International Poplar Commission Meeting of the Environmental Applications of Poplar and Willow Working Party

Tully Genetics Field Station Tour

SUNY College of Environmental Science and Forestry

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www.esf.edu/willow/

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Paper Sludge and Dairy Manure Applications on Shrub Willow at Tully NY.

This study was conducted to evaluate the response of shrub willows (*Salix* x *dasyclados*; SV1) to amendments of paper sludge and cattle manure as sources of N in Central New York, and determined the impact of the amendments on soil chemical properties. Identical rates of total N were used in order to compare the effectiveness of the organic amendments with inorganic fertilizer in terms of increasing plant productivity, as well as the effects on leaching losses. Specific objectives were to determine: 1. the effect of fertilization by comparing the treatments to a control, 2. the availability of N in manure and sludge relative to inorganic fertilizer and to each other and 3. the effect of mixing manure and sludge.

The treatments, applied in a randomized complete block design with four replications, were: 100 kg N/ha as urea (I), 100 kg total N/ha as dairy cow manure (ML), 100 kg available N/ha as dairy cow manure (MH), 100 kg total N/ha as paper sludge (S), 100 kg total N/ha sludge + 100 kg available N/ha of manure (SM) and Control (no amendment). These materials were applied in the spring of 2005 to fields of SV1 at two different stages of growth. Field one was one year old above ground on a 10 year old root system, while the second field was just beginning regrowth after being coppiced at the end of its first growing season. Treatment plots measured 65 m^2 within which a 21.9 m^2 measurement plots were used for data collection and analysis. Fig 1 below shows the mean survival rate (%) and biomass production (ton/ha) from the two fields.

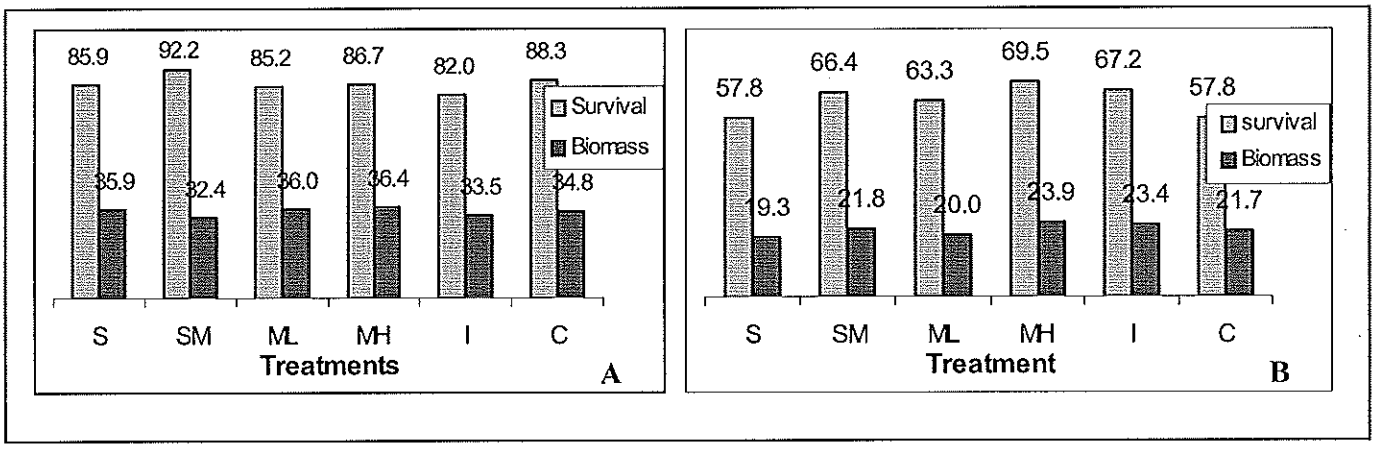

Fig 1: Mean survival rate (%) and biomass production (ton/ha) of 3-year old, field 1 (A) and 2-year old, field 2 (B) willow (*Salix* x *dasyclados*; SV1) shrub in different organic and inorganic fertilization.

This work is supported by a grant from USDA CSREES through the National Research Initiative

Treatment locations for Tully 'SV1' 1994 planting. USDA Paper Sludge Application Project

Routes 11 & 80 To Village of Tully →

North ↑

Plot 6 CONTROL	Plot 12 SLUDGE/MANURE	Plot 18 MANURE LOW	Plot 24 CONTROL
Plot 5 SLUDGE/MANURE	Plot 11 UREA	Plot 17 UREA	Plot 23 UREA
Plot 4 MANURE LOW	Plot 10 SLUDGE	Plot 16 MANURE LOW	Plot 22 CONTROL
Plot 3 MANURE LOW	Plot 9 UREA	Plot 15 CONTROL	Plot 21 MANURE HIGH
Plot 2 SLUDGE	Plot 8 MANURE HIGH	Plot 14 SLUDGE/MANURE	Plot 20 SLUDGE/MANURE
Plot 1 SLUDGE	Plot 7 SLUDGE	Plot 13 MANURE HIGH	Plot 19 MANURE HIGH

SERVICE ROAD

Fig 2: Layout Map of field 1: Three year old above ground on a 10 year old root system.

