history of acid tolerance were tested with lime rates. The main plots had 3, 6, and 9 T/A of pulverized ground limestone and 1000 lbs/A of a 10-20-10 fertilizer applied with a hydroseeder. Next the seed treatments were applied and mulched with 2 T/A of straw and tacked with wood-fiber @ 750 lbs/A. The treatments and results are given in Table 5.

#### Results and Interpretation

Vegetative Cover: Initially, for all seed treatments, the best vegetative cover occurred with 3 T/A of lime. All treatments showed a surprisingly good vegetative cover 3 months after seeding when considering the very low soil acidity. Deertongue with Kentucky 31 fescue gave the most plant cover on 7/29/75 at the low and high rates of lime (Table 5). Legume stands with crownvetch and flat pea were similar for the lime rates. However, the yellowing noted on some of the species was apparently phosphate deficiency. This occurs with high amounts of Ca that fix phosphates into unavailable forms. Micro-nutrient deficiencies were also suspected on some plants.

A year later, the vegetative cover declined on all plots, being best where lime was applied at 6 T/A. The 9 T/A rate of lime apparently induced other stresses on an already critical soil habitat resulting in sparse vegetation. At the last date of making observations, all plots lacked vigor and had abnormal growth, although both crownvetch and flat pea were nodulated. Deertongue produced a good dense cover where it was growing, but it had a yellow stunted appearance as for all other species.

It is postulated that as this subsoil is exposed to the air creating extremely acid conditions (sulfur oxidation) that the slope will eventually lose all vegetation. This may be alleviated by using large stair-step grading on such slopes and applying up to 2 feet of topsoil to establish and maintain grass and legume species. However, with a long period of time, the soil pH will decline as the sulfur compounds are oxidized and leached away.

During the year since straw was applied, no straw decomposition had taken place because soil bacteria cannot live under these acid conditions. The soil pH at 3, 6, and 9 T/A of lime was 4.8, 5.1, and 5.6, 2 months after application.

Table 5. Effects of lime rates on establishing companion grass species and legumes.\* I-95 South near Quantico Marine Base; established 4/29/75.

Grasses, rates/A	Lime rates											
	7/29/75									7/7/76		
	Total cover, %			Legume plants/ft <sup>2</sup>						Total cover, %		
	3T	6T	9T	Crownvetch			Flat pea			3T	6T	9T
A. Deertongue @ 20	85	85	77	10	9	11	6	3	5	52	65	46
B. Deertongue @ 20 + LG @ 5	82	80	75	9	14	11	3	7	5	58	81	38
C. Deertongue @ 20 + Redtop @ 4	85	87	72	12	14	6	3	2	2	54	80	21
D. Deertongue @ 20 + creeping red fescue @ 30	85	70	76	12	10	10	3	4	5	34	45	38
E. Deertongue @ 20 + Ky 31 fescue @ 40	87	77	86	11	9	10	2	3	5	59	72	55
	<u>85a</u>	<u>80b</u>	<u>77c</u>							<u>51b</u>	<u>69a</u>	<u>40c</u>

\* Legumes were seeded at 30 lbs/A.

6. Route 729 near Floyd; established 6/18/75.

This split-plot experiment with three replications was established on a stair-step graded 1.5:1 south facing cut slope. The chemical properties of this soil were: pH - 5.3, CaO - L, MgO - L, P<sub>2</sub>O<sub>5</sub> - L, and K<sub>2</sub>O - L. The main plots were lime and fertilizer rates and the subplots were four legume species. The purpose of this experiment on this infertile subsoil was to determine legume nodulation and growth responses to rates of lime, phosphorus, and potassium. After all treatments were applied, as shown in Table 6, Kentucky 31 fescue was applied with a hydroseeder @ 30 and then mulched with straw and tacked with 750 lbs/A of woodfiber.

## Results and Interpretation

Nodulation Effects: Two months after seeding nodulation was best at the high lime rate with 150 lbs/A of P (Table 6). Although the soil was low in K, it was not essential for nodulation for the legumes. Phosphorus is a very important element for all of the legumes species but sweet pea and sericea were least responsive. Calcium and Mg were found to be low according to soil tests but are not necessary for good nodulation. Although the soil was not tested, it was suspected that Al was low in this soil and not a toxic factor.

Vegetative Cover: By August 1975, plant stands responded to P but responses were confounded with lime rates which increased growth of legumes in one instance and not the other. A year later on 6/23/76, lime rates did not show a definite response; however, responses to P were good with all legumes except sericea which died for no apparent reason. Potassium did not give a response with the legumes; hence, it may be applied in low amounts where legumes are desired. Grass offered little competition to the legumes since no N was applied.

### 7. Indian River Road - I-64 Interchange; established 10/6/75.

A split-split plot experiment with perennial sweet pea and flat pea being the main plots, lime rates being the sub-plots, and fertilizer rates being the sub-subplots was established on a 1.5:1 north facing slope. This experiment was designed to study the adaptability of both pea species to the soils and climate of the Coastal Plains.

This area had a thin stand of Kentucky 31 fescue. The entire area was tilled lightly prior to treatment applications. The initial pH of the soil was 5.7, being medium in Ca, Mg, P, and K.

Data collected on 7/8/76 showed peas in only four plots. The failure of this experiment is thought to be due to winter kill or the dry winter and spring. Subsequent observations will be made to determine whether dormant seeds might develop stands.

Table 6. Effects of lime, phosphorus, and potassium rates on the establishment of several legumes, crownvetch (CV), Perennial sweet pea (PSP) and flat pea (FP) and sericea lespedeza (Ser). Route 729 near Floyd, Established 6/18/75.

Lime, phosphorus (P = P <sub>2</sub> O <sub>5</sub> ) and potassium (K = K <sub>2</sub> O) in lbs/A	8/14/75				6/23/76**					
	Average nodules/plant		Avg. total		% cover					
	FP	CV	Ser	Avg*	FP	PSP	CV*	Ser		
Lime 0, P @ 150, K @ 100	7.3	4.5	3.0	2.2	4.3ab	7.9b	28a	38a	42a	0
Lime @ 3000, P @ 150, K @ 100	7.0	3.5	2.8	1.3	3.7b	9.5ab	7c	23b	42a	0
Lime @ 6000, P @ 150, K @ 100	7.3	5.8	2.0	2.3	4.4ab	11.3a	23a	40a	43a	0
Lime @ 6000, P @ 0, K @ 100	4.7	4.7	1.7	1.8	3.2c	8.5b	Od	5c	0c	0
Lime @ 6000, P @ 150, K @ 0	9.5	4.8	4.2	3.0	5.4a	15.3a	15b	25b	28b	0

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

\*\* Ky 31 fescue had a uniform cover between 50 and 60% on the experimental area.

## B. Fill Slope Preparation Methods and Seed Mixtures

### 1. Route 785 near Endicott; established 9/27/74.

A split plot experiment was established on a 4:1 west facing fill slope. The main plots were smooth versus rough surfaces. The rough parts were tilled with a rototiller. A 10-20-10 fertilizer @ 1000 and lime @ 2 T/A were applied uniformly with a hydroseeder over the entire site. After seed treatments were applied, straw @ 3000 lbs/A was applied with a strawblower to the entire experimental area. The seed treatments were designed to find if crownvetch or flat pea would thrive with different seeding rates and companion species.

### Results and Interpretation

Plant Populations: The stands of legumes were much better for seedings on rough than smooth slope surfaces (Table 7). For crownvetch there were 2.3 and 1.3 and for flat pea 3.25 and 2.75 plants/sq.ft. for roughened and smooth surfaces, respectively. Legume stands were generally best when seeded in the legume mixture at high rates. Heights of the legumes on 6/30/75 showed flat pea to be more hardy and aggressive than crownvetch.

Subsequent Leguminous Cover: The plot that was seeded alone @ 50 lbs/A and the treatment that was seeded with annual ryegrass @ 30 had significant difference in vegetative cover. Flat pea has a much hardier seedling than does crownvetch and is much more drought resistant being able to withstand light competition to a greater degree. Some stems of the flat pea had elongated as much as 20 inches through annual ryegrass. It is expected that flat pea will completely cover the slope in another year's time.

By 6/23/76, in the various mixtures with crownvetch and companion grasses (rye and annual ryegrass), the average cover was 85.8% for flat pea and only 2% for crownvetch.

Table 7. Effects of roughened slopes and companion grasses on the establishment of flat pea (FP) and crownvetch (CV). Route 785, Franklin County; established 9/27/74.

Species in mixtures, lbs/A	6/30/75*				6/30/75		6/23/76*	
	No. plants/ft <sup>2</sup>				Height of plants (in)		Cover by legumes, %	
	rough		smooth		CV	FP	CV	FP
	CV	FP	CV	FP	CV	FP	CV	FP
CV 35, FP 50	4.0a	6.5a	1.0b	2.5b	1.0	24	0	56c
CV 50, FP 15	1.5b	3.0b	1.5b	2.0b	1.0	22	8	82ab
CV 35, FP 15	1.5b	2.5b	1.0b	2.0b	.5	18	2	88ab
CV 35, FP 15, rye 20	.5c	2.5b	1.0b	2.0b	1.5	21	0	87ab
CV 35, FP 15, rye 40	2.5b	5.0a	2.0a	3.5ab	1.0	25	0	100a
CV 35, FP 15, ryg 30	3.5ab	2.5b	1.5b	2.0b	.5	19	4	76b
CV 35, FP 15, ryg 60	2.5b	2.5b	1.0b	3.0b	.5	22	4	96a
CV 35, FP 15, ryg 30, Ky31 30	3.0b	2.0b	1.5b	2.5b	1.0	20	2	99a
CV 35, FP 15, ryg 30, Ky31 60	1.5b	2.5b	.5c	4.0a	1.0	18	0	93a
CV 50, FP 50	<u>2.5b</u>	<u>3.5ab</u>	<u>2.0a</u>	<u>4.0a</u>	1.5	26	0	81ab
Avg.	2.3	3.25	1.3	2.75			2	85.8

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

C. Experiments in Medians with Seed Mixtures, Fertilizers, Mulches, Nets, and Chemical Binders

1. Old Route 3, 2 miles north of Gloucester, Established 4-25-74.

This split-split plot experiment was established in a median of yellow-brown clay subsoil with chemical properties of pH 5.2, CaO-L, MgO-L+, P<sub>2</sub>O<sub>5</sub>-L, and K<sub>2</sub>O-L+. Topsoiling vs subsoil were the main plots; subplots were rough vs smooth hard surfaces (conventional) as follows:

1. Rough surface and then lime and fertilizer. 2. rough surface with fertilizer and lime incorporated to a depth of 4 to 6 inches and, 3. smooth hard surfaces with lime and fertilizer applied on the surface. A seed mixture of Kentucky 31 fescue @ 60, annual ryegrass @ 10, crown-vetch @ 20 and white clover @ 3 lbs/A was applied uniformly over the entire experimental area. The area was then mulched with woodfiber @ 1500 lbs/A. The treatments and data are shown in Table 8. The surfaces were roughened with tiller feet of a road grader.

Results and Interpretations

Plant Population: When considering both legumes, the stands were 2-fold better where lime and fertilizer were incorporated into the soil than for roughening the soil and making surface applications, and 10-fold better than for applying lime, fertilizer, and seed on a smooth, hard slope surface (Table 8). The legume stands were generally best for the low or intermediate rate of applying fertilizer with rough slope surfaces. The high rate of fertilization with 150 lbs/A of nitrogen gave the poorest legume stands because the stimulated grasses retarded the slower growing legumes.

With smooth and hard slope surfaces, the stands of legumes varied with fertilizer rates, the results being inconsistent.

Vegetative Cover: By May 5, 1974, the vegetative cover was similar for top and subsoil. The best total vegetation was obtained with 10-20-10 fertilizer @ 1000, the 1500-lb rate being next. The low rate 750 lbs/A of a 10-20-10 fertilizer was unsatisfactory for producing a plant cover 1 month after seeding, even though legume stands were best, Table 8. A compromise of using 10-20-10 fertilizer @ 1000 provided a good cover while without seriously depressing the legumes. This experiment was destroyed by construction operations so further data could not be obtained.

The excellent stands and vegetative cover with rough vs smooth and hard slope surfaces is attributed to a better moisture habitat due to more water infiltration. Incorporating the lime and fertilizer, made these to stimulate growth materials more available to seedling plants because of a better moisture environment.



Surface seedings on rough soil surfaces give seed coverage to improve germination and speed up the development of vegetative covers.

2. Route 58, 2 miles east of South Boston, Established 7-11-74.

This split-split plot experiment was established in a median with an 8% grade. The chemical characteristics of the soil were: pH-5.9, CaO-M-, MgO-VH, P<sub>2</sub>O<sub>5</sub>-L, and K<sub>2</sub>O-L. A 10-20-10 fertilizer @ 1000 and lime @ 2T/A was applied uniformly over the entire experimental area with a hydroseeder. The main plots were rough and smooth slopes and incorporation of the lime and fertilizer, Table 9. Straw was applied after treatments @ 3000 and tacked with Landlock @ 80 gal/A.

Results and Interpretation

Plant Populations: Legume stands were generally highest when seeded with creeping red fescue, (Table 9). This was due to very slow seedling growth as compared to Ky 31 fescue during summer. Lovegrass and millet provided a major part of the cover in all plots by 8-12-74.

Vegetative Cover: The vegetative cover was best where lime and fertilizer were incorporated into the soil, leaving a rough surface (Table 9). The vegetation was significantly lower with roughened slopes when applying fertilizer and lime on the surface than with incorporation. The median with conventional practices (applying seed and fertilizer on hard surfaces), had the least amount of total vegetation. Incorporation of lime and fertilizer creates a more favorable environment for root exploration, incorporating lime and phosphorous is especially desirable for soils that are high in aluminum. Raising the soil pH reduces toxicity from it. The rough tilled median allows more water infiltration which helps modify temperatures creating a more favorable environment for germination and growth of both grasses and legumes.

The Landlock held the straw in place, even though there were high winds from nearby traffic. This experiment was destroyed after the data was collected to widen the road.

Table 9. See separate page.

3. Route 114 near Fairlawn, Established 10/23/74.

This split plot experiment was established in a median with a 3% grade. A seed mixture of annual ryegrass @ 15, creeping red fescue @ 40, Ky 31 fescue @ 60, and crownvetch @ 20 lbs/A, with 10-20-10 fertilizer @ 1000 and lime @ 2 T/A, were applied uniformly over the entire experiment prior to mulch treatments. The main plots were rough surfaces versus smooth, "conventional" grading of medians. The surfaces were roughened with a tractor with a tiller prior to seeding operations.

Results and Interpretations

Straw Stability and Erosion Ratings: On the first date of observation (11/2/74), straw was most stable with the mat of woodfiber @ 750 lb/A (Table 10). The high rate of Landlock latex was a satisfactory tack for

Table 9. Effects of rough and hard, smooth surfaces and incorporation and surface applications of fertilizer on stands of legumes with companion grass species.\* Route 58, near South Boston; established 7/11/74.

Grass - legume mixtures, lbs/A **	Slope Surfaces, Companion Species and Fertilizer Application											
	Rough surface fert.			Smooth surface fert.			Rough fert. incorp.			Rough fert. incorp.		
	Lovegrass* Leg/ft <sup>2</sup> cover %	Millet* Leg/ft <sup>2</sup> cover %	Millet* Leg/ft <sup>2</sup> cover %	Lovegrass Leg/ft <sup>2</sup> cover %	Millet Leg/ft <sup>2</sup> cover %	Millet Leg/ft <sup>2</sup> cover %	Lovegrass Leg/ft <sup>2</sup> cover %	Millet Leg/ft <sup>2</sup> cover %	Lovegrass Leg/ft <sup>2</sup> cover %	Millet Leg/ft <sup>2</sup> cover %	Lovegrass Leg/ft <sup>2</sup> cover %	Millet Leg/ft <sup>2</sup> cover %
CRF 30, CV 15	6b	7b	41	3a	27	7b	35	13b	50	12b	54	
CRF 30, CV 30	14a	18a	38	8a	32	14a	32	20a	51	20a	46	
CRF 30, Ser 30	7b	1b	44	9a	34	11b	36	6b	57	7b	49	
Ky 31 60, CV 15	5b	8b	40	9a	29	10b	33	10b	48	12b	52	
Ky 31 60, CV 30	7b	9ab	45	6a	31	6b	29	14b	49	23a	48	
Ky 31 60, Ser 30	4b	4b	39	7a	37	8b	31	15b	50	3b	50	
Ky 31 60, FP 15	5b	3b	40	4a	30	2b	34	2b	53	5b	51	
Average	42b	41b	41b	31c	33c	33c	51a	50a	50a	50a	50a	

\* Lovegrass seeded @ 5 and German millet @ 15 lbs/A.

\*\* Creeping red fescue = CRF, Kentucky 31 fescue = Ky 31, crownvetch = CV, sericea lespedeza = Ser, flat pea = FP.

\*\*\* Means in vertical or horizontal columns followed by different letters are significantly different at the 5% level of probability.

straw. Erosion was controlled by all 3 types of nets at approximately 3 months after establishing the experiment. Straw tacked with 750 lbs/A of woodfiber controlled erosion very well as did a layer of large gravel. The data for all treatments are for the center drainage way of the median.

