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VEGETATIVE REPRODUCTION IN POPULATIONS OF *JUSTICIA AMERICANA* IN OHIO AND ALABAMA[1]

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Abstract. Community structure and the role of vegetative reproduction were studied in the essentially monotypic stands of water willow within the Scioto and Hocking Rivers of Ohio and the Flint and Paint Rock Rivers of Alabama. Vegetative reproduction in both Ohio and Alabama populations was most successful with rhizome portions, if the sections were subject to soil deposition. If soil deposition over the sections was not involved, then upright stem sections were most successful. Total darkness is inhibitory to vegetation reproduction, and reproduction is significantly less under a 500 lux light regime as compared to that under 5,000 or 20,000 lux. Vegetative reproduction is not increased by free floating, as might occur during flooding.

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Numerous anatomical studies have been completed on *Justicia americana* (L.) Vahl, but relatively few have considered the ecology of this important flood plain species (Boyd 1969, Stuckey and Wentz 1969). The role of vegetative reproduction was only briefly mentioned by Penfound (1940) in his study of Lake Wilson, a reservoir of the Tennessee River in northern Alabama. He observed numerous fragmented sections of mature stolon with young plants attached floating in the Tennessee River in late May, 1938. The purpose of my study is to describe the water willow community and the conditions under which vegetative reproduction is likely to occur.

METHODS

Six water willow communities were surveyed, 2 on the Hocking River south of Athens, Ohio, one on the Scioto River east of Chillicothe, Ohio, one on the Flint River and 2 on the Paint Rock River in Alabama. The Alabama rivers are east of Huntsville, Alabama. The stands of Justicia were sectioned into a numbered grid of 1 m^2 quadrats and 5 quadrats in each stand were chosen by random numbers. The Braun-Blanquet cover-abundance scale was used to measure the herbaceous vegetation. No other class of vascular vegetation was ever observed in the quadrats. Data on the 6 abiotic parameters, soil moisture, soil mechanical composition and organic matter percent, pH, temperature (above and below herbaceous canopy), light (above and below herbaceous canopy), and elevation above river surface were collected.

Vegetative propagation was studied in the lab using portions of both horizontal shoot (rhizome) and vertical shoot (stem). Sections were cut 2 cm long centered on a node. In all experiments, 10 replicates of 10 sections each were used. Rhizome and stem sections were segregated to determine if they had differential responses to the various treatments. Sections were subjected to regimes of disposition at 2 cm, 5 cm and 10 cm, light at 500, 5,000, 20,000 lux or total darkness. Sections of rhizome were buried at 5 cm depth in silt-clay soil and in sandy-gravelly soil. These sections were then subjected to watering, using distilled water, at the following intervals: daily (saturation), 2, 4, 6, 8 and 10 day intervals. Sections were also allowed to float for 25 days to determine if this increased the level of vegetative propagation.

All experiments were conducted in a Sherer model CEL 255-6 growth chamber, with the exception of the 20,000 lux light regime that was done in the research greenhouse. In the deposition experiments, sections were placed at the specified depths in 15 cm pots in alluvium collected from existing water willow communities. All other experiments were done in 15 cm pots filled with fine vermiculite. Hoaglands nutrient solution was provided in all experiments except the deposition experiments where nutrients were already available in the soils. In all cases, the plant material used was freshly collected in the field, immediately brought to the lab, sectioned and placed into the appropriate experimental treatment. All experiments were allowed to run for 31 days to de-

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termine if there was any change in initial response.

RESULTS AND DISCUSSION

Justicia americana was the only vascular plant found within the randomly located quadrants of the communities studied. Observed, but never falling within the quadrants, were occasional clumps of *Salix interior* Rowlee (sandbar willow). Soil moisture was usually high due to the closeness of the water table a few centimeters below the surface. Soils were never observed to be saturated during non-flood stages, but upon excavation, the roots of water willow were found to extend several decimeters into the water table. Soil pH was generally neutral to alkaline (pH 7.0–7.8), closely following the pH of the adjacent river. Temperatures at the soil level below the water willow canopy were generally 4 °C to 6 °C lower than the temperatures above the canopy. In July this temperature would typically be approximately 30 °C to 32 °C above and 24 °C to 26 °C below the herbaceous canopy. In most cases, the temperature of the river was 1 °C lower than the temperature under the herbaceous canopy. It seems likely that the proximity of the water table to the surface within these stands contributed, in part, to the cooler temperatures observed under the canopy. In well established water willow stands, light reduction was considerable. The light levels above the herbaceous canopy on a clear day at 10:00 a.m. averaged 20,000 lux while below the canopy light was reduced to an average of near 500 lux. Soils were generally composed of large gravel intermixed with finer substrate which was 80% to 95% sand, 1% to 8% silt and 6% to 12% clay. Soil percent organic matter was low, averaging 2.58% in a range of .32% to 4.76%. Elevation above the river surface ranged from 0 to 50 cm. Most stands were 10 cm to 30 cm above the level of the river in summer.

