TREE IMPROVEMENT ACTIVITIES INVOLVING WINDBREAK SPECIES

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Abstract.--Current genetic research and tree improvement activities in the Great Plains are summarized. Fifty-three species of trees and shrubs are under study. Over 20 traits are listed as in need of improvement with growth rate, survival, disease resistance, crown form, and drought resistance most important. Tables summarize the activities of 18 agencies or institutions. Additional tables summarize, over agencies, work being done on nine major species.

Additional keywords: Windbreaks, shelterbelts, tree improvement, genetic improvement.

My interpretation of the task I have been asked to perform by serving on this panel today is to answer the following questions: (1) Who is conducting research in the genetic improvement of windbreak species, (2) which species are being improved, and (3) Which traits are being improved.

METHODS

The procedure I used to answer these questions involved the use of a questionnaire form that I sent to 22 agencies and institutions who I believed were involved in the genetic improvement of trees or shrubs for use in windbreaks. The response to my request was gratifying. Eighteen people responded by filling out a form of the type shown in Table 1. All of the forms that were returned were typed and copies of the whole packet of forms from the 18 respondents are available upon request from the author. The names and addresses of the respondents are listed in Table 2. The forms were summarized and the results are shown in Tables 3-12.

RESULTS AND DISCUSSION

A total of 53 different woody species are being improved. Thirty-six are angiosperms and 17 gymnosperms. Table 3 lists the species and the institutions or agencies working on each species. The species receiving the greatest attention, listed in order of decreasing activity are: junipers; green ash; poplars; hackberry; ponderosa pine; Scotch pine; and the spruces, primarily blue, white, and Engelmann.

At least 20 different traits are receiving attention (Table 4). Of highest priority are growth rate, survival, disease resistance, crown form, and drought resistance.

In Tables 5-12 I have summarized the activities of the various respondents working on the major species. A brief summary of the major activities involving each of these species follows:

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Green ash

Six respondents in Montana, North Dakota, South Dakota, and Nebraska are working with green ash (*Fraxinus pennsylanica* Marsh.). Activities include provenance tests, seed orchards, and one cultivar release.

The major traits under improvement include survival, growth rate, crown density, pest resistance (primarily the ash borer and carpenterworm), and drought resistance.

The source populations include 105 origins, 154 clones, 63 half-sib families, and one cultivar 'Cardan' which has been cooperatively released by the USDA-ARS and the USDA-SCS. Fifteen different sites are involved and total 33.24 acres.

Several pounds of open-pollinated seed of 'Cardan' have been distributed to nurserymen.

Poplars

Six respondents in North Dakota, South Dakota, Nebraska, and Saskatchewan are attempting to improve the hybrid poplars (Populus sp.) and the eastern cottonwood (*P. deltoides* Bartr. ex Marsh.), or Plains cottonwood (*P. deltoides* var. *occidentalis* Rydb.). A wide variety of activities include provenance tests, clone banks, clonal tests, breeding arboretums, progeny tests, hybridization, and cultivar releases.

Major traits under improvement are growth rate, resistance to stem cankers and leaf rusts, drought resistance, survival, and winter hardiness.

About 323 clones have been selected. Three cultivars have been released by the University of Nebraska. They are 'Platte,' 'Mighty Mo,' and 'Nor' Easter.' Ten sites occupy a total of 16.83 acres.

The Nebraska Forest Service is distributing 40-50 thousand cuttings of improved clones per year through their Clarke-McNary program.

Siberian elm

Three respondents in Montana, North Dakota, and South Dakota are trying to solve the many problems that plague Siberian elm (*Ulmus pumila* L.). Their activities include superior tree selection, clone bank establishment, species hybridization, and seed collection from a superior seed source.

Major traits in need of improvement are resistance to stem cankers and cankerworms, crown form, crown density, and growth rate.

Over 241 phenotypically superior trees have been selected, several F1 and backcross hybrids have been developed, and one superior seed source has been identified. Three sites occupy a total of six acres.

About one pound of open-pollinated seed has been collected from the superior seed source.

Hackberry

Five respondents in North Dakota, South Dakota, Nebraska, and Kansas are involved in the improvement of hackberry (Celtis occidentalis L.). Field testing, provenance testing, and the development of a seed production area are their primary concerns.