Woodfiber with binders was completely unsatisfactory for medians during the winter season, and straw tacked with Terra Tack II was little better. Straw tacked with Landlock latex gave good results for winter erosion control but this material is not manufactured.

Table 10. Route 114 near Fairlawn, Established 10/23/74. Effects of rough and smooth median surfaces and mulches on erosion control and vegetative cover.

Treatment/A*	Observation dates			3/15/75 % vegetative cover***
	11/2/74 Straw stability	1/14/75 Erosion rating**	1/14/75 ** Vegetation	
Straw @ 2 T + WF @ 750 lb. on top	3	3	3	65a
Straw @ 2 T + LL @ 60 gal	6	6	5	32b
Straw @ 2 T + LL @ 120 gal	4	6	5	38b
Straw @ 2 T + TT II @ 60 gal	6	9	5	35b
Straw @ 2 T + TT II @ 120 gal	5	9	5	40b
Jute matting		1	2	72a
Hold Gro (brown)		2	8	15c
Hold Gro (white)		2	7	10c
WF @ 1500 lb. + Pet @ 80 gal		10	8	17c
WF @ 2500 lb. + ECL @ 80 gal		10	8	21c
Stone 1" size - 1/2" deep		2	3	69a

\* WF = woodfiber, LL = Landlock (no longer available) TT = Terra Tack II, Pet = Petroset SB, ECL = 743 latex, and Hold Gro = paper strip nets.

\*\* Ratings from 1 to 10 with 1 being best, ratings 1-3 = excellent, 3-5 = satisfactory, 5-7 = marginal, 7-10 = unsatisfactory.

\*\*\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

Vegetative Cover: The vegetation on 1/4/75 was best with jute matting followed by straw tacked with woodfiber and large gravels. The vegetation under all straw plots with binders gave fair cover, while woodfiber plots and treatments with the paper net (Hold Gro) generally had poor vegetative covers. The gravels, jute and straw modified soil temperatures and moisture, creating more favorable environments for growth of the vegetation. Poor vegetation under the paper nets (Hold Gro) was due to it not degrading enough to allow the germinating grass seedlings to emerge from under the net. By 3/15/75, the three best mulches for both controlling erosion and establishing vegetation in drainage medians, had 65% or better vegetative covers (Table 10). The vegetation on the rough tilled areas was about 50% better than on the smooth area.

D. Experiments with Fertilizers as They Affect Plant Species and Mixtures

1. Route 17, 12 miles west of Saluda; established 6/4/74.

This split plot experiment was established on a 2:1 west facing cut slope. A seed mixture of Kentucky 31 fescue @ 50, creeping red fescue @ 10, crownvetch @ 10, sericea @ 15, and lovegrass @ 5 lbs/A and lime @ 3000 lbs/A was applied uniformly over the entire experimental area. The main plots of mulch were applied uniformly with a hydroseeder and the sub-plots of fertilizer were applied to plots by hand. Treatments along with data are given in Table 11.

Results and Interpretation

Vegetative Cover: The vegetation was best at the high rate (1500 lbs) of a 10-20-10 fertilizer with 150 lbs/A of urea formaldehyde (UF), followed by the high rate of 10-20-10 alone, and then by the medium rate of 10-20-10. The low rates of 10-20-10 with UF are apparently too low in soluble N to stimulate grass growth as compared to high rates of 10-20-10 fertilizer. Applications of UF do not give a big stimulation of grass growth initially because of its slow release, unless application rates are high. Therefore, 10-20-10 @ 750 with 150 lbs/A of UF gave less initial grass growth than 10-20-10 @ 1000. Urea formaldehyde is water insoluble; its availability depends on microbial activity to form available N. However, when seeding legumes with a grass mixture, stimulation of grass over a period of 3 to 4 years may not be desired. Prolonged grass competition may delay encroachment of legumes to minimize weeds and reduce mowing and fertilizer costs.

Woodfiber @ 1500 lbs/A gave a significant increase in vegetative cover over both 750 lbs/A and no woodfiber. However, vegetative cover was not good on any areas after 3 months due to prolonged drought. Woodfiber at high rates or straw @ 3000 lbs/A improves vegetative establishment under critical conditions.

All slopes in this area had been topsoiled and seeded and were very weedy. This experiment was established on subsoil material that was roughened to a depth of 8 inches with tiller feet of a road grader. The area was overseeded in late September to show the value of rough slopes and that topsoil was not needed to provide complete vegetative covers in a years time. Observations made in the spring of 1975 showed the area to have 100% vegetative cover with good growth of crownvetch and sericea with no weeds being present.

Table 11. Effects of fertilizer and nitrogen rates with three rates of mulch on vegetative cover on a rough slope. Route 17, near Saluda; established 6/4/74.

Treatment**	% vegetative cover, 9/17/74			
	Woodfiber rates, lbs/A			
	0	750	1500	Average*
10-20-10 @ 750	34	36	53	41d
10-20-10 @ 1500	43	46	54	51b
10-20-10 @ 750 + UF @ 150	37	40	59	45cd
10-20-10 @ 1500 + UF @ 150	52	62	72	61a
10-20-10 @ 1000	42	47	65	52bc
Average	41b	46b	62a	

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

\*\* All plots had lime @ 3000, Ky 31 @ 50, creeping red fescue @ 10, crownvetch @ 10, sericea lespedeza @ 15, and weeping lovegrass @ 5 lbs/A.

## 2. Route 856, near Fairystone; established 6/26/74.

This split plot experiment was established on a 1:1 south facing cut slope. The chemical properties of the soil were: pH - 5.0, CaO - L, MgO - L, P<sub>2</sub>O<sub>5</sub> - L-, and K<sub>2</sub>O - L. The main plots of lime rates were spread uniformly by use of a hydroseeder and subplots of fertilizer and seed were spread uniformly by hand prior to applying woodfiber @ 1500 with weeping lovegrass @ 5 lbs/A over the entire experimental area with a hydroseeder. The treatments and data on plant populations and vegetative cover are shown in Table 12.

### Results and Interpretation

Plant Populations: Six weeks after seeding, without and with lime @ 2 T/A, all legumes were surviving with no apparent effect from N or lime rates. The pH of 5.0 did not seem to depress crownvetch or flat pea. Lovegrass growth was best without lime and the high N rate.

About 3 months later on 11/4/74, crownvetch had survived without lime and stands of sericea and flat pea were approximately half as good as those with lime @ 2 T/A. Generally sericea does not respond to lime applications because of its tolerance to high soluble aluminum in acid soils. However, with Ca and Mg availability being low in this soil according to soil tests, liming to supply these nutrients increased the survival of all three legumes.

Vegetative Cover: By 8/4/75, flat pea and sericea encroached over the lovegrass to cover over 90% of the soil when liming (Table 12). The somewhat better cover for flat pea and sericea with low N and lime is attributed to more active nodulation and less competition. Without lime, sericea gave a better soil cover on both 8/4/75 and 6/23/76 with the low rate of N. The nodulating bacteria of sericea are apparently more tolerant of high Al and low pH than those of most legumes. Flat pea had more plant cover with the high N rate without lime; the reverse occurred with lime.



At this date, crownvetch had only a 45 to 65% cover with lime, failing without lime. It is significant that legume cover was very substantially improved for all three species by liming; however, sericea gave a much better vegetative cover without lime than crownvetch or flat pea. Crownvetch generally spreads faster than sericea because of its proliferating, vigorous root system. When this did not occur, the soil was tested on the limed plots and the chemical characteristics were: pH - 5.2, CaO - L, MgO - M-, P<sub>2</sub>O<sub>5</sub> - L-, and K<sub>2</sub>O - L. The low pH and low P were depicted as the reasons that crownvetch had spread more slowly than the other two legumes.

By 6/23/76, the soil vegetative cover on limed areas was nearly 100% with sericea and flat pea as compared with a 64 to 81% cover with crownvetch. Without lime, the final protective legume cover was nil for crownvetch and poor with flat pea, whereas sericea had a good protective vegetative cover, ranging from 42 to 70%.

Flat pea and crownvetch will be observed in coming years to determine if they continue to grow in the unlimed soil. Lovegrass appeared best without lime the first year but this reversed during the second and third years.

### 3. Route 635, near Fairystone; established 7/5/74.

This split plot experiment was established on a 2:1 west facing cut slope. The pH of this soil was 5.4. A seed mixture of Ky 31 fescue @ 50 and 10-20-10 fertilizer @ 1000 lbs/A were applied uniformly to the entire experimental area. The main plots of lime rates and subplots of legume species were applied and mulched with straw @ 3000 lbs/A. The treatments and data on plant populations and cover are shown in Table 13.

#### Results and Interpretation

Plant Populations: Legume plant numbers were erratic with no definite fertility response on 8/15/74. One month later this variability was not as pronounced and no lime response was noted.

Vegetative Cover: Data taken on 6/23/76 show that crownvetch and flat pea covered two-thirds of the soil at the 1 T/A and 4 T/A lime rate. The flat pea encroached into the thick stand of Ky 31 fescue. Sericea lespedeza was depressed by all lime rates which allowed the Ky 31 fescue to completely dominate; hence, sericea gave a poor soil cover. Lime rates of 2 T/A may be used when seeding crownvetch or flat pea for optimum growth, when soils are in the pH range of 5.0 to 5.5. The optimum rate of lime for sericea was not determined. Sericea may have failed to grow due to the competition of the fescue, which was aggressive.

Table 13. Effects of lime rates on establishing legumes on rough slopes. Kentucky 31 fescue (Ky 31), crownvetch (CV), flat pea (FP), sericea lespedeza (Ser), lovegrass (LG). Route 635, near Fairystone; established 7/5/74.

Species lbs/A**	8/15/74				9/10/74				6/23/76			
	legumes/ft <sup>2</sup> *				legumes/ft <sup>2</sup>				Legume cover, %			
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
LG 10, Ky 31 50, CV 15	11a	4b	5b	4b	5	5	4	5	73b	92a	62a	82a
LG 10, Ky 31 50, Ser 30	4b	3b	3b	14a	5	3	2	2	8a	5a	5a	5a
LG 10, Ky 31 50, FP 15	4b	3b	9a	6ab	1	3	1	1	73ab	77a	80a	65b
Millet 20, Ky 31 50, Ser 30	7ab	12a	9ab	3b	2	2	3	2	8a	5a	8a	5a

\* Means in a horizontal column followed by different letters are significantly different at the 5% level of probability.

\*\* All plots received Ky 31 @ 50 lbs/A and 10-20-10 fertilizer @ 1000 lbs/A.

#### 4. Route 126, near Lynchburg; established 7/31/74.

This split-plot experiment was established on a 1:1 south facing cut slope. The chemical properties of the soil were: pH - 5.1, CaO - L+, MgO - H, P<sub>2</sub>O<sub>5</sub> - L, and K<sub>2</sub>O - L. Lime was applied to the entire experimental area @ 1.5 T/A and straw was applied last with a strawblower @ 1.5 T/A. Main plots were straw tacked with Landlock latex @ 60 gal or with Petroset SRB @ 60 gal/A. The fertilizer ratio treatments as subplots with data are given in Table 14.

#### Results and Interpretation

Plant Populations: Crownvetch seeded with lovegrass alone produced better stands than that seeded with lovegrass and Ky 31 fescue after 1 month. The fertilizer ratios did not influence legume stands significantly.

Vegetation Cover: Total vegetative cover was best with high N applications on 9/5/74. Only 7% cover occurred without N as compared to 82% with N. A similar trend was noted a month later (Table 14). On 7/24/75 and 6/24/76 the legume cover was best on the low N treatments. This was attributed to little competition from grasses. There was no response to K or it may have been hidden by N effects.

Table 14. Effects of nitrogen and potassium and grass associations on legume and grass [Kentucky 31 fescue (Ky 31), Lovegrass (LG), Crownvetch (CV), Flat Pea (FP), Sericea (Ser)] establishment on a rough slope.\* Route 126, near Lynchburg, established 7/31/74.

Fertilizers @ 1500 lbs/A	9/5/74		Total vegetative cover, %		Legume cover, %	
	Legume plants/ft <sup>2</sup> in grass mixtures**		9/5/74		7/24/75	
	CV, LG	Ky31, LG, CV	Ky31, LG, FP	Ky31, LG, Ser	CV	FP
0-20-10	10	6	3	9	58a	95a
5-20-10	3	9	3	13	38ab	92a
10-20-10	12	3	2	5	31b	80b
10-20-0	12	3	2	9	31b	78b
				22		100a
				75		100a
				86		92b
				92		85b

\* Means in a column followed by different letters are significantly different at the 5% level of probability.

\*\* All plots had lime and straw @ 1.5 T/A.

These data show that N is very important for grass growth and development but high rates generally slow down the establishment of legumes. Some N should be used for immediate growth of grasses for erosion control, but rates should be low to allow the legumes to encroach into the grasses over a period of 2 to 4 years to minimize maintenance costs.

Petroset SRB was found to be somewhat toxic to seedlings when used as a tacking agent for straw as there was 30% less vegetative cover than when Landlock was used. Landlock latex held straw with an elastic bond for several months during germination and growth proceeded. Landlock is not now manufactured.

5. I-64 East, near Toano; established 9/17/74.

This experiment was established on a 2:1 south facing cut slope. The main plots were rough versus smooth seedbeds; the subplots were crownvetch and sweet pea seeded with various companion species; the sub-subplots were fertilizer treatments. Lime @ 1 T/A and woodfiber @ 1500 lbs/A were applied to the experimental area after applying other treatments. The mixtures in lbs/A were:

- A. Annual ryegrass @ 30, crownvetch @ 15, sweet pea @ 15.
- B. Cereal rye @ 25, crownvetch @ 15, sweet pea @ 15.
- C. Perennial ryegrass @ 30, crownvetch @ 15, sweet pea @ 15.
- D. Kentucky 31 fescue @ 40, crownvetch @ 15, sweet pea @ 15.

Fertilizer treatments in lbs/A were:

- a. 5-20-10 @ 1000
- b. 10-20-10 @ 1000
- c. 5-40-10 @ 1000
- d. 10-40-10 @ 1000
- e. 5-20-10 @ 1500
- f. 10-20-10 @ 1500

Two weeks after establishing the experiment the slope was retilled and seeded by the seeding contractor by mistake. However, by 7/7/76, about 50% of the slope was covered with sweet pea but very little crownvetch. Sweet pea, like flat pea, is very competitive but may take from 3 to 4 years to completely vegetate a slope because of spreading from seed and spreading crowns.

6. Route 613, near Hoges Chapel; established 2/19/75.

This experiment was established on a thin Kentucky 31 fescue sod on a 1:1 northeast facing cut slope. The main plots were perennial sweet pea coated with a sticky latex material, inoculation, lime, and phosphorus versus dry inoculation of the seeds. Phosphorus and lime rates were the subplots which were designed to study fertility requirements of perennial sweet pea. Chemical characteristics of this soil were: pH - 5.7, CaO - M, MgO - M+, P<sub>2</sub>O<sub>5</sub> - L+, and K<sub>2</sub>O - H-. The treatments and data are given in Table 15.

## Results and Interpretation

Plant Populations: Highest plant numbers per square foot on both the coated and non-coated pea seeds were generally found when both lime and P had been applied at high rates. The stands with coated seeds responded better to the 2 T/A lime rate than with non-coated seeds. This was probably due to the triple superphosphate being acid forming, creating a lower pH around the seed and then being neutralized with the lime material. The check plot had the least number of legumes followed by P alone (Table 15). On the average coated seeds decreased stands as compared to dry inoculation.

Vegetative Cover: Legumes covered 22 and 21% of the soil when both lime and P were applied by 7/26/76. The check plot and the treatment with P only had the least cover. Therefore, lime and P seem to be very important for enhancing the encroachment of sweet pea in thin fescue stands. It is expected that the perennial sweet pea will continue to spread and completely dominate the fescue stand. Nitrogen need not be applied when a thin stand of fescue is present as for this experiment.

Table 15. Effects of coating seeds with a lime-phosphorus-inoculation mixture versus a dry inoculation with Rhizobia and lime and phosphorus on establishing sweet pea.\* Route 613, near Hoges Chapel; established 2/19/75.

Treatment rate/A	7/26/76		Average	7/26/76 Legume cover, %
	Coated seeds	Dry inoculant		
	Legume plants/ft <sup>2</sup> **			
Check	1.3d	4.5c	2.9	11c
Lime @ 1 T	6.3b	5.0b	5.7	15b
P <sub>2</sub> O <sub>5</sub> @ 100	5.0c	3.8c	4.4	10c
P <sub>2</sub> O <sub>5</sub> @ 100 + lime @ 1 T	6.3b	10.0a	8.2	22a
P <sub>2</sub> O <sub>5</sub> @ 100 + lime @ 2 T	8.8a	7.5ab	8.2	21a
Average	5.5	6.1		

\* Perennial sweet pea was seeded @ 30 lbs/A.

\*\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

7. Route 617, near Dublin; established 2/20/75.

This randomized block experiment was established on a 2:1 south facing cut slope with soil chemical properties of: pH - 6.6, CaO - VH, MgO - VH, P<sub>2</sub>O<sub>5</sub> - L, K<sub>2</sub>O - H. This roughened slope seeded in late fall of 1974 failed to produce a vegetative cover. Flat pea and crownvetch were seeded at various rates with several phosphate rates shown in Table 16.

