NINE-YEAR PERFORMANCE OF A VARIETY OF *POPULUS* TAXA ON AN UPLAND SITE IN WESTERN KENTUCKY

Randall J. Rousseau, Joshua P. Adams, and David W. Wilkerson[1]

Abstract—A variety of hybrid poplars have been planted on upland sites throughout the Midwest and Midsouth regions of the United States. Very few of these clones have proven to be worthwhile due to susceptibility to a variety of diseases. Five different *Populus* taxa were planted on an upland site in western Kentucky as a means of assessing resistance to local diseases, especially *Septoria musiva*. These taxa included combinations of *P. trichocarpa* crossed with *P. deltoides*, *P. maximowiczii*, and *P. nigra*, as well as backcrosses to *P. deltoides* and *P. maximowiczii*. Age 9 results indicated that survival for all five taxa was rather low with the *P. trichocarpa* × *P. deltoides* (TD) taxon being highest at 53.9 percent and the *P. trichocarpa* × *P. nigra* the lowest at 8.8 percent. In addition, the TD taxon also exhibited the best volumetric performance for age 9 diameter and height at 4.7 inches and 27.9 feet, respectively. Clone 24, a TD clone, exhibited the best age 9 survival, diameter, height, volume, and a good disease index rating at 96 percent, 7.2 inches, 37.4 feet, 4.34 cubic feet, and 2.20, respectively. Although, the TD taxon was the overall best performing taxa through age 9, a tremendous amount of variability exists among clones dictating testing of numerous clones prior to recommendation of large-scale plantings.

INTRODUCTION

Performance of fast-growth hardwood species established under plantation culture in the South, except for those planted on highly fertile alluvial and bottomland sites, has been rather poor. The ability to identify a specific hardwood species that combines rapid growth, ability to sustain rapid juvenile growth when grown over a wide geographic area and numerous soil types, disease resistance, and wood characteristics needed for an array of products has never been obtained. However, by limiting the geographic area, soil type, and the product, it may be possible to identify a fast-growth hardwood. The work reported in this paper was such an attempt made by Westvaco Corporation for upland sites in western Kentucky.

In general, eastern cottonwood (*Populus deltoides* Bartr.) plantations perform exceptionally well when grown on alluvial sites along the Mississippi River (Krinard 1985, Krinard and Johnson 1984, Rousseau 1987). Westvaco's Central Region had established thousands of acres of successful Mississippi River alluvial cottonwood plantations beginning in the mid-1970s but had not been successful in duplicating this performance outside of the alluvial area. The rapid growth of alluvial cottonwood plantations resulted in shorter rotation lengths and favorable economic returns. Unfortunately, alluvial cottonwood plantations are inaccessible during much of the winter and spring of each year thus dictating an additional source of this type of fiber. One approach to this problem was to investigate the possibility of fertigated plantations, i.e., plantations that are both fertilized and irrigated, and upland sites as sources of such fiber (Rainwater 1999). While the fertigated plantations concentrated on growing cottonwood plantations, the upland sites were more focused on hybrid poplars and aspen (*P. tremuloides* Michx.).

The reasoning behind this approach was partially taken from earlier studies that involved *P. trichocarpa* × *P. deltoides* hybrids on alluvial sites, Oxford Paper Company clones (also known as NE or OP clones) on upland sites, and a limited number of *P.* ×*canadensis* (synonym *P.* ×*euramericana*) hybrids (Dickmann and others, 2001) all of which were shown to be susceptible to Septoria leaf spot and stem canker (*Septoria musiva* Peck). This was not unexpected as work by Newcombe and Ostry (2001) has shown similar results in much of the Mississippi and St. Lawrence River drainages. The canker stage of Septoria causes the most damage, eventually ending in death of the infected tree (Ostry and others 1989). Hybrid poplars grown on the Mississippi River alluvial sites in western Kentucky quickly succumbed to Septoria cankers. Although some hybrid poplars survived on upland sites in western Kentucky when located in the Ohio River drainage, their growth was not suitable for large-scale plantation establishment. In addition, the majority of these clones were bred for survival and performance in either Europe or the Northeastern United States. It was hoped that planting the hybrid poplars on the uplands would remove them far enough from the main source of Septoria inoculum to prevent infection.