Growth rate, cold tolerance, drought resistance, survival, and insect resistance are under improvement. Thirty origins and 250 selected trees are being tested or propagated on 8.4 acres of land.

Junipers

Seven respondents in Montana, North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma are testing Juniperus scopulorum Sarg. and J. virginiana L. primarily as a part of the cooperative GP-13 Technical Committee's provenance test. A seed orchard of J. virgini ana has been established by the Nebraska State Forest Service.

Major traits to be improved include survival, growth rate, and disease resistance. At least 205 origins are being tested on eight sites totaling 56.5 acres.

Ponderosa pine

Eight respondents in Montana, North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma are interested in ponderosa pine (Pinus ponderosa Dougl. ex Laws.). The major activity is the provenance test initiated by the Forest Service. Seed production areas and seed orchards have also been established.

Improvement are sought in growth rate, survival, resistance to tip moth (Rhyacionia sp.) and pitch nodule moth (Petrova sp.), winter burn resistance, and crown density.

A base population of 81 origins and 161 select trees are being tested on 14 sites comprising 119 acres.

Scotch pine

Five respondents in North Dakota, Nebraska, and Saskatchewan are interested in Scotch pine (Pinus sylvestris L.) for windbreaks. Major activities involve provenance tests, progeny tests, seed collection areas and seed orchards.

Of greatest concern is the improvement of survival, growth rate, crown density, foliage color, and drought tolerance. The germplasm base is composed of 85 origins, 71 clones, 230 full-sib families, and 30 half-sib families. Eighteen sites occupy a total of 50 acres.

Over 22 pounds of open-pollinated seed has been collected from selected origins in a North Dakota provenance test.

Spruce

Four respondents in North Dakota, Nebraska, and Saskatchewan are involved in the improvement of Colorado blue spruce (*Picea* pungens Engelm.) and to a limited extent Engelman spruce (*P. engelmannii* Parry ex Engelm.). The major activity involves the blue spruce-Engelman spruce provenance test initiated by Michigan State University. The North Dakota Forest Service is also selecting phenotypically superior blue spruce in windbreaks and ornamental plantings.

Objectives include improvement of survival, growth rate, foliage color, and branch angle. Forty-five origins, 229 half-sib families, and 145 selected trees are being evaluated at 5 sites involving nearly six acres of land.

SUMMARY

Considerable effort and resources are involved in the genetic improvement of trees and shrubs for use in windbreaks. Both research and action agencies are attempting to improve 52 woody species in one or more of 20 traits. Most activities involve the early stages of a genetic improvement strategy such as provenance testing. These basic steps should form the foundation for the more sophisticated breeding programs that are necessary to provide well adapted tree and shrub cultivars for planting in field and farmstead windbreaks.

Table 1.-- Example of questionnaire on windbreak tree improvement activities.

STATE	Nebraska	PERSONNEL	William R. Lovett	DATE	
ORGANIZATION	Nebraska State Forest Service & Dept.		Dr. James R. Brandle	REPORTER	WRL
LOCATION	Forestry, Fisheries & Wildlife; Univ.		Bruce Bolander		
	of Nebraska; Lincoln, NE 68583				

ACTIVITY	SPECIES	MAJOR TRAITS	POPULATION SIZE	NUMBER OF SITES	AVERAGE ACREAGE PER SITE	QUANTITY IMPROVED PROPAGULES
Provenance test	Fraxinus pennsylvanica	Growth rate, drought tolerance	43-1/2 sib families	1	3	--
Clonal tests	Populus sp.	Growth rate, resistance to stem cankers, drought tolerance	13 clones	3	1	--
Seed orchard	Pinus sylvestris	X'mas form & color	42 clones	1	15	7 lbs OP seed
Seed orchard	Pinus nigra	Dothistroma resistance	(1 source) 308 seedlings	1	5	--
Provenance/ 1/2 sib progeny test	Acer saccharinum	Survival, growth rate, form, drought tolerance	120-1/2 sib families	3	10	--

Table 2. --Agencies and institutions involved in windbreak tree improvement activities

