УДК 581.524.2:635.9.053

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INVASIVENESS OF ORIENTAL BITTERSWEET (*CELASTRUS ORBICULATUS* THUNB.) IN MINNESOTA

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(Received 11.2014)

Introduction. Oriental bittersweet (*Celastrus orbiculatus*) is an invasive woody vine that is becoming an increasing problem in the Midwestern United States. It was introduced to the United States from eastern Asia in the 1860's, primarily for ornamental use of its showy yellow flowers and red fruit [2]. Over time it has escaped cultivation and is significantly damaging woodlands and other forest habitats. Dense infestations shade-out and smother other vegetation forming nearly pure stands in forests. Oriental bittersweet vines climb and strangle shrubs and mature trees by girdling their trunks and by breaking their tops from excessive weight. In addition, Oriental bittersweet is displacing the native American bittersweet *(Celastrus scandens* L.) through competition and hybridization. In the past 30 years, Oriental bittersweet has become established in southern Minnesota and is spreading to the north [1]. The purpose of this study was to learn more about the biology of Oriental bittersweet and in particular to see if its distribution may potentially be limited by cold hardiness or by higher soil pH levels throughout the state.

Materials and methods. *Cold hardiness research.* Oriental bittersweet is native to temperate and tropical regions of Southeastern Asia. Originally it was reported in the literature to be hardy to USDA Plant Zone 5a (–26.1 to –28.9 ^{o}C) [5]. Although Minnesota has small areas that are Zone 5a in the southern central and the Twin Cities metropolitan area of the state, the remainder of the southern half of the state is either Zone 4a or 4b and the northern half of Minnesota is Zone 3a and 3b (Fig. 1) [4].

Vines of Oriental bittersweet were collected in Winona and North Oaks (St. Paul), Minnesota on January 23, 2013. The material was prepared for the freezing test described in McNamara and Hokanson, 2010 [3]. Four-cm-long internode sections of one, two, and four+-year-old wood from each location were color-coded and placed in polyethylene bags inside a programmable freezer. Copper-constantan thermocouples were inserted into the pith of one cutting located near the center of each bag and the bags were sealed. The samples were held overnight in the freezer at a temperature approximating the previous 24 h outdoor minimum temperature. An extra bag of cuttings was held overnight under refrigeration at 2^{o} C (3.6 ^{o}F) and served as a control treatment. The following day the temperature in the freezer was dropped at a rate of 3^{o} C (5.4 ^{o}F) per hour. Bags containing six cuttings of each location/age combination were removed from the freezer at 2^{o} C (3.6 ^{o}F) intervals and allowed to thaw under refrigeration at 2^{o} C (36 ^{o}F) for 24 hour. The samples were then incubated at ambient room temperature (22 ± 2 ^{o}C; 72 ± 4 ^{o}F) for 5 days. Stem sections were then cut longitudinally and visually evaluated for injury with the aid of a dissecting microscope. Browning of the vascular or cambial tissue was considered fatal. The lowest survival temperature (LST) was calculated as the mean of the lowest temperatures at which individual stem samples exhibited no injury.

Soil pH research. Literature suggests that Oriental bittersweet has a preference for moderately to mildly acidic soils (pH 5.6–6.5) [2]. Currently Oriental bittersweet occurs primarily in the northeastern part of the United States from Maine to North Carolina and westward to Illinois, Wisconsin, and southern Minnesota. East coast soils are generally acidic (pH 4.7–6.1) and soils in eastern Asia where Oriental bittersweet is native are also generally acidic. Minnesota soils range from pH 4.1 to 7.9. Most soils in the western and the southwestern to south central portion of the state have soil pH of 7.5 or higher.

