TREE IMPROVEMENT NEEDS IN WINDBREAK SPECIES-USERS' VIEWPOINT

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Abstract.--While windbreaks have been planted in the plains area of the United States for many years, relatively little breeding effort has been expended on common trees used in these plantings. Future work should be concentrated on high priority species with the aim of improving initial survival, growth rate, insect and disease resistance, form, and drought resistance. Renewed emphasis on the use of source-identified seed and establishment of larger, better designed provenance tests is needed. Applied breeding programs need to be implemented with species for which we have sufficient knowledge of genetic variation patterns.

Additional keywords: Windbreaks, shelterbelts, tree improvement, eastern redcedar, Rocky Mountain juniper

The lack of trees has been an area of concern almost from the time the first settlers arrived on the Great Plains. They were accustomed to the more heavily wooded areas of the eastern U. S., and began planting trees almost immediately. Their efforts were poorly organised, and lacked coordination until the U. S. Forest Service instituted the Prairie States Forestry Project (1935-1942). This project provided direct assistance to land owners in planning and planting windbreaks and shelterbelts (Read, 1964).

Sometimes distinction is made between windbreaks and shelterbelts, though the two are similar. A windbreak is simply a planting of one or more rows of woody plants on the north and west sides of a farmstead or livestock feedlot providing protection from winter winds and snow. Often a row of deciduous trees is also placed along the south side of a farmstead for summer wind protection. Shelterbelts or field windbreaks differ in the type of areas they are designed to protect. Shelterbelts are composed of one or more rows of plants placed on the north and west sides of field crop land for protection from wind erosion, and to aid in snow dispersal. Also, summer fallowed or irrigated fields sometimes have rows along their south sides for summer wind protection.

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WINDBREAK ESTABLISHMENT FACTORS

While there is certainly a great deal of research left to be done in the area of windbreak design and culture, greater emphasis should be placed on establishment. We have, in fact, been doing this for many years now with limited success. One reason for this limited success lies in the fact that there is often a broad gap between general knowledge of how to perform a task and actually performing it. That is where we are now with respect to windbreak establishment. We know what we want, and usually know how to do it; but, difficulties are encountered when we attempt to plant windbreaks. These establishment difficulties result from a variety of environmental factors over which we have little or no control. Among the more important are:

1. Moisture

The Great Plains is a very difficult area in which to establish trees. While there is theoretically sufficient moisture throughout the area to permit establishment, in practice, lack of soil moisture is perhaps the largest single deterrent to success. Rainfall averages for the entire plains area vary from approximately 10 to 40 inches per year. The problem is--we seldom experience anything approaching an average year. Normally, tree planters either wallow in a sea of mud, or choke in a cloud of dust.

2. Wind

A second problem that interferes with successful planting is wind. Because of the continental climate and openness of the landscape, the Great Plains are characterised by high wind velocities. This, of course, leads to a high evaporation rate, and serves to compound the problem of insufficient soil moisture.

3. Temperature

A third environmental problem closely intertwined with the previous two is that of growing season temperatures. Virtually all of the plains area experiences summer temperatures in excess of 100°F, sometimes greater. This in itself is no real problem for the plants from a strictly biological sense; however, combined with the low rainfall patterns and high wind velocities, the heat compounds the moisture problem.

Plants often experience injury during the cold months of the year. This damage takes many forms, depending on the species of plants involved. While some plants are killed outright from the cold temperatures, more often they are damaged by early fall or late spring frosts, or suffer desication during warm spells when soils are still frozen, preventing root absorption.

4. Soils

Yet another environmental problem causing difficulty during establishment of a windbreak relates to soils. Large areas in the plains states are so affected. In general, problem soils are either highly alkaline or saline. Both situations, if severe, substantially limit the choice of species to be used in designing a windbreak.

5. Planting Experience

The last establishment problem which should be mentioned relates to the experience of the planters. At least in Kansas, virtually all of the tree planting is done by small, non-industrial private land owners. Most are farmers having no experience in tree planting. The number of ways to limit success is almost endless. This is an educational and not a breeding problem, but it should be recognized as part of the overall problem of establishment.