Hybrids resulting from the breeding of black cottonwood (*P. trichocarpa* Torr. & Gray) of the Northwestern United States and Canada have performed very well at various locations in the United States and Europe and warrant further investigation in experimentally designed tests. However, many F_1 hybrid poplars, especially black cottonwood hybrids, are susceptible to Septoria stem canker that renders them useless for plantation forestry. Eastern cottonwood is highly resistant and Japanese poplar (*P. maximowiczii* A. Henry) shows some resistance to Septoria stem canker. Backcrossing *P. trichocarpa* F_1 hybrids to their resistant parent may provide resistant offspring with the rooting and growth potential of the F_1 hybrids.

The Poplar Molecular Genetics Cooperative (PMGC), which was headquartered at the University of Washington, was

[1] Associate Extension/Research Professor and Graduate Research Assistants, Mississippi State University, Department of Forestry, Mississippi State, MS, respectively.

formed in 1995. Westvaco became a member the following year. PMGC was established to increase the understanding of molecular genetic mechanisms causing variation in productivity and quality traits in hybrid poplar and to use the research results to accelerate progress in poplar breeding. Species and hybrid types created through controlled breeding that are used in their research are referred to individually as a “taxon.” A byproduct of the cooperative’s work is the generation of thousands of pedigreed progeny from a wide variety of interspecific and backcross hybrids. The breeding program primarily uses black cottonwood as the female parent with eastern cottonwood, black poplar (*P. nigra* L.), and Japanese poplar as the pollen parents. Balsam poplar (*P. balsamifera* L.) has been used to a lesser extent. F_1, backcross, and F_2 hybrids have been formed using most of the possible combinations. To take advantage of these diverse hybrid types, a series of studies were established on upland sites in Kentucky, Tennessee, West Virginia, and Virginia from 1999 through 2001. The western Kentucky test site will be reported on in this paper. The purpose of this study was to select hybrid poplar clones that exhibit excellent survival, rapid growth, and disease resistance making them suitable candidates for large-scale plantings on upland sites in western Kentucky.

METHODS

Planting Stock

Clones for the study originated from the breeding program of the PMGC. Three taxa were used as the female parents including pure *P. trichocarpa* (T) selections native to the Pacific Northwest and southwestern Canada, *P. trichocarpa* × *P. maximowiczii* (TM) hybrids, and *P. trichocarpa* × *P. deltoides* (TD) hybrids. Pollen parents included *P. deltoides* (D), *P. nigra* (N), and *P. maximowiczii* (M). Selection of clones for testing was based on parental pedigree information (table 1) and 1- or 2-year nursery growth data supplied by the cooperative. The decision was made to primarily use clones from progeny with parents from southern portions of their respective ranges, but other clones were included to provide diverse genetic backgrounds. No hybrids using *P. balsamifera* were selected. The PMGC was notified about the desired selections approximately 14 months prior to study establishment. They provided 1-year-old, dormant whips to Broadacres Nursery, Inc.,(Hubbard, OR) for propagation in the spring of the year preceding study establishment. Stock plants were propagated from dormant single bud cuttings, and additional ramets for the study were produced from in-leaf cuttings. The plants were grown throughout the summer in 24-cell trays with approximately 2.5- by 2.5- by 3-inch cell dimensions. After attaining dormancy, the plants were trimmed to 8-inch tops, removed from the containers, and stored in plastic bags at 28 °F. The dormant plants were shipped to Wickliffe, KY, in February 1999. In late March, the plants were sorted into replications and taxon blocks for the study site, repackaged in plastic bags, and stored at 35 °F until planted.

