SCHOOL OF CIVIL ENGINEERING

JOINT HIGHWAY RESEARCH PROJECT

JHRP-76-35

DEVELOPMENT OF TECHNIQUES FOR PLANT ESTABLISHMENT ON THE ROADSIDE

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PURDUE UNIVERSITY
INDIANA STATE HIGHWAY COMMISSION

Final Report

DEVELOPMENT OF TECHNIQUES FOR PLANT
ESTABLISHMENT ON THE ROADSIDE

TO: J. F. McLaughlin, Director
Joint Highway Research Project

December 1, 1976
Revised Nov. 1977
Project: C-36-48G

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 9-5-7

Attached is the Final Report titled "Development of Techniques for Plant Establishment on the Roadside" on the HPR Part II Research Study titled "Development of Techniques for Plant Establishment on the Roadside". The Report has been authored by Messrs. P. L. Carpenter and David Hensley. Professor Carpenter was the primary investigator and directed the research.

The Final Report presents a summary of the four Interim Reports which were submitted on the project. These are concerned with evaluation of several mulch materials, plant response to "slow release" fertilizers, factors influencing nitrogen fixation, and evaluation of several methods of establishing plant cover by direct seeding. As the Report is in effect an executive summary of the findings of the entire project a separate executive summary is not included with this Final Report.

The Report is submitted as the final item in fulfillment of the objectives of the Study. After acceptance by the JHRP Board it will be forwarded to ISHC and FHWA for review and similar acceptance.

Respectfully submitted,

Harold L. Michael
Associate Director

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Final Report

DEVELOPMENT OF TECHNIQUES FOR PLANT ESTABLISHMENT ON THE ROADSIDE

by

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Joint Highway Research Project

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16. Abstract

The establishment of plants on the roadside is difficult at many sites due to the highly disturbed soils that are present after highway construction. The success of plant establishment is often related to the availability of nutrients at the site and particularly the long term availability of nitrogen. Also involved is merely the selection of the right plant species that will adapt to the conditions found at a particular site. Finally, modification of the site to be more hospitable to plant survival needs should be accomplished.

Four Interim reports were prepared during the three year period that this project covered. These reports were on the use of "slow release" fertilizers as a nitrogen source for landscape plants; the factors that influence nitrogen fixation by woody plant species; the effects of various mulches on the growth of landscape plants; and various methods for establishing plant cover on the roadside by seeding.

This Final Report presents summaries of the four Interim Reports that were submitted.

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Introduction

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Four Interim reports were prepared during the three year period that this project covered. These reports were on the use of "slow release" fertilizers as a nitrogen source for landscape plants; the factors that influence nitrogen fixation by woody plant species; the effects of various mulches on the growth of landscape plants; and various methods for establishing plant cover on the roadside by seeding.

The fertilizer study is a continuation of a study initiated in a previous project. The results of the first study were somewhat controversial and the results of the current study are also controversial.

The use of nitrogen fixing plants is a must for permanent plant establishment on the roadside. The study on factors that influence N-fixation by plants relates directly to conditions found at various highway sites. Selecting the right plant for a particular site is of the greatest importance.

Mulch materials for both newly seeded areas and landscape beds were evaluated. Some new mulches might be tried on the roadside, i.e. shredded

hardwood bark and shredded rubber tires.

Finally various seeding experiments were carried out to determine if other plants than those currently used on the roadside might be useful in establishing plant cover on the roadside.

This Final Report presents summaries of the four Interim Reports that were submitted.

Evaluation of Several Mulch Materials on Landscape Plant Growth, Weed Control, Soil Temperature and Soil Moisture.

Abstract

The effect of shredded wood bark, shredded rubber tires and Douglas fir bark chips, used as mulches, on weed control and growth of landscape plants was evaluated. Long lasting weed control (2 seasons) was achieved with 2" of Douglas fir bark and 1" and 2" of shredded rubber mulch. Weed control would decrease over a longer period of time with Douglas fir bark due to decomposition, however decomposition would not affect the shredded rubber tire mulch. Growth of landscape plants did not appear to be reduced with any mulch.

