COMPARISON OF GROWTH AND HEALTH OF SIX POPLAR VARIETIES IN HOMOGENEOUS VERSUS HETEROGENEOUS STANDS AFTER EIGHT GROWING SEASONS IN UPPER MICHIGAN.

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INTRODUCTION

Trees from the genus *Populus* (poplars) have proven to be excellent biomass producers in short rotation (less than ten years) plantations in the Lake States region. The better performers tend to be hybrids of individuals from sections *Aigeiros* and *Tacamahaca* of the genus. These inter-species hybrids (varieties) are clonally propagated as hardwood cuttings. This minimizes the genetic variability in the established crop and yields a uniform stand of trees. However, this same lack of variability can increase the risk of loss from pests or adverse climatic events. Risk of loss might be mitigated by including several poplar varieties within each plantation. Varieties could be thoroughly mixed to form heterogeneous plantings or arranged in alternating single-variety homogeneous blocks. There may be plantation establishment, management, yield, health, and harvesting implications associated with each of these strategies, but little work has been done to understand the relative advantages or challenges.

Trees use available growing space differently when planted together in stands. In some stands faster growing trees compete with and suppress others. These dominant individuals become larger as their neighbors get ever smaller and weaker. In other situations, forest stands composed of varieties with complementary growth strategies can actually benefit from the diversity.

The *Septoria musiva* fungal disease along with other rusts that plague poplar are spread by wind-born spores. It is not clear if the health of homogeneous blocks of poplar varieties might differ from heterogeneous mixtures of the same varieties. Placing resistant varieties in close proximity to infected varieties may result in lower yields than if the varieties had been kept separate in homogeneous blocks.

A rapidly growing stand of trees will have little utility if it dies before reaching biological maturity. No single poplar variety has yet demonstrated both superior growth and superior disease resistance in the Lake States. Planting a mixture of varieties that exhibit either good growth or superior disease resistance might be a way to obtain a plantation that both grows and survives relatively well. The question of whether to plant these poplar varieties in homogeneous, pure variety blocks or in completely heterogeneous mixtures remains. The work described here was a preliminary attempt to explore some of the questions surrounding this management question.

MATERIALS AND METHODS

A pair of trials was established at Michigan State University's Forest Biomass Innovation Center in 2009 and 2010 in order to compare the growth and health of six poplar varieties when established either in homogenous or heterogeneous blocks. Varieties chosen for testing included two *Populus nigra* x *P. maximowiczii* hybrids (NM2 and NM6) and four *P. deltoides* x *P. nigra*

hybrids (DN2, DN5, DN164 and NE222). Hardwood cuttings of these varieties were produced at MSU's Tree Research Center in East Lansing, MI.

The site chosen to establish the trials was an old hay field near Escanaba, MI at MSU's Forest Biomass Innovation Center (45.764126° N latitude, 87.191892° W longitude). Soil at the site was of the Onaway fine sandy loam series. The area was prepared by killing existing vegetation with glyphosate and then repeatedly tilling to a depth of 25cm.

The homogeneous trial was established in the spring of 2009 by planting 25cm-long hardwood cuttings of each variety in 64-tree (8- by 8-tree) rectangular plots with 2.4m between rows and 2.1m between cuttings within rows. Each plot in this trial was replicated five times. Post-planting weed control was achieved using a combination of herbicides and mechanical cultivation. Only the inner 16 trees were measured in each of these plots, leaving a 2-tree border to isolate the measured trees from edge effects of adjacent plots. Eighty trees of each of the six varieties were analyzed in this trial.

The heterogeneous trial was established in the spring of 2010 within 100m of the 2009 planting using similar planting stock, planting spacing, and cultural techniques. Five hardwood cuttings of each variety were randomly planted in each of this plantation's 20 rows (30 trees per row). This planting occupied approximately 0.3ha. One hundred trees of each of the six varieties were analyzed in this trail.

Survival, diameter, and *Septoria* cankering[1] were scored at the end of the eighth growing season in both plantations. Some poplar produced multiple stems, forming a "stool." Diameters of all stems in each stool were recorded and the "basal area" (sum of the cross sectional area of these stems) at breast height (1.4m above the ground) was computed. *Septoria* infection was scored on a five point scale with number "1" indicating no infection and number "5" indicating the most severe infection. An analysis of variance of cankering and basal area among the varieties was conducted for each plantation separately assuming that both were completely randomized experiments (no blocking).

RESULTS AND DISCUSSION

A summary of varietal performance in the heterogeneous trial is presented in Table 1 and of the homogeneous trial is presented in Table 2. In both cases, NM2 produced the most basal area per stool but was most severely infected with *Septoria musiva*. DN164 and NE222 routinely produced the least basal area per stool but had the fewest cankers. Among the six varieties tested here, the fastest growers were the least healthy while the healthy varieties were the slowest growers. This suggests that the paramount need for poplar breeding programs is to concentrate on improving the health of fast growing varieties.