Experimental Design

The experimental design for the study is a compact family (split-plot) design with 8 replications, 5 taxa, and 10 clones per taxon. Main plots within a replication represent one taxon, and the subplots include the clones within a taxon. Each clone is represented by a two-tree plot. Certain clones were in limited supply or unavailable because of propagation difficulties; therefore, not every taxon was represented by 10 different clones. To insure a full subplot some clones are duplicated, but only a single designated two-tree measurement plot was included in the analysis. Thus, for the 1999 test site in western Kentucky there are 5 taxa tested, totaling 48 clones. The TD and TM subplots in Kentucky contain only nine clones (table 1).

Site Preparation and Establishment

The study site is located on the Cullom Tract in Livingston County, KY. The site is on a broad ridge and was previously planted in pine (*Pinus* spp.). Site preparation included shearing, raking, piling, and burning during the fall of 1998. The area was disked then row marked and slit at 10 by 10 feet. Study trees were planted on May 3, 1999. A one-row border of NM-6 (hybrid poplar known for its resistance to Septoria) surrounds the study (fig. 1). The area was disked twice during the summer to control weeds, and fertilizer was applied to each tree in June 1999 at a rate of 150 pounds nitrogen (ammonium nitrate) and 75 pounds phosphorous (triple super phosphate).

Measurements and Analysis

Total height, survival, and crown score measurements were taken at age 2. The crown score included both leaf retention and leaf color (table 2). Survival, total height, diameter, and disease ratings were measured at age 9. The age 9 disease rating system focused on canker development and included both limb and stem (table 2). Volume was calculated using an equation developed by Krinard (1988) for plantation grown eastern cottonwood, which was $0.06+0.00221(D^2H)$. Percent survival data was calculated and transformed using arcsine transformation followed by analysis of variance (ANOVA). ANOVA for all traits was performed using PROC GLM along with the RANDOM option to accommodate the unbalance in the design.