Treatment locations for Tully '2004' planting. USDA Paper Sludge Application Project

Routes 11 & 80 To Village of Tully →

North ↑

Plot 8 SLUDGE	Plot 16 UREA	Plot 24 SLUDGE/MANURE
Plot 7 MANURE HIGH	Plot 15 SLUDGE	Plot 23 CONTROL
Plot 6 SLUDGE/MANURE	Plot 14 MANURE HIGH	Plot 22 MANURE LOW
Plot 5 MANURE LOW	Plot 13 UREA	Plot 21 MANURE HIGH
Plot 4 MANURE HIGH	Plot 12 SLUDGE	Plot 20 SLUDGE/MANURE
Plot 3 UREA	Plot 11 CONTROL	Plot 19 MANURE LOW
Plot 2 MANURE LOW	Plot 10 SLUDGE	Plot 18 UREA
Plot 1 CONTROL	Plot 9 SLUDGE/MANURE	Plot 17 CONTROL

Tully High School

Fig 3: Layout Map of Field 2: Second year regrowth after coppiced at the end of its first growing season

Genetic improvement of shrub willow as a dedicated energy crop, for phytoremediation, and for other environmental applications.

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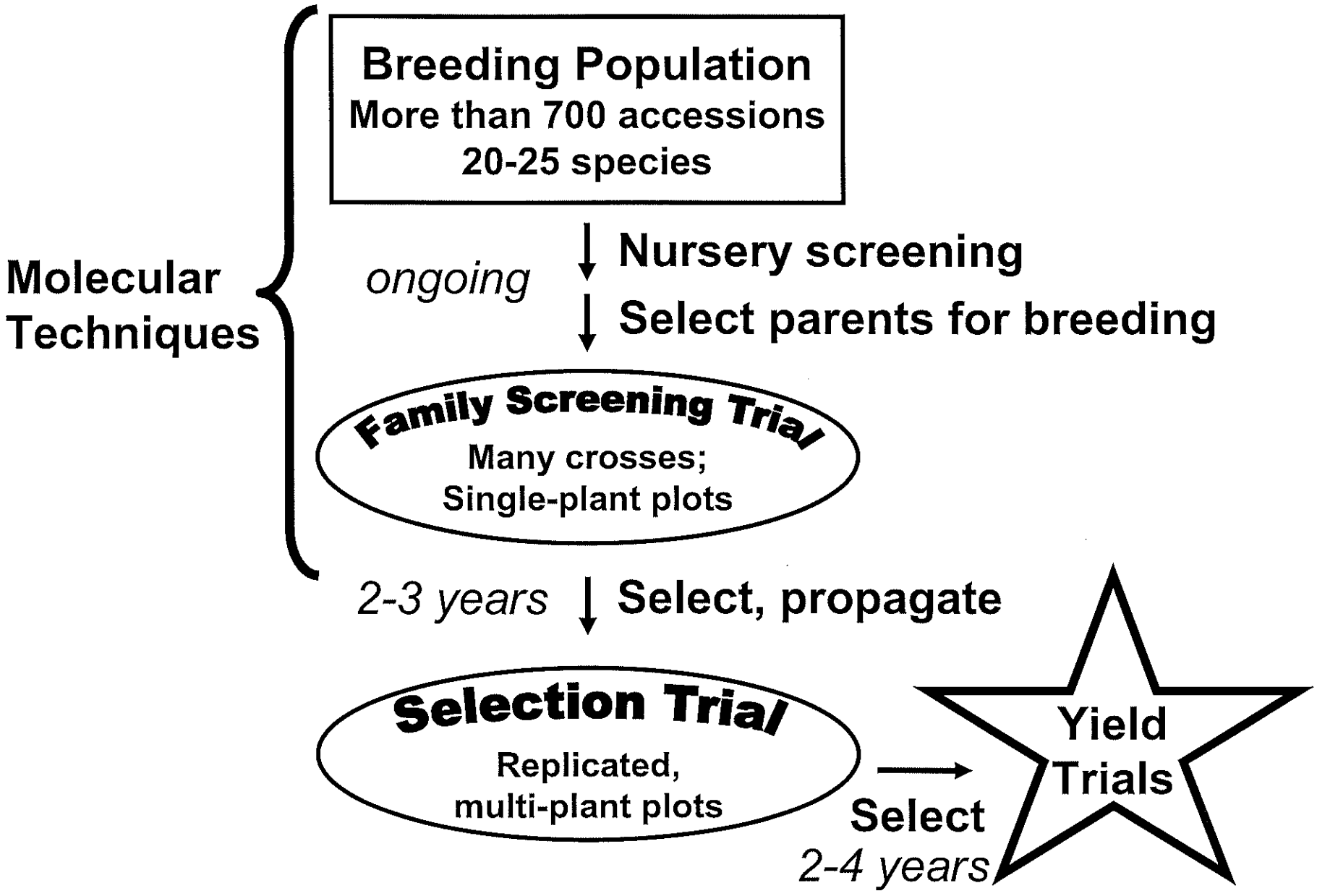
Early commercial-scale demonstration of shrub willow bioenergy crops in the U.S. relied on varieties developed in the breeding program of Dr. Louis Zsuffa at the University of Toronto that had been tested in trials at SUNY-ESF. Many of these varieties were F_1 progeny of crosses of *S. eriocephala*, and a number of these were moderately or severely susceptible to *Melampsora* spp. rust. Varieties developed in Sweden (Larsson, 2001) and deployed commercially by Svalöf Weibull AB (now Lantmännen Agroenergi) were tested in NY and were quickly found to be susceptible to damage by potato leaf hopper (Kopp and Abrahamson, unpublished). Thus, in order to develop new varieties with improved yield and to support the long-term deployment of shrub willow crops in North America, SUNY-ESF initiated a willow breeding program in the mid-1990's. Since 1994, a diverse collection of more than 700 willow accessions representing over 20 species and hybrids has been assembled through collection of naturally established plants in the wild or disturbed environments, contributions of naturally collected or bred germplasm from U.S. and overseas collaborators, and from the purchase of varieties available from commercial nurseries (Smart *et al.*, 2005). Techniques for the collection of pollen and for mechanical pollination were developed and adapted for the species in the breeding program (Kopp *et al.*, 2002). Since 1998, researchers at SUNY-ESF have produced approximately 200 families from more than 575 attempted controlled pollinations.

