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Field Evaluation of Hybrid Poplar Accessions to Soil Salinity

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ABSTRACT

Agroforestry practices offer many conservation benefits in the Northern Great Plains, but trees and shrubs intolerant to salt-affected soils limit their use in these practices. Hybrid poplar (*Populus* spp.) accessions, known for salinity tolerance, 'Robusta' hybrid poplar and Russian olive were evaluated for survival and growth in different salinity ranges from 2014-2017 near Bismarck, North Dakota. Survival and growth of hybrid poplars by 2017 were respectable in the salinity range of 0.1 - 3.9 dS/m (low), but progressively lower on the more saline sites. Performance between hybrid poplar accessions was similar in the low salinity range. Accessions 9094422, 904426, 904427 and Robusta were the only hybrid poplar accessions to survive high salinity through 2017 with survivals of 14%, 43%, 14%, and 25% respectively. Examination of tree survival at the various levels of salinity in 10-15 years would better indicate which accessions are more tolerant of the naturally occurring salinity at this site.

INTRODUCTION

Agroforestry practices (tree and/or shrub planting) moderate winds, manage snow distribution, and reduce energy demands for snow removal, livestock feed, and heating buildings (Shultz et al., 1995). However, salt-affected soils can prevent or reduce long-term survival and growth of trees and shrubs recommended for different agroforesrty practices. Russian olive (*Elaeagnus angustifolia* L.) is one of the few trees that is salt tolerant (Monk and Wiebe, 1961). Russian olive is highly invasive and has spread into riparian habitats of western North America (Katz and Shafroth, 2002). Previous work by the United States Forest Service, Northern Research Station at Rhinelander, Wisconsin (USFS) identified cultivars of hybrid poplars tolerant of salinity as high as 9 dS/m when planted to treat saline leachate on bioremediation sites in Wisconsin. A tall tree tolerant of such salinities would be very desirable for planting in the Northern Great Plains.

The objective of this study was to evaluate the performance of known saline tolerant hybrid poplar accessions from the USFS, against Robusta poplar, commonly assumed to be a saline sensitive tree, and Russian olive, a saline tolerant tree, on a naturally occurring saline soil in Burleigh County, North Dakota.

MATERIALS AND METHODS

The USFS at Rhinelander, Wisconsin provided seven hybrid poplar accessions. Robusta hybrid poplar and Russian olive seedlings were obtained from nurseries in North Dakota and South Dakota (Table 1). Unrooted cuttings of the hybrid poplar accessions, including Robusta were potted and grown for one season at the Plant Materials Center before planting as containerized, rooted trees. Russian olive was bare root conservation grade stock purchased the year of establishment.

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Table 1. Hybrid poplar (*Populus* spp.) accessions/cultivar and Russian olive source.

Accession	Cultivar	Species	Source
9094421	DN5	*P. deltoides* x *P. nigra*	USFS[1/]
9094422	DN182	*P. deltoides* x *P. nigra*	USFS[1/]
9094423	DN17	*P. deltoides* x *P. nigra*	USFS[1/]
9094424	NC14104	*P. deltoides* x *P. suaveolens* subsp. *Maximowiczii*	USFS[1/]
9094425	NC14106	*P. deltoides* x *P. suaveolens* subsp. *Maximowiczii*	USFS[1/]
9094426	NM2	*P. deltoides* x *P. suaveolens* subsp. *Maximowiczii*	USFS[1/]
9094427	NM6	*P. deltoides* x *P. suaveolens* subsp. *Maximowiczii*	USFS[1/]
9094432	Robusta	*P. x euroamericana (P. deltoides & P. nigra)*	Big Sioux[2/]
9019582		*Elaeagnus angustifolia*	Lincoln Oakes[3/]

Poplar cultivars obtained from: 1/US Forest Service, Northern Research Station, Rhinelander, WI; 2/ Big Sioux Nursery, Watertown, SD; 3/ Lincoln Oakes Nursery, Bismarck, ND.