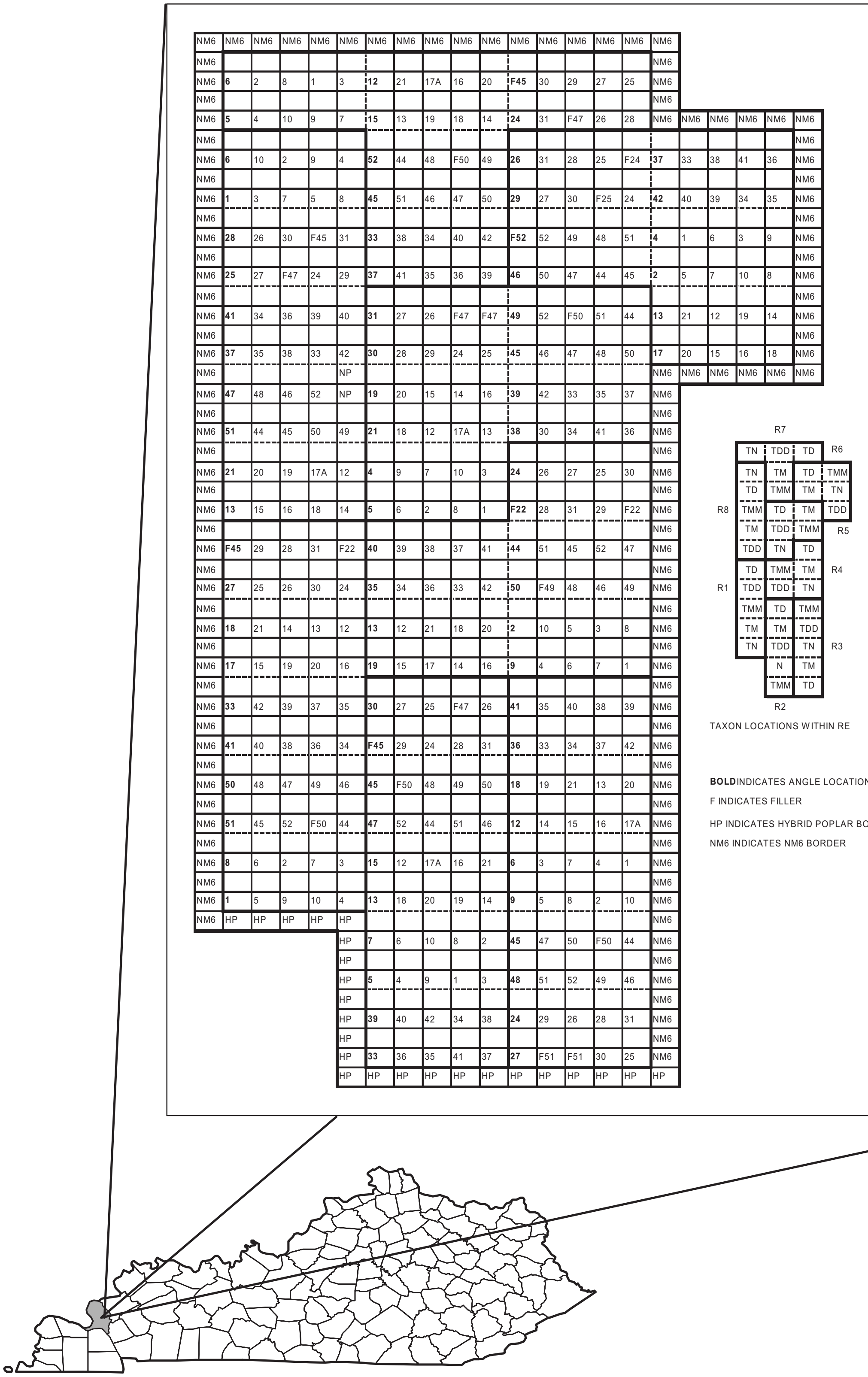
RESULTS

Overall survival in the study at age 2 was 92.4 percent. Among the five taxa, the TD hybrids had the highest survival at 97.7 percent while the TDD hybrids were the lowest at 88.8 percent. The TD and TM hybrids (95.8 percent) were the only two that did not differ significantly at age 2. The TDD, TMM (90 percent), and TN (91.3 percent) hybrids exhibited the lowest age 2 survival but were still acceptable.

By age 9, survival of the study dropped to 23.9 percent. Survival of all five taxa would be considered unacceptable, with the TD hybrids again exhibiting the highest survival at 53.9 percent. Age 9 survival of the TDD, TM, and TMM taxa was very similar at 20.6, 20.6, and 21.5 percent, respectively. The TN taxa had the lowest age 9 survival at 8.8 percent. Age 9 clonal survival was significantly different with two TD clones, i.e., 24 and 25, being the highest at 94 percent. Only one other clone, i.e., 28, which was also a TD hybrid, exhibited an

Table 1—Hybrid poplar clones included in the 1999 study identified by field number, taxa, origin, and parentage