Selection and testing of clones has been accomplished through three levels of field trials: family screening trials, selection trials, and regional yield trials (see scheme below). Crosses were completed in 1998 and a family screening trial was established in the field at LaFayette Road Experiment Station in Syracuse, NY, but due to a facilities management decision, this trial was removed in 1999 and selections were made based only on preliminary growth evaluations. Thirty individuals were selected and propagated in nursery beds for two years to generate sufficient cuttings to establish a replicated selection trial in 2001 consisting of 16 of those clones, as well as four individuals collected from natural stands, and five reference varieties, some of which were used as parents in the 1998 crosses. Crosses completed in 1999 produced 46 families that were evaluated in a family screening trial in the field at LaFayette Road Experiment Station. More than 2,000 seedlings were planted in linear plots by family with 0.3 m spacing between plants and 1 m between rows. The seedlings were coppiced after the first season and then stem height, number of stems, and diameters were measured after two seasons of growth. Based on those measurements, four families were chosen as having superior overall family performance and the top 15 individuals were selected from each family. A total of 22 other exceptional individuals were selected from eight other families. Cuttings were made from these plants for the establishment of a replicated selection trial in 2002.

Generalized Willow Breeding Strategy



2001 Genetic Selection Trial - Tully, NY

The 2001 selection trial was planted at the Tully Genetics Field Station in Tully, NY using dormant 25-cm cuttings in typical production spacing. Each plot contained 40 plants (20 plants per row with one double-row per plot) and was replicated in three completely randomized blocks. These plants were coppiced at the end of the first growing season, then were subsequently harvested after three growing seasons post-coppice (end of 2004). The inner-most 20 plants per plot were weighed and subsample was collected and dried for each to determine moisture content, so that total dry biomass could be calculated per plot. Based on these first-rotation harvests, nine of 16 clones produced through breeding yielded greater mean biomass than the reference variety *S. dasyclados* 'SV1', which had mean yield of 7.4 odt ha^{-1} yr^{-1} (Fig. 1). The top variety in this trial after one harvest rotation was *S. miyabeana* 'SX64', with mean yield of 11.3 odt ha^{-1} yr^{-1}, 153% higher than that of 'SV1'.

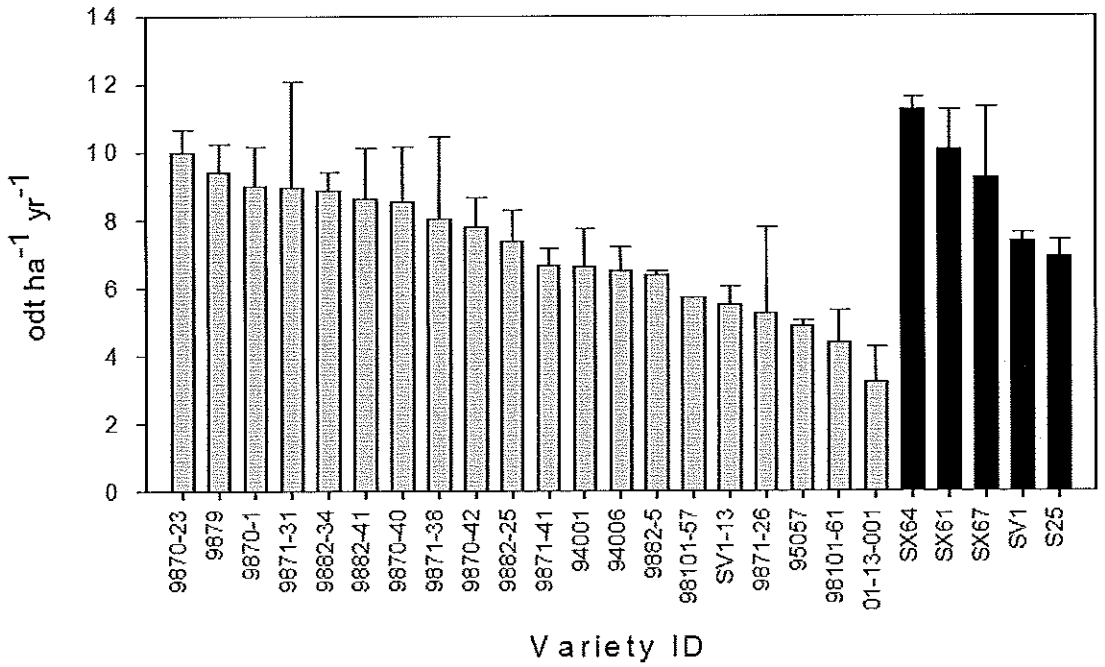
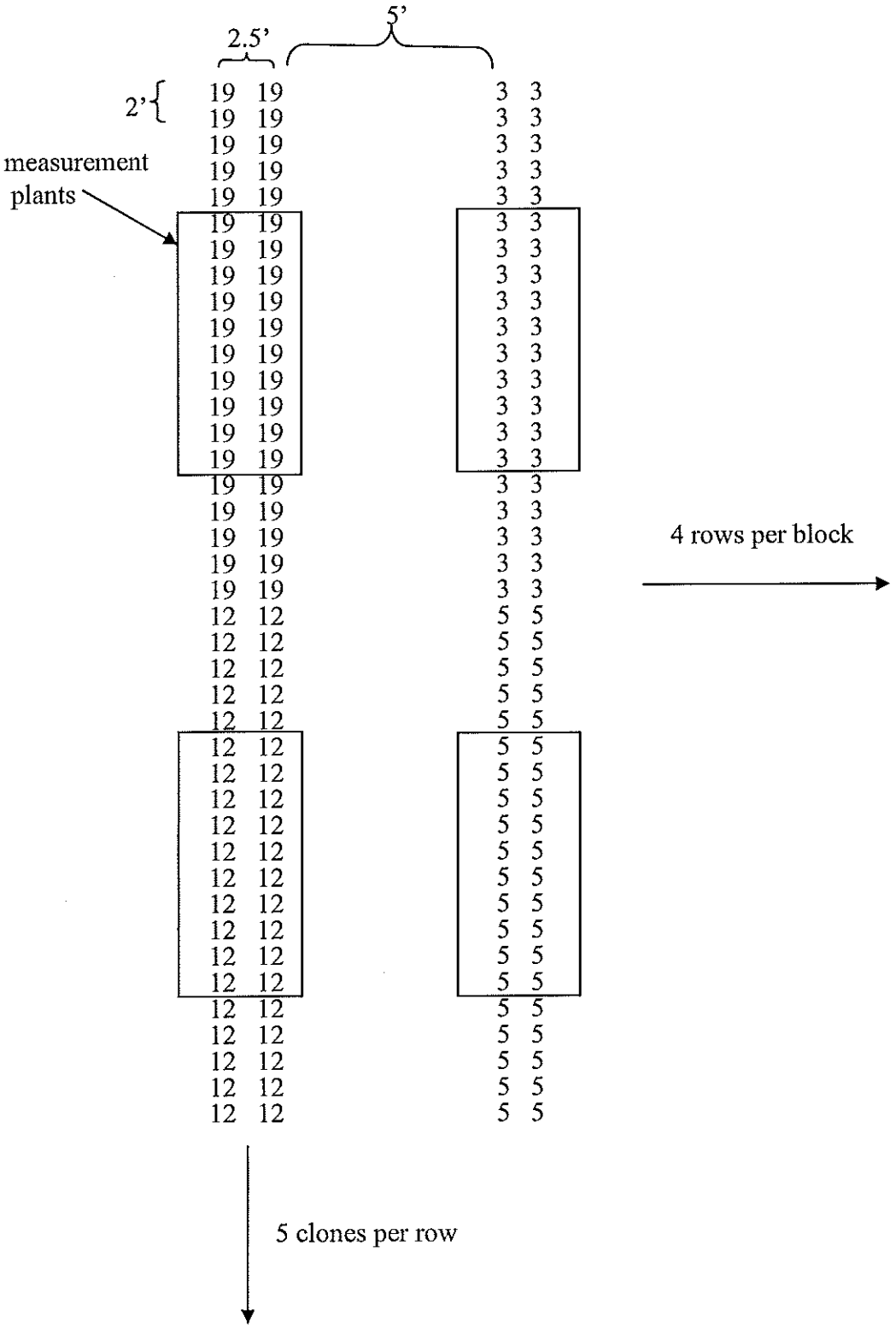


