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Irrigated and unirrigated eastern cottonwood and water oak in a short rotation fiber system on a former agricultural site

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IRRIGATED AND UNIRRIGATED EASTERN COTTONWOOD AND WATER OAK IN A SHORT ROTATION FIBER SYSTEM ON A FORMER AGRICULTURAL SITE[1]

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Abstract-Seedlings from an open-pollinated family of water oak (Quercus *nigra* L) and cuttings from *Populus* clones of eastern cottonwood *(Populus deltoides* Bartr. ex Marsh) and hybrid poplar *(P. trichocarpa* Torr. and Gray X P. *deltoides* Bartr. ex Marsh.) were tested on a Perry clay soil in east central Arkansas (St Francis County). The test site received a preplant application of 100 pounds of nitrogen per acre and weed control for two growing seasons. Unirrigated and irrigated test families were monitored for survival and growth through age two. Some *Populus* clones survived best when irrigated and other clones when unirrigated. All test material exhibited significantly more volume per planted tree when irrigated. After two growing seasons, irrigated exceeded unirrigated saplings with enhanced mean performance for height, diameter, and volume per planted tree of 3.1 feet, 0.6 inches and 19.9 feet^3, respectively. Hybrid poplars exhibited more uniform early growth.

INTRODUCTION

In the Northwest, environmental and political factors plus Japanese competition in domestic markets have contributed to record demands and prices for hardwood and softwood fiber. With limited fiber supply there, national and international demand shifted to southern forests. This has contributed to record demands and prices for pine and hardwood timber and fiber.

The 1996 Farm Bill reduces the support price of various agricultural commodities over the next seven years. Marginal, fine textured soils, that were traditionally in soybean production, may become less profitable and in need of an alternative crop. Short rotations of eastern cottonwood (Populus *deltoides* Bartr. ex Marsh.) are a possible alternative to soybeans and have the potential for integrated, agroforestry production as well.

Over 3 million acres of fine-textured "Sharkey-clay-type" soils occur in the Mississippi Delta with the potential for conversion to short rotation fiber systems. Most intensive plantations in cottonwood production today are on highly productive sites. Research is needed that examines the potential of eastern cottonwood on marginal sites receiving intensive culture such as furrow irrigation.

OBJECTIVE

The objective of this study was to compare the survival and growth of furrow irrigated and unirrigated Populus clones and water oak seedlings growing in an intensive short-rotation on a fine textured, moderately drained, former agricultural site.

METHODS

The study was installed on a remote 15-acre site in east central AR (St. Francis County) near Pine Tree. The soil there was a Perry clay (Gray and Catlett 1966). This site had been in a crop rotation system for soybeans, wheat-soybeans, and grain sorghum since 1981.

One-half of the area was bedded, planted, and furrow irrigated. The second half of the study plots was subsoiled and planted without irrigation. Levees were constructed to furrow irrigate 7.5 acres, protect the remaining 7.5 acres from irrigation water, and secure the entire study from other unwanted waters. Data for soil type, crop planting date, program activation date, daily temperature, and rainfall were entered into a soybean irrigation scheduler (Tacker et al 1996) to predict soil moisture deficits. Clones were irrigated when a 2-inch soil moisture deficit existed, i.e. when two inches of rainfall were required to bring the top 12 inches of soil to field capacity. The study was irrigated three times during each of the 1997 and 1998 growing seasons.

A one-time application of fertilizer (100 pounds of nitrogen per acre) was injected approximately 20 inches in depth in the unirrigated area. An equivalent amount of liquid fertilizer (100 pounds of nitrogen per acre) was surface-sprayed in a two-foot band and covered with a 20-inch bed on the irrigated portion of the study area. Early competitors were controlled with a preplant, broadcast application of oxyfluorfen+glyphosate (Goal®+Roundup® 5 pints+1 quart).

Test clones included cuttings from hybrid poplar (P. *trichocarpa* Torr. and Gray X P. *deltoides* Bartr. ex Marsh.) clones 49-I 77 and 1529, from Texas cottonwood clones S13C20 and S7C15, as well as from Stoneville, MS clones ST72, ST1 24, ST1 63, ST148 or Delta View (a mixture of Stoneville clones). An open-pollinated family of water oak *(Quercus nigra* L.) was also planted for testing. Cuttings were planted on a 1 O-feet X 1 O-feet spacing in treatment plots containing eight rows and seven trees in a row. Internal to each treatment plot was a measurement plot of six rows with five trees per row, leaving one row of border trees around each plot.

Mechanical weed control was maintained for two growing seasons by disking down row middles. Weeds around seedlings were removed by hand or hoe or treated with directed applications of glyphosate (Roundup@) or glufosinate (Finale@).