Field		Female			Male		
Number	Taxa	Parent	Origin	Clone	Parent	Origin	Clone
1	TN	*Populus trichocarpa*	Washington	2499	*Populus nigra*	France	2554
2	TN	*P. trichocarpa*	Washington	2498	*P. nigra*	France	2554
3	TN	*P. trichocarpa*	Washington	2498	*P. nigra*	France	2557
4	TN	*P. trichocarpa*	Idaho	2518	*P. nigra*	France	2554
5	TN	*P. trichocarpa*	Washington	2499	*P. nigra*	France	2557
6	TN	*P. trichocarpa*	Washington	2499	*P. nigra*	France	2557
7	TN	*P. trichocarpa*	Washington	5103	*P. nigra*	France	2557
8	TN	*P. trichocarpa*	British Columbia	5092	*P. nigra*	France	2554
9	TN	*P. trichocarpa*	British Columbia	5051	*P. nigra*	France	2554
10	TN	*P. trichocarpa*	British Columbia	5098	*P. nigra*	France	2554
12	TDD	TD F_1	WA × TX	177	*P. deltoides*	Texas	961
13	TDD	TD F_1	WA × TX	177	*P. deltoides*	South Carolina	962
14	TDD	TD F_1	WA × TX	177	*P. deltoides*	Illinois	101
15	TDD	TD F_1	WA × TX	177	*P. deltoides*	Illinois	101
16	TDD	TD F_1	WA × IL	255	*P. deltoides*	South Carolina	982
17	TDD	TD F_1	WA × TX	177	*P. deltoides*	South Carolina	979
18	TDD	TD F_1	WA × MS	29	*P. deltoides*	Mississippi	951
19	TDD	TD F_1	WA × MS	29	*P. deltoides*	Mississippi	953
20	TDD	TD F_1	WA × TX	177	*P. deltoides*	Texas	960
21	TDD	TD F_1	WA × TX	177	*P. deltoides*	Mississippi	951
22	TDD	TD F_1	WA × TX	177	*P. deltoides*	Mississippi	951
24	TD	*P. trichocarpa*	Washington	2499	*P. deltoides*	South Carolina	982
25	TD	*P. trichocarpa*	Washington	2499	*P. deltoides*	South Carolina	982
26	TD	*P. trichocarpa*	Washington	2550	*P. deltoides*	Illinois	101
27	TD	*P. trichocarpa*	Washington	2550	*P. deltoides*	Illinois	101
28	TD	*P. trichocarpa*	British Columbia	5098	*P. deltoides*	South Carolina	982
29	TD	*P. trichocarpa*	Washington	2499	*P. deltoides*	Texas	961
30	TD	*P. trichocarpa*	Washington	2499	*P. deltoides*	Texas	961
31	TD	*P. trichocarpa*	British Columbia	2437	*P. deltoides*	Mississippi	953
33	TMM	TM F_1	F_1	256	*P. maximowiczii*	Hokkaido	5105
34	TMM	TM F_1	F_1	265	*P. maximowiczii*	Hokkaido	5105
35	TMM	TM F_1	F_1	265	*P. maximowiczii*	Hokkaido	5105
36	TMM	TM F_1	F_1	252	*P. maximowiczii*	Hokkaido	5105
37	TMM	TM F_1	F_1	252	*P. maximowiczii*	Hokkaido	5105
38	TMM	TM F_1	F_1	256	*P. maximowiczii*	Hokkaido	5105
39	TMM	TM F_1	F_1	256	*P. maximowiczii*	Hokkaido	5105
40	TMM	TM F_1	F_1	256	*P. maximowiczii*	Hokkaido	5105
41	TMM	TM F_1	F_1	279	*P. maximowiczii*	Hokkaido	5105
42	TMM	TM F_1	F_1	279	*P. maximowiczii*	Hokkaido	5105
44	TM	*P. trichocarpa*	Washington	2499	*P. maximowiczii*	Hokkaido	5105
45	TM	*P. trichocarpa*	Washington	2499	*P. maximowiczii*	Hokkaido	5105
46	TM	*P. trichocarpa*	Washington	2499	*P. maximowiczii*	Hokkaido	5105
47	TM	*P. trichocarpa*	Washington	2499	*P. maximowiczii*	Hokkaido	5105
48	TM	*P. trichocarpa*	British Columbia	2437	*P. maximowiczii*	Hokkaido	5104
49	TM	*P. trichocarpa*	British Columbia	2437	*P. maximowiczii*	Hokkaido	5104
50	TM	*P. trichocarpa*	Washington	2499	*P. maximowiczii*	Hokkaido	5105
51	TM	*P. trichocarpa*	Washington	2499	*P. maximowiczii*	Hokkaido	5105
52	TM	*P. trichocarpa*	British Columbia	2437	*P. maximowiczii*	Hokkaido	5104



Code	Family	Clone	Taxon
1	422	3135	TN
2	423	3150	TN
3	424	3372	TN
4	449	4779	TN
5	543	7526	TN
6	543	7527	TN
7	587	10128	TN
8	646	7659	TN
9	688	11014	TN
10	575	7852	TN
12	430	4955	TDD
13	431	11286	TDD
14	493	8336	TDD
15	493	11248	TDD
16	504	6130	TDD
17	426	3549	TDD
18	480	8301	TDD
19	481	11899	TDD
20	429	4954	TDD
21	425	3502	TDD
22	425	3505	TDD
24	447	4708	TD
25	447	4711	TD
26	584	5133	TD
27	584	5136	TD
28	573	11893	TD
29	446	4645	TD
30	446	4650	TD
31	465	4974	TD
33	526	6844	TMM
34	514	11960	TMM
35	514	11964	TMM
36	518	8855	TMM
37	518	8857	TMM
38	526	6837	TMM
39	526	6848	TMM
40	526	6859	TMM
41	530	11154	TMM
42	530	11155	TMM
44	547	11576	TM
45	547	11579	TM
46	547	11590	TM
47	547	11593	TM
48	537	11518	TM
49	537	11525	TM
50	547	11561	TM
51	547	11591	TM
52	537	11031	TM