Vegetative propogation was reported as the number of plantlets produced per 100 sections. Response to treatments was consistently similar in the Alabama and Ohio populations; thus, no ecotypic variation is apparent from this study. Stem sections were most productive when sections were at the substrate surface (figure 1). Slight deposition at 2 cm

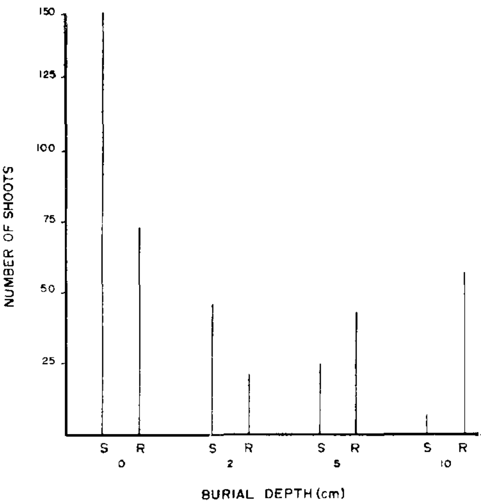

FIGURE 1. Response in number of shoots produced by stem (S) and rhizome (R) sections when buried by artificial deposition at depths of 0, 2, 5 and 10 cm.

depth reduced vegetative propagations to 28.67% of the propagation at the surface. Vegetative propagation by the stem sections was further reduced to 16.67% and 7.33% of the surface propagation at 5 cm and 10 cm depths, respectively. Rhizome sections produced the highest number of sections when at the surface, but production was about one-half that of the stem sections. Initial response to deposition was a 69% reduction in vegetative production at 2 cm depth (figure 1). At 5 cm and 10 cm depths, the number of shoots increased to 56% and 93% of the rate of vegetative propagation at the surface for rhizome sections. Significantly, the vegetative propagation at 10 cm depth for rhizome sections was 6 times that of the stem sections.

Although Penfound suggests that fragmentation may result from either mechanical action or herbicidal activity, I have not found such a response to the herbicides 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid during the past 3 years of their use by the Tennessee Valley Authority on Lake Wilson. Water willow is usually stunted or killed by the herbicides. Mechanical fragmentation, however, commonly results from flood activity on all 4 rivers studied. It seems likely the sections observed by Penfound were the result of flooding in the rivers feeding into Lake Wilson.

In riparian ecosystems, water willow is usually associated with sandy-gravelly point bars, spits and small, low-lying islands and except during periods of high water, water willow is not generally found submerged. A rather different situation prevails in lakes where Boyd (1969) and Penfound (1940) report water willow growing on submerged silt-clay substrate at depths of up to 1.5 m. This habitat difference is likely due to the need for increased substrate stability within the riparian system.

The responses of Justicia sections to darkness and to 3 levels of light are shown in table 1. The number of shoots

TABLE 1

*Response of Justicia americana (L.) Vahl. Vegetative Propagules to 4 Light Regimes and to Darkness.**

Light Intensity (lux)	No. Plants Produced	Av. Height (cm)	Av. Dry Wt. (gm)
dark	25	.31	0.0038
500	8	1.45	0.0497
5,000	25	1.04	0.1307
20,000	28	1.09	0.2159

*A hundred horizontal sections used in 10 replicates of 10 sections per pot on vermiculite (fine), feeding with Hoagland's solution for 31 days.

formed in total darkness is somewhat misleading, since these plants were etiolated, small and low in dry weight (table 1). Furthermore, unlike plants in the light, those produced in darkness failed to develop roots. Significantly, although approximately the same number and size of plants were produced at the 2 higher light levels, those produced at 20,000 lux were 61% heavier (dry weight) than those produced at 5,000 lux.

It is apparent from the data shown in figure 2 that *Justicia* required high levels of available water for successful vegetative propagation. The change from sufficient to insufficient water seemed to occur abruptly. Free floating of sections, as might occur in a flood, did not appear to affect the level of vegetative propagation in either stem or rhizome sections (table 2).

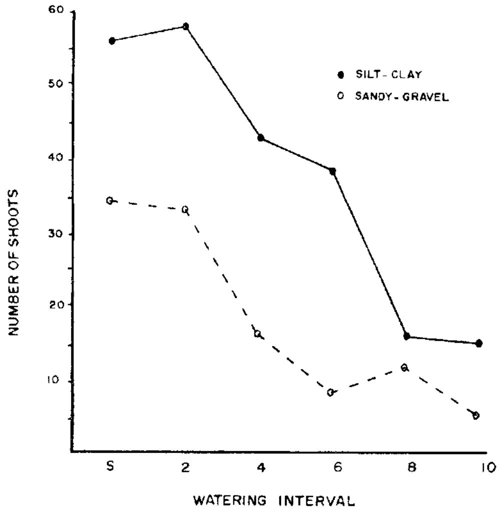

FIGURE 2. Number of shoots produced by rhizome sections, buried to 5 cm, when subjected to watering at saturation and 2, 4, 6, 8 and 10 day intervals in silt-clay soils and sandy-gravel soils.

TABLE 2

Adult Plant Free Floating Reproduction From Sections of the Horizontal and Vertical Stems of Justicia Americana (L.) Vahl.

Sections*	Shoots No.	Roots No.
Horizontal	76	60
Vertical	145	41

*A hundred sections in 10 replicates of 10 sections per plate using Hoaglands nutrient solution. Treatment period 31 days.

All 4 rivers experience many floods each year of sufficient severity during the growing season (U. S. Geologic Survey 1966, 1967, 1968, 1973, 1974) to disrupt existing *Justicia* communities and thus release portions of rhizome and/or stem as observed by both Penfound (1940) and me. Late summer flooding on the 4