The study was installed according to a split-plot design. The whole plot effect was irrigation and the split-plot effect was water oak and Populus clone. Six randomized complete blocks were installed perpendicular to slope with clones

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assigned randomly within each block. Treatment effects were analyzed using an analysis of variance with means separated using Duncan's New Multiple Range test. All tests were conducted at the $p=0.05$ level.

Clones were measured initially and at the end of each growing season for total height and diameter (dbh). Analyses were conducted to detect differences in survival, height, diameter, and volume per planted tree. Height and diameter measurements were expressed in feet and volume computed as $volume=height*dbh^2$. Dead trees and trees less than 4.5 feet tall were assigned a volume of zero.

RESULTS AND DISCUSSION

First-year survival (1996) was low and considered unacceptable (< 50 percent) for irrigated and unirrigated plots of clones ST1 63, S7C15, ST72, Delta View, and ST148. For these plots surviving stems were rogued and stump cut surfaces treated in February with .001 quarts of concentrated Garlon 3A per inch of diameter. Plots were replanted with the same clone. On opposite sides in the bed row and two feet from the newly planted cutting, holes were punched with a IO-inch dibble. Holes were filled with ammonia nitrate at 50 pounds of nitrogen per acre and covered. Weed control in newly planted plots was maintained as described above. Control of unwanted ramets by Garlon 3A was excellent with 100 percent control. This effort improved survival overall by about 10 percent across all clones.

The analysis that follows is for data comparing survival and growth for the same age since planting, although some first-year clone measurements were from 1996 or 1997 growing-seasons. Year effects are confounded but may not be too serious since competition was controlled and fertilizer and water applied.

Survival

The main effect, irrigation, did not significantly influence survival at age one (1997) or two (1998) (tables 1 and 2). Survival averaged 64 percent for irrigated and unirrigated plantings. The clone by irrigation interaction was statistically significant for hybrid poplar 49-177, which survived 18 percent better if irrigated than unirrigated. Cottonwood clones ST1 24 and ST1 63 each exhibited 10 percent better survival if unirrigated. High investments in intensive cultures render large initial stocking differences highly undesirable. Data, at age two, suggest planting hybrid poplar clones (49-177, 1529) provides better stocked stands than planting cottonwood clones from Texas (S13C20, S7C15) or Stoneville (ST 124, ST-163, ST-148 or Delta View).

Growth

For height and diameter, irrigation was a significant source of variation at age one and two (tables 1 and 2). After one growing season, furrow irrigation provided more *Populus* height than no irrigation by 2.1 feet. Height growth differences increased to 3.1 feet by the end of two growing seasons. Similarly, *Populus* irrigated clones yielded 0.18 inches more diameter at age one and 0.6 inches more dbh after two growing seasons than unirrigated clones. All clones, except Delta View, exhibited larger diameters at age one when irrigated than when not irrigated (table 1). At age two, diameters for all clones including Delta View, were greater when irrigated than unirrigated.

Volume per planted tree at age one was best for the hybrid poplar, 1529. The Texas clone, S7c15, the Stoneville clone, ST124, and the hybrid poplar clone, 49-l 77 were intermediate. The Texas clone, S13C20, and Stoneville clones St72, ST1 63, ST148 and Delta View exhibited the least *Populus* growth. Oak growth was the least of all test material.

Clone rank for growth at age two changed little from age one with the exception of hybrid poplar 49-l 77 which moved from the fourth best performer at age one to the second best performer at age two. At ages one and two, volume per planted tree was enhanced by irrigation for all clones. At age two, irrigated out performed unirrigated test material with enhanced mean performance for height, dbh and volume of 3.1 feet, 0.6 inches and 19.9 $feet^3$ per tree, respectively.

The most significant result to date may be in survival and early stand development of cottonwoods versus hybrid poplars. For example, the hybrid poplars survived and performed best when irrigated. Thus, of the 180 ramets of 49-l 77 planted, 159 survived and 151 of these exceeded 4.5 feet in height after one growing season (table 1). Similar values were observed for irrigated hybrid poplar 1529. In contrast, cottonwood clones ST124, ST163 and ST148 survived and performed best when unirrigated. Even there, only 53 of 95, or 23 of 133 or 6 of 116, respectively, unirrigated ramets survived and exceeded 4.5 feet in height at age one. Clearly, the hybrid poplars survived and initiated more desirable early stand development than the clones of eastern cottonwood, regardless of origin.