Figure 1. Mean first-rotation production of varieties tested in the 2001 genetic selection trial at Tully, NY. Grey bars represent varieties produced through controlled breeding or collected from naturally established stands. Black bars represent current production varieties for reference. Bars indicate standard error.

Randomized complete block design, 3 blocks, 20 clones, 20 measurement plants for each clone in each block. Swedish spacing: 2' (0.61 m) between plants in a row, 2.5' (0.76 m) between rows, 5' (1.52 m) between double rows.



9879	9871-31	9871-38	9870-42	SV1-13
Sx64	9871-26	S25	9870-40	9882-41
94001	9870-23	98101-61	98101-57	Sx67
9882-25	9870-1	01-13-001	9871-41	94006
95057	9882-34	Sx61	9882-5	SV1

9882-41	9871-26	94001	9870-1	9882-34
Sx61	9870-23	9882-25	9879	9871-31
9871-41	9871-38	95057	9870-40	SV1
94006	Sx67	S25	Sx64	01-13-001
9870-42	98101-57	SV1-13	9882-5	98101-61

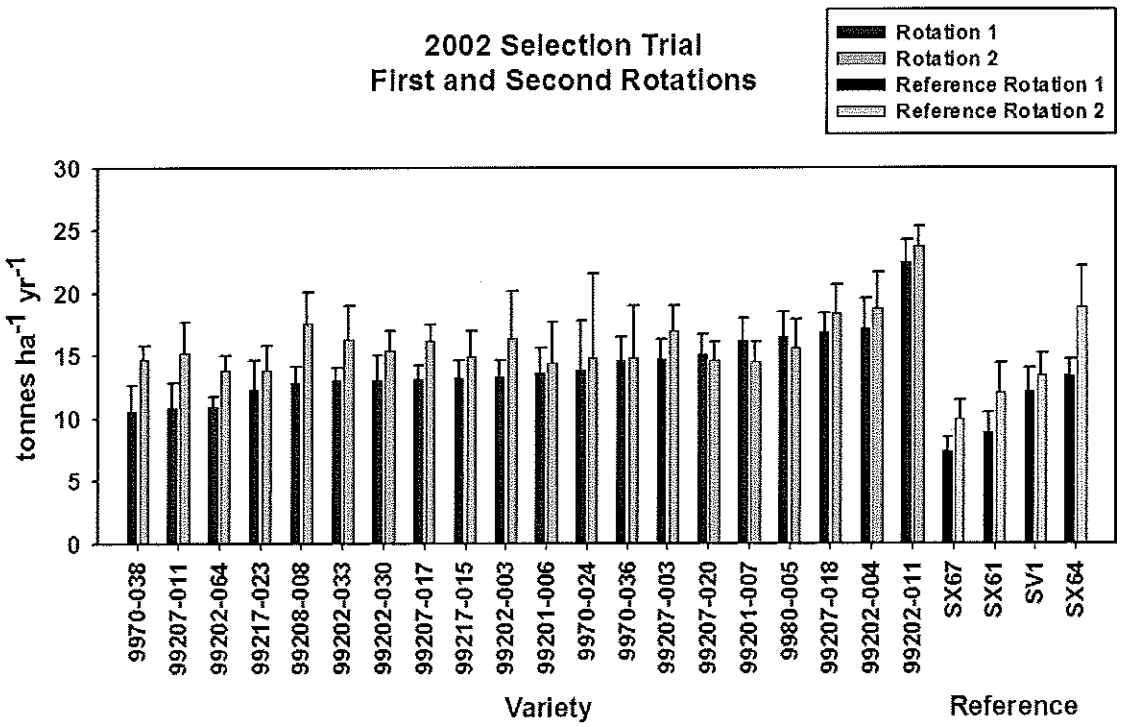
9870-23	94001	SV1-13	9871-41	Sx61
9882-5	98101-61	Sx64	95057	S25
9870-1	9871-26	9882-25	9871-38	94006
9882-41	SV1	9882-34	9870-42	Sx67
01-13-001	9870-40	98101-57	9871-31	9879