Studies were conducted to determine the effect of shredded rubber tire mulch, Douglas fir bark, stone and stone over black plastic on soil moisture and temperatures. Shredded tire, Douglas fir bark and stone over plastic had noticeably higher moisture levels than either bare soil or soil covered with stone. The use of mulch modified soil temperature. There appeared to be very little difference in mulches as far as their effect on soil temperature was concerned.

Applications

The use of shredded rubber tires as mulch will provide a minimum of two seasons of good weed control in roadside landscape plantings and there is no reason to assume it will not last for several years beyond that. Extended weed control is important in highway maintenance programs because it will eliminate the time and expense necessary for

constant hand weeding of beds and periodic herbicide applications.

Growth will not be reduced by any of the mulches tested. Mulches should be applied a minimum of 2" deep to achieve best weed control.

The benefits of moderating soil temperature fluctuations and conservation of soil moisture on plant growth are obvious. Mulches will reduce the chance of low temperature injuries to plant roots, reducing maintenance costs by minimizing the necessity for frequent replacement of plants due to freezing injury to the roots. By eliminating weed competition, the additional moisture reserve due to mulches is available for growth of roadside landscape plants.

Landscape Plant Response to Different Levels of Four "Slow Release" Fertilizers.

Abstract

The slow release fertilizers magnesium ammonium phosphate, urea-formaldehyde, isobutylidene diurea and spikes of urea-formaldehyde resinated fertilizer (16-8-8) were evaluated for their effect on establishment and subsequent development of landscape plants. The materials were placed in the hole at planting. No further fertilization was provided and the only irrigation was that recommended for establishment the first year. Plant survival appeared to be more affected by the treatments than did growth each year after planting. High levels of various treatments reduced the survival rate of all plant species involved. Plants were especially sensitive to high fertilizer levels.

Results

Viburnum dentatum appeared to be much more sensitive to fertilizers than Fraxinus pennsylvanica or Lonicera morrowii, and was affected even at low rates.

One of the reasons that a large loss of plant material occurred during the first year was the large amount of rainfall during June 1973, after planting. The concentrations of dissolved fertilizer salts in the root zone could have reached sufficiently high levels to have killed the roots of these newly planted trees and shrubs, or at least possibly weaken the plant to where it was unable to withstand ensuing environmental stress.

Applications

Certain plant species will not tolerate even moderate fertilizer additions in the backfill mixture. Further studies should be conducted to select species that will survive the inherent low fertility situations found along roadsides or species that are tolerant to fertilizer additives and will respond with increased survival and growth.

Survival of landscape material grown on disturbed soils of certain roadside sites may not be as limited by the lack of nitrogen as by other environmental factors, such as water stress. Tolerant species and efficient and economic methods to overcome this stress should be sought.

At present, the use of "slow release" fertilizer materials can not be recommended at the time of planting.

Factors Influencing Nitrogen Fixation by

Several Woody Shrubs and Trees

Abstract

The influences of temperature, light intensity, solar radiation and moisture on nitrogen fixation that occurs in root nddules of several species of trees and shrubs were investigated.

Excised nodules of nine plant species have been characterized as to the effect of temperature on their ability to reduce acetylene (C_2H_2) to ethylene (C_2H_4). Nodules from the nonlegumes, with the exception of H. rhamnoides, have a maximum C_2H_2-reduction rate at 30 C. A maximum C_2H_2-reduction rate for nodules from H. rhamnoides and the legume, R. pseudoacacia, occurs at 20 C. At temperatures near freezing the C_2H_2-reducing rate is very low. Reducing activity decreased sharply between 30 C and 40 C for all species except E. angustifolia.

When A. glutinosa and E. umbellata were grown in growth chambers under 950 and 4200 ft-candle light intensities, there was no increase in C_2H_2-reducing ability by nodules from plants under the higher light intensity versus plants grown under the lower light intensity.

Field grown A. glutinosa did indicate response in C_2H_2-reducing a ability due to fluctuation in solar radiation or temperature or both when the plants were not under moisture stress. Ample soil moisture was needed for nodules of A. glutinosa to be responsive to solar radiation or temperature.

