

**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

June 7, 2007



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 m² within which a 21.9 m² 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.

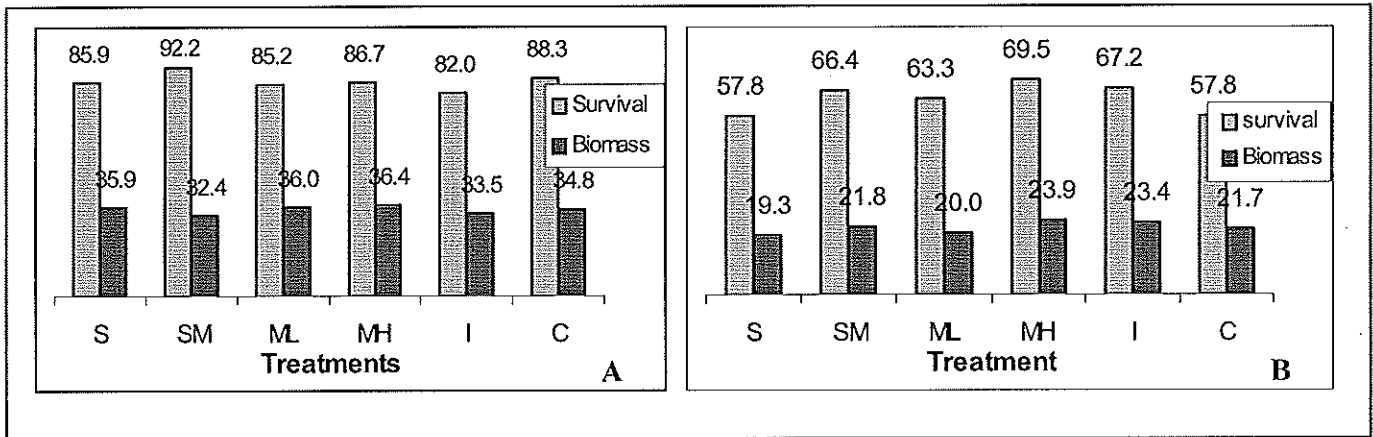


Fig 1: Mean survival rate (%) and biomass production (ton/ha) of 3-year old, field 1 (A) and 2-year old, field 2 (B) willow (*Salix x dasyclados*; SV1) shrub in different organic and inorganic fertilization.

