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THE UTILIZATION OF NATIVE GRASS SPECIES FOR RECLAMATION OF DISTURBED LAND IN THE ALPINE AND SUBALPINE REGIONS OF ALBERTA

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INTRODUCTION

Asay, in a recent paper dealing with the revegetation of surface raining spoils in the western United States (1978), states that surface mining disturbed approximately four million acres and if all the coal in the United States now considered to be recoverable by strip mining were removed, 46 million acres would eventually be disturbed. I quote these estimates for the United States since they illustrate the immense task of revegetation facing this continent. Estimates reveal that nearly half the land area in Alberta, more than 100,000 square miles, is underlain by coal, of which some 400 billion tons is expected to be ultimately recoverable. While most of Alberta's coal reserves are too deep for surface mining, the sheer size of the resource and the pressures to develop it, portend a steady increase in the numbers of new mines, which signifies a steady increase in the amount of land to be disturbed and to be reclaimed so that "these lands afterwards become at least as productive, if not more so, than it was before", as stated in the Government of Alberta policy for coal development in the Province (June 1976). Some of our large mining spoils in the Province of Alberta are located in the subalpine and alpine regions and it can be expected that more will be created in the future, regardless of the legislative concern for environmentally sensitive areas.

The revegetation of subalpine and alpine regions is somewhat of a misnomer, in that the specification of subalpine and alpine regions would indicate that we deal with a problem which requires a revegetation technique sufficiently different from techniques in use for mountain and lower altitude areas. In principal however this is not the case; revegetation of alpine areas follows the same biological procedures and there is very little reason any more to deal with these disturbances under a special heading. As Soward and Leroy Balzer point out, "there is much potential for reclamation programs to suffer because of poor quality, insufficient quantities and limited varities of commercially available plant materials." Consequently, what has limited us in the reclamation of environmentally sensitive areas, such as subalpine and alpine regions, has been the availability of suitable biological material for reclamation purposes. Until 8 years ago very little breeding work had been done to develop improved varities specifically for mine land revegetation, yet it has been evident from the many failures in revegetation efforts, that no single species or variety will be adapted to the diverse environmental conditions encountered and it has become obvious that new genetic combinations with rather specific adaptive characteristics have to be incorporated into the material to be used in revegetation, be it grasses or other flowering elements. Cuany and co-workers at Colorado State University initiated a breeding and species evaluation program in 1974 to develop improved plant materials for reclamation of oil shale disturbed lands and revegetation of high altitude problem sites. Several native and introduced species were evaluated. Breeding efforts for the oil shale areas were centered around western wheatgrass *(Agropyron smithii),* Indian rice grass *(Oryzopsis hymenoides),* Lupines *(Lupinus spp.)* and Utah sweetvetch *(Hedysarum boreale).* In the high altitude program emphasis was on smooth bromegrass *(Bromus inermis)* and to a lesser extent western wheatgrass and thickspike wheatgrass *(A. dasystachyum)*. Similarly, in 1974, the United States Department of Agriculture and the Forest Service initiated a grass breeding program to complement the existing cytogenetics and plant exploration program. In cooperation with Utah State University an attempt was made by Dr. Dewey to develop new grass varieties for arid range and for reclamation of lands disturbed by surface mining. This project emphasizes crested wheatgrass *(A. cristatum* and *A. desertorium),* and Russian wildrye *(Elymus junceus).* In addition, over 150 interspecific and intergeneric hybrids have been developed from crosses among these species. Several of these hybrids have excellent potential for use on rangeland and for revegetating surface mining spoils.

THE ALBERTA PROGRAM

Independently, similar efforts have been made in Alberta. In 1974 contracts with Alberta Environment, Alberta Fish and Wildlife, Alberta Forestry and Parks Canada, made it possible to start an evaluation program of native grasses originating on the eastern slopes of the Rocky Mountains for eventual use in reclamation efforts in the Province. Dr. Walker and co-workers assembled a large collection of native grasses comprising 37 species from alpine regions of the eastern slopes of the Rocky Mountains and transplanted these isolates to the Experimental Farm of the University of Alberta at Ellerslie at an elevation of 2,500 feet. In subsequent years seed was harvested from this collection and seedlings were raised in the growth-room facilities of the University. These seedlings were planted in small test plots throughout the Rocky Mountains at subalpine and alpine elevations at natural as well as disturbed sites and their performance was observed over several years. The evaluation of these different native grass species took into account several criteria. Survival rate, spreading ability, reproductive ability in terms of the production of mature seed under extreme environmental conditions, were necessarily the most important characteristics for eventual use in reclamation of subalpine and alpine regions. Walker in his initial study was able to recognize those native grass species which were best adapted to the very harsh climate of the alpine region of our mountainous area and therefore of potential importance for revegetation of alpine disturbed sites. The group of grasses based on their applicability can be divided into two groups: the Major Native Grasses to which *Agropyron dasystachyum, riparium, trachycaulum, latiglume, Deschampsia caespitosa, Poa alpinum* and *interior* belong, and the Minor Native Grasses with *Festuca idahoensis, saximontana, Koeleria cristata, Phleum alpinum, Poa cusickii, Trisetum spicatum,* and *Agrostis scabra* as representatives.