Results and Discussion

Nitrogen fixation is the process whereby the gaseous nitrogen in the atmosphere, which is useless to plants as a nutrient, is converted to a form which they can use. One type of nitrogen fixation occurs in a symbiotic relationship between a micro-organism and a woody plant. Not all species of plants appear to be capable of this type of relationship which enables the plant to have use of this supplemental source of nitrogen.

Along Indiana's highways, nitrogen is the most limiting nutrient in the soils. Therefore, the use of nitrogen fixing plants which are capable of converting atmospheric nitrogen into a usable form, appears to be a potential solution to at least this one aspect of the problem. In addition, many nitrogen fixing plants are well adapted to dry, sandy conditions.

Once it has been established that a given species is capable of having a symbiotic relationship with the micro-organism which enables the plant to use this supplemental source of nitrogen, many other factors become relevant. Even a species capable of fixing nitrogen will not necessarily produce the root nodules required for the process, if the environmental conditions are not conducive. The research was an investigation into some of the environmental factors that influence a plant's ability to fix nitrogen.

The influences of temperature, light intensity, solar radiation a and moisture on nitrogen fixation that occurs in root nodules of several species of trees and shrubs were investigated.

Excised nodules of nine plant species [Alnus glutinosa (L.),

Gaertn (European Alder), A. rugosa (DuRoi) Spreng. (Speckled Alder), Comptonia peregrina (1.) Coult. (Sweet fern), Elaeagnus angustifolia L. (Russian olive), E. commutata Bernh. (Silver berry), E. umbellata Thunb. (Autumn olive), Hippophae rhamnoides L. (Sea Buckthorn), Robinia pseudoacacia L. (Black locust) and Shepherida argentea Nutt. (Buffalo berry)] have been characterized as to the effect of temperature on their ability to reduce acetylene (C_2H_2) to ethylene (C_2H_4). Acetylene reduction has been shown by others to be an effective means of determining N_2 fixation by root nodules. Nodules from the nonlegumes, with the exception of H. rhamnoides, have a miximum C_2H_2-reduction rate at 30 C. A maximum C_2H_2-reduction rate for nodules from H. rhamnoides and the legume, R. pseudoacacia, occurs at 20 C. At temperatures near freezing the C_2H_2-reducing rate is very low. The rate increases rapidly as the temperature increases until the maximum rate is obtained. Reducing activity decreased sharply between 30 C and 40 C for all species except E. angustfolia.

When A. glutinosa and E. umbellata were grown in growth chambers under 950 and 4200 ft-candle light intensities, there was no increase in C_2H_2-reducing ability by nodules from under the higher light intensity versus plants grown under the lower light intensity.

Field grown A.glutinosa did indicate response in C_2H_2-reducing ability due to fluctuation in solar radiation or temperature or both when the plants were not under moisture stress. When solar radiation and temperature increased during the day, the rate of C_2H_2 reduced increased. Ample soil moisture was needed for nodules of A. glutinosa to be responsive to solar radiation or temperature.

Nodules from container grown E. umbellata did not respond with increases in C_2H_2 reduction when solar radiation or temperature increased. The lack of response is in part believed to be due to moisture stress. When solar radiation, temperature and evaporation were high, the C_2H_2-reducing ability of the nodules decreased as the day progressed.

Application

It has been determined in strip mine reclamation that it is more difficult to establish plants on south facing slopes. It is believed that this is due to higher soil temperatures and possibly less available moisture. The same conditions have been observed on some south and west facing slopes along the roadsides in Indiana. This research was conducted to determine what envirnmental factors might effect nitrogen fixation by plants that could be used on the roadside. It was determined that both high temperatures and moisture stress reduce nitrogen-fixation and hence would reduce the chances of the plants becaming well established on south and west facing slopes.

Elaeagnus angustifolia fixed nitrogen at high soil temperatures. Elaeagnus umbellata fixed nitrogen at relatively low light intensities. No plants studied fixed nitrogen under moisture stress.

The following recommendations can be made:

1. Continual reseeding of problem areas with the same plants should be stopped. Plants adapted to the conditions should be selected.