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

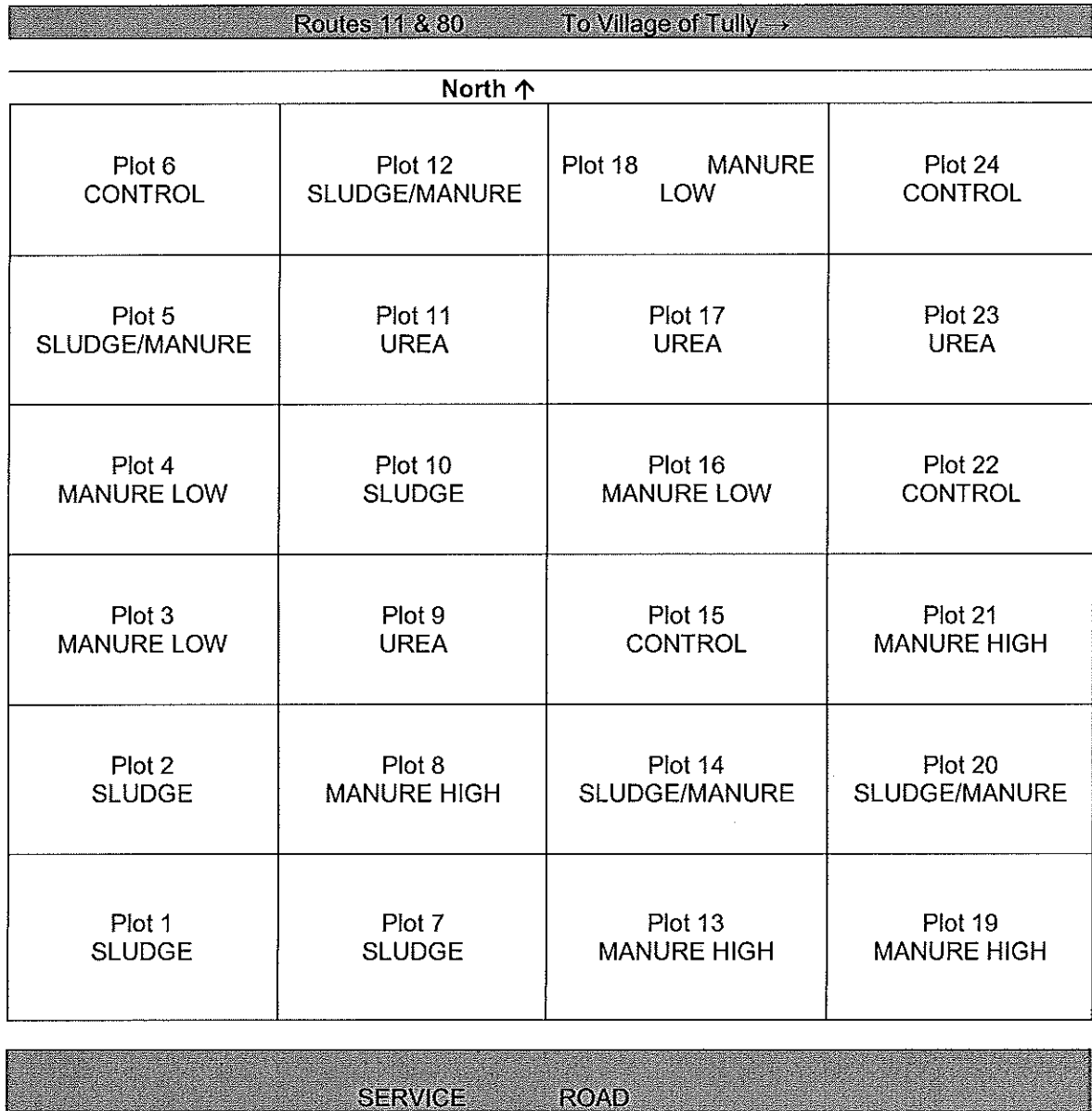


Fig 2: Layout Map of field 1: Three year old above ground on a 10 year old root system.

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	Tully High School