		Parents		
Clone	Species	Female	Male	Gender
SV1-13	dasy x ?	SV1	?-OP	F
9882-5	pur x pur	94006	94001	F
9882-41	pur x pur	94006	94001	F
9882-34	pur x pur	94006	94001	M
9882-25	pur x pur	94006	94001	F
9871-41	sach x miya	SX61	SX67	F
9871-38	sach x miya	SX61	SX67	F
9871-31	sach x miya	SX61	SX67	F
9871-26	sach x miya	SX61	SX67	F
9870-42	sach x miya	SX61	SX64	M
9870-40	sach x miya	SX61	SX64	M
9870-23	sach x miya	SX61	SX64	F
9870-1	sach x miya	SX61	SX64	F
98101-61	dasy x miya	SV1	SX64	F
98101-57	dasy x miya	SV1	SX64	M
95057	pur			M
9879	pur x miya	94006	SX64	M
SV1	dasy			F
Sx64	miya			F
94006	pur			M
Sx61	sach			F
Sx67	miya			M
94001	pur			M
01-13-001	nigra			?
S25	erio			F

Planted 5/01 at Tully Genetics Field Station. Marking stakes in SW corner of each plot. Swedish spacing. Randomized complete block design with 3 blocks, 25 clones, 40 plants per plot. Planted area is 22500 sq ft. Planted as unrooted cuttings, area treated with Goal 2XL and Princep each at 1 lb ai/ac prior to planting.

2002 Genetic Selection Trial - Tully, NY

The 2002 selection trial was planted at the Tully Genetics Field Station using rooted 12- to 17-cm cuttings in four-plant row plots with 0.6 m between plants in a row and 0.9 m between rows (~18,500 plants ha^{-1}). Each four-plant plot was replicated in eight completely randomized blocks, each of which contained 82 new clones and four reference varieties. Some plots suffered mortality soon after planting, most likely due to exposure and sensitivity of the roots to herbicide that had been applied at planting time, since there has been little further mortality after year one. These plants were coppiced at the end of the first growing season, then stem height, number, and diameters of the inner two plants per plot were measured at the end of the first growing season post-coppice (end of 2003). Based on calculations of total stem area per plant after one growing season, 69 of 82 new varieties produced greater total stem area per plant than the reference variety 'SV1' (Fig. 2). The mean total stem area of the top clone (99202-011) was 214% greater than 'SV1'. Based on these measurements, cuttings were made from one-year-old stems of 42 of the original family screening trial plants and planted in nursery beds to scale-up for future trials. First-rotation harvest of the 2002 selection trial was completed after the second growing season post-coppice (end of 2004) and a second harvest was done two years later (end of 2006). To obtain an estimate of growth potential and account for the anomalous establishment mortality, measurements of plots with less than three living plants were removed from the data set. A modest amount of fertilizer (100 kg N ha^{-1}) was applied in the spring after the first harvest. Based on yields from each harvest, 24 of the new clones and variety 'SX64' produced greater dry biomass than reference variety 'SV1', which produced 11.9 odt ha^{-1} yr^{-1} in the second two-year harvest rotation of this trial. The top clone (99202-011) produced a mean biomass yield of 21.9 odt ha^{-1} yr^{-1} in these small experimental plots. Overall mean yields increased 6.2% from first harvest to second, and 60 of the 86 clones in the trial produced greater yield in the second rotation. Although these yields are impressive, they were produced in very small plots on a single site. To test the potential yield in commercial-style plantings and plasticity to varying site conditions, it is necessary to test these clones at many varying sites in larger plantings.



2002 Genetic Selection Trial - Tully, NY

Experimental design

Randomized complete block design with 86 clones (82 produced by breeding, 4 reference clones); 8 replications; 4-plant linear plots

Clones include:
15 clones from each of the following families;
99217 (*S. purpurea* 95026 x *S. miyabeana* SX64)
9970 (*S. sachalinensis* SX61 x *S. miyabeana* SX64)
99202 (*S. viminalis* SV2 x *S. miyabeana* SX67)
99239 (*S. purpurea* SH3 x *S. purpurea* 95058)

Varying numbers of clones from the following families;
99113 - 3 clones (*S. purpurea* SH3 x *S. purpurea* 94002)
99201 - 4 clones (*S. viminalis* SV2 x *S. miyabeana* SX64)
99207 - 8 clones (*S. viminalis* SV7 x *S. miyabeana* SX64)
99232 - 2 clones (*S. purpurea* 94006 x *S. purpurea* 94003)
9979 - 1 clone (*S. purpurea* 94006 x *S. miyabeana* SX64)
9980 - 1 clone (*S. purpurea* 94006 x *S. miyabeana* SX67)
99208 - 2 clones (*S. viminalis* SV7 x *S. miyabeana* SX67)
99227 - 1 clone (*S. purpurea* 94003 x *S. purpurea* 95042)

Reference clones for comparison: *S. sachalinensis* SX61, *S. miyabeana* SX64, *S. miyabeana* SX67, *S. dasyclados* SV1.