Results and Interpretation

Plant Populations: Legume stands were generally best with high seeding rates. Stands of both flat pea and crownvetch were better with high P and high seeding rates. The high pH may have enhanced growth of both legumes without P fertilization.

Vegetative Cover: Crownvetch when seeded at medium to high rates gave as much as 80% cover by the second year at both the high rates of P. The poorest soil cover of 32% crownvetch was obtained from a low seeding rate and low P fertilization.

The vegetative cover from flat pea was generally best with the higher seeding rates, but responses to phosphorus were variable. Soil cover was not as good with flat pea as with crownvetch, except at the low seeding and phosphate rate. This is attributed to much lower seeding rates with flat pea as there are fewer seeds per pound as compared to crownvetch.

If complete legume cover of slopes is desired in a short period of time, high seeding rates may be practical; however, both legumes spread very rapidly to dominate a slope in 2 to 4 years with low seeding rates. Legumes generally respond to liberal applications of phosphorus. It is likely that some residual lime and phosphorus from a previous seeding by the highway department was in the soil.

Table 16. Effects of phosphorus and seeding rates on growth of crownvetch (CV) and flat pea (FP).\* Route 617, near Dublin; established 2/20/75.

Legumes and P <sub>2</sub> O <sub>5</sub> lbs/A	6/21/75	6/25/76
	Legume plants/ft <sup>2</sup>	Legume cover, %
CV 20 + P <sub>2</sub> O <sub>5</sub> 50	3.5b	32c
CV 20 + P <sub>2</sub> O <sub>5</sub> 100	5.5b	62b
CV 30 + P <sub>2</sub> O <sub>5</sub> 50	9.0a	57b
CV 30 + P <sub>2</sub> O <sub>5</sub> 100	8.5a	80a
CV 40 + P <sub>2</sub> O <sub>5</sub> 50	10.5a	75a
CV 40 + P <sub>2</sub> O <sub>5</sub> 100	9.5a	80a
FP 20 + P <sub>2</sub> O <sub>5</sub> 50	2.0b	35c
FP 20 + P <sub>2</sub> O <sub>5</sub> 100	2.5b	20c
FP 30 + P <sub>2</sub> O <sub>5</sub> 50	4.0b	23c
FP 30 + P <sub>2</sub> O <sub>5</sub> 100	3.0b	45c
FP 40 + P <sub>2</sub> O <sub>5</sub> 50	4.0b	62b
FP 40 + P <sub>2</sub> O <sub>5</sub> 100	8.0a	38c

\* This slope had been seeded by the highway department in the late fall of 1974 and failed to give a vegetative cover.

8. Route 617, near Dublin; established 3/6/75.

This split plot experiment was established on a 1.5:1 east facing cut slope. The area had been seeded the previous year but the slope had less than 5% vegetative cover. The soil chemical properties were: pH - 6.4, CaO - M, MgO - VH, P<sub>2</sub>O<sub>5</sub> - M, and K<sub>2</sub>O - H. The lime and phosphorus treatments with two legumes and data are shown in Table 17.

## Results and Interpretation

No lime response occurred with either crownvetch or sweet pea because the pH and Ca and Mg contents of the soil were relatively high. Data taken on 6/25/76 showed that crownvetch cover improved as rates of P increased; however, perennial sweet pea responded erratically. These data suggest that a pH of 6.4 was adequately high for crownvetch and perennial sweet pea and that liming to a pH higher would probably not speed legume encroachment. It is expected that perennial sweet pea will eventually spread over the entire slope area. Crownvetch made remarkable growth, giving an 80% cover for the best treatment in 1 year. The proliferating root system of crownvetch allows it to encroach at a much faster rate than the sweet pea.

Table 17. Effects of lime and phosphate on stands and growth of crownvetch (CV) and perennial sweet pea (PSP). \* Route 617, near Dublin; established 3/6/75.

Treatments		6/24/75		6/25/76	
Lime	P <sub>2</sub> O <sub>5</sub>	Plants/ft <sup>2</sup>		Legume cover, %**	
T/A	lbs/A	CV	PSP	PSP	CV
1	50	14	2.5	20b	58b
1	100	15	1.5	13c	65ab
1	150	10	5.0	30a	80a
3	50	16	2.0	15c	45c
3	100	11	2.0	23b	75a
3	150	11	3.0	23b	68ab

\* Crownvetch and sweet pea were seeded @ 30 lbs/A.

\*\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

9. Piedmont Experiment Station, near Orange; established 4/8/75.

This split plot experiment with three replications was established on a Davidson clay loam with the following soil characteristics: pH - 6.0, CaO - H, MgO - VH, P<sub>2</sub>O<sub>5</sub> - L+, and K<sub>2</sub>O - M+. Lime was applied to the entire experimental area @ 2 T/A and disked in. Kentucky 31 fescue was seeded @ 10 lbs/A followed by hand applications of the fertilizer treatments. The main plots were two seeding rates of 20 and 40 lbs/A of sweet and flat pea. Straw was applied over these treatments @ 1.5 T/A tacked with woodfiber @ 750 lbs/A with a hydroseeder. Treatments and data on plant heights, nodulation, and vegetative cover are given in Table 18.

### Results and Interpretation

**Growth:** Tallest growth of both flat and sweet pea was noted where high rates of both phosphorus (P) and potassium (K) were used. These responses were not proportional to the rate used. The shortest peas occurred without P and the low rate of K.

**Nodulations:** Nodulation of both sweet and flat pea was increased by both K and P alone or in combination with each other, except by the low K rate alone. Increased nodulation generally increases plant height by supplying or having the capacity to supply more N for plant growth. Phosphorus alone at low rates and in combination with K tended to increase nodulation more than for high rates of P alone or any rate of K alone.

**Vegetative Cover:** Flat pea gave more than a 77% vegetative cover for all treatments with P 15 months after seeding. High rates of K alone increased plant cover of sweet pea but had no effect on flat pea. The treatments without P with the flat pea had only 23 to 36% cover; the vegetative cover was not increased by K fertilization. Sweet pea responded little to either P or K, there being less than a 27% cover, except when applying  $P_2O_5$  at 75 lbs/A. The vegetative cover was very poor, 11%, for sweet pea without fertilizer or for  $K_2O$  at 75 lbs/A. It is apparent that P fertilizer is needed in greater amounts than K for legume growth as it is usually more deficient in soils.

It is expected that both flat and sweet pea will completely cover their respective areas after a few years. Flat pea spreads much faster than sweet pea during the first year due to its proliferating root system as compared to the non-spreading taproot system of the sweet pea. Both legume species are very drought tolerant and plants with all fertility treatments are healthy and vigorous. This experiment will be studied for several more years.

Table 18. Effects of seeding rate, phosphorus, and potassium on growth of flat and perennial sweet pea (FP and PSP).\* Piedmont Experiment Station, near Orange; established 4/8/75.

Treatment lbs/A**	8/12/75	8/12/75	7/7/76	
	Average legume ht. (in)	Average nodule no./plant	Cover, % FP	PSP
$P_2O_5$ @ 0 + $K_2O$ @ 0	11.2bc	9.4c	36b	11c
$P_2O_5$ @ 0 + $K_2O$ @ 75	10.0c	9.0c	30b	11c
$P_2O_5$ @ 0 + $K_2O$ @ 150	13.5ab	14.6ab	23b	25b
$P_2O_5$ @ 75 + $K_2O$ @ 0	12.8abc	16.3a	89a	56a
$P_2O_5$ @ 75 + $K_2O$ @ 75	11.7bc	15.1ab	77a	17bc
$P_2O_5$ @ 75 + $K_2O$ @ 150	13.0abc	15.7a	81a	25b
$P_2O_5$ @ 150 + $K_2O$ @ 0	12.2bc	12.8b	81a	27b
$P_2O_5$ @ 150 + $K_2O$ @ 75	14.8ab	14.3ab	89a	25b
$P_2O_5$ @ 150 + $K_2O$ @ 150	15.5a	13.4b	87a	20b

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

\*\* The seeding rates of flat and sweet pea at 20 and 40 lbs/A had little effect on stands or on vegetative cover a year later.

10. Kipps Farm, near Blacksburg; established 4/22/75.

This experiment was established to determine the effects of phosphorus and potassium and seeding rates on stands and vegetative cover of flat pea. The chemical properties of the soil were: pH - 4.3, CaO - L, MgO - L, P<sub>2</sub>O<sub>5</sub> - VH, and K<sub>2</sub>O - M. Lime @ 2 T/A and 25 lbs of N as NH<sub>4</sub>NO<sub>3</sub> were applied uniformly to the entire experimental area and then mixed with the soil to a depth of 6 inches by disking. The main treatments were rates of seeding flat pea and the subplots were rates of potassium and phosphorus. Kentucky 31 fescue @ 10 lbs and straw @ 3000 lbs/A were then applied uniformly over the entire experimental area. The treatments and data are shown in Table 19.

## Results and Interpretation

Plant populations increased by about 4 plants per square foot where seeded @ 40 lbs versus 20 lbs/A. Fertility treatments did not influence stands significantly, the data being variable. However, total legume cover was increased by 7/15/76. The soil cover with flat pea was 54% without fertilizer and 75% with the highest rates of P and K (Table 19). These fertilizer elements generally increased growth and vegetative cover, but the responses were erratic. This may be attributed to the high P and medium K in the soil before fertilization.

Flat pea made a remarkably good vegetative cover of 60 to 75% in 15 months. The experiment will be continued to obtain information on cover and persistence.

Table 19. Effects of seeding rate and phosphorus and potassium on growth and cover of flat pea.\* Kipps Farm, near Blacksburg; established 4/22/75.

Treatments lbs/A	6/15/75		7/15/76
	Legume plants/ft <sup>2</sup>		Legume cover, %
	20 lbs/A	40 lbs/A	
Check	6.6	11.0	54c
P <sub>2</sub> O <sub>5</sub> @ 75 + K <sub>2</sub> O @ 0	8.0	7.3	60b
P <sub>2</sub> O <sub>5</sub> @ 150 + K <sub>2</sub> O @ 0	5.3	12.5	68ab
P <sub>2</sub> O <sub>5</sub> @ 0 + K <sub>2</sub> O @ 75	6.0	6.8	70ab
P <sub>2</sub> O <sub>5</sub> @ 75 + K <sub>2</sub> O @ 75	7.6	7.1	67ab
P <sub>2</sub> O <sub>5</sub> @ 150 + K <sub>2</sub> O @ 75	6.0	12.3	67ab
P <sub>2</sub> O <sub>5</sub> @ 0 + K <sub>2</sub> O @ 150	7.0	14.3	64b
P <sub>2</sub> O <sub>5</sub> @ 75 + K <sub>2</sub> O @ 150	6.0	15.3	65b
P <sub>2</sub> O <sub>5</sub> @ 150 + K <sub>2</sub> O @ 150	<u>8.6</u>	<u>9.3</u>	75a
Average	6.8	10.5	

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

E. Experiments with Species for Temporary Vegetative Cover

1. Near Charlotte Court House; established 10/19/73 and 1/15/74.

This experiment with three replications was established to evaluate the winter growth of various cool season grasses seeded in October and January. The cool season grasses were seeded at medium to very high rates. A seed mixture of Kentucky 31 fescue @ 15, and crownvetch @ 20 and 10-20-10 fertilizer @ 750 lbs/A were applied uniformly over the entire experimental area with a hydroseeder. After hand seeding the plots, woodfiber was applied @ 1000 lbs/A. The treatments with data are shown in table 20.

Results and Interpretation

When seeding on October 19, the vegetative cover for erosion control by the next January generally increased as the seeding rates of each species increased, ranging from 65 to 100% cover for the highest two seeding rates. For example seeding rates of 40 and 320 lbs/A of cereal rye gave a 38 and 88% cover; 40 and 320 lb/A of roughstalk bluegrass gave a 41 and 93% cover; annual ryegrass at 25 and 200 lbs per acre gave a 66 and 100% cover and creeping red fescue at 40 and 320 lb/A gave a 43 and a 90% cover, respectively. By March 25, the vegetative cover for all species and seeding rates were satisfactory except for the lowest rate of seeding rye, roughstalk bluegrass and creeping red fescue.

When seeded on January 15, the vegetative cover obtained by March again increased with rates of seeding, but only cereal rye @ 320 lbs and annual ryegrass at 200 lbs/A developed satisfactory vegetative, 65 and 63% cover respectively by the next March. By April the vegetative cover for rye and annual ryegrass improved, but the protective cover was satisfactory only for the higher seeding rates. However, by April cover of some species degenerated possibly because of diseases.

These results were obtained on good soil conditions with a mild slope, thus environments on highway slopes would not give the favorable responses reported herein.

Arresting erosion during winter construction is a problem. The solution of this problem depends on finding species that grow during the winter to give protective covers or to find species that remain dormant and germinate the subsequent spring. The latter would require mulching techniques that persist for several months.

2. Route 635. Fairystone; established 5/24/74.

This split plot experiment on a west facing 1:1 cut slope was established to study lovegrass and millet in mixtures with crownvetch and flat pea. Kentucky 31 fescue was seeded uniformly over the entire experimental area with a 10-20-10 @ 1500 lbs. and lime @ 3000 lbs/A with a hydroseeder. The main plots of no mulch straw @ 3000 lbs/A were spread by hand. The treatments with data are shown in table 21.

Table 20. Vegetative cover of various cool season grasses when seeded at different seeding seasons at various rates at Charlotte Court House.\*

Grasses	lbs/A	Seeded Oct. 19		Seeded Jan. 15	
		% cover		% cover	
		1/15/74	3/25/74	3/25/74	4/16/74
Cereal rye	40	30h	65gh	23def	58abcd
Cereal rye	80	55fg	83bcde	40bcd	58abcd
Cereal rye	160	65def	82bcde	51ab	66abc
Cereal rye	320	38ab	93ab	65a	73ab
Roughstalk bluegrass	40	41gh	61h	18ef	40bcdef
Roughstalk bluegrass	80	78bcd	73efg	28def	28cdef
Roughstalk bluegrass	160	71cde	80cdef	33cde	28cdef
Roughstalk bluegrass	320	93ab	90abcd	30def	15ef
Perennial ryegrass	25	43gh	78def	18ef	10ef
Perennial ryegrass	50	60ef	78def	25def	16ef
Perennial ryegrass	100	86ab	91abc	30def	36bcdef
Perennial ryegrass	200	98a	97a	46bc	50abcde
Annual ryegrass	25	66def	93ab	30def	35bcdef
Annual ryegrass	50	81bc	98a	35cde	46abcde
Annual ryegrass	100	100a	100a	38bcd	70ab
Annual ryegrass	200	100a	100a	63a	81a
Creeping red fescue	40	43gh	68fgh	13f	22def
Creeping red fescue	80	70de	76ef	18ef	40bcdef
Creeping red fescue	160	85abc	83bcde	25def	35bcdef
Creeping red fescue	320	90ab	90abcd	30def	26def

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

## Results and Interpretations

Plant Populations: Legume stands in June were similar with straw and no mulch. The stands were better in November than in May and improved by mulching. The increased number of legume plants at the later date was attributed to modification of the microenvironment during summer and better legume survival. Seeding rates of weeping lovegrass and German millet did not influence crownvetch and flat pea stands significantly. Weeping lovegrass @ 15 tended to inhibit crownvetch growth which had a significantly lower stand in the no mulch plot.

Legume cover: Sixteen months after seeding the legume cover was excellent ranging from 56 to 95%. The reduced competition with frost killed millet, did not seem to stimulate the growth of flat pea, but increased the crownvetch cover substantially. Flat pea seedlings are hardy and taller growing than crownvetch, hence more shade tolerant. The lower crownvetch cover with lovegrass than with millet on 9/8/75 is attributed to the boosted grass growth with 150 lbs/A of N. The good growth with crownvetch seeded with millet may be attributed to lack of competition from the dead grass and desirable mulch effects. By 6/23/76, 25 months after seeding, crownvetch or flat gave 100% vegetative covers on these steep 1:1 slopes.

High applications of N with grass legume mixtures often depress legumes for a year or more. Lovegrass was much more competitive to crownvetch than millet, differences with flat pea were small.

Table 21. Effects of mulch and rates of companion grasses on establishing legumes (crownvetch (CV) and flat pea (FP) on a rough slope.\* Route 635 near Fairystone, established 5/24/74.

Seed treatments, lbs/A**	Legume plants/ft <sup>2</sup>				Legume cover, %	
	6/24/74		11/4/74		9/8/75	6/23/76
	Straw	Check	Straw	Check		
Lovegrass 5, CV 15	8	10	12cd	11b	56c	100
Lovegrass 10, CV 15	8	10	10d	10b	71b	100
Lovegrass 15, CV 15	10	7	9d	6c	65c	100
CV 15	6	11	14c	13ab	56c	100
G. millet 10, CV 15	12	8	15c	16a	90a	100
G. millet 20, CV 15	5	8	13cd	12ab	80ab	100
Lovegrass 5, FP 30	12	6	23ab	9b	92a	100
Lovegrass 10, FP 30	11	7	17b	13ab	80ab	100
G. millet 10, FP 30	7	9	27a	10b	78b	100
G. millet 20, FP 30	11	6	21ab	11b	80ab	100
FP 30	8	8	15c	12ab	95a	100
Avg.	8.9	8.2	16	11.2		

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

\*\* Also received the following in lbs/A: lime @ 3000, 10-20-10 @ 1500 and straw @ 3000.