The study site is in Burleigh County, near Bismarck, North Dakota (N 46.82707 W -100.59790). The soil on this site is a Harriet loam. Prior to planting the trees, salinity levels were mapped at the site. Electrical conductivity (EC) readings were taken using a Spectrum Technologies Field Scout EC Meter (Spectrum Technologies, Inc. Plainfield, IL) at depths of 3" and 9" on May 1, 2014. The site was gridded into three salinity ranges based on the 9" depth EC readings. Salinity was reported as 1:1 measurements. The salinity ranges were categorized as: low = 0.1-3.9 dS/m; medium = 4.0-5.9 dSs/m; and high = 6.0-10 dS/m (Figure 1).

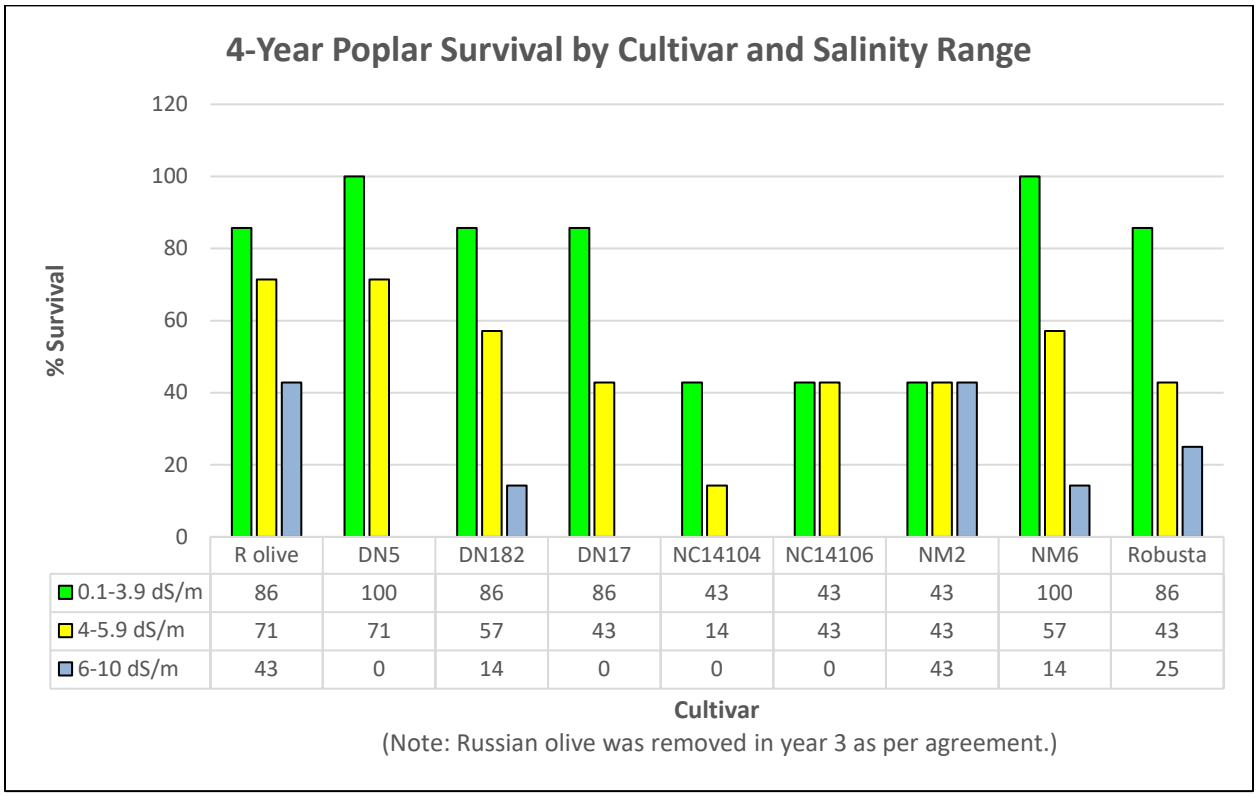
Figure 1. Saline soil in center of test site.