GENETIC IMPROVEMENT

After establishment of our initial evaluation plots at Ellerslie Experimental Farm it became evident that all species assembled, represented a broad genetic variation but that some were plagued with cytological meiotic irregularities and sterility problems, which without genetic improvement, would render them unsuitable for commercial production. Selection in the *Agropyron* species was already started in 1976 and after the appointment of Dr. Sadasivaiah, genetic improvement of all species was undertaken. The main criteria used in this selection were:

1. winter hardiness
2. plant vigor and growth habit
3. tillering date
4. heading date
5. disease and insect resistance
6. uniform growth and maturity
7. seed shattering habit
8. seed yield

Of these characteristics winter hardiness, the ability to produce tillers as a means of vegetative reproduction, the ability to flower early in the vegetative cycle of the grass and to produce seed within the growing season and the overall seed yield are the most important. The characteristic of seed shattering, that is to say the ability to shed seed over a prolonged period of time, is of ecological importance, thereby minimizing the effect of adverse weather and other environmental conditions upon the natural process of seed dispersion and seedling establishment. Of the native grass species chosen for genetic improvement, all except *Agrostis scabra* have been grown for at least three selection cycles and as a result of this, sterility problems, as we encountered initially in some of the grasses, have been overcome. Remarkably uniform lines have been established for those species which are self pollinators or apomictic. For a cross-polinating species such as *A. dasystachyum,* isolates from different collection locales were planted together in a breeding field and were allowed to intercross freely. Seed of individual but promising plants was collected and seeded into selection lines. Further selection among these lines have produced high yielding progenies, which although cross-polinating, transfer the ability of high seed yield to their offspring. These polycross selection lines have the advantage of a built-in genetic variation, so highly desirable for the industrial use of this plant material. For instance, genetic variation in heading dates makes it possible to prolong the time of seed dispersal as compared to a highly uniform line which results from selection of a self-pollinating native grass species. It is for this reason that selected lines from self-pollinating species, showing a high degree of uniformity for all the characteristics used in the selection, are in themselves too restricted for reclamation purposes under extreme environmental conditions. In the development of commercial varieties attention has to be paid to the selection of lines differing in heading dates or, in other words, early and later maturing varities have to be established. For reclamation purposes the seed of these lines differing in maturing dates (but similar with regard to drought resistance, shattering habit, winter hardiness and seed yield), are mixed. Such a mixture would allow for a relatively long seed disposal time which especially under severe environmental conditions (as prevails in subalpine and alpine regions) may benefit the natural reproduction of the species. Other grasses such as the Poas and *Deschampsia* are apomictic to a high degree. They tend to reproduce almost true to type and selection in these grasses is relatively simple since a superior isolate will transmit its characteristic to its progeny with little or no segregation. Lines developed in these grasses show a remarkable homozygosity and therefore the actual selection procedure is greatly reduced timewise. So far this selection project with different native species (which is the largest on the continent) has produced several selections which have been registered for licensing. This year selection lines of *A. dasystachyum, A. trachycaulum* and *A. subsecundum* have been submitted to Canada Department of Agriculture and it is envisaged that selected lines of *Poa interior* and *Poa alpina* will become available for licensing some time late 1982 with the rest *(Deschampsia caespitosa, Festuca saximontana, Koeleria cristata* and *Trisetum spicatum)* in subsequent years. A start has been made with the seed increase of selected lines to allow commercial development of these lines within the near future.