1. PFRA Tree Nursery
   Indian Head, Saskatchewan
   CANADA

2. Montana Department of Natural
   Resources and Conservation
   2705 Spurgin Road
   Missoula, MT 59801

3. Montana Interagency Tree
   or Shrub Improvement Study (MITOSIS)
   c/o Mr. Harold Hunter
   USDA-Soil Conservation Service
   P. O. Box 9780
   Bozeman, MT 59715

4. USDA-Forest Service
   Shelterbelt Laboratory
   1st St. & Brander
   Bottineau, ND 58318

5. Plant Materials Center
   USDA-Soil Conservation Service
   Federal Building, Box 1458
   Bismarck, ND 58501

6. Northern Great Plains Research Center
   USDA - Agricultural Research Service
   P. O. Box 459
   Mandan, ND 58554

7. North Dakota Forest Service
   NDSU - Bottineau Branch
   Bottineau, ND 58318

8. Horticulture and Forestry Department
   South Dakota State University
   Brookings, SD 57006

9. South Dakota Division of Forestry
   Big Sioux Tree Nursery
   Watertown, SD 57201

10. Nebraska State Forest Service
    Room 101, Plant Industry Bldg.
    University of Nebraska, East Campus
    Lincoln, NE 68503

11. Department of Forestry
    107 Plant Industry Bldg.
    University of Nebraska, East Campus
    Lincoln, NE 68583

12. USDA-Forest Service
    Forestry Sciences Laboratory
    University of Nebraska, East Campus
    Lincoln, NE 68583

13. Department of Forestry
    Call Hall
    Kansas State University
    Manhattan, KS 66506

14. Plant Materials Center
    USDA-Soil Conservation Service
    Box 314
    Manhattan, KS 66502

15. Department of Forestry
    Oklahoma State University
    Stillwater, OK 74074

16. USDA-Soil Conservation Service
    Box 17107
    Denver, CO 80217

17. Colorado State Forest Service
    Colorado State University
    Fort Collins, CO 80521

18. Department of Horticulture
    New Mexico State University
    Las Cruces, NM 88001

Table 3.--Woody species being improved for use in windbreaks and the agencies or institutions involved.

SPECIES	AGENCIES OR INSTITUTIONS[a/]
Acer saccharinum	5, 10
Atriplex canescens	16
Celtis occidentalis	5, 8, 9, 11, 14
Celtis reticulata	14
Colutea arborescens	16
Crataegus sp.	5
Elaeagnus angustifolia	2, 3, 5, 11
Elaeagnus umbellata	10, 11
Fraxinus americana	11
Fraxinus nigra	5
Fraxinus pennsylvanica	2, 3, 4, 5, 8, 9, 10, 11
Gleditsia triacanthos	5
Juglans nigra	11
Juniperus scopulorum	3, 4, 6, 8, 10, 12, 13, 15
Juniperus virginiana	4, 6, 8, 10, 12, 13, 15
Larix leptolepis	12
Larix sibirica	10
Lonicera maackii	5, 10
Malus baccata	3
Malus hupehensis	4, 12
Picea engelmannii	3, 4, 7, 12
Picea glauca	1, 3, 4, 7, 12
Picea pungens	12
Pinus banksiana	18
Pinus brutia	6, 17
Pinus contorta	18
Pinus eldarica	18
Pinus halepensis	10, 12
Pinus nigra	2, 3, 4, 7, 9, 12, 15, 17
Pinus ponderosa	1, 4, 7, 9, 10, 12, 17
Pinus sylvestris	11
Platanus occidentalis	6, 17
Populus angustifolia	3, 6, 10, 11
Populus deltoides	1, 3, 6, 9, 10, 17
Populus hybrids	17
Populus tremuloides	6, 16
Potentilla fruticosa	3, 5, 14
Prunus americana	14
Prunus angustifolia	5
Prunus armeniaca	5, 10
Prunus virginiana	3
Pseudotsuga menziesii	9
Pyrus ussuriensis	3, 5, 11
Quercus macrocarpa	11

Table 3. -- Continued

SPECIES	AGENCIES OR INSTITUTIONS
Quercus rubra	10, 16
Rhus trilobata	9
Salix sp.	5
Shepherdia argentea	14
Thuja orientalis	14
Ulmus parvifolia	3, 6, 8
Ulmus pumila	6, 8
Ulmus rubra	1, 6

a/ Number codes shown in Table 2.