Figure 1—Geographic location of the study in western Kentucky and field design by taxa and clone.

Table 2—Age 2 crown ratings and age 9 Septoria disease index

Age 2 crown scores
1 = Full crown with leaves being green in color
2 = 25 percent defoliation with pale green leaves
3 = 75 percent defoliation with yellowish leaves
4 = >75 percent defoliation with remaining leaves yellow to brown in color
Age 9 Septoria disease rating
1 = No symptoms shown on either limbs or stem
2 = Canker visible on limbs but not on stems
3 = Canker visible on both stem and limbs
4 = Canker damage extensive enough to cause dieback to the groundline

age 9 survival >70 percent. A total of 14 clones had complete mortality. Three of these were TN clones, six TDD clones, and five TMM clones.

ANOVA for age 2 total height showed significant differences among taxa and among clones within taxa as well as the interaction terms of block by taxa and block by clones within taxa. Age 2 mean height for the study was 9.0 feet. The age 2 mean height for the five taxa were 9.5 feet for the TD and TM clones, 8.9 feet for the TMM clones, and 8.5 feet for the TDD and TN clones. Age 2 height of the TD clones ranged from 10.7 feet (clone 29) to 8.6 feet (clone 27). The age 2 height of the TM clones ranged from 10.3 feet (clone 52) to 8.8 feet (clone 46). The age 2 height range of the TMM clones was from 10.3 feet for clone 39 to 8.0 feet for clone 36. Age 2 heights for the clones in the TDD and TN taxa ranged from 9.7 feet (clone 14) to 7.2 feet (clone 20) and 9.6 feet (clone 4) to 6.4 feet (clone 8), respectively.

ANOVA for age 9 diameter and total height showed significant differences among taxa and among clones within taxa. Unlike the age 2 results, the interaction terms of block by taxa and block by clones within taxa were nonsignificant for age 9 diameter and total height. Age 9 mean diameter and height across all taxa in the study was 3.2 inches and 19.7 feet, respectively. The age 9 mean diameters for the five taxa were 4.7, 3.8, 2.5, 4.2, and 3.4 inches for the TD, TM, TMM, TN, and TDD taxa, respectively. The age 9 mean heights of the five taxa were 27.9, 18.5, 14.1, 18.6, and 19.4 feet for the TD, TM, TMM, TN, and TDD taxa, respectively. Clones within the TD taxon ranged from 37.4 (clone 24) to 20.6 (clone 31) feet, for age 9 height and 7.2 (clone 24) to 2.9 (clone 31) inches for age 9 diameter (table 3). Clones within the TDD taxon ranged from 24.0 (clone 16) to 12.5 (clone 18) feet for age 9 height and 4.8 (clone 16) to 2.5 (clone 21) for age 9 diameter (table 3). Age 9 diameter and height performance of the clones within the TM taxon ranged from 5.6 (clone 45) to 1.8 (clone 48) inches and 28.0 (clone 47) to 11.3 feet (clone 49), respectively (table 3). The clones of the TMM taxon showed a range of 3.6 (clone 34) to 1.6 (clone 39) inches and 19.6 (clone 35) to 7.0 (clone 42) feet for age 9 diameter and height, respectively (table 3). Lastly, the TN taxon exhibited clones with a range in values for age 9 diameter and height from 5.6 (clone 8) to 3.0 (clone 10) and 27.1 (clone 8) to 13.0 (clone 10) feet, respectively (table 3).