EVALUATION OF NATIVE GRASSES

In order to monitor the performance of native grasses, as compared to commercial agronomics, and to determine a method of revegetation for disturbed areas at high elevation, a large testing area was established in 1977 at the Ptarmigan site of Whitehorn Mountain in the Lake Louise ski area beside the Trans Canada Highway, 40 miles west of Banff. The Ptarmigan site has an elevation of 2,290 m (7,50O[1]) and is located just above the treeline. The site faces east and has a slope of varying degrees ranging from 30 to 10. This site was disturbed by bulldozing equipment during the construction of the ski run. The soil structure is a coarse glacial till with a large amount of rocky material of all sizes. The soil analysis characterizes this soil as high in potassium (148 lb./acre). Nitrogen is present at 3 lb./acre, phosphorus at 11 lb./acre and sulphur at 2.7 ppm. The number of frost-free days during the summer season varies between 45 to 58. The following parameters were incorporated into the experiment:

1. Nineteen species of native grasses were planted to compare against each other and against four commercially available varieties in nine replications.

2. Two rates of inorganic fertilizer 26-13-0 at 100 kg/ha and 25 kg/ha were applied to six of the replications. Three replications were left untreated for a control.

3. A light covering of peat moss was applied to the seeded species of grass to determine if seedling establishment can be improved by this treatment. This test was replicated three times.

4. The effect of different gradients of slope was monitored. Three replications were at a slope of 30°, three were at 20° and three were at 10°.

The testplot was evaluated in 1980. The plots were examined for vegetative growth, ground cover and ability of species to reproduce. Those species which showed good ground cover and also flowered in most plots, were considered valuable in reclamation programs of high elevations.

The various species used in this study showed significant differences in their performance. In general, the native species performed better than the agronomic species, which due to their late flowering in the alpine season are unable to reproduce. Some of the native species that were found to be superior in their ability to survive and reproduce under alpine conditions were *Agropyron latiglume, Agropyron dasystachyum, Agropyron trachycaulum, Agrostis scabra, Deschampsia caespitosa, Festuca saximontana, Festuca rubra, Phleum alpinum, Poa alpina, Poa interior,* and *Trisetum spicatum.*

The application of a peat mulch did not have a significant influence on seedling establishment; however one has to take into account that a sloped area was used with an angle variation of 30° to 10°. Light material such as a peat mulch may have slid off the site applied or blown away before it could become effective. Notwithstanding this, there is some evidence that some grasses react adversely to mulching. From the percentage seedling establishment it can be deduced that mulching at the time of seeding is not required.

Similarly the application of fertilizer at the time of seeding had no effect. These results correlate with those obtained at Ellerslie Farm of the University of Alberta where no significant differences were observed between fertilized and unfertilized test rows. For genetic reasons these results can be predicted. The native grasses collected by us originated from areas where environmental conditions including soil conditions were extremely poor and hence these native grasses acquired in time a hereditary low requirement for nutrients as they did for tolerance toward the economic niche in which they developed. Native grasses at alpine elevations are slow growing but persistent. They flower very early during the alpine summer and are able to produce mature seed. It is our view that very little can be gained by fertilization at these altitudes and indeed, there are more drawbacks to this than benefits. The alpine summer is extremely short and the combination of fertilizer, drought and late rains may extend the growing season of the native grasses beyond the time that these grasses have to become dormant. Although long term fertilization of native grasses may have an aesthetic influence by increasing biomass, there is no evidence that such a fertilization program will greatly influence the tillering ability of the native grasses and no evidence that it has an influence on seedling establishment. As with many things in life, time is what is needed in order to come to good results. In the reclamation of sub-alpine and alpine spoils time is a most important factor.

Due to their low nutrient requirement as a genetic adaptation to the alpine environment, native grasses are slow growing at alpine sites, and hence it is unreasonable to expect instant coverage. Overseeding, a practice not uncommon to reclamation, is no solution to improve initial coverage. Our experiences with native grasses points to the fact that it will take approximately three years before these grasses reach maturity and become reproductive. The tolerance of native grasses toward the substrate is most remarkable. Our test plots at 6,500' at Sunshine Valley all located on a shale slag with a minimum of fine soil material indicates that although slow growing, native grasses are able to establish themselves at this high altitude regardless of the poor soil condition. Sowards and co-workers in their publication on seed procurement of native species of plants for arid land reclamation, state that the quality of plant materials used in reseeding disturbed lands probably has as much impact on the success or failure of a revegetation project as any factor subject to the control by the reclamation specialist. This issue is particularly timely with present emphasis on coal development. It would be in Canada's interest to follow the United States in this respect who now require that mine operators use native plant species to reclaim lands to equal or better production and moreover to enforce adequately the regulation that the operator proves his ability to successfully reclaim the land before a permit to mine will be issued by the regulatory authority.