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	

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

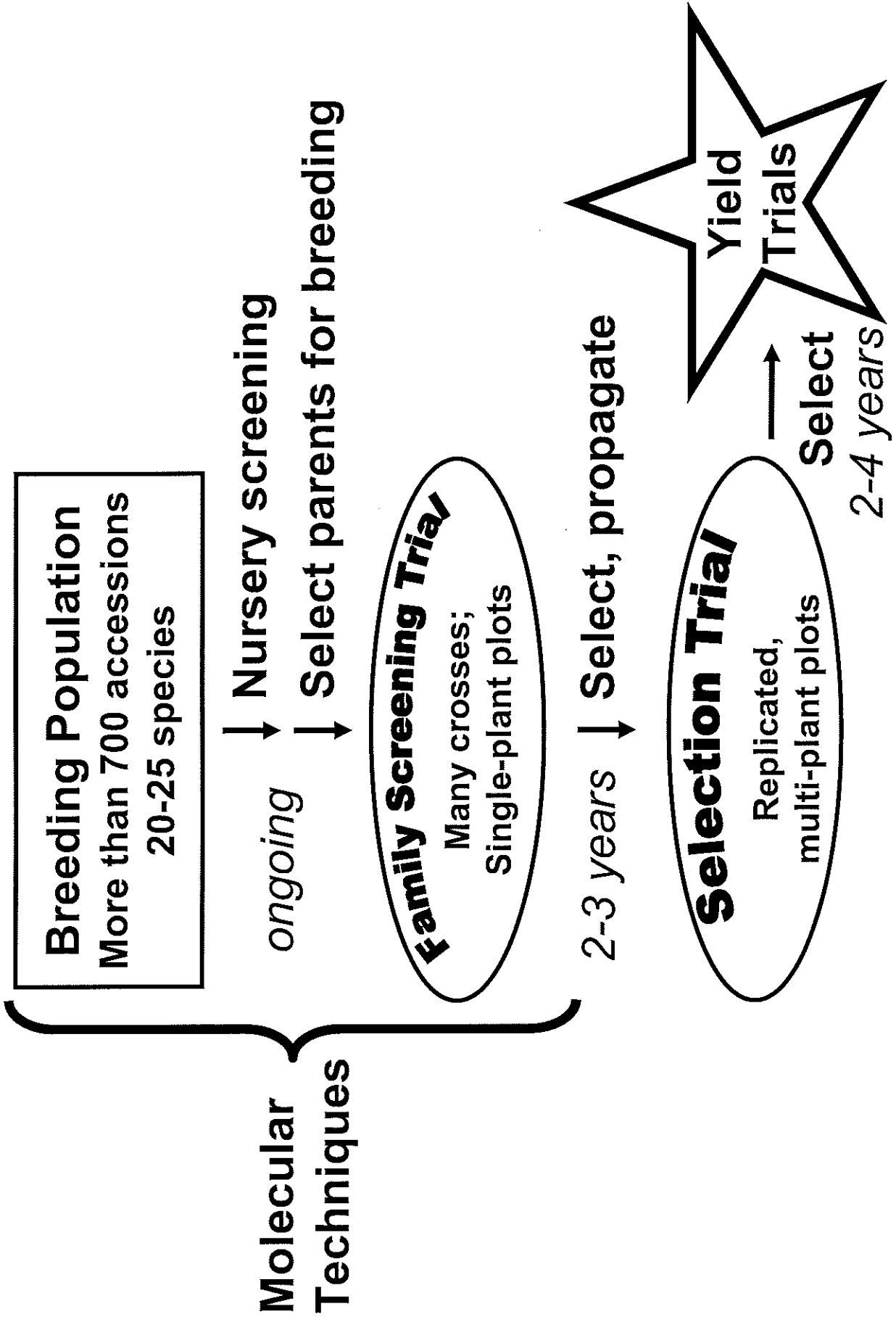
Genetic improvement of shrub willow as a dedicated energy crop, for phytoremediation, and for other environmental applications.