3. Route 617 near Floyd; established 5/31/74.

This split plot experiment was established on a rough graded 1:1 north facing cut slope. The chemical properties of the soil were: pH-5.4; CaO-L; MgO-VH; P<sub>2</sub>O<sub>5</sub>-L, K<sub>2</sub>O-M+. A 10-20-10 fertilizer @ 1000 and lime @ 2T/A were applied uniformly over the entire experimental area with a hydroseeder. The main plots of woodfiber rates were applied with a hydroseeder after hand applications of the mixture subtreatments. Treatments with data are shown in table 22.

#### Results and Interpretation

Plant Population: The stands of a given legume were not appreciably influenced by rate of applying woodfiber. This attributed to the excellent moisture conditions on the slope at time of seeding and good rainfall. The best stands with sericea lespedeza as compared to the other legumes is attributed to applying more seeds.

Vegetative Cover: Nine months after seeding, flat pea gave a 60 to 70% vegetative cover, being better with millet and creeping red fescue. Crownvetch provided vegetative covers ranging from 32 to 55%, much lower than for flat pea. Sericea gave the lowest cover at this date. Crownvetch produced better cover with German millet than with creeping red fescue. This was attributed to the German millet dying after the first frost and providing a non-competitive in situ mulch for the crownvetch growth. Even though sericea had the most plants/ft<sup>2</sup> it gave the lowest legume cover on 5-3-75 because it does not possess proliferating roots.

Sericea and flat pea had 81 to 97% soil cover, except where sericea was seeded with creeping red fescue. This indicates that creeping red fescue is more competitive to developing legumes than Ky 31 fescue or millet. The final cover of crownvetch was best where seeded with millet, and poorest where seeded with creeping red fescue.

Crownvetch and flat pea usually spread when seeded with an annual grass as German millet as millet competes with legumes the first year there being no further water or nutrient competition to them thereafter. It is an excellent for soil cover mulch during the summer season. Sericea responds in a similar manner with millet. However, in most cases a permanent grass should be seeded with a fast growing companion grass as millet to protect against soil erosion when legumes develop slowly.

Table 22. Effects of rate applying woodfiber and companion grasses on legume establishment (Crownvetch (CV), Kentucky 31 fescue (Ky 31), Creeping red fescue (CRF), Sericea (Ser), flat pea (FP). Route 617 near Floyd. Established 5/31/74.

Treatments lbs/A	Legumes/ft <sup>2</sup> with 2 wood- fiber rates,		Legume cover, %*	
	9/10/74		5/3/75	6/23/76
	750	1500		
A. CV 20 millet 20	5	6	42	60c
B. Ky 31 50, CV 20, millet 20	4	3	40	45d
C. Ser 30, millet 20	14	15	32	91a
D. Ky 31 50, Ser 30, millet 20	14	11	34	97a
E. CRF 50, CV 20	8	5	32	45d
F. CRF 50, CV 20, millet 20	6	7	41	54c
G. CRF 50, Ser 30, millet 20	20	11	28	70b
H. FP 40, millet 20	8	6	70	94a
I. CRF 50, FP 40, millet 10	7	7	60	81ab
J. CRF 50, CV 20, millet 10	3	7	55	56c
K. CRF 50, Ser 30, millet 10	15	15	22	85ab

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

#### 4. Route 58 near South Boston; established 7/11/74.

This split plot experiment was established on a 2:1 south facing cut slope. The chemical properties of the soil were: pH - 5.7, CaO - M, MgO - VH, P<sub>2</sub>O<sub>5</sub> - L, and K<sub>2</sub>O - L. The entire experimental area had 10-20-10 fertilizer @ 1500 and lime @ 2 T/A applied uniformly with a hydroseeder. The main plots were "conventional" smooth grading of slopes versus rough surfaces which was accomplished with a tiller and a tractor. The treatments and data on plant populations and vegetative cover are shown in table 23.

#### Results and Interpretation

Plant Populations: By September, the legume were good even though dry weather persisted during the season. Legume stands were best on the rough slope. Cereal rye as a companion species produced the best legume stands because most of the rye failed to germinate or grow thereby giving little competition for light or water. All rates of German millet reduced sericea stands due to its aggressive summer growth.

When both crownvetch and sericea were considered together, the rough slope averaged about 5 more legume plants per square foot than did the smooth slope. Canopy heights were much taller on the rough than the smooth slope due to better water infiltration and less loss of nutrients from erosion.

Table 23. Effects of slope preparation and companion grasses on legume encroachment and cover (Sericea (Ser), crownvetch (CV). \* Route 58. South Boston slope. Established 7/11/74.

Companion grass lbs/A	9/5/74				12/3/74				7/15/75				7/15/75				7/8/76			
	rough surface		smooth surface		rough surface		smooth surface		rough surface		smooth surface		rough surface		smooth surface		rough surface		smooth surface	
	Ser.	CV	Ser.	CV	Ser.	CV	Ser.	CV	Ser.	CV	Ser.	CV	Ser.	CV	Ser.	CV	Ser.	CV	Ser.	CV
A. ryegr 10	14	4	12	2	7.7a	6.0	4.0	90	55	70	2	80a	5							
A. ryegr 20	12	5	10	4	7.4ab	3.5	2.5	70	55	10	15	8d	10							
C. rye 30	22	6	6	4	6.7abc	4.5	4.0	90	65	35	15	35c	40							
Lovegr 5	15	4	10	2	7.2ab	5.5	3.5	97	77	35	35	15d	22							
Lovegr 10	18	5	6	1	7.1ab	5.0	3.0	92	70	40	3	10d	10							
Lovegr 20	19	5	7	2	8.1a	5.5	3.5	95	90	20	27	15d	20							
G. millet 15	9	3	6	1	4.4c	4.5	3.0	90	70	42	7	45c	10							
G. millet 25	10	5	8	2	6.1abc	5.5	3.0	90	80	42	35	52b	32							
G. millet 35	9	4	6	2	4.9bc	6.5	3.0	95	77	60	27	32c	32							
Check	17	4	4	3	6.8abc	6.5	3.5	87	55	32	20	68ab	30							

\* All plots were seeded with Ky 31 @ 60, CV @ 15, and sericea @ 20 and had 10-20-10 @ 1500 and lime @ 2 T with straw @ 1 T. Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

Vegetative Cover: Vegetative cover was 90% or better for all treatments, except the check and an annual ryegrass treatment on the rough tilled plots on 7-15-75. This was probably due to annual ryegrass dying out during the summer after shading out the legumes and Ky 31 fescue. There a good 90% cover on the smooth slope with only one treatment, weeping lovegrass @ 20 lbs/A.

One year after seeding, crownvetch covered 60% or more of the soil with only the treatments with annual ryegrass @ 10 or German millet @ 35 lbs/A. Neither of these grasses offered serious competition the second year, thereby allowing crownvetch to spread. The 20 lb rate of annual ryegrass caused severe shading of legume seedlings and little crownvetch grew. The lower rates of millet allowed fescue to grow vigorously. Fescue became competitive to the legumes and decreased their rate of spread the second year. The smooth slope environment had much less crownvetch than the roughened area and prohibited crownvetch from encroaching rapidly.

Two years after seeding, crownvetch had developed an 8 to 80% soil cover on the roughened slope, the best cover being without a companion grass or with annual ryegrass @ 10 lbs/A. Crownvetch gave good vegetative covers with low rates of millet and cereal rye. The cover on smooth slope surfaces was generally poor, ranging from 5 to 40% for the companion grasses.

Rough tilled slopes aided in establishing vegetation and encroachment of legumes by modifying the microenvironment for rapid germination and growth. Roughened slope surfaces are as important for stimulating vegetative cover quickly as seed mixture and fertilization. High rates of a fast growing grasses as annual ryegrass are more objectionable than high rates of German millet or weeping lovegrass. Ryegrass grows during a long season, hence light and water competition depress developing perennial grass and legume seedlings and weaken stands. Grasses are important to control erosion, especially on smooth slopes while legumes become established.

#### 5. Route 61 near Rocky Gap; established 9/18/74.

This split plot experiment with 2 replications was established on a 1:1 east facing slope on a red, clay subsoil. The subsoil had a pH of 5.3 with Ca, Mg, and K being medium and P, low. The main plots had straw @ 1.5 T/A and woodfiber @ 1500 lbs/A. The seed mixtures and their effects on crownvetch and flat pea establishment are shown in table 24.

All plots received a uniform application of 10-20-10 fertilizer @ 1000 and lime @ 3000 lbs/A prior to the seed treatments and mulching. A hydroseeder and straw blower were used to apply the woodfiber and straw, respectively.

#### Results and Interpretation

Vegetative Cover: Kentucky 31 fescue, perennial ryegrass and annual ryegrass having straw as a mulch gave 84 to 94% vegetative cover about 2 months after seeding. With woodfiber @ 1500 lbs/A, only annual and perennial ryegrass gave 77 and 50% cover, respectively. Crownvetch and flat pea seeded alone gave an unsatisfactory cover for controlling erosion during the first winter but had more plants per square foot on 11-6-74 than any other treatment.

This is attributed to little competition from grass. This is further verified from the data taken on 6-5-75. Legumes gave the best vegetative cover when seeded alone where there was the least competition.

By 6-22-76, the effect of straw mulch was still detected averaging a 72.4% cover versus 59% for woodfiber. The data suggest that the legumes are versatile for seeding with various species and mulches and that they will grow on acid soils with proper soil amendments. Legumes grow well when seeded alone although erosion may occur while legumes develop a complete cover.

F. Experiments with Cultural Variables for Establishing Persistent Legumes

1. Seeding Legumes into Thin Grass Stands on Various Dates at Afton Mountain, Green Bay, Bottoms Bridge and Virginia Beach.

Similar split-split experiments were designed for "hot" and "cool" cut slopes. The main plot methods were: 1. surface seeding with a thin stand of grass, 2. strips of grass killed with paraquat to eliminate competition and thin seeded and, 3. tilled strip of sod to reduce competition to provide a good seedbed. The subplots were: 1. no fertilizer amendments and, 2. applying  $P_2O_5$  @ 200 and lime @ 2T/A. The sub-sub plots consisted of different leguminous species. Long slopes were selected at each location so that similar experiments could be established at 4 dates. The soil characteristics of the different locations varied as follows: Afton Mountain - pH 6.3, CaO-H, MgO-VH,  $P_2O_5$ -VH and  $K_2O$ -H; Bottom Bridge - pH 5.2, CaO-L-, MgO-L+,  $P_2O_5$ -M-, and  $K_2O$ -M-; Green Bay - pH 4.9, CaO-L-, MgO-M-,  $P_2O_5$ -M-,  $K_2O$ -L+; Virginia Beach at Indian River road - pH 5.7, CaO-L-, MgO-M-,  $P_2O_5$ -M-, and  $K_2O$ -M-; and Virginia Beach on Route 44 - pH 5.1, CaO-VH, MgO-VH,  $P_2O_5$ -L-, and  $K_2O$ -L. The soils around Green Bay were generally higher in aluminum than for the experimental locations.

Results and Interpretation

Plant Populations and Vegetative Cover: Fall seeding of crownvetch, sericea, and sweet pea produced similar stands with all seeding methods and fertilizer treatments at Afton Mountain (Table 25). There was no response to lime and phosphorus (P) due to the high pH and P present in the soil before seeding. One year later crownvetch had covered an 87 to 100% soil cover with and without fertilizer amendments and for all seeding methods. Sericea lespedeza did poorly with all seeding methods but had slightly better cover with a tilled seedbed. Perennial sweet pea grew best where strips of grass were killed with paraquat, tillage being next best. Surface seeding of sweet pea resulted in very poor cover. These trends were similar on 6-15-76, with crownvetch giving a complete cover on all treatments. Sericea spread little by the second year having a 12 to 22% cover with tillage. Sweet pea spreads rapidly, having 80 to 87% cover where paraquat was used and 55 to 67% cover on the tilled plots.

The experiment is to be continued to evaluate sweet pea as compared to the other legumes. Sericea may not spread because of competition from grass as the high level of fertility allows a healthy cover of Ky 31 fescue.

Soils at Indian River road in Virginia Beach were less fertile and responses were not as good as at Afton Mountain. Sweet pea made good growth when seeded during the fall while crownvetch or sericea grew poorly. It is not known whether these legumes winter killed or did not survive the hot droughty summer of 1974. Sweet pea gave a 100% cover in less than a year after seeding while no crownvetch plants and very few sericea plants remained. Top growth of perennial sweet pea died during the early summer but regrew in late summer and fall to give a protective cover in the summer of 1974 and 1975. The temperatures of the area may be too warm for summer growth and it may be necessary to fall seed sweet pea in the Coastal Plains.

Table 24. Effects of mulches and companion grasses on the establishment of crownvetch (CV) and flat pea (FP) and Perennial sweet pea (PSP)\*. Route 61 near Rocky Gap. Established 9/18/74.

Grasses and legumes lbs/A	11/6/74		11/6/74		6/5/75		6/22/76	
	Straw	MF 1500 Cover, %	Straw	MF 1500 Legumes/ft <sup>2</sup>	legume per ft <sup>2</sup> *	Straw	legume cover, % MF	MF
C rye 30, CV 15, PSP 15	47	17	5	4	12a	62	56	
P ryegr 40, CV 15, FP 15	89	50	5	5	11ab	74	63	
A ryegr 40, CV 15, FP 15	94	77	3	4	11ab	62	55	
Ky 31 40, CV 15, FP 15	84	27	6	6	9ab	83	60	
CV 30, FP 15	20	1	7	7	13a	81	61	
						72.4	59.0	

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability. All plots received 10-20-10 @ 1000 and lime @ 3000.

Table 25. Effects of seedbed preparation and soil amendments on establishing legumes in thin stands of Kentucky 31 fescue. Crownvetch (CV), Sericea lespedeza (Ser) and perennial sweet pea (PSP).\* Afton Mountain, I-64 East. Established 8/30/73.

Treatments* lbs/A	9/30/74			8/22/75						6/15/76						
	No. plants/ft <sup>2</sup>			Legume cover, %			Legume cover, %			Legume cover, %						
	Surface*	Paraquat	Tillage	Surface	Paraquat	Tillage	Surface	Paraquat	Tillage	Surface	Paraquat	Tillage				
	P + L	P + L	Ck	P + L	Ck	P + L	Ck	P + L	Ck	P + L	Ck	P + L				
CV @ 20	15	17	17	17	17	16	95	95	100	97	95	87	100	100	100	100
Sericea @ 40	5	2	4	9	2	6	5	0	5	0	12	4	10	0	15	0
Sweet pea @ 40	4	2	4	5	3	3	5	5	45	40	18	15	125	30	80	87

\* P = P<sub>2</sub>O<sub>5</sub> at 200 lbs/A, L = lime @ 2 T/A and Ck = 0 treatment

Fall seeding on a poor subsoil at Bottoms Bridge resulted in success with only perennial sweet pea. Little difference was noted between seeding methods of herbicides, tillage or surface seeding. Sweet pea responded to the fertilizer amendments. Neither crownvetch or sericea seedlings survived. The extreme heat in summer, 1974, and competition from weeds are suspect in their failure.

Fall seeded legumes at Greenbay grew slowly due to the low availability of all nutrients, low pH and high soil aluminum. Crownvetch grew only where P and lime were applied with all 3 seedbed preparation methods. Sericea produced the most plants but cover was not affected by soil amendment treatments the following year. Sweet pea grew best where P and lime were added, growth on other treatments failed. After 2 years none of the legumes covered more than 20% of the soil. The lovegrass provided a competitive canopy to all of the legumes because of its ability to grow on infertile soils. These legumes may eventually encroach to provide a vegetative cover when fertilized and limed. These legumes should be seeded with the grasses on initial seedings to insure proper seedbed conditions and fertility.

The February 1974 seedings of crownvetch, sericea and sweet pea gave results similar to those for fall seedings at Afton Mountain. Crownvetch did best when surface seeded and seeded into a tilled area while sweet pea did best when seeded into paraquat killed sod followed closely by tillage. Because of the high fertility of the soil, no response was noted to P and lime and sericea grew very little and developed less than a 30% cover 18 months later; crownvetch and perennial sweet pea encroached, giving a complete soil cover.

The February 1974 seedings at Bottoms Bridge gave the best crownvetch cover with tillage or paraquat each with P and lime applications. No sericea or sweet pea plants were noted, except for tilled areas. By summer 1975, the slopes with tillage or paraquat had over 40% crownvetch cover; sweet pea had 70% cover when the sod was tilled and had lime and P. Sericea had developed less than a 20% vegetative cover on tilled plots without amendments. Sericea grew poorly in this area due to weed competition to the developing seedlings. Lime and P were necessary for developing sweet pea and crownvetch cover, tilling the sod before seeding was desirable.

With February seedings at Virginia Beach, the best seedling stands of legumes during summer occurred when the sod was tilled. This gave seed coverage and reduced above and below soil competition. By June of 1975, sweet pea had fair cover in all plots with and without P and lime. Crownvetch grew on tilled areas with and without P and lime and in paraquated plots where lime and P were added. Sericea plants were noted in all plots, developing no more than a 10% cover where P and lime were added to the tilled soil.