Volume at age 9 followed along the same trends as shown by the diameters at age 9, with the TD taxon being significantly different than the other four taxa. The mean age 9 volume for the TD, TM, TN, TDD, and TMM taxa were 1.77, 0.82, 0.86, 0.63, and 0.32 cubic feet, respectively. Clones among all five taxa ranged from a high of 4.34 cubic feet for clone 24 in the TD taxon to a low of 0.11 cubic feet for clone 42 in the TMM taxon.

The crown rating scheme that was used at age 2 to provide a sense of disease incidence among the five taxa showed all of the taxa, except the TN taxon, averaged the lowest possible score (crown score of “4”). The TN taxon had the best crown score of all the taxa, yet it was among the shortest in mean height at age 2. The age 9 disease rating scheme among the five taxa showed that the TD and TDD taxa were the most resistant to Septoria, while the TM, TMM, and TN taxa were extremely susceptible. This became even more evident when looking at the range of disease scoring within each taxon. The TD and TDD taxa exhibited clones across the range of values while the TM, TMM, and the TN taxa only exhibited values representative of the severest disease rating.

Clonal performance within taxa indicated that selection should be confined to only the TD taxon. Clones 24 and 25 of the TD taxon were the top performing individuals at age 9. Clone 24 ranked first for every age 9 trait, with 94 percent survival, d.b.h. of 7.2 inches, 37.4 feet in total height, 4.34 cubic feet of volume, and a 2.3 disease rating. Clone 25 performed similarly, exhibiting 94 percent, 6.0 inches, 35.6 feet, 2.89 cubic feet, and 2.7 for survival, d.b.h., total height, volume, and disease rating, respectively. Clone 16 was the top performing clone within the TDD taxon exhibiting age 9 survival, d.b.h., total height, volume, and disease rating of

Table 3—Identification of surviving hybrid poplar clones in the 1999 taxon study located in Livingston County, KY, by taxa and clone number along with the respective age 9 mean performance for survival, d.b.h., total height, volume, and disease resistance

Taxa	Clone	Survival	D.b.h.	Height	Volume	Disease index
		percent	*inches*	*feet*	*cubic feet*	
TN	3	37.5	4.3	16.5	0.73	4.00
TN	4	68.8	3.9	21.1	0.77	4.00
TN	5	31.3	4.2	20.3	0.85	4.00
TN	6	6.3	4.5	17.6	0.85	4.00
TN	7	37.5	3.9	14.8	0.56	4.00
TN	8	18.8	5.6	27.1	1.94	3.67
TN	10	6.3	3.0	13.0	0.32	4.00
TDD	14	62.5	3.1	22.6	0.54	2.70
TDD	15	50.0	3.8	22.4	0.77	1.50
TDD	16	68.8	4.9	24.0	1.33	3.27
TDD	18	6.3	2.6	12.5	0.25	4.00
TDD	21	18.8	2.5	15.4	0.27	3.67
TD	24	93.8	7.2	37.4	4.34	2.20
TD	25	93.8	6.0	35.6	2.89	2.53
TD	26	50.0	6.2	34.0	2.95	3.50
TD	27	25.0	3.7	25.3	0.83	3.75
TD	28	81.3	3.8	20.7	0.72	4.00
TD	29	6.3	3.6	23.6	0.74	2.00
TD	30	31.3	4.5	25.8	1.21	3.00
TD	31	50.0	2.9	20.6	0.44	3.00
TMM	34	12.5	3.6	17.0	0.55	4.00
TMM	35	31.3	3.6	19.6	0.62	4.00
TMM	39	6.3	1.6	12.7	0.13	4.00
TMM	40	6.3	2.0	14.3	0.19	4.00
TMM	42	31.3	1.8	7.0	0.11	4.00
TM	44	6.3	5.0	19.6	1.14	3.00
TM	45	6.3	5.6	23.4	1.68	4.00
TM	46	37.5	3.3	18.3	0.50	4.00
TM	47	56.3	5.2	28.0	1.73	3.78
TM	48	12.5	1.8	13.2	0.15	4.00
TM	49	6.3	2.3	11.3	0.19	4.00
TM	50	25.0	4.6	24.1	1.19	4.00
TM	51	25.0	3.8	13.2	0.48	4.00
TM	52	18.8	2.6	15.1	0.29	4.00

TN = *P. trichocarpa* x *P. nigra*; TDD = TD x *P. deltoides*; TD = *P. trichocarpa* x *P. deltoides*; TMM = TM x *P. maximowiczii*; TM = *P. trichocarpa* x *P. maximowiczii*.