Rationale: The selection criteria for including clones in this experiment was primarily based on performance in the 1999 Family Screening Trial at LaFayette Road Experiment Station in terms of total stem area. Four families with excellent mean stem area were identified and the largest 15 individuals from each of these families were selected.

Planting stock was produced from cuttings made from two-year-old stems that ranged in diameter from 5 to 20 mm and were cut to 12-17 cm in length, then were established in tubes in the greenhouse. Every effort was made to use material that was as uniform as possible. This trial includes 704 linear four-plant plots planted at 2 feet (0.61 m) between plants and 3 feet (0.91 m) between rows, giving a final density of ~18,500 plants ha^{-1} (~7,400 plants ac^{-1}). There was some mortality at establishment from exposure of herbicide to the roots of the plants (rooted cuttings were used). Very little mortality has occurred since the establishment year. To adjust for that initial mortality, only plots with 75% or greater survival are included in the analysis of growth potential.

The trial was coppiced after the establishment year (2002). Stem diameters and heights were measured in Jan. 2004 (first-year post-coppice). It was harvested in Jan. 2005 and again in Jan. 2007 (each two years post-coppice).

2002 Genetic Selection Trial-1999 F1s - Established May 2002 at Tully NY - 4 plants per plot, planted as rooted 5" cuttings - S25 border
Stakes at south end of plots
Harvested - Jan. 2005, Jan. 2007