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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 F₁ 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'.

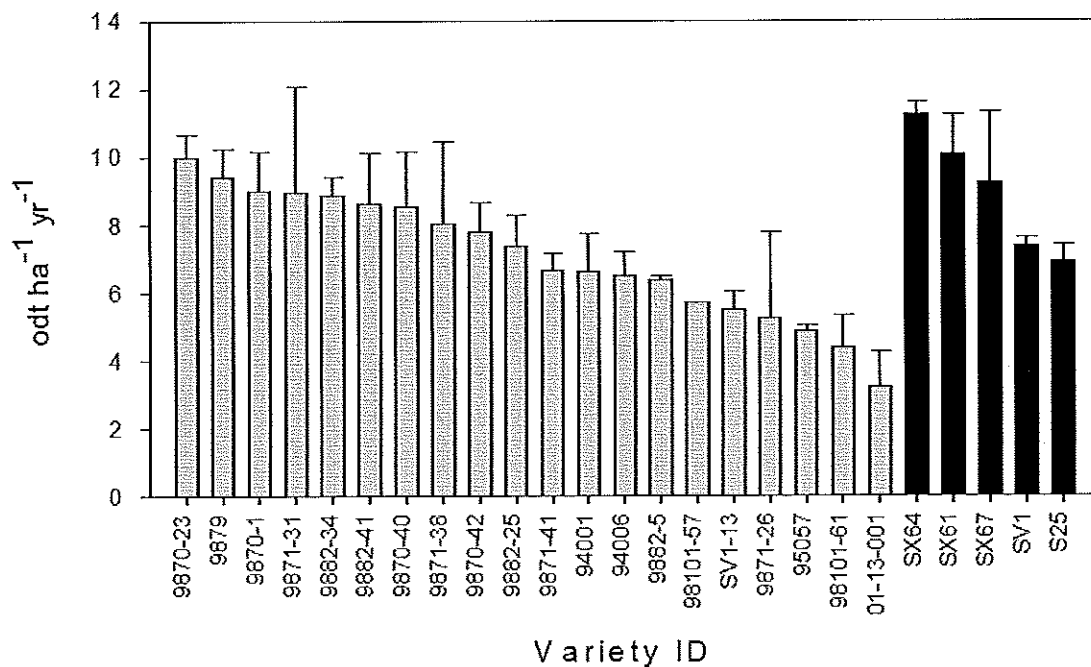
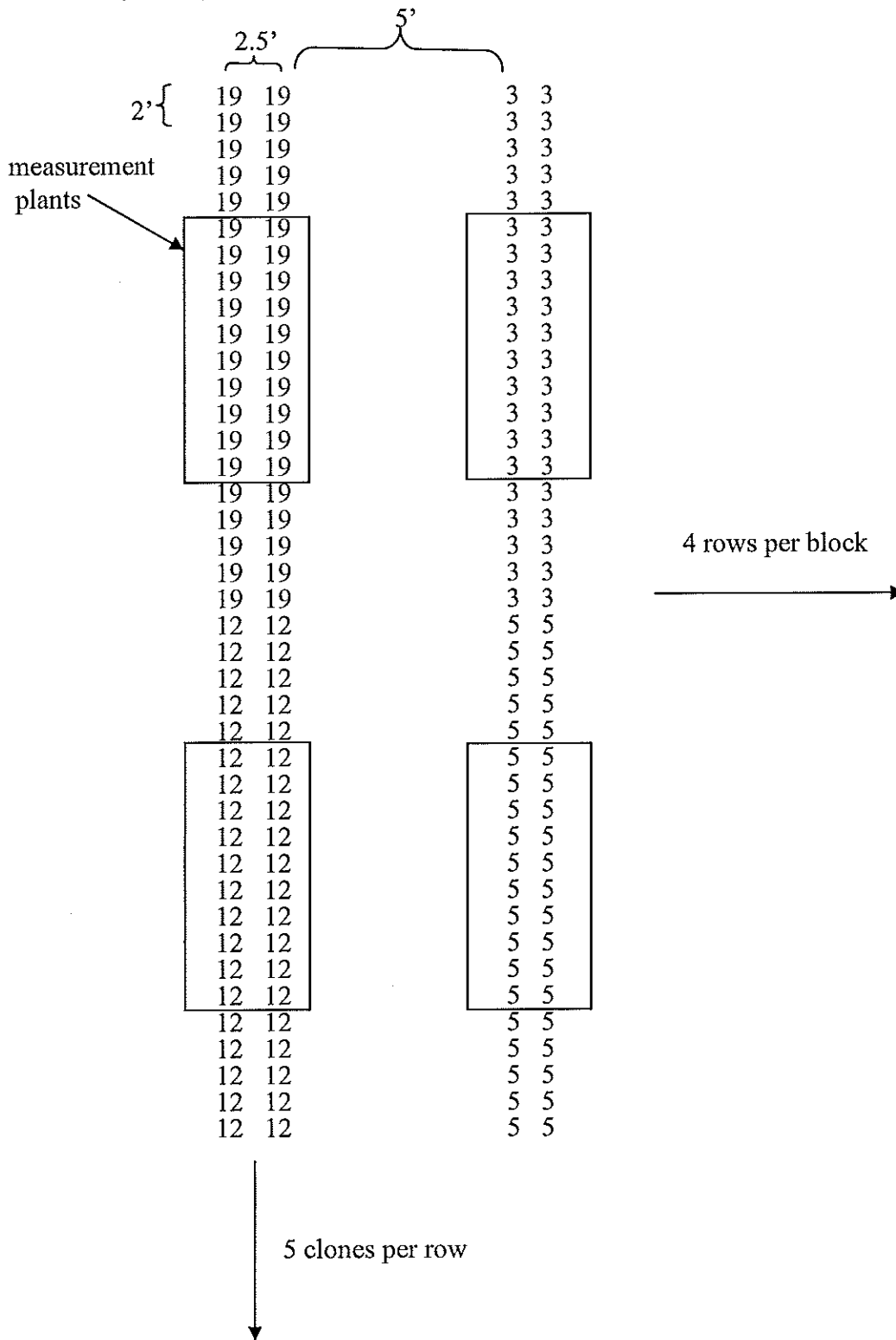


Figure 1. Mean first-rotation production of varieties tested in the 2001 genetic selection trial at Tully, NY. Grey bars represent varieties produced through controlled breeding or collected from naturally established stands. Black bars represent current production varieties for reference. Bars indicate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