Data from the homogeneous planting was collected from the eight year period beginning in 2009 and extending through 2016. Data from the heterogeneous trial was collected from the eight year period beginning in 2010 and extending through 2017. Thus, the eight growing seasons being

[1] *Septoria* cankering was not scored in the homogeneous planting until the end of the ninth growing season (2017) due to an oversight.

compared were not identical. Even though there were differences in survival and growth among varieties within plantations, overall survival and average basal area of both plantings was similar. 89% of the trees in the heterogeneous planting survived with an average basal area of 0.049 ft^2 while 93% of the trees in the homogeneous planting survived with an average basal area of 0.043 ft^2. This suggests that the potential differences between the two eight-year growing periods had little effect on overall survival and growth.

Average canker scores were different between the two plantations. The homogeneous planting had slightly higher average cankering (2.9) than the heterogeneous planting (2.2). This may represent a true difference between the plantings, but is more likely the result of the subjective way in which cankering was scored. It is difficult to obtain the same overall score between two observers or over multiple observations. Another complication was that cankering in the homogeneous trial was not scored until the end of the ninth growing season. Thus the trees in the homogeneous plantation had an extra year to develop more cankering than those in the heterogeneous planting, possibly contributing to the slightly higher scores.

Regardless of the absolute cankering scores of each variety, it was possible to identify statistically distinct groups of varieties with “medium” and “low” canker scores in both plantations. NM2 was always the most heavily cankered variety even though it grew largest. The average growth of varieties with medium or low cankering was compared with NM2 in each plantation (Tables 1 & 2). Varieties with moderate cankering yielded between 16% and 17% less than NM2 regardless of whether they were planted homogeneously or heterogeneously. Relatively healthy varieties like DN164 and NE222 grew 32% less than NM2 when planted heterogeneously but only 22% less than NM2 when planted in homogeneous blocks. Apparently mixing healthy varieties with sick ones produces a measurable reduction in yield of those healthy varieties.

Yield differences (as measured by basal area) among varieties was far more pronounced in the heterogeneous planting than in the homogeneous planting. This suggests that individuals develop more uniformly when they are planted with the same, rather than different varieties as neighbors. Trees of similar size may be more efficiently harvested which could drive down the cost of harvesting, which constitutes over one third of the total cost of biomass production in short rotation plantations.

It is important to point out that this test occurred at a single site, over a single set of years, and was composed of a particular set of six poplar varieties. The results may change for other poplar varieties growing under different conditions.

SUMMARY

- The best yielding variety in both tests was NM2 but it was also the most susceptible to the deadly cankering by *Septoria musiva*.
- The varieties most resistant to cankering were DN164 and NE222 but these also produced the smallest trees.
- Healthy varieties tended to grow less well when planted in heterogeneous mixtures than in homogeneous blocks.

- There was less variation in size among varieties when they were planted in homogeneous blocks rather than in heterogeneous mixtures.
- The overall yield of these six varieties was not effected by the way in which they were planted.

Table 1.
Heterogeneous Mixture of Six Poplar Varieties

Average Survival (%) and Basal Area (ft^2) after eight years and Canker Severity (1= none - 5=severe) after nine years in a completely ramdomized plantation in Escanaba, MI.

Variety	*Survival*	*Canker Score*	*Canker Severity Group*	*BA*	*Growth Reduction vs NM2*
NM2	83%	3.6 a	High	0.063 a	
NM6	97%	2.2 b	Medium	0.055 b	17%
DN5	81%	2.4 b		0.048 c	
DN2	92%	1.9 c	Low	0.045 c	32%
DN164	89%	1.6 d		0.046 c	
NE222	94%	1.7 c d		0.039 d	
Plantation Mean	***89%***	***2.2***		***0.049***	

Means followed by the same letter are not significantly different α=0.05

Table 2.
Homogeneous Blocks of Six Poplar Varieties

Average Survival (%) and Basal Area (ft^2) after eight years and Canker Severity (1= none - 5=severe) after nine years in a completely ramdomized plantation in Escanaba, MI.

Variety	*Survival*	*Canker Score*	*Canker Severity Group*	*BA*	*Growth Reduction vs NM2*
NM2	80%	4.3 a	High	0.051 a	
DN2	98%	3.0 b	Medium	0.044 b	16%
NM6	99%	2.8 b		0.044 b	
DN5	96%	3.0 b		0.041 b	
DN164	91%	2.2 c	Low	0.040 b	22%
NE222	96%	2.2 c		0.040 b	
Plantation Mean	***93%***	***2.9***		***0.043***	

Means followed by the same letter are not significantly different α=0.05