High School →

Rep 1			Rep 2				Rep 3			Rep 4				Rep 5			Rep 6				Rep 7			Rep 8			
99239-025	99202-049	99207-022		99230-011	99239-007	99239-010	9970-030	99239-005	99217-010		99217-057	99217-003	99239-026	99202-060	99232-045	99201-007		SX01	99201-001	99239-038	99202-033	99239-025	99202-011		9970-036	99202-008	99239-015
99208-008	99217-057	99202-006		9970-023	99239-038	99239-025	9980-005	99207-015	99207-020		99202-033	99239-007	9970-046	9970-052	99208-038	99217-003		99239-025	99207-003	99239-033	99202-064	99217-041	9970-036		99113-001	9970-046	99217-023
99217-003	99239-031	9970-047	99202-033	9979-036	99207-018	99202-004	9970-052	9970-038	99239-031	99207-003	99239-019	99113-001	99202-008	99202-052	99217-004	99202-013	99217-015	99202-049	99207-018	99239-011	9970-035	99202-015	9970-058	99113-012	99239-033	99217-003	9970-023
99202-008	9970-025	99113-012	99232-045	99202-011	99217-003	99207-020	9970-047	9970-036	99217-057	99207-006	9970-024	99217-007	9979-036	99239-010	99207-005	9970-063	99202-005	99208-008	99217-057	99202-003	99239-011	99208-036	9970-024	99202-011	99202-003	SX04	99202-033
99239-011	99217-015	99207-013	9970-014	99217-011	9970-047	99202-052	9970-052	99227-003	99201-007	99202-030	99207-017	99202-013	99202-004	SX04	99207-017	99217-048	99217-003	9970-021	9970-023	99202-064	99217-045	99202-004	9970-043	99239-025	9970-021	99207-017	99202-004
99113-001	99239-033	99217-023	99239-037	99207-017	99217-004	99217-046	99202-006	99201-000	99202-052	9970-030	99217-020	99207-011	99201-002	99113-001	9970-024	99202-049	99239-007	99217-018	99239-031	99201-007	99207-020	99239-001	99113-012	99217-045	99202-045	99201-000	99239-020
99207-017	9970-063	99202-052	99113-001	9970-063	SV1	99201-007	99239-007	99217-020	99232-057	99239-037	99217-016	99202-015	99239-038	99113-012	99227-003	9970-023	99202-033	99217-004	99217-009	99202-045	99217-020	99217-023	9980-005	99207-003	99208-005	99207-013	99217-011
9970-030	99202-004	99202-013	99201-002	99239-019	SX01	9970-043	SX04	99113-010	99239-001	992117-011	99217-009	9980-005	9970-030	99202-045	99217-011	9970-036	99239-015	99239-010	99201-006	9970-038	SX01	99217-018	9970-030	99207-022	9970-014	99217-010	9970-003
99113-010	99202-015	99202-003	9970-035	99217-016	9970-052	99202-008	99239-021	99202-006	99207-017	99202-014	99217-048	99239-033	99217-004	99239-031	99202-014	99207-018	SX04	9970-003	99207-022	99217-010	99232-057	99239-021	9970-047	99217-057	9970-058	SV1	99239-005
9970-036	99232-045	9970-058	9970-030	99113-012	99207-003	99202-014	99202-040	9970-058	99217-009	99113-012	99208-038	SV1	99217-010	99217-023	99239-025	99113-010	99239-005	9970-043	SX07	99202-008	99207-017	99217-003	99201-007	99239-010	99202-049	99207-020	99232-057
99239-010	99201-002	99201-007	9970-040	99239-020	9970-024	99202-005	99202-045	SX01	99217-018	99207-022	9970-014	99207-013	99239-001	99208-006	99217-010	99239-038	99202-052	99207-013	9970-040	99202-013	99207-018	9970-036	99202-052	99227-003	99239-037	99113-010	99207-018
SX07	99217-018	99202-043	99207-011	9970-038	99201-000	99239-031	99239-025	99202-033	99217-048	99202-004	99201-006	SX07	99202-011	9970-047	99239-021	99239-033	9980-005	99207-017	99239-020	99239-006	99217-057	99208-008	99232-045	99217-004	99202-030	SX07	9970-024
99202-030	99201-008	99207-020	99208-008	99239-005	99217-041	9970-058	99202-043	99217-009	99202-015	99201-001	99201-007	SX01	99208-008	9970-030	SV1	99202-004	99202-011	9970-030	99202-043	9970-063	99217-004	99239-038	99239-015	99201-002	99217-015	99217-016	99202-005
99239-005	99217-015	99239-001		99217-009	9970-021	99207-013	9970-023	99217-004	99207-003		99202-049	9970-043	99217-015	99207-022	99202-015	99202-033		99202-004	99208-038	9970-024	99239-019	99239-031	99207-003		99239-021	9970-038	9970-030
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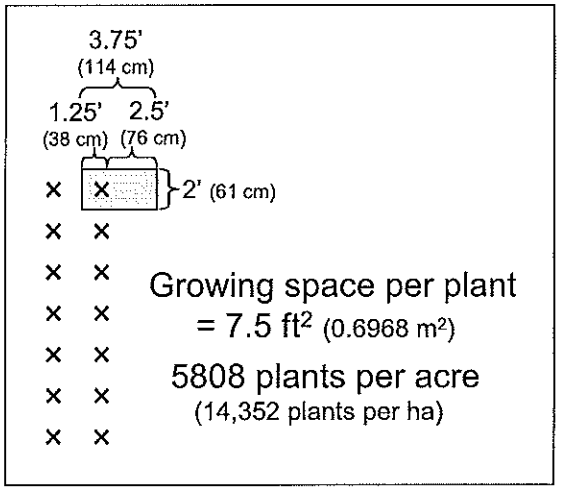
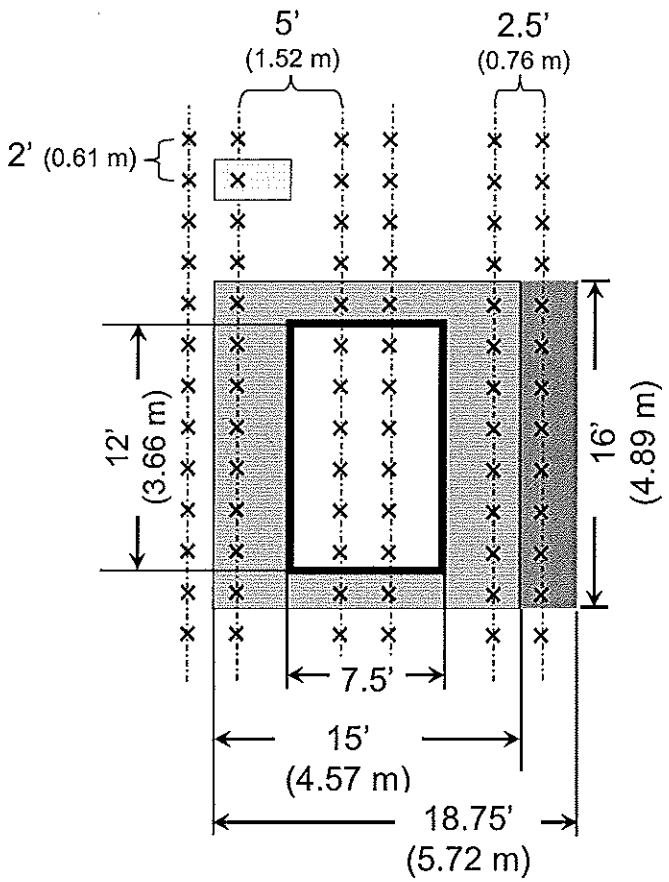
9970-014	99239-008	SX04	99239-037	99113-010	99202-049	99239-021	99232-045	9970-021	99239-038	99202-003	99239-011	9970-035	99239-015	99202-005	99217-020	99217-018	99217-015	99217-048	99217-010	99207-020	99113-001	9970-023	99217-008	9970-038	99207-005	99201-001	99217-010
9970-036	9970-036	99202-003	99202-064	99207-022	99239-033	SX07	99202-004	9970-040	99202-013	99217-015	9970-023	9970-036	99239-031	9980-005	99239-001	99239-008	99201-002	9979-036	99202-014	99113-010	99239-033	99201-000	9970-021	99217-015	9970-035	99202-015	SX01
9970-021	9980-005	99217-011	99201-001	99217-007	9970-036	99202-003	99201-001	9970-014	99217-041	99239-037	99113-010	99202-045	99239-020	99202-030	9970-063	99202-004	99202-043	SV1	9970-052	9970-058	99207-011	99202-030	9970-063	99202-014	9970-052	99202-014	99232-045
99207-011	99217-010	99217-020	99239-019	99227-003	99202-013	99217-010	99202-064	99217-015	9970-035	99201-002	SX04	99217-023	99217-015	99217-041	99217-009	99217-010	99207-020	99207-005	99239-021	99201-002	99239-020	99202-008	99202-043	99217-010	9970-047	99217-008	99239-019
99227-003	99202-011	99217-006	99217-003	99202-064	SX04	99201-001	99202-030	99239-033	99208-038	99208-008	99239-005	99217-041	9970-058	99217-007	9970-035	99202-008	99239-011	99217-020	99239-019	99217-023	99202-049	99217-011	99217-007	99207-022	99208-038	9980-005	99207-011
99207-006	SX01	9970-053	99202-014	99217-023	99217-015	99202-015	99207-022	99217-011	99207-013	99113-012	9970-052	9970-053	99239-010	99202-011	99201-006	99239-005	SX01	99227-003	99239-037	9970-014	99207-005	SV1	99227-003	99217-010	9970-053	99202-052	99201-007
SV1	99217-007	9970-052	9970-024	9980-005	99217-008	9970-053	9970-003	SX07	99207-005	99202-011	99202-005	99202-045	99239-021	99207-003	99239-007	99232-057	99207-013	9970-030	99217-011	99202-015	SX07	99201-002	99217-009	99202-003	99217-020	99239-007	99239-038
99239-007	9970-046	99239-015	99207-015	99232-057	99207-005	99239-015	99113-001	99239-010	99239-019	99217-007	99227-003	99217-008	9970-021	9970-021	99217-057	9970-043	9970-036	99202-030	99232-045	9970-047	9970-053	99207-013	99202-045	99239-010	99202-013	99202-043	99239-031