By July of 1976, about 2.5 years after seeding, sweet pea developed around a 50% cover on all plots where it was seeded. Sericea covered no more than 10% of the soil and crownvetch cover was less than 2%. It is expected that sweet pea will give a complete cover and spread into adjoining plots due to seed dehiscence. Seedling vigor of the perennial sweet pea is much better than for other legumes resulting in better competitive growth. It grows later in autumn than crownvetch.

Mid-May seedings were made at 4 locations with sericea, crownvetch, and flat pea. Flat pea and sericea grew well when seeded into tilled or paraquated areas at Bottoms Bridge. Flat pea was best when lime and P were also applied. Sericea grew with or without lime and P. Crownvetch failed with all treatments. It is possible that woodfiber mulch would have aided in establishing all of these legumes with May seedings. This would improve the micro-environment, giving better moisture conditions for germinating seeds.

Greenbay had the poorest stands of legumes, when seeded on 5-16-74. This was attributed to the poor subsoil, lovegrass competition and a hot, dry summer. Sericea had the best plant population with tillage or paraquated areas with or without lime and P. Flat pea produced next best cover, when lime and P were applied. Crownvetch grew only when tilled and lime and P were applied. A year later in 1975, the sericea gave about a 30% cover on areas where the sod was paraquated or tilled and had lime and P applications. Sweet pea covered about 15% of the soil on plots that were tilled and treated with lime and P. Crownvetch covered less than 5% of the tilled, limed and fertilized plots. Lovegrass was very competitive with all legumes, resulting in poor legume growth on these infertile soil conditions.

The mid-May 1974 seeding made at Afton Mountain was successful for all legumes. By August 1975, 16 months after seeding, flat pea developed a complete vegetative cover and encroached into adjoining plots. Sericea covered about 40% of the soil during the second year and crownvetch had about 30% cover. The soil was fertile enough so that no responses were noted with lime and P. Tillage of the seedbed resulted in about 10% better cover than paraquating the fescue.

Two experiments established at Virginia Beach on May 16, 1974 had similar results. Table 26 shows the treatments and data from the Indian River road exit. Flat pea had the most plants per area with tillage and paraquat, with or without P and lime. Crownvetch failed to persist one year after seeding. Sericea had only a 5% cover on the best treatments. Flat pea developed a 95 to 100% cover in a little over 12 months, even crowding out Ky 31 fescue. Top growth of flat pea did not die in the summer of 1975 or by July of 1976 as sweet pea had. Flat pea seedlings appear to be more drought and heat tolerant than sweet pea, the latter being more hearty than crownvetch or sericea in the Coastal Plains. Flat pea may be seeded in late spring into thin grass sods with lime and P to enhance growth. May 15 is generally too late a seeding date for crownvetch and sericea and should be seeded in late February or March for best results as for flat and sweet pea. However, the best dates for seeding flat and perennial sweet pea are unknown.

Table 26. Effects of seedbed preparation and fertilizer amendments on the establishment of legumes into a fescue stand. Indian River Road at I-64 East. Virginia Beach.

Treatments* lbs/A	10/1/74				6/3/75			
	No. plants/Ft <sup>2</sup>				legume cover, %			
	Paraquat		Tillage		Paraquat		Tillage	
	P + Lime	Ck	P + Lime	Ck	Ck	P + Lime	Ck	P + Lime
CV @ 20	1	0	2	1	0	0	0	0
Sericea @ 40	6	0	2	3	5	5	4	2
Flat pea @ 40	7	7	7	6	100	95	100	100

\* P<sub>2</sub>O<sub>5</sub> at 200 lbs/A, and lime @ 2 T/A, crownvetch = CV.

## 2. Route 126 Near Lynchburg. Established 7-31-74.

This randomized block experiment was established on a 1:1 north facing cut slope. The chemical properties of this subsoil were: pH-5.1, CaO-L+, MgO-H, P<sub>2</sub>O<sub>5</sub>-L, and K<sub>2</sub>O-L. Lime @ 3000 and a 10-20-10 fertilizer @ 1500 lbs/A were applied uniformly with a hydroseeder over the entire experimental area and straw was applied @ 3000 after the seed treatments. The treatments and data on this rough graded slope are shown in Table 27.

### Results and Interpretation

Plant Population: The stands of crownvetch were best when seeded alone or with a low rate of Ky 31 fescue; also, the stands increased with seeding rates. However, on 9-5-74 there was a 100% vegetative cover on all plots due to the small grain in the straw.

Flat pea followed much the same trend as crownvetch, the high seeding rates alone with little competition producing the most plants. However, flat pea with 40 lbs/A of fescue was as good as the treatments with little competition. This may be expected with flat pea since it seems to be more competitive with grass species than crownvetch because of its seedling vigor.

Vegetative Cover: Vegetative cover was best with crownvetch when seeded alone at high rates followed by lower seeding rates alone, with fescue, or with German millet on both 7-1-75 and 7-7-76. German millet in fescue mixtures, killed by the first frost stimulated legume encroachment. The millet apparently depressed Ky 31 tall fescue stands, hence there was little competition from fescue and the dead millet.

Flat pea responded similar to crownvetch. Millet is desirable in the seed mixture along with a perennial grass in summer seedings to provide a protective, noncompetitive area for the encroachment of legumes.

Table 27. Effects of seeding rates and companion species on the establishment of legumes on a rough slope [Crownvetch (CV), flat pea (FP), Kentucky 31 fescue (Ky 31)]. Route 126 near Lynchburg. Established 7/31/74.

Treatments - lbs/A	9/5/74	Legume cover, %	
	Plants per ft.*	7/1/75	7/7/76
CV 15	16c	15	32cd
CV 20	18c	18	61b
CV 25	15c	18	65b
CV 30	29b	37	75b
CV 40	35a	41	90a
CV 20, Ky 31 20	17c	15	30cd
CV 20, Ky 31 20, millet 10	8d	25	67b
CV 20, Ky 31 40	10d	22	45c
CV 20, Ky 31 40, millet 10	10d	31	60b
FP 10	4ab	10	18d
FP 20	6a	15	65b
FP 30	5ab	30	72a
FP 20, Ky 31 20	1c	8	43c
FP 20, Ky 31 20, millet 10	2c	29	67b
FP 20, Ky 31 40	4ab	18	50c
FP 20, Ky 31 40, millet 10	3b	30	65b

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

### 3. Blacksburg Country Club Estates, Established 6/26/74.

This split plot experiment with four replications was established with two replications on a "hot" south facing slope and two replications on a "cool" north facing slope. Lime @ 3000 and a 10-20-10 fertilizer @ 1500 lbs/A were applied uniformly to the entire experimental area with a hydroseeder. Mulches were the main plots with seed mixtures being the subplots. Treatments and data on legume populations are shown in Table 28.

#### Results and Interpretation

Plant Populations: Sericea, crownvetch and flat pea germinating was best with woodbark @ 35 cu yds/A, straw being next and woodfiber rates giving the lowest germination. When averaging all data, germination was somewhat better with German millet than for weeping lovegrass. No differences in germination occurred with slope exposure on 7-30-74.

Woodbark or woodchips modify the soil environment to a greater degree than other mulches and creating favorable temperature and moisture conditions for legume and grass germination and growth. Straw is generally next to woodbark in modifying the microenvironment and enhancing vegetative growth. Woodfiber when used at high rates may produce excellent vegetative cover, but often fails under critical conditions.

After the data were collected, the management at the country club mowed the experimental area, maintaining a close mowing management. This inhibited legume establishment; however, flat pea, with a low growing prostrate growth, appears to be surviving. Crownvetch and sericea have almost been eliminated by this mowing practice.

Table 28. Effects of mulches and companion grasses on the establishment of legumes [Crownvetch (CV), flat pea (FP), sericea (ser)]. Blacksburg Country Club Estates. Established 6/26/74.

Mulch* rate/A	7/30/74							
	Millet				Lovegrass			
	Ser	CV	FP	Avg.	Ser	CV	FP	Avg.
Straw 2T	15	17	2	11.3	10	3	3	5.3
Check	3	2	1	2	2	7	2	3.7
Woodfiber 750	6	14	1	7	5	14	1	6.7
Woodbark 35 yd <sup>3</sup>	17	27	3	15.7	18	17	3	12.7
Woodfiber 1500	10	6	1	5.7	8	10	2	6.7

\* All plots had lime @ 3000 and 10-20-10 @ 1500. Weeping lovegrass was seeded @ 10, German millet @ 15, sericea @ 30, crownvetch @ 30, and flat pea @ 20.

4. Turf Center at Blacksburg. Established 4/14/75.

This randomized block experiment with 21 replications was established to evaluate sweet pea collected from various locations in Virginia versus commercial varieties from Northrup King, Oregon and Pennsylvania in comparison to Lathco flat pea. The entire experimental area had been limed and fertilized the year prior to seeding. Straw @ 2T/A was spread uniformly over the entire experimental area by use of a straw blower and tacked with woodfiber @ 750. All peas were seeded @ 40 lbs/A in 3' x 3' plots with 4' between plots. By 6/26/76 all the seed sources had grown together and were in full bloom. Subsequent data on height seed quality and yield will be taken for evaluation. Flat pea plants were much shorter and without conspicuous blooms as for sweet pea.

Species and sources were:

A. Flat pea - Lathco

B. Perennial sweet pea - Bristol, Draper, Composite sample, Northrup King, Oregon and Broadnax.

This experiment will be evaluated over the next several years.

5. I-64W, 4.2 mi. E. of Bottom Bridge. Established 6/9/75.

A randomized block experiment was established on a south facing 1:1 cut slope. The area had been seeded previously and during a period of years reverted to weeds. The chemical characteristics of this Piedmont subsoil were: pH 5.9, CaO-L+, MgO-M-, P<sub>2</sub>O<sub>5</sub>-VH, and K<sub>2</sub>O-L. Data from other experiments indicate that this soil would be satisfactory for

growing legumes; also the pH and fertility were favorable. However, even with an application of 0-20-10 fertilizer @ 1000 lbs/A, lime @ 2T/A, straw mulch @ 1.5 T/A, and tillage for a seedbed, no legumes were found on 7-7-76. The seeding failure of sweet pea, flat pea, crownvetch and sericea was attributed to the drought and weed competition in the summer of 1975 and the late seeding date.

It is likely that February - March or October seedings might have given successful stands of flat and sweet pea.

## G. Experiments with Mulches and Chemical Binders

### 1. Route 29, 3 miles south of Charlottesville; established 6/5/74.

This randomized block experiment was established on a 1:1 south facing cut slope. A seed mixture of Ky 31 fescue @ 30, creeping red fescue @ 10, German millet @ 10, 10-20-10 fertilizer @ 1000 and lime @ 2 T/A was applied uniformly over the entire experimental area with a hydroseeder. All wood-fiber or chemical binder treatments or combinations of the two were applied with a hydroseeder. Straw and woodbark were applied by hand. The treatments and data on plant populations and vegetative cover are shown in Table 29.

#### Results and Interpretation

Plant Populations: Legume stands were generally good on all treatments after 9 weeks, except those having Petroset SRB either alone or in combination with woodfiber. Also stands with Aerospray and woodfiber were low as compared to other mulch treatments. Aerospray has been found to be slightly toxic to seedlings in other experiments.

Vegetative Cover: About 2 months after seeding the vegetative cover was best with straw tacked with Landlock followed closely by straw alone and woodbark. The check or no mulch treatment had a better vegetative cover than Petroset SRB alone or with woodfiber. Woodfiber with Landlock and woodfiber @ 750 with Petroset SB had vegetative covers similar to the no mulch treatment. Woodfiber @ 750 gave as good a cover as at 1500 lbs/A.

This stair-step graded slope had better vegetative cover in the horizontal part of the stairsteps than for the overall slope cover on 8/16/74. This is attributed to covering of seed and fertilizer by sloughing subsoil and a more favorable moisture habitat.

Chemical binders used alone on the slopes were not visible nor could they be detected on the surface on 8/16/74. All chemical binders except Terra Tack I with 750 lbs/A of woodfiber apparently prolonged the stability of woodfiber on the slope. These binders gave from a 4 to 8 fold difference in the amount of woodfiber @ 1500 over the woodfiber applied @ 1500 lbs/A alone. A 3 to 4 fold difference was noted with woodfiber @ 750 lbs/A.

Although woodfiber with binders stabilized the mulch for longer periods of time than woodfiber alone @ 1500, no woodfiber-binder combination had as many legume seedlings per square foot as the woodfiber alone. With 750 lbs/A of woodfiber, Terra Tack and Landlock gave slight improvements in stands with crownvetch. Straw alone gave better stands of legumes than straw and Landlock.

The best total vegetative cover occurred with woodbark and straw treatments, ranging from 80 to 93%. Two binders, Aerospray and Landlock, with woodfiber @ 750 lbs/A had better total cover than woodfiber alone. At 1500 lbs/A of woodfiber, no woodfiber-binder combination gave better vegetative cover than woodfiber alone. Three binders used with woodfiber gave values lower than for woodfiber alone.

Table 29. Effects of mulches and binding agents on mulch stability and establishment of vegetation on a bench slope (Crownvetch (CV), Sericea (Ser) ).\* Route 29, Charlottesville. Established 6-5-74.

Mulches and binders in lbs/A or as stated**	8/16/74		8/16/74		8/16/74		9/5/74		9/5/74	
	No. Plants/ft <sup>2</sup>		Total vegetative cover, %		Vegetative cover in rows, %		Mulch Visible, %		Plants/ft <sup>2</sup> CV Ser.	
	CV	Ser.	Average*				CV	Ser.		
WF 750	23	38	30 ab	50 cdef	63 abcde	8 ef	13	18	53 defgh	
WF 1500	27	33	30 ab	48 def	75 abcd	10 ef	21	20	70 abcde	
WF 1500, PetSB 120 gal	30	43	36 a	73 abcd	88 abc	65 abc	9	17	73 abcd	
WF 1500, Pet SRB 120 gal	2	1	1 d	20 fgh	30 ef	63 bcd	7	2	35 ghi	
WF 1500, aerospray 120 gal	12	16	14 bcd	55 bcde	73 abcd	83 ab	8	20	63 bcdef	
WF 1500, TT I 300	15	28	21 abc	58 bcde	83 abcd	63 bcd	4	10	70 abcde	
WF 1500, LL 120 gal	28	17	23 abc	35 efgh	50 cdef	38 cde	12	9	48 efghi	
Check	16	15	15 bck	38 efgh	45 def	0 f	8	16	43 fghi	
Straw alone	32	43	32 a	85 ab	93 a	100 a	28	25	85 ab	
Straw, LL 120 gal	38	21	29 ab	93 a	95 a	100 a	11	19	93 a	
750 WF, Pet SB 120 gal	21	35	28 ab	40 efg	53 bcdef	28 def	12	15	63 bcdef	
750 WF, Pet SRB 120 gal	2	1	1 d	15 gh	33 ef	35 cdef	3	3	30 hi	
750 WF, Aero. 120 gal	23	34	28 ab	60 bcde	83 abcd	dd cdef	12	15	70 abcde	
750 WF, TT I 300 lbs	30	6	18 abde	43 defg	60 abcde	5	18	19	50 efghi	
750 WFL 120 gal	24	44	34 ab	55 bcde	68 abcde	25 ef	17	19	73 abcd	
Pet SRB alone 120 gal	7	1	4 cd	8 h	15 f	0 f	3	1	28 i	
LL alone 120 gal	27	20	23 abc	50 cdef	65 abcde	5 ef	5	15	58 cdefg	
Woodbark 75 cu yds.	25	27	26 ab	80 abc	90 ab	93 ab	17	14	80 abc	

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability. All plots had 10-20-10 @ 1000 lb/A, Lime @ 2 Tons/A, seeds of Ky 31 @ 60, CRF @ 10, German millet @ 10, CV @ 15, and sericea @ 30 lbs/A.

\*\* Petroset SB = Pet SB, Landlock = LL, Woodfiber = WF, Terra Tack I = TT I, Aerospray = Aero.

The data indicate that total vegetative cover was not improved by adding chemical binders to high rates of woodfiber or straw. Chemical binders used alone at high rates were totally unsatisfactory. Thus it is best to use organic mulches at high rates rather than low rates. Petroset SRB, an experimental material not available commercially, was toxic to germinating seedlings. Some of the binders reduced water infiltration.

Straw and woodbark are excellent mulches and should be used under critical environmental conditions. They may be used when easily available and in winter seasons. Much labor is often involved in their application and high rates of woodfiber (1500 to 2000 lbs/A) may be substituted for them.

2. Route 460, near Hoges Chapel; established 1/30/75.

This randomized complete block experiment was established on a 1:1 east facing cut slope. A seed mixture of cereal rye @ 125, creeping red fescue @ 40, a 10-20-10 fertilizer @ 1000 lbs/A, and lime @ 2 T/A were applied uniformly with a hydroseeder to the entire slope prior to mulch treatments. Binders were used in various ways with straw, straw being applied to all plots @ 2 T/A. The treatments and data are shown in Table 30.

#### Results and Interpretation

Straw Stability: Three days after establishing the experiment, Petroset SB with woodfiber @ 750 gave the best straw stability followed closely by woodfiber alone @ 750, Terra Tack with woodfiber @ 750, and Landlock latex with woodfiber @ 750 lbs/A. Binders used alone with straw were unsatisfactory. Total mulch cover on 3/6/75 and 4/16/75 followed patterns similar to stability of the straw, except that Petroset SB with woodfiber gave the best bond with straw. Petroset SB was bound so tightly with the straw that large mats of it rolled off the slope by wind. However, by 5/22/75 about 70% of the straw remained in place where either woodfiber alone or woodfiber with chemical binders were applied topically over straw, except for Petroset.