Table I-Age one mean survival, height (n=number of trees), diameter (n=number of trees), and volume per planted tree for an open-pollinated water oak family and for cottonwood and hybrid poplar clones growing with and without furrow irrigation near Pine Tree, AR

Clones	Survival		Height[a]			
	Irrigated[b]	Unirrigated[b]	Irrigated[b]		Unirrigated[b]	
	Percent		*Feet*	*No.*	*Feet*	*No.*
49-177	88.3a	71.1abc	7.1b	*159*	5.5c	127
1529	72.8b	78.9a	8.2a	131	6.5a	142
S13C20	61.1c	61.1cde	7.0b	110	6.1b	110
ST72	67.8bc	67.8bc	5.5cd	122	2.4ef	122
S7C15	67.2bc	64.4bcd	5.5cd	121	2.7e	116
ST124	42.2e	52.8e	7.9a	76	4.9d	95
ST1 63	64.4bc	73.9ab	5.0e	116	2.7e	133
ST148	59.4cd	64.4bcd	5.5de	107	2.2f	116
Delta View	50.6de	55.6de	5.7c	91	2.5ef	100
Oak	69.4bc	51.7e	1.6f	125	1.5f	93
Mean[c]	64.3a	64.2a	5.8a		3.8b	

	Diameter[a]				Volume[a]	
	Inches	*No.*	*Inches*	*No.*	*Ft³*	
49-I 77	0.53cd	151	0.32cd	96	1.87c	0.39bc
1529	.69a	124	.44ab	117	3.32a	1.22a
S13C20	.51cd	104	.39bc	79	1.27d	.61b
ST72	.48d	81	.28d	16	.93de	.04e
S7C15	.63b	64	.45ab	16	2.59b	.29cd
ST124	.73a	73	.37bc	53	2.13bc	.44bc
ST163	.52cd	51	.29d	23	.87de	.07de
ST148	.42e	71	.28d	6	.51ef	.02e
Delta View	.53c	59	.49a	10	.83de	.10de
Oak	.oo	0	.oo	0	.00	.oo
Mean[c]	.56a		.38b		1.43a	.32b

[a] Irrigated versus unirrigated means for Delta View d.b.h. is not significantly different (Duncan's New Multiple Range Test, p = 0.05). All other irrigated versus unirrigated contrasts by clone for height, d.b.h., and volume are significantly different (Duncan's New Multiple Range Test, p = 0.05).

[b] Means within a column sharing a letter are not significantly different (Duncan's New Multiple Range Test, p =0.05).

[c] Attribute means within a row and sharing the same letter are not significantly different (Duncan's New Multiple Range Test, p = 0.05).

Table 2-Mean survival, height (n=number of sample trees), diameter (n=number of trees), and volume per planted tree at age two for an open-pollinated water oak family and for cottonwood and hybrid poplar clones growing with and without furrow irrigation near Pine Tree, AR

Clones	Survival		Height[a]			
	Irrigated[b]	Unirrigated[b]	Irrigated[b]		Unirrigated[b]	
	----- Percent -----		Feet	No.	Feet	NO.
49-177	88.3a	70.5ab	16.2b	159	14.1b	127
1529	72.8b	78.9a	19.8a	131	15.7a	142
S13C20	60.6cd	61.1bcd	15.1d	109	12.3c	110
ST72	67.8bc	67.8bc	12.1de	122	8.5f	122
S7C15	62.2cd	63.3bc	12.5d	112	8.7ef	114
ST124	42.2e	51 .lde	16.6b	77	11.4d	92
ST163	61.1cd	70.6ab	11.8e	110	9.2e	127
ST148	56.1d	64.4bc	12.1de	101	7.9g	118
Delta View	50.6cd	55.6cd	11.8de	104	8.6f	105
Oak	62.2cd	47.8e	3.9f	112	2.2h	86
Mean[c]	63.10a	64.0a	13.3a		10.2b	

	Diameter[a]				Volume[a]	
	Inches	No.	Inches	No.	------- Ft^3 --------	
49-177	2.0b	158	1.7b	127	58.31b	34.94b
1529	2.5a	131	1.9a	142	98.14a	54.27a
S13C20	2.0b	108	1.5c	108	39.80c	23.60c
ST72	1.4cd	118	.6e	118	24.84de	3.0ef
S7C15	1.5c	105	.7d	106	28.34d	5.06e
T124	2.3a	77	1.4c	90	42.13c	16.92d
ST163	1.3d	106	.7d	121	19.52e	4.43ef
ST148	1.3cd	98	.6e	113	16.60e	2.53ef
Delta View	1.3cd	99	.6de	92	19.13e	3.35ef
Oak	.3e	8	.0d	4	.oo	.00
Mean[c]	1.7a		l.lb		34.68a	14.81 b

[a] All irrigated versus unirrigated means per clone are significantly different (Duncan's New Multiple Range test, p = 0.05).

[b] Means within a column sharing a letter are not significantly different (Duncan's New Multiple Range Test, p = 0.05).

[c] Attribute means within a row and sharing the same letter are not significantly different (Duncan's New Multiple Range Test, p = 0.05).

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