TREE CHARACTERISTICS

Since the major emphasis of this meeting is on forest genetics and tree breeding, characteristics that should be considered in a breeding program with windbreak species are:

1. Initial survival

This characteristic is really a conglomerate of many other more specific characteristics. High initial survival is an important consideration in any breeding program, but it becomes critical when one considers the types of high stress sites found in the plains states.

All too often, new windbreak plantings are total failures due to poor survival. Part of the problem, as Read (1976) has pointed out, is that we are using many non-native plants whose populations have not been sufficiently sampled to find those sources best adapted to the plains area. In many cases, only one or at most a few sources of seed have been used for a particular species. Many of these species, while useful, are not well adapted to the environment in which they are planted. To solve the problem of survival, we are probably going to have to examine a number of factors such as root structure, cold hardiness, heat tolerances, juvenile growth rate, drought tolerance in juvenile stages, and perhaps others.

In my opinion, the single most important characteristic a potential windbreak species must possess is a high survival rate. In most cases, a fully stocked windbreak may be lacking in a number of other characteristics, and still perform its function; however, a windbreak with 50% stocking is practically useless.

2. Growth rate

Growth rate is another important characteristic in any breeding program. First, early rapid growth will quickly get the plant above herbaceous competition, which is a serious problem in windbreak establishment, therefore insuring better survival, and reducing the amount of care one must take of the planting. Second, it shortens the time between windbreak establishment and the time the planting reaches sufficient height to provide adequate protection.

3. Insect and disease resistance

As with the production of almost any crop, windbreak species have their share of insect and disease problems. Many of these problems could be solved by better matching species to site, or by using better adapted sources. The correct matching of species or source to site will result in more vigorous plants, and indirectly result in better resistance to insect and disease attack. Some of the more common pests affecting windbreak species are--tip moth on ponderosa pine; woodborers on cottonwood, honeylocust, green ash, and common lilac; Dothistroma needle blight on Austrian pine; elm leaf beetles and bacteria wetwood on Siberian elm, and probably many others.

Breeding resistance to pests is difficult; however, significant progress has been made in some species. Some of the most useful information to come out of the Ponderosa Pine Provenence Test, which the U. S. F. S. started a number of years ago, is the identification of three seed sources which appear to be highly tolerant of tip moth damage.

4. Form

With windbreak species, we are not as concerned about form as we are about the production of strong trees reasonably resistant to breakage from wind, ice, and snow. Desirable form characteristics would include a reasonably straight stem, no forks, and branches forming large angles with the main stem. Trees with reasonably dense crowns are more desirable than those with thin crowns because they are less permeable to air movement.

5. Drought resistance

The need for this characteristic is evident to anyone familiar with the climate of the plains region. Though we may be able to establish many species or sources of trees on the plains in a near normal year, drought years such as 1980 always lead to problems. Trees either die outright, or become so weakened they succumb to secondary problems such as insects or disease. Plants are needed that are equipped to deal with moisture deficits through efficient

water use, or by means of drought avoidance mechanisms such as leaf abscission.

6. Herbicide tolerance

Herbicide damage to windbreak trees is a problem that is growing in importance throughout the plains area. Numerous examples of damage to trees following agricultural pesticide applications surface each year. Perhaps we should be screening individual genotypes for herbicide tolerance.

There are probably many other important traits in the area of genetic improvement of windbreak species; however, traits mentioned here indicate the general areas in need of study.

SPECIES PRIORITIES

Inevitably, one has to deal with the problem of what species should have priority in a breeding effort. This is difficult because of the vast array of plants available which hold at least some promise. The GP-13 Cooperative Regional Project Outline written in April, 1974, was used to evaluate species needs throughout the plains area. The outline included a list of species which members from plains states had rated as high priority species for improvement work in their respective states. The list included. 94 species--far more than any organization could possibly handle at once. The GP-13 Committee chose to work on the two common junipers--Eastern redcedar and Rocky Mountain juniper; however, the list of high priority species they developed is still one of the best evaluations on "felt" need in tree improvement for the Great Plains.

Selecting only species listed by at least five of the GP-13 cooperators as high priority trees in their area, the following list of gymosperm and angiosperm species was developed.