Table 4.--Traits being improved in windbreak species

TRAIT	TIMES MENTIONED[a/]
Growth rate	73
Survival	47
Disease resistance	20
Form	17
Drought resistance	13
Foliage color	7
Crown density	7
Insect resistance	6
Fruit production	5
Cold tolerance	4
Vigor	3
Apical dominance	2
Seed production	2
Flowering	2
Pest resistance	1
Frost tolerance	1
Thornless	1
Winter burn resistance	1
High altitude adaptation	1
Leaf fall	1

a/ Total number of times trait was listed for each species by all respondents.

Table 5.--Windbreak tree improvement activities involving Fraxinus pennsylvanica

AGENCY	ACTIVITY	TRAITS	POPULATION SIZE	NUMBER OF SITES
Montana Div. Forestry Missoula, MT	Seed Orchard	Survival, growth rate	20 families 300 trees	1
U.S. Forest Service Shelterbelt Lab Bottineau, ND	Provenance Test	Survival, growth rate, pest resistance, crown density	33 origins	5
	Seed Orchard	Survival, growth rate, pest resistance, crown density	74 clones	1
	Seed Orchard	Survival, growth rate, pest resistance, crown density	59 clones	1
South Dakota S. U. Horticulture-For. Dept. Brookings, SD	Provenance Test	Growth rate	7 origins	1
	Provenance Test	Growth rate	18 origins	1
Nebraska State Forest Service Lincoln, NE	Provenance Test	Growth rate, drought tolerance	43 half-sib families	1
Dept. of Forestry Lincoln, NE	Provenance Test	--	47 origins	3
	Seed Orchard	--	20 origins 80 selected trees	1
USDA-ARS Mandan, ND and USDA-SCS Plant Materials Center Bismarck, ND	Cultivar Release	Survival, growth rate	'Cardan'	

Table 6.--Windbreak tree improvement activities involving Ulmus pumila

AGENCY	ACTIVITY	TRAITS	POPULATION SIZE	NUMBER OF SITES
USDA-ARS Mandan, ND	Clone Bank	Resistance to: stem cankers, cankerworms; crown form & density	161 select trees	1
South Dakota Dept. of Forestry Brookings, SD	Hybridization	Growth rate, disease resistance		1
MITOSIS Missoula, MT	Superior Seed Source	Condition, height	80 select trees	1

Table 7.--Windbreak tree improvement activities involving Populus sp

AGENCY	ACTIVITY	TRAITS	POPULATION SIZE	NUMBER OF SITES
USDA-ARS Mandan, ND	Clone Bank	Resistance to: stem cankers, leaf rust, drought, winter damage	180 clones	1
	Breeding Arboretum	Resistance to: stem cankers, leaf rust, drought, winter damage	66 clones	1
South Dakota Div. of Forestry Watertown, SD	Clonal Test	Survival, growth	11 clones	1
Nebraska State Forest Service Lincoln, NE	Clonal Tests	Growth rate, drought tolerance, resistance to stem cankers	13 clones	3
	Stool Beds	Growth rate, drought tolerance, resistance to stem cankers	13 clones	1
Univ. of Nebraska Dept. of Forestry Lincoln, NE	Provenance Test	Growth rate, drought tolerance, resistance to stem cankers	119 clones	1
	Progeny Test			1
	Cultivar Release	Growth rate, drought tolerance, resistance to stem cankers	3 named cultivars	--
PFRA Tree Nursery Indian Head, Sask.	Hybridization	Survival, pest resistance	3 F_1 families 105 selected trees	1

Table 8.--Windbreak tree improvement activities involving Celtis occidentalis

AGENCY	ACTIVITY	TRAITS	POPULATION SIZE	NUMBER OF SITES
USDA-SCS Plant Materials Center Bismarck, ND	Field Testing	Survival, growth rate, cold tolerance	1 origin	
South Dakota Dept. of Forestry Brookings, SD	Provenance Test	Growth rate, cold tolerance	6 origins	1
South Dakota Div. of Forestry Watertown, SD	Seed Production Area	Growth rate	250 selected trees	1
Univ. of Nebraska Dept. of Forestry Lincoln, NE	Provenance Test		5 origins	1
USDA-SCS Plant Materials Center Manhattan, KS	Provenance Test	Resistance--drought --insects	18 origins	6