69 percent, 4.9 inches, 24.0 feet, 1.33 cubic feet, and 3.3, respectively. Within the TM taxon clone 47 was the best performer at age 9 with 56 percent survival, d.b.h. of 5.2 inches, 28 feet in height, 1.73 cubic feet of volume, and a disease rating of 3.8. Clone 8 was the top performing clone within the TN taxon, exhibiting 19 percent survival, d.b.h. of 5.6 inches, total height of 27.1 feet, 1.94 cubic feet of volume, and a disease rating of 3.7. The best clone within the TMM taxon was clone 35 which had 31 percent survival, d.b.h. of 3.6 inches, total height of 19.6 feet, volume of 0.62 cubic feet, and a disease rating of 4.0.

DISCUSSION

This test was designed to evaluate the potential of various hybrid poplars based upon their parentage when established on upland sites. The parentage bias toward black cottonwood was simply due to the fact that this material was available and had never been tested in the Midsouth area. In addition, the inclusion of the eastern cottonwood and Japanese poplar germplasm into the hybrid makeup also provided incentive for screening in hopes of finding individuals that would combine hybrid vigor or growth and disease resistance. This was especially true of the backcross TDD taxon, since eastern cottonwood is resistant to Septoria.

As expected, early age performance, in this case age 2, did not adequately predict future performance of the taxa or clones especially in relationship to the Septoria disease resistance. Although there was variability within all taxa for age 2 height, TM was the top performer, with 5 of the top 10 tallest clones. In comparison, the TD taxon had only 2 of the top 10 clones. However, by age 9 this trend was nearly reversed, with 6 of the top 10 tallest clones coming from the TD taxon and only 2 of the tallest clones from the TM taxon. In fact, the top three tallest clones were all from the TD taxon. Surviving clones within the TM, TN, and TMM taxa showed very little resistance to Septoria canker based upon the age 9 disease index. This suggests that within the Midsouth area of the United States, these types of hybrid clones should not be included in plantation culture. Newcombe and Ostry (2001) stated that TD F_1 hybrids were uniformly susceptible to Septoria stem canker and that up to one-half of the backcross TDD taxon would be susceptible. Clones 24, 25, and 29 all of which are in the TD taxon showed good Septoria resistance with disease indices of 2.20, 2.53, and 2.00, respectively, indicating that the disease is limited to only limbs. It has been our experience that the disease seems to affect the limbs first and then move into the stem. If indeed this continues to be the norm, then we would expect none of the clones capable of reaching the size needed for traditional harvest methods. However, if the disease remains limited to the limbs, it may be feasible that a few clones could reach harvest size. Interestingly, clones 24 and 25 share the same male and female parentage, while clone 29 shared the same female parent. The TDD taxon showed similar variability in the disease index rating. It had the only one clone (clone 15) that was nearly free of disease, but this suggests that similar Septoria resistance might be found within this taxon.

Although the test indicated that resistance to Septoria canker disease can be found within the hybrid poplar taxa tested, only two clones, i.e., clones 24 and 25, exhibited survival, growth, and disease resistance sufficient enough to warrant inclusion into an upland plantation program. Even clone 24, which was the fastest growing clone within the test averaged only 4.2 feet and 0.8 inches in diameter per year. While eastern cottonwood was not included in the study, clonal material was established adjacent to the test site. This material showed excellent survival and growth rates superior to the hybrid poplar taxa tested. Development of a *Populus* hybrid that exhibits rapid growth rates and disease resistance is still necessary for plantation culture on upland sites, especially in the arena of biomass production.

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