2. The use of nitrogen-fixing plants should be encouraged since nitrogen is limiting on most highway soils and the

cost and means of applying fertilizers on a continued basis is not practical.

3. The use of woody nitrogen-fixing species as over story plants to provide shade on south facing slopes until understory plantings are established should be tried. The Elaeagnus species should be considered for this purpose.

4. Plants should be well mulched to conserve moisture until deep root systems are established.

5. Additional research needs to be conducted to determine what other species are adaptable to south and west facing slopes.

Evaluation of Several Methods of Establishing Plant Cover by seeding on the Roadside

Esperiment 1: Seeding of Roadside Slopes with Woody Plant Species.

Abstract

Several woody tree and shrub species were evaluated as to their suitability for direct seeding as roadside slope covers. The seed had received dormant treatments to provide germination. Grass and legume nurse crops were overseeded. Periodic evaluations and plant counts were made. No fertilization or irrigation program was established, however, the seeded area were mulched. Myrica pensylvanica, Rhus copallina, and Alnus glutinosa failed to germinate, and the germination of Taxodium distichum and Rhus typhina was very poor. Germination of Robinia fertilis, Robinia pseudoacacia and Cercis canadensis was good over a period of time. However, survival of the seedling of all germinating species declined over time, probably due to environmental factors, such as water stress. Natural seeding of the area from native plants of R. pseudoacacia and C. canadensis occurred through out the plots and buffer area during the period of this experiment.

Application

The direct seeding of woody species as cover on highway slopes is not currently feasible with current technology. Hovever, recent research in the dormancy and germination of seeds of woody plants have provided some solutions to problems of low germination and timing. Further studies in this area could make direct seeding of woody plants a feasible and economic solution to the problem of providing perennial cover for roadside slopes.

Experiment 2: Erosion Control by Rapid Plant Cover

Abstract

The establishment of rapid by grass and herbacious legume mixtures was evaluated on badly eroded slopes. The gullies were approximately 18" deep. The entire area was mulched with spent mushroom soil after seeding.

All seed washed and collected in the bottom of the gullies. The seed was held in the gullies by the rapid germination of spring oats, and prevented from being washed to the bottom of the slope.

By the end of the second growing season, alfalfa and crown vetch had substantially covered the sides of the gullies. Approximately 50% cover had been established over the slope and erosion in the gullies had been completely halted.

During the third growing season crown vetch has covered approximately 90% of the slope, however coverage in the alfalfa plots was beginning to decline.

Application

It is possible to establish cover on moderately eroded slopes without regrading the area by use of a fine textured mulch and a rapidly germinating nurse crop. The nurse crop will hold the more permanent cover seed in place and reduce erosion. Crown vetch proved to be a more permanent cover than alfalfa.

The ability to reclaim moderately eroded slopes and establish permanent covers with out extensive reworking should reduce the labor and expense necessary for these operations.

Experiment 3: A Comparison of Three Mulch Materials for Covering Newly Seeded Slopes

Abstract

Wheat straw, shredded hardwood bark and shredded rubber tires were compared as mulch materials for covering newly seeded areas. The materials were applied after fertilizing and seeding with travois alfalfa.

During the first two growing seasons hardwood bark and wheat straw were superior to shredded tires and the unmulched check. Fresh weights of the cover indicated bark and wheat mulch were still superior, however growth in the check had nearly caught up to the mulch treatments. Rubber tire mulch was still inferior.

These conclusions may not be applicable to seeding under adverse temperature and moisture conditions as they were not encountered in the experiment.

Applications

Wheat straw or shredded bark will both provide adequate cover for a newly seeded area. The final choice will depend on availability, economics, and ease of application.

Rubber tire mulch is not acceptable for use on newly seeded sites. Newly germinated seedlings were probably killed due to the build up of heat by the dark colored material.