Seven trees of each accession, including the Russian olive and 'Robusta' poplar were randomly planted within each salinity range as described above [3 replications (reps) with 63 trees per rep]. Due to inherent irregularity of saline sites, none of the reps were contiguous to itself. Trees were hand planted on June 10-11, 2014 at a spacing of 10' x 10' with depth to the bottom of the root ball approximately 12 inches. Due to the sticky nature of the soils on the site, approximately ¼ cu. ft. of Mandan silt loam soil was used to backfill the planting hole. Once planted, 5 foot shelters were installed on each tree for deer protection. Aluminum identification tags, with accession number and plot number, were attached to stakes supporting the tree shelters. A 6' x 6' polypropylene weed barrier fabric square was installed around each tree.

Plant height and survival were measured in late June or early July each spring, and September or October each fall. Only a fall measurement was taken in 2017. Plant height was determined by measuring from the base of the tree to the absolute height. Beyond the first year, dry soils hindered EC probe operation and salinity measurements were sporadic. As agreed to before the study was initiated, Russian olive was removed in year 3, due to its invasive nature.

Researchers from USFS took tissue and soil samples on August 27, 2014 to analyze for salt uptake. Analysis has not been completed as of December 2018.

RESULTS AND DISCUSSION



	R olive	DN5	DN182	DN17	NC14104	NC14106	NM2	NM6	Robusta
0.1-3.9 dS/m	86	100	86	86	43	43	43	100	86
4-5.9 dS/m	71	71	57	43	14	43	43	57	43
6-10 dS/m	43	0	14	0	0	0	43	14	25

Figure 2: Four-year survival by cultivar and salinity range Oct 2017.

At the end of the first year, most of the poplars had survived and were performing well in the various salinity ranges (Tables 2, 3, and 4). At the end of 2015 there were distinct differences between accessions for survival and growth, especially in the salinity range of 6–10 dS/m where there was substantial loss in tree numbers. In the following years, poplars continued to die across all ranges of salinity, while maintaining similar survival percentages between cultivars. Robusta poplar had survival on medium salinity levels equal to or greater than cultivars DN17, NC14104, NM2 and NM6. At high salinities, Robusta survived better than all clones except cultivar NM2 (Figure 2 and Table 3). Cultivar NC14104 seems to be the least tolerant of the salinity found in a Harriet loam.

Figure 3: Tree shelter protecting hybrid poplar from wildlife damage.

Over all, only 75 trees were living at the end of 2017. Tree heights less than 5' were usually the result of top growth dieback and resprouting. Salinity is difficult to measure and manage because it continually changes. It is affected by various parameters including vegetation, depth, temperature and moisture (Steve Sieler soil scientist, personal communication). It is unknown how trees living in 2017 will be impacted by salinity in future years.

Tree shelters likely impacted growth, mortality and resprouting of the hybrid poplars. Tree shelters protect trees from deer but they also abrade tree trunks where they emerge from the shelter (Figure 3) resulting in tree deformity and they may affect the tree's ability to harden off for winter or grow at a rate incompatible with available water.

CONCLUSION

Suvival and growth of hybrid poplar cultivars and Robusta varied by salinity with the best performance occurring at the lower salinity range of 0.1-3.9 dS/m. Of the known salt tolerant cultivars obtained from the USFS only clone, NM2, performed better than Robusta on high salinity soils. A few plants of DN182 @14%, NM2 @ 43%, , NM6 @ 14%, and Robusta @ 25% survived in the salinity range of 6-10 dS/m. Surprisingly, several poplar cultivars at all salinity ranges had better survival than Russian olive. This may have been a due to fragile Russian olive planting stock. Examination of the site in 10-15 years would better indicate which accessions are more tolerant of the naturally occurring salinity at this site.

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Table 2. Percent survival and height of hybrid poplars by year within a low salinity range of 0.1-3.9 dS/m, Burleigh County, North Dakota, 2014-2017.