Woodfiber @ 750 lbs/A proved to be a very effective material for tacking straw for prolonged periods. This is desirable as woodfiber may be used at any temperature above freezing and it serves as an additional mulch with straw and helps avoid pollution. Chemical binders did not prolong the stability of straw; also, straw-woodfiber stability was not improved by the chemical binders.

Table 30. Effects of chemical binders and woodfiber on stabilizing straw for erosion control during winter.\* Route 460, near Hoges Chapel; established 1/30/75.

Mulches (rate/A)**	Total mulch cover, %		Straw** binding strength			5/22/75 Straw re- maining, %
	3/6/75	4/16/75	2/3/75	3/6/75	4/16/75	
Straw alone	57	52	10	10	10	15b
LL latex 80 gal on top	67	55	8	8	8	15b
LL latex 80 gal, WF 750 lbs on top	78	72	2	2	4	70a
Pet SB 80 gal on top	40	37	9	9	10	12b
Pet SB 80 gal, WF 750 lbs on top	60	30	1	1	3	23b
WF 750 lbs on top	83	75	2	2	5	70a
TT II 45 lbs on top	67	45	9	9	10	20b
TT II 45 lbs, WF 750 lbs on top	87	77	2	1	3	72a
LL latex 40 gal on soil, 40 gal on top	57	40	9	8	10	20b

\* All plots received 10-20-10 @ 1000, lime @ 2 T, and cereal rye @ 125, and creeping red fescue @ 40.

\*\* Straw was applied to all plots @ 2 T/A. Landlock latex = LL latex, Petroset SB = Pet SB, Woodfiber = WF, Terra Tack II = TT II.

\*\*\* Ratings were from 1 to 10 with 1 being best; 1-3 = excellent, 3-5 = satisfactory, 5-7 = marginal, 7-10 = unsatisfactory.

### 3. Route 460, .5 mile west of Pembroke; established 2/14/75.

This randomized block experiment with two replications was established on a 1:1 north facing cut slope. A seed mixture of cereal rye @ 125, creeping red fescue @ 40, and flat pea @ 30 lbs/A and a 10-20-10 fertilizer @ 1000 and lime @ 2 T/A were applied uniformly over the entire experimental area with a hydroseeder before mulch treatments were applied. Mulch treatments applied were:

- A. Woodfiber @ 2000 lbs/A;
- B. Woodfiber @ 2000, Petroset SB @ 80 gal/A;
- C. Woodfiber @ 2000, Landlock latex @ 80 gal/A;
- D. Woodfiber @ 2000, Landlock latex @ 80 gal/A applied topically;
- E. Woodfiber @ 2000, Terra Tack III @ 45 lbs/A.

All of these treatments were applied with an ambient air temperature of 42°F out of a hydroseeder. Within 2 weeks after treatment, approximately five freeze-thaw cycles negated any effect that the binders may have had. All plots sloughed and had around 50% of the mulch on the slope at the end of 2 weeks. The chemical binders tested did not persist during these hard freeze-thaw cycles. It has been observed that mulches such as woodbark or straw, bound with woodfiber, persist under freeze-thaw conditions.

4. Route 613, near Mountain Lake; established 7/11/75.

This randomized block experiment with two replications was established on a 1:1 south facing cut slope. The chemical characteristics of this shale soil material were: pH - 5.3, CaO - L, MgO - H, P<sub>2</sub>O<sub>5</sub> - Mt, and K<sub>2</sub>O - Lt. Lime @ 2 T/A and 10-20-10 fertilizer @ 1000 were applied uniformly to the entire experimental area with a hydroseeder.

Previous experiments show woodfiber to be an excellent tacking agent @ 750 lbs/A on top of straw. This experiment was designed to compare a two-step operation of first applying straw and then tacking and seeding simultaneously with a woodfiber-seed-fertilizer slurry with a three-step operation of applying seed and soil amendments, then straw, then hydroseeding woodfiber topically on the straw. The treatments and data are shown in Table 31.

#### Results and Interpretation

All treatments had identical amounts of seed, fertilizer, and straw mulch; hence grass stands were good for all treatments. When using woodfiber to bind straw, applying straw as Step 1 and a seed-fertilizer-woodfiber slurry as Step 2 gave better grass stands than the three-step operation (Treatment A). Also grass stands were better when applying seed and fertilizer after than before straw (Treatments D vs. B). With paper fiber the grass stands were better with the three-step than the two-step method.

Crownvetch stands were variable and could not be associated with treatments.

Five weeks after seeding the vegetative covers for all treatments were satisfactory, the lowest cover being 60% where a slurry of seed and fertilizer was applied over straw. When seed and fertilizer were applied before straw there was a 95% cover. Woodfiber as a straw binder gave excellent cover with the two- or three-step methods (Treatments A and C). With paper mulch (Treatments E and F) the two-step treatment had a better cover than the three-step treatment. These variable responses are not explainable. However, all treatment combinations were highly satisfactory for establishing crownvetch and obtaining a 100% vegetative cover in about 11 months. There was little erosion with any treatment. Normally it is risky to apply straw without a binder on smooth steep slopes as it is apt to blow off.

It may be concluded that two-step applications (Treatments C and E) are as satisfactory as three-step applications (Treatments A and F, Table 31).

Table 31. Methods of applying seed, fertilizer, and woodfiber as a straw binder on grass and crownvetch (CV) stands and vegetative cover.\* Route 613, near Mountain Lake; established 7/11/75.

Treatments lbs/A**	8/18/75		6/22/76		
	Grass /ft <sup>2</sup>	CV/ft <sup>2</sup>	Total cover, %	CV, %	Total cover, %
A. Seed, fert, straw tacked with Conwed 750	39b	6b	100a	25	100
B. Seed, straw	41b	11a	95a	40	100
C. Straw, then seed-Conwed 750	50a	5b	95a	32	100
D. Straw, then seed, fert	51a	5b	60c	35	100
E. Straw, seed with IFMC 750, fert	38b	5b	95a	30	100
F. Seed, fert, straw tacked with IFMC 750	55a	7b	87b	42	100

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

\*\* All treatments had straw @ 1.5 T/A; WF = Conwed woodfiber @ 750, and PF = IFMC paper fiber @ 750 lbs/A.

- |  |   |
|--|---|
| A. 1. Seed-fertilizer slurry<br>2. Straw<br>3. WF tack | D. 1. Straw<br>2. Seed-fertilizer slurry          |
| B. 1. Seed-fertilizer slurry<br>2. Straw               | E. 1. Straw<br>2. Seed-PF-fertilizer slurry       |
| C. 1. Straw<br>2. Seed-fertilizer-WF slurry            | F. 1. Seed-fertilizer slurry<br>2. Straw<br>3. PF |

5. Route 613, near Mountain Lake; established 9/4/75.

This randomized block experiment was established on a 1:1 south facing cut slope. The entire experimental area was seeded with Kentucky 31 fescue @ 40 and sweet pea @ 20 lbs/A with 10-20-10 fertilizer @ 1000 and lime @ 2 T/A with a hydroseeder prior to mulch treatments. The treatments are given in Table 32. Straw was tacked with various binders and a paper fiber mulch was compared with woodfiber.

### Results and Interpretation

**Straw Stability:** Straw tacked with 750 lbs/A of IFMC (paper fiber) held straw more firmly than any of the woodfiber treatments which were also excellent. Adding Terra Tack II to woodfiber did not improve results over woodfiber alone. Asphalt @ 80 gal/A was marginal as a straw tacking agent while Petroset SB and Aerospray 70 @ 80 gal/A were of no value for tacking straw.

**Vegetative Cover:** A protective vegetative cover was established by 6/22/76 on all straw mulch treatments, but paper mulch (IFMC) alone at 1500 lbs/A gave poor cover. Straw stabilized with woodfiber alone at 500 or 750 lbs/A or woodfiber and Terra Tack II gave the best vegetative covers of 100%. Paper mulch was inferior to woodfiber. The sweet pea cover followed similar trends.

Using woodfiber to stabilize straw for developing vegetative covers was superior to chemical binders.

Table 32. Effects of mulches and chemical binders as straw tacking agents.\*  
Route 613, near Mountain Lake; established 9/4/75.

Mulch rate/A ***	9/19/75	6/22/76	
	Straw** stability	PSP	Cover, % vegetative
Straw 3000	10d	18a	93b
Straw 3000, Petroset SB 80 gal	10d	8c	80bc
Straw 3000, Aerospray 70, 80 gal	10d	8c	73c
Straw 3000, Asphalt 80 gal	6c	11b	76bc
Straw 3000, WF 750 lbs, TT II 45 lbs	2b	19a	100a
Straw 3000, WF 500 lbs	2b	14ab	100a
Straw 3000, WF 750 lbs	2b	19b	100a
Straw 3000, IFMC 750 lbs	1a	9c	86b
IFMC 1500 lbs	--	4d	57d

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

\*\* Ratings from 1 to 10; 1-3 = excellent, 3-5 = satisfactory, 5-7 = marginal, 7-10 = unsatisfactory.

\*\*\* Woodfiber = WF; IFMC paper fiber = IFMC; Terra Tack II = TT II.

#### 6. Near Radford High School; established 11/26/75.

This randomized block experiment with four replications using various mulches and chemical binders was established on an east facing 1:1 smooth slope. The slope was seeded with creeping red fescue @ 40 and roughstalk bluegrass @ 40 with 10-20-10 fertilizer @ 1000 and lime @ 2 T/A. These slow growing and relatively non-aggressive species gave little or no growth during fall and winter. Thus, without protective vegetation, a critical evaluation on erosion and binding properties of chemicals and mulches was facilitated. Treatments and data are shown in Table 33.

#### Results and Interpretation

This experiment established in late November for winter erosion control allows critical evaluation. Two months after the experiment was established little erosion had occurred on most treatments. The check (no mulch) and Esco 101 chemical binder were unsatisfactory for controlling erosion; other binders with woodfiber or woodfiber alone were marginal for erosion control during winter. Chemical binders did not improve woodfiber stability after

Table 33. Evaluation of several mulches and chemical binders for erosion control and binding straw.\* Near Radford High School. Established 11/26/75.

Mulches***	Rate/A	1/26/76		3/12/76	
		Erosion rating**	straw loss, %	Binding strength	mulch remaining, %
WF	1000 lbs	6		8.8c	22
Ver mulch	1000 lbs	6		8.0c	24
WF	2000 lbs	5		8.0c	36
WF + Ver Com	1000 lbs, 80 gal	7		8.0c	30
WF, TT III	2000 lbs, 45 lbs	5		8.0c	40
Esco 101	200 gal (1:7 dilution)	10		10.0d	0
Ver mulch + Com	1000 lbs, 80 gal	5		8.0c	22
Check		10		10.0d	0
Straw	3000 lbs	3	31.7c	8.8c	14
Straw + WF	3000 lbs, 750 lbs	1	0.0a	2.8a	95
Straw + Asp	3000 lbs, 300 gal	3	11.7b	3.5b	90
Straw + Esco 101	3000 lbs, 100 gal	3	33.3c	8.8c	15

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

\*\* Ratings were made from 1 to 10, with 1-3 = excellent, 3-5 = satisfactory, 5-7 = marginal, and 7-10 = unsatisfactory.

\*\*\* Woodfiber = WF, Verdyol mulch = Ver mulch, Verdyol complex = Ver Com, Terra Tack III = TT III, Asphalt = Asp.

2 months. Woodfiber @ 750 lbs/A was the superior tacking agent for straw as no straw had been lost by 1/26/76. This is further verified by data taken on 3/12/76 showing 95% of the straw remaining on the slopes after 4 months. Straw tacked with asphalt @ 300 gal/A was the second best treatment. Esco 101 with straw was no better than straw alone.

Verdyol mulch and woodfiber at the same rates gave similar results in erosion control, being marginal and unsatisfactory for prolonged winter stabilization as compared to straw alone or tacked with woodfiber. The Verdyol complex with Verdyol mulch did not improve stability over Verdyol mulch alone. However, Verdyol complex binder improved the stability of woodfiber. Over 50% of the woodfiber and Verdyol mulch with and without chemical binders were lost during the harsh winter season. The woodfiber @ 2000 lbs/A was better than the 1000 lb rate for erosion control. Terra Tack III did not improve woodfiber stability. According to woodfiber responses, high rates of Verdyol mulch would have given better persistence.

It may be concluded that only straw tacked with woodfiber @ 750 lbs/A or asphalt @ 300 gal/A could be recommended for winter erosion control.

7. Route 613, near Mountain Lake; established 2/26/76.

This randomized block experiment with two replications was established on a 1.5:1 south facing slope. This erodible material was seeded with a mixture of creeping red fescue @ 40, Kentucky 31 fescue @ 40, flat pea @ 20, and annual ryegrass @ 13 lbs/A with a 10-20-10 fertilizer @ 1000 and lime @ 2 T/A. This slurry was sprayed uniformly from a hydroseeder onto the entire slope prior to treatment applications. The treatments with ratings on the stability of both straw and woodfiber and vegetative cover are given in Table 34.

#### Results and Interpretation

Erosion Control: There was a prolonged drought after establishing this experiment. No hard rains occurred on this area before vegetation stabilized the soil and mulches and gave erosion control. A rating made on stability of mulches on 3/15/76 showed small differences among treatments, except that values for straw without a tacking agent and straw tacked with 150 lbs/A of woodfiber were inferior. Asphalt used in this experiment did not have usual binding properties; hence, data was excluded. Superior tacking agents for straw based on data taken on 3/15/76 and 5/21/76 were woodfiber @ 750, woodfiber @ 150 with Dow @ 40 gal/A, woodfiber @ 750 with Dow @ 40 gal/A. Excellent bonding of woodfiber @ 1000 and 2000 lbs/A was obtained with the Dow binder at 40 and 60 gal/A.

Vegetative Cover: Very little difference in vegetative cover was noted among the mulch treatments due to an unusually dry late winter to late spring season. The poorest vegetation occurred without mulch and straw without tacking agents. High winds accounted for most of the loss of straw.

Straw tacked with 750 lbs/A of woodfiber and Dow @ 40 gal/A fully stabilized the straw for 3 months. Straw tacked with 750 lbs/A of woodfiber alone or 150 lbs of woodfiber with 40 gal/A of Dow allowed 13 and 10% straw loss after 3 months, respectively. A low rate of woodfiber and a high dilution of Dow was intermediate as a straw tacking agent. A 1:6 dilution of Dow @ 60 gal/A or Terra Tack II @ 45 and woodfiber @ 150 lbs/A gave similar mediocre results for tacking straw, 45 and 47% of the straw remaining after 3 months.

Because of the prolonged drought and low erosion from rainfall, the results are inconclusive. However, the trends are significant.

Table 34. Effects of various mulches and binders on stability and establishing vegetation. Route 613, near Mountain Lake; established 2/26/76.

<u>Treatments</u>	<u>Stability rating*</u>	<u>Vegetative cover, %</u>	<u>Straw** remaining, %</u>
Straw 2 T	10	32	12e
Straw 2 T, Dow 40 gal 1:9 dil	3	57	55c
Straw 2 T, Dow 60 gal 1:6 dil	3	65	45d
Straw 2 T, WF 150	5	59	62c
Straw 2 T, WF 750	3	68	87b
Straw 2 T, WF 150, Dow 40 gal	3	62	90b
Straw 2 T, WF 750, Dow 40 gal	1	58	100a
Straw 2 T, WF 150, TT II 45	3	65	47d
WF 1000	3	47	
WF 2000	3	65	
Verdyol 1000	3	42	
Verdyol 1000, complex 80 lbs	3	48	
WF 2000, TT III @ 45	3	55	
WF 2000, Dow 60 gal	1	42	
Check	-	24	
WF 1000, Dow 40 gal	2	41	
WF 1500, Dow 50 gal	1	47	

\* Ratings were made from 1 to 10, with 1-3 = excellent, 3-5 = satisfactory, 5-7 = marginal, and 7-10 = unsatisfactory.

\*\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

8. Route 613, near Mountain Lake; established 3/3/76.

A randomized complete block experiment with treatments shown in Table 35 was established to evaluate tacking agents on a 1:1 slope with a southern exposure. The slope had weathered for 4 to 5 months after grading, but had little erosion due to the shaley nature of the soil material. A seed mixture of Kentucky 31 fescue @ 40, creeping red fescue @ 40, crownvetch @ 20, and annual ryegrass @ 5 lbs/A was applied from a hydroseeder in a slurry of lime at the rate of 2 T/A and a 10-20-10 fertilizer @ 1000 lbs/A. Woodfiber and chemical binders were applied with a hydroseeder and straw was applied @ 2 T/A for all treatments with a straw blower.

Results and Interpretation

There was no apparent erosion on any plots before the vegetation became established; thus data on vegetative cover did not differ significantly. The cover averaged 50%, being low because of the severe drought during the March-June season in 1976.

One week after applying straw, the Esco product applied with a hydroseeder or a straw blower, and all Dow product treatments used applied with a straw blower, allowed much of the straw to blow off the plots. Thus, results were similar to straw alone. However, the Dow binder applied by a hydroseeder at the various dilutions with or without woodfiber were excellent straw tacking agents after 1 week. The Dow product used with straw without woodfiber exhibited no improvement over woodfiber on straw and was inferior to woodfiber in most cases. Grass germinated sufficiently to hold the remaining straw in place by 5/26/76. The Dow product with woodfiber exhibited a strong bond with straw at the latter date, being 100%.