Experiment 4: Evaluation of Several Herbaceous Plants for Direct Seeding on Roadside to Provide Rapid Cover

Abstract

Twenty-six species of grasses and herbaceous legumes were evaluated for their rapidity of cover and hardiness to local environmental conditions. All plots located on level sites and mulched after planting. No fertilization or irrigation program was initiated, however herbicide was applied during the second season to eliminate severe week competition. Observations were made and the growth and coverage of all species were rated. The following species provided excellent or very good cover: Hairy vetch, red clover, alsike clover, tall fescue ryegrass, red fescue.

The evaluation of various herbaceous plants reported here was not performed on the roadside and such research should be the next step. The conclusions therefore are directed at such implementation.

Applications

Hairy vetch and red clover provided a rapid and substantial cover, and should be included in seeding mixtures for roadsides. In addition to providing cover, these legumes are capable of providing nitrogen for other plants in the community.

Other species which provided good two year cover and would also merit use on highway areas include alsike clover, tall fescue, ryegrass and red fescue. The coverage of Teton alfalfa, Korean lespedeza and Serica lespedeza was good the first year but declined the second season. These species can be recommended for situation where only short term cover is desired or as nurse crops.

Conclusion and Practical Application

I. Use of Slow Release Fertilizers for Landscape Plants.

A. Factors other than plant nutrition control establishment of landscape plants on the roadside.

B. Certain plant species do not respond well to the addition of fertilizer in the planting hole.

C. Under certain conditions of poor drainage (tight soils) the slow release fertilizers will dissolve in periods of high rainfall and fertilizer 'burn' can injure newly planted landscape plants.

II. Factors Influencing Nitrogen Fixation by Several Woody Shrubs and Trees

A. The use of nitrogen fixing species should be encouraged for roadside plantings.

1. Nitrogen fixing species will thrive under conditions of low fertility levels without the addition of fertilizer.

2. Herbaceous and woody nitrogen fixing species will improve nitrogen levels in the soil and act as 'nurse' crops for the non-nitrogen fixers being grown on the roadside.

B. Some nitrogen fixing species continue to fix nitrogen at high soil temperatures and should be considered for use on south and west facing slopes.

1. Elaeagnus species appear to be well suited for this purpose.

C. Mulches should be used if the site is droughty to help conserve soil moisture since most nitrogen fixing species do not fix nitrogen when stressed by lack of moisture.

D. If a roadside site is a problem area the environmental causes of the problem should be analyzed and plants that will tolerate the conditions should be selected for the replanting operation.

1. Additional research needs to be conducted to increase the level of knowledge about the plants that will tolerate adverse planting conditions.

III. An Evaluation of Several Mulch Materials on Landscape Plant Growth Weed Control, Soil Temperature and Soil Moisture

A. Use of stone mulch on highway landscape plantings may not provide the most effective material for soil moisture conservation.

B. Shredded rubber tires and Douglas Fir bark both provided superior weed control and modified low soil temperatures by several degrees.

1. These mulches also were better conservers of soil moisture.

C. More permanent weed control probably can be obtained by using shredded rubber tires as the surface becomes very warm and blow-in weed seeds will be killed as they germinate.

D. No mulch material evaluated reduced plant growth. The plants growing under those mulches that provided better weeded control also grew better.

1. This was probably due to loss of weed competition.

E. The cost of obtaining shredded rubber tires may be prohibitive.

IV. Evaluation of Several Methods of Establishing Plant Cover by Seeding on the Roadside

A. At the present the direct seeding of woody plants on the roadside is not practical.

1. Further research is needed to improve and control germination of woody species before this means of establishing trees and shrubs on roadside slopes is practical.

B. The use of a 'nurse' crop such as spring oats may permit the direct seeding of herbaceous perennials on eroded slopes.

1. The 'nurse' crop germinates very rapidly and traps the other seed before it is washed off the slope.

C. Shredded hardwood bark or straw appear to be equally effective as mulches for newly seeded areas.

1. Cost and method of application should determine which material should be used.

2. Shredded rubber tires for this purpose are not satisfactory.

D. The addition of new plant species to the seeding program should be considered. Emphasis should be on nitrogen fixing species.

1. Those nitrogen fixing species that give good rapid cover are hairy vetch, red clover, alsike clover, and Travois alfalfa.

a. These plants should be given a trial on some problem roadside area.

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