			Year							
			2014		2015		2016		2017	
Acc.[1/]	Cultivar	Salinity[2/]	Surv.[3/]	Ht.[4/]	Surv.	Ht.	Surv.	Ht.	Surv.	Ht.
		-dS/m-	-%-	-ft-	-%-	-ft-	-%-	-ft-	-%-	-ft-
9019582	R olive	1.6	100	2.8	100	5.3	86	7.8	0	0.0
9094421	DN5	2.0	100	6.2	100	8.1	100	10.0	100	10.8
9094422	DN182	1.5	100	5.8	100	6.1	86	7.9	86	8.7
9094423	DN17	1.8	100	6.2	100	7.7	100	9.6	86	10.3
9094424	NC14104	2.1	100	5.6	71	6.4	71	7.1	43	7.8
9094425	NC14106	2.4	100	5.1	71	7.0	43	8.0	43	8.6
9094426	NM2	1.9	100	5.2	86	4.4	57	5.6	43	2.8
9094427	NM6	1.1	100	5.4	100	7.5	100	8.4	100	9.3
9094432	Robusta	2.6	100	6.0	86	7.4	86	8.8	86	9.1

1/ Acc.=accession; 2/ Salinity is the initial averge salinity; 3/Surv.=survival; 4/Ht.=height

Table 3. Percent survival and height of hybrid poplars by year within a medium salinity range of 4.0-5.9 dS/m, Burleigh County, North Dakota, 2014-2017.

			Year							
			2014		2015		2016		2017	
Acc.[1/]	Cultivar	Salinity[2/]	Surv.[3/]	Ht.[4/]	Surv.	Ht.	Surv.	Ht.	Surv.	Ht.
		-dS/m-	-%-	-ft-	-%-	-ft-	-%-	-ft-	-%-	-ft-
9019582	R olive	5.2	100	2.9	86	5.3	71	6.3	0	0.0
9094421	DN5	4.8	100	5.4	86	6.9	71	8.2	71	8.9
9094422	DN182	5.1	86	4.9	71	5.7	86	6.0	57	6.7
9094423	DN17	4.7	100	5.0	100	6.5	57	7.3	43	5.8
9094424	NC14104	4.7	100	4.8	71	5.0	57	4.4	14	3.0
9094425	NC14106	4.7	86	5.4	86	5.3	57	6.4	43	5.8
9094426	NM2	4.6	100	4.8	86	5.5	86	6.4	43	7.5
9094427	NM6	5.0	100	5.4	100	6.5	57	7.9	57	8.3
9094432	Robusta	5.0	100	5.1	100	7.1	71	8.3	43	9.1

1/ Acc.=accession; 2/ Salinity is the initial averge salinity; 3/Surv.=survival; 4/Ht.=height

Table 4. Percent survival and height of hybrid poplars by year within a high salinity range of 6.0-10 dS/m, Burleigh County, North Dakota, 2014-2017.

			Year							
			2014		2015		2016		2017	
Acc.[1/]	Cultivar	Salinity[2/]	Surv.[3/]	Ht.[4/]	Surv.	Ht.	Surv.	Ht.	Surv.	Ht.
		-dS/m-	-%-	-ft-	-%-	-ft-	-%-	-ft-	-%-	-ft-
9019582	R olive	8.5	100	2.3	71	3.4	43	6.7	0	0.0
9094421	DN5	7.4	86	5.3	43	4.6	0	0.0	0	0.0
9094422	DN182	7.4	86	4.8	100	4.5	29	6.1	14	6.8
9094423	DN17	7.4	100	4.8	75	4.8	13	4.5	0	0.0
9094424	NC14104	7.8	100	5.0	14	4.3	0	0.0	0	0.0
9094425	NC14106	7.8	71	4.5	29	2.9	14	3.0	0	0.0
9094426	NM2	7.2	100	4.3	71	4.5	57	5.3	43	6.3
9094427	NM6	8.0	100	4.7	29	4.5	14	4.8	14	4.0
9094432	Robusta	8.0	88	5.0	25	4.8	25	4.1	25	2.0

1/ Acc.=accession; 2/ Salinity is the initial averge salinity; 3/Surv.=survival; 4/Ht.=height