Gymnosperms

Gymnosperm species meeting the high priority criteria as defined above include the following species: Rocky Mountin Juniper (*Juniperus scopulorum* Sarg.), eastern redcedar (*Juniperus virginiana* L.), Austrian pine (*Pinus nigra* Arnold), Scotch pine (*Pinus sylvestris* L.), Colorado blue spruce (*Picea pungens* Engelm.), and Siberian larch (*Larix sibirica* Ledeb.). It is interesting that these species are currently part of breeding efforts by many agencies. Some of these species have been the subject of research for many years though not always for the purpose of improving them as windbreak plants.

One important species not on this list is ponderosa pine (*Pinus ponderosa* Laws). When the list was compiled, the Committee

believed that sufficient effort was being devoted to this species. While this was true then, results of that early work provided knowledge which should be expanded through new and redirected studies of ponderosa pine.

Angiosperms

The angiosperm species listed by the GP-13 Committee were: black walnut (Juglans nigra L.), green ash (Fraxinus pennsylvanica Marsh.), hackberry (Celtis occidentalis L.), Russian olive (Elaeagnus angustifolia L.), Poplus spp., and bur oak (Quercus macrocarpa Michx.). Again, most of these species are the subject of current research or breeding efforts. A couple of notable exceptions are bur oak and Russian olive. Although most are important windbreak species, no breeding effort appears to be currently underway for them. Two species omitted by the GP-13 Committee but deserving of breeding effort are the Siberian elm (Ulmus pumila) and Osage orange (Maclura pomifera (Raf.) Schneid). Both plants suffer poor reputations for various reasons, but have potential in the high plains region.

In two previous listings, no shrubs were listed. If we should be criticized for past emphasis, this is the vulnerable area. With the exception of some work by various SCS Plant Material Centers, little or no attention has been given to shrubs. Three species in this category having high priority are chokecherry (Prunus virginiana L.), American plum (Prunus americana Marsh.), and common lilac (Syringa vulgaris L.).

BREEDING EFFORT

Little can be added to breeding efforts that hasn't already been suggested by many researchers in the plains states; however, it may be appropriate to emphasize some points made by previous investigators.

1. Source-identified seed

Identification of seed source is one of the quickest and easiest ways of assuring reasonably well-adapted material for use in any given area. Provisional Tree and Shrub Seed Zones for Plains Region has been published by Cunningham (1975) but, although almost everyone agrees the information should be used, it often is not. Another problem is that the desired seed source is often inaccessible to individual states, for instance, the Yugoslavian source of Austrian pine seed and the Niobrara River source for Ponderosa pine. A central seed collection agency is needed which can make infrequent, large bulk collections to serve multi-state areas' needs.

2. Provenance testing

Many of the provenance tests currently underway were

designed as first steps in evaluating the variations within the species. This is particularly true of the research on species needing improvement where many of the tests were limited, and contained a few sources from widely separated points within the natural range of the species. Some contained too few replications, or were planted in only one location. With many species, larger, better designed tests are in order.

3. Breeding

The previous two points are forms of breeding; however, a narrower meaning of the term is used here. With many species, we have sufficient knowledge to allow us to progress beyond provenance testing, and to begin to select plants for use in control cross-breeding schemes, or for inclusion in production seed orchards Two examples are Austrian pine and Ponderosa pine.

4. Plant introductions

Plant introductions might have been listed as the first priority under methods of improvement; however, it is being mentioned last intentionally because it is least important now. As Read (1976) and others have pointed out, there are many species that may have potential use as windbreaks, but have yet to be tested. However, our emphasis should be placed on species currently used, rather than dissipating our limited money, time, and effort on a large number of unknown plants.

SUMMARY AND CONCLUSIONS

The challenge to the plant breeder from the user viewpoint is fairly simple. What is needed is a number of angiosperm and gymnosperm plants in a range of sizes at maturity with extremely high survival capability, good form, rapid growth rate, insect and disease resistance, and wide adaptability to severe climates and soils. These plants should be easy to grow in greenhouse or nursery situations, and be capable of surviving the most abusive forms of planting.

LITERATURE CITED

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