It may be concluded that the Dow product with woodfiber or woodfiber alone @ 750 lbs/A proved to be excellent for tacking straw over the 2 month period.

Table 35. Effects of rates and dilutions of tacking agents on stabilizing straw on a 1:1 cut slope. Route 613, near Mountain Lake; established 3/3/76.

Mulches and binders, rate/A*	Straw remaining, %	
	3/10/76	5/26/76
A. Check (straw alone)	45	30
B. Woodfiber @ 750 lbs	90	80
C. Dow @ 40 gal 1:9 dilution	85	67
D. Dow @ 40 gal 1:9 dilution**	50	45
E. Dow @ 40 gal 1:1 dilution	65	45
F. Dow @ 40 gal 1:3 dilution**	45	25
G. Dow @ 60 gal 1:6 dilution	90	80
H. Dow @ 60 gal 1:6 dilution**	45	40
I. Dow @ 40 gal, WF @ 750 lbs	100	100
J. Dow @ 60 gal 1:18 dilution	90	77
K. Esco @ 60 gal 1:3 dilution**	50	30

\* All plots had straw @ 2 T/A.

\*\* Treatments were co-sprayed with straw.

## II. Experiments with Establishing Woody Species from Seed.

### 1. Rt. 100 4 miles N of Dublin, Established 3/4/74.

This randomized block experiment was established on a 1.5:1 east facing cut slope. The chemical properties of the soil were: pH 5.0, CaO-L+, MgO-M-, P<sub>2</sub>O<sub>5</sub>-L-, K<sub>2</sub>O-L. A seed mixture of Ky 31 fescue @ 40 and crownvetch @ 20 and 10-20-10 fertilizer @ 1000 and lime @ 1T/A were applied uniformly to the entire experimental area with a hydroseeder. Woody species were seeded in rows under Landlock binder with both straw and woodfiber and under woodbark. The treatments and data with binders and woody species are shown in table 36 and 37.

#### Results and Interpretation

**Mulch Stability:** The best stability of straw or woodfiber was obtained with Landlock. Petroset SB was a satisfactory binder for woodfiber as shown by data on 3 dates; however it was not satisfactory for tacking straw. Terra Tack I and Genaqua were satisfactory for stabilizing woodfiber initially but degenerated after 3 to 4 weeks; these 2 binders were not satisfactory for tacking straw (table 36).

**Woody Species:** Woody species had the most plants when planting under woodbark followed by straw tacked with Landlock; woodfiber with Landlock had the fewest number of woody species (Table 37). Of all species seeded, sweet pea and scotch broom provided the most seedlings. Hackberry and black locust both had many seedlings, other species had few plants. Poor stands may be caused by poor germination due to the lack of knowledge on breaking dormancy of these seeds and poor seed quality.

On June 1976, only sweet pea, black locust, Scotch broom, and sumac were present on any of the plots; these species were tall and vigorous in July of 1974. All other species that germinated were smothered out by competition from grasses in 1975.

Table 36. Effect of various binders on tacking straw and woodfiber on growth of woody species.\* Route 100. 4 miles N of Dublin.

Treatment rate/A	Firmness of bond (1-10)**					
	Woodfiber			Straw		
	3/8/74	3/27/74	4/25/74	3/8/74	3/27/74	4/25/74
Check	10d	10	10	10b	10	10
Petroset SB 150 gal	3b	4	5	8b	10	10
Landlock 150 gal	2a	2	3	1a	1	2
Terra Tack 150 lb	4c	5	7	10b	10	10
Genaqua 150 gal	4c	5	3	10b	10	10

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

\*\* Ratings from 1 to 10: 1-3 = excellent, 3-5 = satisfactory, 5-7 = marginal, 7-10 = unsatisfactory. Woodfiber was applied @ 1500 and straw @ 3000 lbs/A.

Table 37. Stands of woody species seeded under different mulches. Route 100, 4 miles N of Dublin. Established 3/4/74.

Species* rate/A	Plants/15' row				Ht. (in)		
	Straw + LL**		WF + LL		Woodbark		
	5/20/74	7/3/74	5/20/74	7/3/74	5/20/74	7/3/74	
Sumac 5	3	17	5	8	6	7	10
Sweet pea 10	323	285	77	75	350	426	8
Redbud 5	2	3	5	9	6	12	3
Russian olive 5	8	-	2	-	10	11	3
Hackberry 5	36	33	19	19	42	43	6
Black locust 5	67	51	80	57	113	102	18
Thornless honey- locust 5	7	2	17	2	16	14	6
Scotch broom 10	341	328	219	200	382	348	14
Total Plants	787	719	424	370	925	963	

\* All species were planted in rills on a newly prepared slope with 1 ton of lime and 1000 lbs of 10-20-10 applied per acre.

\*\* LL = Landlock.

## 2. Kipps Farm, established 10/17/73 and 2/5/74.

These split-split plot experiments were established to determine dates and mulches that might enhance stands and growth of woody species. Cereal rye was seeded @ 180 and 10-20-10 fertilizer @ 500 lbs/A was incorporated to a 6-inch depth of soil at the time of seeding. Either woodbark @ 35 yd<sup>3</sup> or woodfiber @ 1500 lbs/A was used after seeding on the surface or incorporating seeds to a depth of 0.5-inch. Treatments and plant counts are shown in the table 38.

### Results and Interpretation

Plant Populations. Sweet pea, sumac, Scotch broom, Russian olive and black locust had the most plants when seeded in late fall or late winter. Woody species seeded in February produced about twice as many plants as those seeded in October with woodbark mulch. Sweet pea produced more plants than other species at any date with any mulch. Redbud, Russian olive and hackberry germinated better when seeded in late winter than in late fall with woodbark. Thornless honeylocust germinated poorly at either date for all mulch treatments. Poor germination may be attributed to the lack of information on breaking dormancy and poor seed viability. Redbud, Russian olive and hackberry grew well during the first year but died during the second year due to competition or lack of an environment suitable for their growth. It is possible that the appropriate strains of micorrhizae may not have been in the subsoil

Applying seeds on the surface or 1/2" deep did not effect germination of these species. For late winter seedings of woody species woodbark enhanced stands over woodfiber. Sweet pea and Scotch broom seed may be seeded without any seed treatment, whereas other seeds used in this experiment should be treated either by cold storage, with acid, or other means to obtain germination.

Table 38. Effect of mulches on establishment of woody species and legumes when seeded in the winter season.\* Kipps Farm. Established 10/17/73 and 2/5/74.

Species rate/A	Seeded 10-17-73 No. plants/8' row				Seeded 2-5-74 Data taken 8-15-74 No. plants/8' row			
	Woodbark		Woodfiber		Woodbark		Woodfiber	
	4/5/74	5/10/74	4/5/74	5/10/74	Surface	Inc.	Surface	Inc.
Sweet pea 15	9.7a	14.8a	7.5a	7.0a	35	35	9	16
Sumac 15	.0c	.3c	.0b	.0c	15	5	2	2
Scotchbrome 5	6.1b	4.9b	6.2a	3.3b	10	8	2	4
Redbud 5	.1c	.9c	.0b	.3c	2	2	0	0
Russian olive 5	.0c	1.7bc	.0b	1.2bc	9	10	0	1
Hackberry 5	.0c	.6c	.0b	.8bc	2	1	0	2
Black locust 5	.2c	.6c	.0b	.1c	4	5	0	2
Thornless honey- locust 5	.0c	.0c	.0b	.1c	0	0	0	0

\* Means in a vertical column followed by different letters are significantly different at the 5% level of probability.

\*\* Cereal rye was broadcast at 180 lbs/A and 10-20-10 @ 500 lbs/A and incorporated to a depth of 6" on all plots. Woodbark was used @ .95 yd<sup>3</sup>/A and woodfiber @ 1500 lbs/A.

3. Route 291 - 460 Interchange near Lynchburg. Established 4/2/75.

The woody species were established on a southeast facing 1:1 cut slope. The entire area had a uniform slurry of creeping red fescue @ 30, a 10-20-10 fertilizer @ 1000, and lime @ 2 T/A applied from a hydroseeder. The woody species were:

- |                           |  |
|---------------------------|--|
| A. Spreading cottoneaster | K. Bicolor lespedeza                                   |
| B. Hackberry              | L. European alder                                      |
| C. Indigo bush            | M. Thornless honeylocust (acid treated<br>1-1/2 hours) |
| D. Scotch broom           | N. Siberean pea shrub                                  |
| E. Honey suckle           | O. Cockspur thorn                                      |
| F. Virginia creeper       | P. Amur honeysuckle                                    |
| G. Red chokeberry         | Q. Mazzard cherry                                      |
| H. Redbud                 | R. Silky dogwood                                       |
| I. Black chokeberry       | S. Common lilac  |
| J. Russian olive          | T. Smooth sumac  |

After seeding straw was applied @ 3500 and tacked with woodfiber @ 750 lbs/A. Observations made on several dates showed an absence of plants, possibly due to competition from grass or a prolonged dry period. The seeds were old so viability may have been a factor.

### III. Summary of Findings and Recommendations for Implementation.

Research is done to implement pertinent findings into highway specifications to minimize erosion and potential pollution during and after highway construction. While research is progressing, recommendations are made to the Advisory Committee of Environmental Research set up by the Virginia Highway and Transportation Research Council. Recommendations approved by the committee pass through the channels of Virginia Department of Highways and Transportation to the appropriate division for implementation. All recommendations are not implemented and reasons for rejections are made to the committee. Thus some of the recommendations in this section, resulting from research findings, have already been implemented.

Research findings dating back to 1956 have been summarized in a handbook titled "Manual for Establishing a Vegetative Cover in Highway Corridors of Virginia." This manual was written as a guide line to pertinent highway personnel covering grading and all phases for establishing protective vegetative covers quickly and developing persistent vegetation. The handbook, written simply, is a summary of many years of findings. Chapters in the handbook are:

1. Geology, soils, climate for establishing vegetation on bare soil areas, 2. Construction of slopes, 3. Liming and fertilizing, 4. Mulches and binding agents, 5. Seed mixtures for establishing desirable vegetation in highway corridors, 6. Multistep seeding and fertilization and, 7. Maintenance of vegetative cover.

High personnel frequently arrange meetings with the research staff to discuss special problems and to make on site inspections in view of solving unexpected problems and for assisting with implementation recommendations. These associations have aided in conducting pertinent research.

#### A. Grading Cut Slopes

##### 1. Findings

Grading to leave smooth hard surfaces and a "finished grading appearance is a common practice with cut slopes during highway construction in Virginia and other states. This practice often causes seeding failures. Water infiltration and adsorption capacity on such slopes are low causing slow germination, seedling growth and canopy development and potential erosion and pollution because of moisture stress.

Findings clearly show that stair-step grading, rough grading leaving loose surfaces or grooving of cut slopes create favorable microenvironments for rapid germination, growth, and plant succession to leguminous persistent canopies to arrest erosion. Such slope surfaces are of paramount importance for obtaining vegetative cover and may ~~reduce~~ reduce the mulching and seeding rates and make plants more responsive to given rates of mulch seed and fertilizer. Also rough grading practices are more important than topsoiling and make it easier to obtain stands of vegetative cover at any season. Rough grading practices do not increase construction costs and decrease costs of establishing and maintaining vegetation.

Slopes steeper than 2.5:1 should be stair-step graded. The vertical wall in the stair-step design should be no more than 20" and the width of the horizontal cut equal to or exceeding the height of vertical walls. Little erosion and some seed and fertilizer coverage usually augments germination and canopy development.

All cuts 2.5:1 or flatter should be rough graded or tilled to leave furrows parallel to the road to increase water infiltration and modify soil temperatures. Findings show better vegetative cover on rough tilled areas without mulch than on smooth areas with mulch. Excellent growth on loose, rough slope surfaces was attributed to seed and fertilizer coverage, increased water infiltration, reduced erosion, and a more favorable microenvironment than for smooth slopes.

Widening old highway corridors especially with secondary roads often results in steep, smooth, cut slopes. Grooving such slopes, with grooves 18 to 24 inches apart and 4 to 8" deep, has resulted in four-fold better vegetative cover than for smooth surfaces. The grooves collect sloughing soil, seed, and soil amendments as well as water which enhances establishment of vegetative covers. Grooves are the least desirable of rough grading methods since smooth areas between the grooves are conducive to flow off and erosion.

## 2. Recommendations

It is recommended that all slopes steeper than 2.5:1 be stair-step graded with vertical walls not exceeding 20" and horizontal steps being equal to or larger than the vertical wall.

Slopes 2.5:1 or flatter should be left with rough loose surface or tilled to a depth of 8" leaving furrows parallel to roadways.

## B. Constructing Fill Slopes

### 1. Findings

Findings show that protective vegetative covers are more easily established on fill than cut slopes due to less compaction of the rock and soil materials. Also established vegetation on fill slopes is more persistent than with cut slopes. Thus only one experiment was conducted on fill slopes. Establishing grass and legume cover on a tracked slope occurred more slowly than for roughening the tracked surface before applying the mulch, seed, lime and fertilizer.

Observations along highways in the Piedmont region of Virginia showed poor vegetative development on tracked fill slopes due to several compaction from cleats which inhibited water infiltration, causing severe erosion.

### 2. Recommendations

It is suggested that fill slopes be constructed with a wide base to make regrading of the fill unnecessary as the lift is constructed. Variable contours with rocks left in place are desirable. Fill slopes may be prepared in two ways to minimize erosion and facilitate establishing of vegetation:

(1) let material fall naturally and undisturbed as the lift is constructed, and  
(2) leave roughened surface with a sheeps foot roller. Fill slopes with rough loose surfaces impede water runoff, and improves moisture relationships to reduce erosion and stimulate developing vegetation as with cut slopes.

This section is suggestive as research and observations are not adequate for making strong and specific recommendations.

### C. Grading Medians

#### 1. Findings

Findings show that roughened subsoils in medians gave a 10-fold better vegetative cover than seedings on a smooth topsoiled median with identical mulch, seed, lime and fertilizer treatments. Establishing a vegetative cover quickly in the roughened median reduced erosion as water infiltration was much better than for smooth surfaces. Soil moisture was increased by 8% on the roughened versus the smooth slope. The moisture improvement and lower soil temperatures caused 3-fold more legume plants. Incorporating the lime and fertilizer increased the establishment and growth rate of grasses and persistent legumes.

#### 2. Recommendations

It is recommended that all medians be graded with flat, rather than "v", bottoms. This reduces rate of water flow to facilitate the establishing of vegetation. The slopes should be roughened to leave furrows perpendicular to the slope. This procedure is much more important and replaces topsoiling. If topsoil is used the data show that roughening sharply improves vegetative cover as for subsoil material.

D. Fertilization

1. Findings

Erosion control is achieved by establishing a vegetative cover quickly that develops into a persistent vegetation through plant succession. Obtaining vegetative covers depends on applying adequate soil amendments and adjusting the pH to a favorable level by liming. Subsoil and rock material on slopes in highway corridors of Virginia are nearly void of organic matter and nitrogen; low in nutrients calcium, magnesium, and phosphorus supplied by lime and fertilizer; and usually highly acid or low in pH. Low soil nitrogen causes slow growth and degeneration of grassy vegetation. Findings show that certain perennial legumes persist for many years on harsh slope environments with rock and subsoil materials. Legumes, such as crownvetch, sericea, and flat pea, through nodule bacteria, fix nitrogen and persist. Native woody species tolerate low organic matter and acid soils but require many years to establish protective vegetative canopies. Thus, effective erosion control begins with establishing grassy vegetative covers terminating with persistent legumes or woody species.

Soils and subsoils in Virginia are usually very acid (pH 4.7 to 5.7) and usually require 2 T/A of lime per acre for good grass and legume growth. Phosphorus in soils and subsoils is invariably low and often fixed in unavailable forms with aluminum. It doesn't leach; hence it may be applied liberally for recycling and long lasting residue effects. Low soil potassium is a minor problem in highway corridors except in the Coastal Plains. However, applying potassium is usually additional assurance for success.

Findings show that a 10-20-10 fertilizer @ 1000 and lime @ 2 T/A furnish adequate amounts of nitrogen, phosphorus, and potassium to promote the shift of botanical species from temporary grass to perennial grass to persistent legumes over a 2 to 3 year period when combined with other good cultural practices of slope preparation, seed mixtures, and mulches. Initial liberal lime and phosphorus rates later promote successful encroachment of legumes. Nitrogen at rates higher than 100 lbs/A often cause failure of legumes due to light and water competition from the fast growing, aggressive grasses. The legumes currently used on highway corridors possess slow developing seedlings that are readily lost in dense canopies.

Slopes with degenerating grasses along highways (interstate, primary, and secondary) are potential sites for erosion. Findings show that crownvetch may be established in sparse grass by applying phosphorus and lime. With sparse grass cover light applications of nitrogen stimulate growth and persistence of grasses to avoid erosion. Findings show that legumes are severely depressed when nitrogen is used; hence it should not be used unless necessary. Also, light rates result in the least competition. Woodfiber along with phosphorus and lime helps establish legumes when grass cover is 50% or less.