Yield Trial (European)





Treatment plot layout

- 1 + (2 half) double-rows
- 8 plants per row
- 32 plants per plot
- 7.5 x 16' (2.29 x 4.89 m) measurement plot (white □, 12 plants)
- Variety randomly assigned to plots
- Growing space per plant = 7.5 ft²

N

2007 European-US Yield Trial - Tully, NY

16 ESF Varieties, 12 N. Ireland Varieties, 4 Blocks (n=120 plots total)

(Variety was randomly assigned to plots)

(Dims in ft.)	Cum. Width	18.75	33.75	52.5	67.5	86.25	101.25	116.25	135 ft	
Cum. Length	Plot width	18.75	15	18.75	15	18.75	15	15	18.75	135
	Cum. Width	18.33	33	51.33	66	84.33	99	113.67	132	
	Ken's width	18.33	14.67	18.33	14.67	18.33	14.67	14.67	18.33	132
		2.5	2	2.5	1	2.5	2	2	2.5	17
	Plot length	2.5 D-R	1+2(0.5 D-R)	2.5 D-R	1 D-R	2.5 D-R	1+2(0.5 D-R)	1+2(0.5 D-R)	2.5 D-R	(D-R total)
4	4	2-plant buffer (planted with SQ83)								
20	16	Ashton Sloff 1	Beagle 2	980451 3	unplanted buffer					
36	16	970381 4	970253 5	Sq83 6	unplanted buffer					
52	16	Resolution 7	Nimrod 8	Endeavour 9	unplanted buffer	2-plant buffer, starting at 48'				
68	16	Tordis 10	mixed 11	970608 12	unplanted buffer	9871-31 57	99201-007 58	99113-012 59	99217-015 60	
84	16	Terranova 13	Endurance 14	Tordis 15	unplanted buffer	9970-036 61	S25 62	9980-005 63	99239-015 64	
100	16	Resolution 16	Sq83 17	Terranova 18	unplanted buffer	9882-034 65	SV1 66	9879 67	SX64 68	
116	16	Nimrod 19	Endeavour 20	970608 21	unplanted buffer	94001 69	SX61 70	99202-011 71	99207-016 72	
132	16	Ashton Sloff 22	Beagle 23	970381 24	unplanted buffer	9980-005 73	99207-016 74	9970-036 75	99239-015 76	
148	16	980451 25	970253 26	mixed 27	unplanted buffer	9882-034 77	99202-011 78	SV1 79	S25 80	
164	16	Endurance 28	Sq83 29	Nimrod 30	unplanted buffer	SX61 81	SX64 82	94001 83	99113-012 84	
180	16	Ashton Sloff 31	980451 32	970381 33	unplanted buffer	99201-007 85	9871-31 86	99217-015 87	9879 88	
196	16	Tordis 34	970608 35	Resolution 36	unplanted buffer	S25 89	9970-036 90	99201-007 91	SX64 92	
212	16	Terranova 37	Beagle 38	Endurance 39	unplanted buffer	9871-31 93	99239-015 94	9879 95	9980-005 96	
228	16	Endeavour 40	mixed 41	970253 42	unplanted buffer	SX61 97	99113-012 98	99217-015 99	99207-016 100	
244	16	Sq83 43	Resolution 44	Tordis 45	unplanted buffer	SV1 101	99202-011 102	9882-034 103	94001 104	
260	16	Endurance 46	Endeavour 47	970608 48	unplanted buffer	SX64 105	99239-015 106	99202-011 107	SX61 108	
276	16	980451 49	970253 50	Ashton Sloff 51	unplanted buffer	99113-012 109	9879 110	9871-31 111	SV1 112	
292	16	Nimrod 52	mixed 53	970381 54	unplanted buffer	9980-005 113	9882-034 114	S25 115	94001 116	
308	16	Terranova 55	Beagle 56	#N/A empty	unplanted buffer	99217-015 117	99201-007 118	9970-036 119	99207-016 120	
312	4	2-plant buffer (planted with SQ83)			unplanted buffer	2-plant buffer (planted with US variety)				

ft

References

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Larsson S (2001) Commercial varieties from the Swedish willow breeding programme. Aspects of Applied Biology, 65, 193-198.

Smart LB, Volk TA, Lin J, Kopp RF, Phillips IS, Cameron KD, White EH, and Abrahamson LP (2005) Genetic improvement of shrub willow (*Salix* spp.) crops for bioenergy and environmental applications in the United States. Unasylva, 56, 51-55.