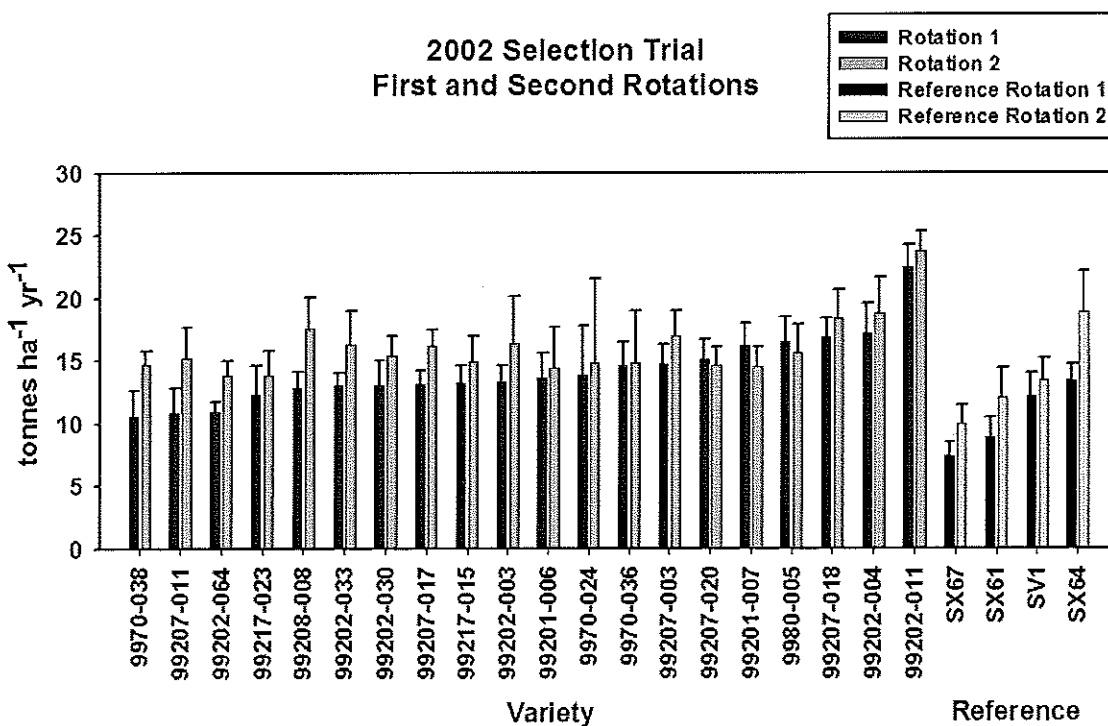
Clone	Species	Parents		Gender
		Female	Male	
SV1-13	dasy x ?	SV1	?-OP	F
9882-5	pur x pur	94006	94001	F
9882-41	pur x pur	94006	94001	F
9882-34	pur x pur	94006	94001	M
9882-25	pur x pur	94006	94001	F
9871-41	sach x miya	SX61	SX67	F
9871-38	sach x miya	SX61	SX67	F
9871-31	sach x miya	SX61	SX67	F
9871-26	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

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

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)

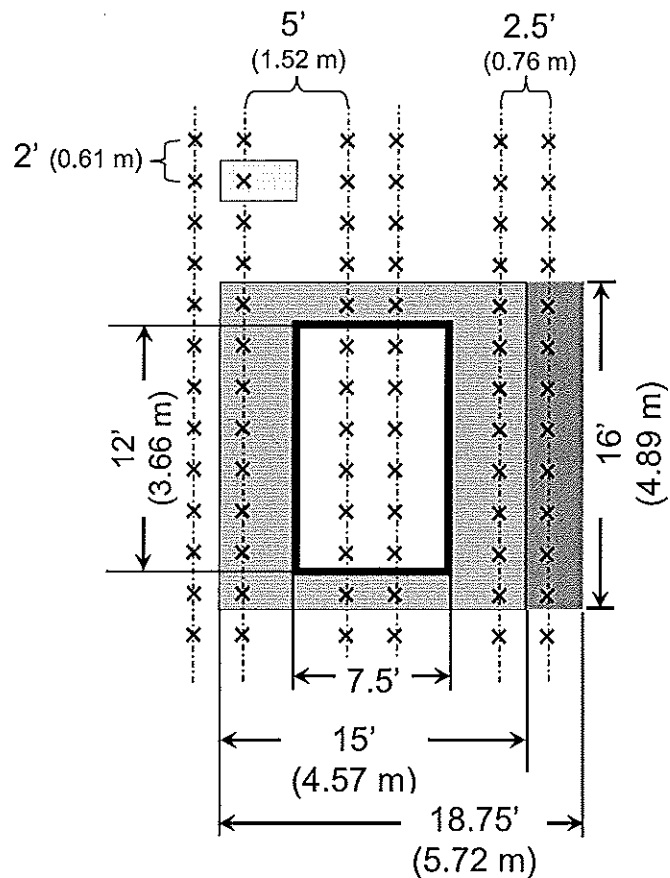
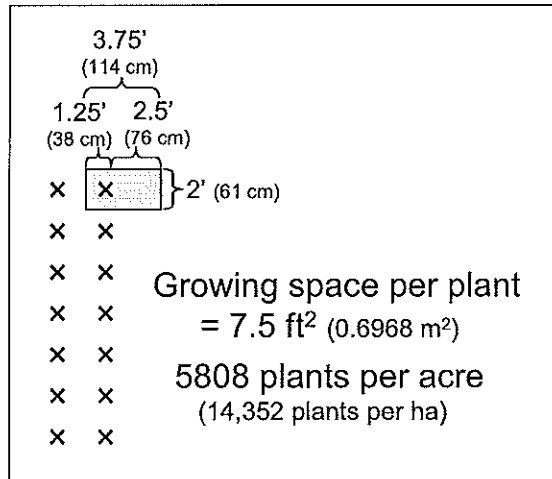
Reference clones for comparison: *S. sachalinensis* SX61, *S. miyabeana* SX64, *S. miyabeana* SX67, *S. dasyclados* SV1.