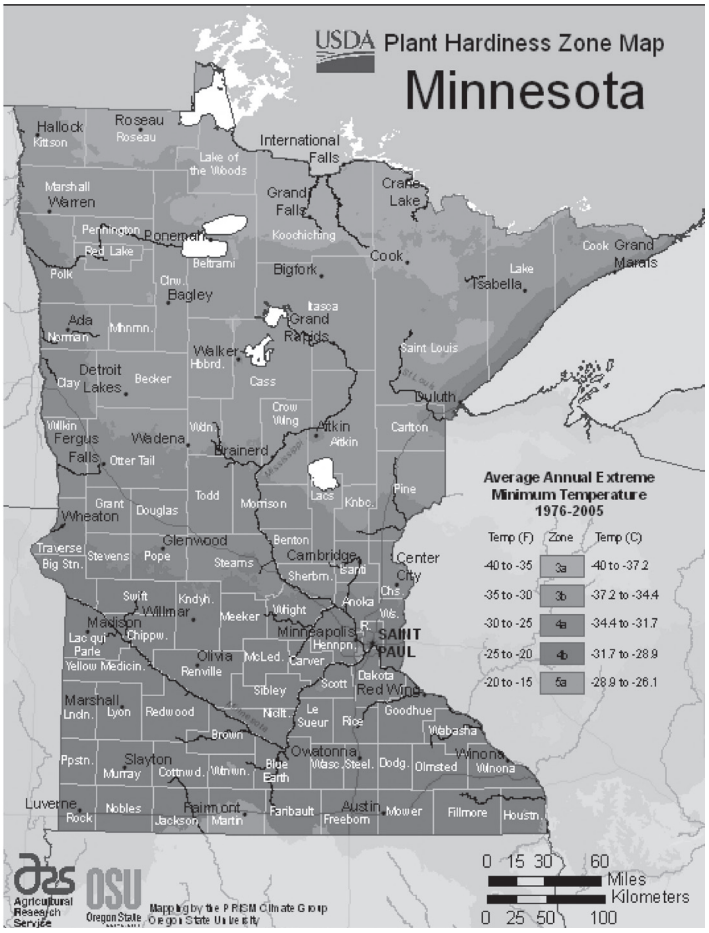

Fig. 1. Minnesota plant hardiness zones

To determine the soil pH tolerance of Oriental bittersweet in Minnesota, we conducted a hydroponic seedling vigor experiment. The seedling vigor experiment was conducted in the laboratory under artificial illumination. Pre-germinated seeds collected from Winona, MN in November 2012 were transplanted into flats in an ebb and flow hydroponic rockwool system. Treatments consisted of irrigating flats containing 50 actively growing seedlings every 2–3 days with either pH 6.5, 7.2, or 7.9 nutrient solutions. There were three flats per pH treatment. Once the rockwool medium was completely saturated, flats were allowed to drain and flow-through solutions were discarded. The flats were periodically flushed with deionized water prior to the application of the nutrient solutions to avoid an accumulation of excess salts. Seedling deaths were recorded throughout the trial and the experiment was terminated after 27 days.

Results. *Cold hardiness research*. Our results (Tab. 1) indicate that Oriental bittersweet will experience some cold injury in Zone 4b (–28.9 to –31.7 C) and will likely experience greater cold injury in Zone 4a (–31.7 to –34.4 C). However, this doesn't take into account any protective influence of snow cover on the basal portion of the vines. It appears that the older wood may be hardier than the younger material.

T a b l e 1. **Lowest survival temperature (LST, ºC) for Oriental bittersweet wood produced in 2012 (1 year), 2011 (2 year), and basal portions (4–7 years) at two locations in Minnesota**

Location	Age of Stem	LST (ºC)
Winona	1-year	–29.4
Winona	2-year	–29.4
Winona	4 +-year	–31.7
North Oaks	1-year	–29.4
North Oaks	2-year	–31.1
North Oaks	4 +-year	–31.7

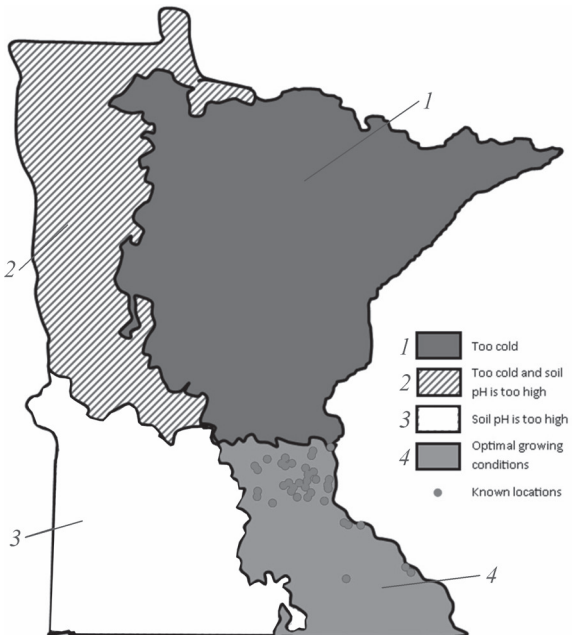

Fig. 2. Potential distribution of *Celastrus orbiculatus* in Minnesota

LST – mean of the lowest temperatures at which individual stem samples exhibited no injury ($n = 6$).

Soil pH research. Results from our seedling vigor experiment (Tab. 2) show that there is a relationship between seedling deaths and soil pH; therefore pH is affecting seedling vigor. These results indicate that higher pH values cause more seedling deaths and consequently Oriental bittersweet is less likely to survive in parts of Minnesota with higher soil pH values (west, southwest, and south central areas).

T a b l e 2. **Chi-Square analysis of seedling deaths for three pH treatments after 27 days**

pH	Alive	Dead	Total
6.5	142 (116.33)	8 (33.67)	150
7.2	118 (116.33)	32 (33.67)	150
7.9	89 (116.33)	61 (33.67)	150
Total	349	101	450

Expected value in parenthesis. Chi-Square – Summation of $((O–E)^2/E) = 54.947$, $Df = (R–1)(C–1) = 2$, Alpha significance = 0.001.

Conclusion. The potential distribution of Oriental bittersweet was estimated for Minnesota using a combination of cold hardiness and soil pH research. Cold hardiness research indicated that minimum low winter temperatures of –28.9 to –31.7 ºC will reduce Oriental bittersweet's survival rate. Soil pH research indicated that higher pH values will also reduce the species' survival rate. This suggests that Oriental bittersweet will most likely not spread into the northern half of Minnesota (Plant Hardiness Zones 4a or colder) or into the western parts of the state where soil pH values are higher than 7.5 (Fig. 2).

Literature

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Summary

Oriental bittersweet (*Celastrus orbiculatus*) is an invasive vine that is becoming an increasing problem in the Midwestern United States. Recently Oriental bittersweet has become established in southeastern Minnesota and is spreading to the north. The objective of this study was to see if its invasiveness in Minnesota may be limited by cold hardiness or by higher soil pH levels. A cold hardiness study was conducted using one, two, and four+-year-old wood subjected to incrementally lower temperatures using a programmable freezer. For the soil pH study, we conducted a hydroponic seedling vigor experiment with solutions of pH 6.5, 7.2, and 7.9. Our results indicate that minimum low winter temperatures of –28.9 to –31.7 ºC and higher soil pH values will reduce the species' survival rate. This suggests that Oriental bittersweet will most likely not spread into the northern half of Minnesota (Plant Hardiness Zones 4a or colder) or into the western parts of the state where soil pH values are higher than 7.5.