Table 9.- Windbreak tree improvement activities involving Juniperus scopulorum & J. virginiana

AGENCY	ACTIVITY	TRAITS	POPULATION SIZE	NUMBER OF SITES
U.S. Forest Service Shelterbelt Lab Bottineau, ND	Provenance Test	Survival, growth rate, disease resistance	144 origins (half-sib families)	1
USDA-ARS Mandan, ND	Provenance Test	Survival, growth rate, disease resistance	144 origins (half-sib families)	1
South Dakota Dept. of Forestry Brookings, SD	Provenance Test	Survival, growth rate, disease resistance	140 origins	1
U.S. Forest Service Forestry Sciences Lab Lincoln, NE	Provenance Test	Survival, growth rate, disease resistance	205 origins	2
Nebraska Forest Service Lincoln, NE	Seed Orchard (J. virginiana)	Growth rate	250 seedlings	1
Kansas Forest Service Manhattan, KS	Provenance Test	General adaptation	168 origins	1
Oklahoma State Univ. Stillwater, OK	Provenance Test	Survival, growth rate	168 origins	1

Table 10.--Windbreak tree improvement activities involving Pinus ponderosa

AGENCY	ACTIVITY	TRAITS	POPULATION SIZE	NUMBER OF SITES
Montana Div. Forestry Missoula, MT	Seed Collection Areas	Growth rate, survival	--	3
U.S. Forest Service Shelterbelt Lab Bottineau, ND	Provenance Test	Survival, growth rate, pest resistance, crown density	79 origins	1
South Dakota Dept. of Forestry Brookings, SD	Provenance Test	Growth rate, winter injury, pest resistance	73 origins	1
South Dakota Div. of Forestry Watertown, SD	Provenance Test	Growth rate, survival	80 origins	2
U.S. Forest Service Forestry Sciences Lab Lincoln, NE	Provenance Test	Survival, growth rate, pest resistance	80 origins	4
Kansas State Univ. Dept. of Forestry Manhattan, KS	Provenance Test			
Oklahoma State Univ. Stillwater, OK	Provenance Test	Survival, growth rate	40 origins	1
North Dakota Forest Service Bottineau, ND	Seed Orchard (grafted)	Growth rate, vigor, winter-burn resistance	161 select trees	
	Seed Production Area	Growth rate, vigor, winter-burn resistance	2 origins	2

Table 11.--Windbreak tree improvement activities involving Pinus sylvestris

AGENCY	ACTIVITY	TRAITS	POPULATION SIZE	NUMBER OF SITES
U.S. Forest Service Shelterbelt Lab Bottineau, ND	Provenance Test	Survival, growth rate, crown density, winter color	49 origins	3
	Progeny Test	Survival, growth rate, crown density, winter color	30 full-sib families	5
Nebraska Forest Service Lincoln, NE	Seed Orchard	Crown form, color and density	42 clones	1
U.S. Forest Service Forestry Sciences Lab Lincoln, NE	Provenance Test	Crown form, color and density	36 origins	1
	Progeny Test	Crown form, color and density	200(?) full-sib families	3
North Dakota Forest Service	Seed Orchard (grafted)	Drought tolerance, growth rate, foliage color	29 clones	1
	Seed Orchard (seedling)	Drought tolerance, growth rate, foliage color	30 half-sib familes	2
	Seed Collection Area	Drought tolerance, growth rate, foliage color	Best phenotypes in provenance test	1
PFRA Tree Nursery Indian Head, Sask.	Provenance Test	Survival, growth rate, foliage color	31 origins	1

Table 12.--Windbreak genetic improvement activities involving Picea pungens & P. engelmannii

AGENCY	ACTIVITY	TRAITS	POPULATION SIZE	NUMBER OF SITES
U.S. Forest Service Shelterbelt Lab Bottineau, ND	Provenance Test	Survival, growth rate	229 families	1
U.S. Forest Service Forestry Sciences Lab Lincoln, NE	Provenance test		43 origins	3
North Dakota Forest Service Bottineau, ND	Plus-tree Selection	Hardiness, growth rate, branch angle, color	145 selected trees	
PFRA Tree Nursery Indian Head, Sask.	Provenance Test	Survival, foliage color	45 origins	1