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).

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



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)

(Dm in ft.)	Dim. Width	18.75	33.75	52.5	67.5	86.25	101.25	116.25	135 ft	
Dim. Length	Plot width	18.75	15	18.75	16	18.75	15	15	18.75	
	Dim. Width	18.33	33	51.33	66	84.33	99	113.67	132	
	Kern's width	2.5	2	2.5	1	2.5	2	2	2.5	
Plot length		2.5 D-R	1+2(0.5D-R)	2.5 D-R	1 D-R	2.5 D-R	1+2(0.5D-R)	1+2(0.5D-R)	2.5 D-R	
4		2-plant buffer (planted with SQ83)								
16	1	Aerton Star	Beagle	990451	unplanted buffer					
32	4	970381	970253	Sq83	unplanted buffer					
48	7	Resolution	Nimrod	Endavour	unplanted buffer					
64	10	Tordis	mixed	970608	unplanted buffer	9871-31	9920-007	9911-012	9920-015	
80	13	Terranova	Endurance	Tordis	unplanted buffer	9970-036	S25	9900-005	9920-015	
96	16	Resolution	Sq83	Terranova	unplanted buffer	9882-034	SV1	9879	SX64	
112	19	Nimrod	Endavour	970608	unplanted buffer	94001	SX61	9920-011	9920-018	
128	22	Aerton Star	Beagle	970381	unplanted buffer	9980-005	9920-018	9970-036	9920-015	
144	25	990451	970253	mixed	unplanted buffer	9882-034	9882-011	SV1	S25	
160	28	Endurance	Sq83	Nimrod	unplanted buffer	99SX61	99SX64	994001	9911-012	
176	31	Aerton Star	990451	970381	unplanted buffer	9920-007	9871-31	9920-015	9879	
192	34	Tordis	970608	Resolution	unplanted buffer	S25	9970-036	9920-007	SX64	
208	37	Terranova	Beagle	Endurance	unplanted buffer	9871-31	9920-015	9879	9980-005	
224	40	Endavour	mixed	970253	unplanted buffer	99SX61	9911-012	9920-015	9920-018	
240	43	Sq83	Resolution	Tordis	unplanted buffer	SV1	9920-011	9882-034	94001	
256	46	Endurance	Endavour	970608	unplanted buffer	SX64	9920-015	9920-011	SX61	
272	49	990451	970253	Aerton Star	unplanted buffer	9911-012	9879	9871-31	SV1	
288	52	Nimrod	mixed	970381	unplanted buffer	9980-005	9882-034	S25	94001	
304	55	Terranova	Beagle	#N/A	unplanted buffer	9920-015	9920-007	9970-036	9920-018	
312	58	empty	#N/A	empty	unplanted buffer	9920-015	9920-007	9970-036	9920-018	
320		2-plant buffer (planted with US variety)								

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