2. Recommendations

Lime and fertilizer recommendations are given in tables as follows:

- a. for establishing persistent vegetation on bare slopes, Tables 39, 40, and 41;
- b. for establishing legumes on slopes with varying amounts of grass cover and in temporary grass cover, Table 42;
- c. for establishing grasses for temporary cover, Table 43.

## E. Temporary Vegetative Cover

### 1. Findings

It is necessary to establish vegetative covers during all seasons as construction proceeds to minimize erosion. Findings show that cereal rye, annual and perennial ryegrass, German millet, and weeping lovegrass develop temporary vegetative covers quickly, lovegrass being persistent. Cereal rye and annual and perennial ryegrass seeded at heavy rates gave winter vegetative cover when seeded during autumn, rye being best for mid-winter seeding. German millet and weeping lovegrass gave excellent cover for summer seedings, when harsh environments as high temperature and drought are encountered.

Along with using these temporary species for excellent initial vegetative cover, concurrent seeding of perennial grasses and legumes has usually resulted in a shift to a persistent cover at later dates. Findings show that German millet initially provides an excellent canopy for intercepting raindrops and slowing runoff water; later cool season species develop as first frost kills the millet which then serves as an excellent in situ mulch.

Findings show that dense canopies of cereal rye killed down with paraquat and concurrently seeded with persistent legumes were conducive for developing crownvetch and flat pea cover. The findings lend to the conclusion that temporary canopies of annual ryegrass, rye, or German millet would serve for erosion control more effectively than mulches for temporary access roads or other areas where erosion control is needed.

### 2. Recommendations

Species, mixtures, and rates of seeding recommendations are given in tables as follows:

- a. for establishing persistent vegetation on bare slopes, Tables 39, 40, and 41;
- b. for establishing legumes on slopes varying in amounts of grass cover and in temporary grass cover, Table 42;
- c. for establishing grasses for temporary cover, Table 43.

## F. Cultural Practices for Establishing Persistent Grasses and Legumes

### 1. Findings

With many experiments on establishing legumes in different regions of Virginia on slopes with various subsoil materials, grass canopies with soil cover of more than 50% were competitive to legume seedlings when applying more than 50 pounds of nitrogen (N) per acre. Crownvetch and sericea lespedeza seedlings develop slowly and were readily lost because of shading from grass competition. Young seedlings of flat and perennial sweet pea survive under considerable competition.

Findings show that destroying 50% or more of dense grass sods by cultivation gave best stands of all legumes. Killing the top growth of sod also improved seedling stands and the developing legume cover of all species as compared with no sod treatment.

Findings in the Coastal Plain region show that crownvetch and sericea lespedeza are poorly adapted for seeding into slopes with sparse grass sods; conversely results with flat pea are excellent and those with perennial sweet pea are promising. Flat pea crowded out dense stands of grass in a little over 1 year. All four of the persistent legumes generally developed good protective vegetation on various subsoils on slopes in the Piedmont and Appalachian regions. Flat pea generally developed a complete vegetative cover more rapidly than sericea, crownvetch, or perennial sweet pea. It also spread over other legumes in adjacent plots. After further observation on stand longevity, it is very likely that flat pea will be recommended for highway corridors for new seedings on bare slopes and for a persistent cover on slopes with sparse grass cover. Perennial sweet pea appears very persistent but invasion proceeds slowly.

Findings show best seedling survival and spread of crownvetch, flat pea, and perennial sweet pea when soils had a pH above 6.0 and when high in residual phosphorus or when highly acid infertile soils had applications of lime and phosphorus. Responses to potassium were generally low or nil. Sericea lespedeza growth responded to phosphorus when soils were very infertile.

## 2. Recommendations

It is recommended that crownvetch or sericea lespedeza be used in all new seedings in all regions except for crownvetch which should not be used in the Coastal Plain. Crownvetch is persisting in the Coastal Plain region but there are failures. (See Tables 39, 40, and 41.) It is recommended that all new contract seedings have 75 to 80% cover and that 50% of this cover be legumes before turning it over for state maintenance where legumes are specified.

Likewise, for the respective regions, it is recommended that crownvetch or sericea lespedeza be seeded on slopes with degenerating grasses to develop vegetation that will not require maintenance fertilization and mowing. (See Table 42.)

When leguminous cover is desired on slopes with dense grass canopies, it is recommended that seeding of legumes be delayed until the grass degenerates to a 75% cover to reduce competition, then follow recommendations in Table 42.

If legumes are to be established in dense grass canopies, it is recommended that grass competition at or before the seeding date be subdued by tillage or paraquat.

## G. Mulches, Nets and Binders

### 1. Findings

Findings show that organic mulches moderate soil temperatures and improve moisture relations for better germination and seedling growth. Woodbark and straw are superior to woodfiber for erosion control for seedlings during unfavorable seasons. Findings show that woodfiber @ 750 lbs/A applied over straw was a superior technique for prolonged stabilization under a wide array of climatic conditions, especially suitable for winter or summer mulching. Woodfiber as a tacking agent does not form a soil-straw bond but forms a blanket over the straw allowing little or no movement. The woodfiber aids in the establishment of vegetation by its added mulching material. It was found that a simple two-step seeding operation, 1) blowing straw on slopes, and 2) tacking the straw with a slurry of seed-lime-fertilizer and woodfiber, gave results similar to three-step operations, 1) applying a seed-fertilizer slurry, 2) applying straw, and 3) applying woodfiber tack. The woodfiber does not create pollution, may be applied at any temperature above freezing, and may be washed from buildings or sidewalks if the spray has been misguided. The straw-woodfiber combination maintained better cover and stability than the straw-asphalt (300 gal/A) combination.

Chemical binders alone usually failed to aid germination and vegetative cover and were unsatisfactory for erosion control or temperature and moisture moderation. Some increases in woodfiber persistence occurred when certain chemical binders were used with woodfiber. However, the vegetation with woodfiber-chemical binder combinations was usually no better than for woodfiber alone. One new product, Dow, is promising as straw tacking agent.

Woodfiber and paper fiber mulches give similar effects when applied at equivalent amounts of dry matter. Superior paper fiber presently contains 28% water and is being used at the same rates as woodfiber which contains 8% water. The inadequate mulching effects are attributed to the reduced dry matter applications because of high water content.

Limited research with nets shows that Hold Gro inhibited grass emergence although erosion was controlled. Findings with jute show excellent erosion control and vegetative cover. Gravel, 2 inches in diameter, also controlled erosion in a median ditch and resulted in a good vegetative cover.

### 2. Recommendations

It is recommended that woodfiber at 750 lbs/A be used as a binding agent for straw at 3000 lbs/A in a two-step operation: 1) apply straw, and 2) apply the woodfiber-seed-fertilizer slurry.

It is recommended that all woodfiber and paper fiber products be specified on a dry matter basis.

It is recommended that woodbark or wood chips when available be used for prolonged erosion control as during the winter season.

The mulch recommendations for new seedlings, in various regions in Virginia and for various seasons are given in Tables 39, 40, and 41.

Mulches and recommendations for seeding into sparse covers are given in Table 42. Recommendations for mulching for establishing temporary vegetations are given in Table 43.

## H. Establishing Woody Species

### 1. Findings

Findings show inconsistent and inconclusive results because of poor seed viability or poor germination because of dormancy. Good seedling stands have been obtained with sumac, Scotch broom, red bud, Russian olive, and black locust. However, red bud and Russian olive seedlings grew slowly and were shaded out by encroaching weeds and grass. To establish woody species, special care is necessary to control weeds and other competing growths. Nitrogen at high rates caused severe competition. The best seedling stands occurred when placing seeds under woodbark and with seed coverage.

### 2. Recommendations

None.

Table 39. Seed mixtures, fertilizer, lime, and mulch recommendations for establishing and developing a persistent vegetation for erosion and siltation control during various seasons of the year for the Blue Ridge and Appalachian section of Virginia.

Seeding seasons	Seed mixture* lbs/A	Fertilizer** lbs/A	1.5:1 or steeper	Mulches and binders, lbs or (rate/A)***	
				1.5:1 to 3:1	3:1 or flatter
A. Mar 1 to May 15	Ky 31 fescue 50-60	10-20-10	WF 1500	WF 1500 or straw	WF 1500 or straw
Aug 1 to Sep 15	Annual ryegrass 5-7 sericea lespedeza 30 or crownvetch 20	1000 lb		straw 3000 tacked with WF 750	3000 disked in or tacked with WF 750
B. May 16 to Jul 30	Ky 31 fescue 50-60 W. lovegrass 3-5 German millet 20 sericea lespedeza 30 or crownvetch 20	10-20-10 1000 lb	WF 1500	WF 1500, straw 3000 tacked with WF 750	WF 1500, straw 3000 tacked with WF 750 or disked in.
C. Sep 16 to Nov 15	Ky 31 fescue 60-80 C. red fescue 30-40 Cereal rye 40-60 Unhulled sericea 30 or crownvetch 20 next spring	10-20-10 1000 lb	WF 1500	WF 1500, straw 3000 tacked with WF 750	WF @ 1500, straw 3000 disked in or tacked with WF 750
D. Nov 16 to Feb 28	Ky 31 fescue 60-80 C. red fescue 30-40 Cereal rye 150-200 Unhulled sericea 30 or crownvetch 20 next spring.	10-20-10 1000 lb	WF 2000 tacked with asphalt 300 gal	WF 2000 tacked with asphalt 300gal, straw 3000 tacked with WF 750 or as- phalt 300 or woodchips or wood- bark 50-75 cu yds	WF 2000 tacked with asphalt 300 gal. or straw 3000 tacked with WF 750 or wood- bark or woodchips 50-75 cu yds

\* Inoculate crownvetch and sericea at 10 times the rate recommended by the manufacturer.

\*\* Apply lime according to soil tests or @ 2 T/A on most soils.

\*\*\* WF - Woodfiber or paper fiber should be applied at 1500 lbs air dry weight, 10% moisture (1350 lbs dry matter/A)

Table 40. Seed mixtures, fertilizer, lime and mulch recommendations for establishing and developing a persistent vegetation for erosion and siltation control during various seasons of the year for the Piedmont section of Virginia.

Seeding season	Mulches and binders (lbs or rate/A)***			
	Seed mixture lbs/A	Fertilizer** lbs/A	1.5:1 or steeper	1.5:1 to 3:1
A. Mar 1 to Apr 30	Ky 31 fescue 50-60	10-20-10	WF 1500	WF 1500 or straw
Aug 1 to Sep 30	Annual ryegrass 5-7 Redtop 1 Sericea lespedeza 30 or Crownvetch 20	1000 lbs	tacked with WF 750	3000 disked in or tacked with WF 750
B. May 1 to Jul 30	Ky 31 fescue 50-60 W. lovegrass 3-5 German millet 10-15 Crownvetch 20	10-20-10 1000 lbs	WF 1500	WF 1500, straw 3000 tacked with WF 750 or disked in
C. Oct. 1 to No 15	Ky 31 fescue 60-80 C. red fescue 30-40 Cereal rye 40-60 Unhulled sericea 30 or Crownvetch 20 next spring	10-20-10 1000 lbs	WF 1500	WF 1500, straw 3000 disked in or tacked with WF 750
D. Nov 16 to Feb 28	Ky 31 fescue 60-80 C. red fescue 30-40 Cereal rye 150-200 unhulled sericea 30 or Crownvetch 20 next spring	10-20-10 1000 lbs	WF 2000 tacked with asphalt 300 gal, straw 3000 tacked with WF 750 or asphalt 300 gal, woodchips or weadbark @ 50-75 cu yds	WF 2000 tacked with asphalt 300 gal or straw 3000 tacked with WF 750 or wood-bark or woodchips 50-75 cu yds

\* Inoculate crownvetch and sericea at 10 times the rate recommended by the manufacturer

\*\* Apply lime according to soil tests or @ 2 T/A on most soils.

\*\*\* WF - woodfiber or paper fiber should be applied at 1500 lbs air dry weight, 10% moisture (1350 lbs dry matter/A)

Table 41. Seed mixtures, fertilizer, lime, and mulch recommendations for establishing and developing a persistent vegetation for erosion and siltation control during various seasons of the year for the Eastern (Coastal Plains) section of Virginia.

Seeding season	Seed mixture lb/A	Fertilizer lbs/A	Mulches and binders (lbs or rate/A)**		
			1.5:1 or steeper	1.5:1 to 3:1	3:1 or flatter
A. Feb 16 to Apr 15	Ky 31 fescue 50-60	10-20-10	WF 1500	WF 1500 or straw	WF 1500 or straw
Aug 16 to Oct 15	Annual ryegrass 5-7 Redtop 1 sericea lespedeza 30	1000 lbs	WF 1500 tacked with WF 750	straw 3000 tacked with WF 750	3000 disked in or tacked with WF 750
B. Apr 16 to Aug 15	Ky 31 fescue 50-60 W. lovegrass 3-5 German millet 10-15 sericea lespedeza 30	10-20-10 1000 lbs	WF 1500	WF 1500, straw 3000 tacked with WF 750	WF 1500, straw 3000 tacked with WF 750 or disked in
C. Oct 16 to Nov 15	Ky 31 fescue 60-80 C. red fescue 30-40 Cereal rye 40-60 Unhulled sericea 30	10-20-10 1000 lbs	WF 1500	WF 1500, straw 3000 tacked with WF 750	WF 1500, straw 3000 disked in or tacked with WF 750
D. Nov 16 to Feb 15	Ky 31 fescue 60-80 C. red fescue 30-40 Cereal rye 150-200 Sericea lespedeza 30	10-20-10 1000 lbs	WF 2000 tacked with asphalt 300 gal	WF 2000 tacked with asphalt 300 gal, straw 3000 tacked with WF 750 or asphalt 300 gal, woodchips or woodbark 50-75 cu yds	WF 2000 tacked with asphalt 300 gal or straw 3000 tacked with WF 750 or woodbark or wood- chips @ 50-75 cu yds

\* Apply lime according to soil tests or @ 2 T/A on most soils.

\*\* WF - woodfiber or paper fiber should be applied at 1500 lbs air dry weight, 10% moisture (1350 lbs dry matter/A)

Table 42. Recommendations for establishing persistent species by overseeding into temporary vegetative covers or sparse stands of perennial grasses.

Established temporary or sparse vegetation	Seeding seasons	Species Desired lbs/A**	Fertilizer - lbs/acre****	Mulch lbs/acre
Weeping lovegrass	Aug 15 - Oct 1	Ky 31 fescue	Ammonium nitrate 150	None
	Mar 1 - May 15	Crownvetch	Triple superphosphate 400	
German millet	Aug 15 - Oct 1	Ky 31 fescue	Ammonium nitrate 150	None
	Mar 1 - May 15	Crownvetch	Triple superphosphate 400	
Cereal rye**	Mar 1 - May 15	Ky 31 fescue	Ammonium nitrate 150	None
		Crownvetch	Triple superphosphate 400	
Less than 25% cover Kentucky 31 fescue or other grasses	Mar 1 - May 15	Ky 31 fescue	10-20-10 1000	Woodfiber 1500
	Aug 15 - Oct 1	Creeping red Crownvetch	20*** 20***	
25-50% cover, Kentucky 31 fescue	Mar 1 - May 15	Ky 31 fescue	Ammonium nitrate 150	Woodfiber 1000
	Aug 15 - Oct 1	Crownvetch	Triple superphosphate 400	
50-90% cover Kentucky 31 fescue or other grasses	Mar 1 - May 15	Crownvetch	Triple supersphosphate 400	Woodfiber 500
	Aug 15 - Oct 1			

\* Crownvetch or sericea lespedeza should be inoculated with 10 times the commercially recommended rate when seeded with a hydroseeder.  
 \*\* If the cereal rye canopy is extremely dense, Paraquat @ 2 qts/A should be applied with the hydroseeder slurry.  
 \*\*\* Sericea lespedeza @ 40 lbs/A may be substituted for crownvetch in spring seedings.  
 \*\*\*\* Lime according to soil tests, or if pH is below 5.5, apply lime @ 2 T/A.

Table 43. Recommendations for a temporary vegetative cover for any soil materials during construction as for haul road slopes, stockpiled materials, scalped areas, etc.

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Species, seeding rates, fertilizer\*, and mulch recommendations.

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<u>Seeding dates, species, and lbs/A</u>	<u>Mulch lbs/acre</u>
I. <u>October 1 to March 1</u> Cereal rye, 120	Straw*** 4000
II. <u>March 1 - May 15</u> <u>August 15 - October 1</u> Annual ryegrass, 25 Cereal rye, 60	Woodfiber 1500 or straw 3000**
III. <u>May 15 - June 15</u>  Weeping lovegrass, 5 Annual ryegrass, 25	Woodfiber 1500 or straw 3000**
IV. <u>June 15 - August 15</u>  Weeping lovegrass, 5 German millet, 20	Woodfiber 1500 or straw 3000**

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\* Ammonium nitrate @ 150 and triple super phosphate @ 200 lbs/A should be applied with grasses at time of seeding. Extremely acid soils should be limed with 1/2 to 1 ton of lime per acre.

\*\* Straw should be tacked with either woodfiber @ 750 lbs/A (10% moisture), asphalt @ 100 gals/A, or Dow product @ 60 gals/A.

\*\*\* Woodfiber @ 750 lbs/A at 10% moisture or asphalt @ 300 gals/A should be used to tack straw.