Determinants of Handedness in Twining Vines

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Abstract

Just as the majority of people prefer to write with their right hand, others write with their left, and a few are ambidextrous, the vast majority of twining vines wind around a support in a right-handed direction, about 10% twine in a left-handed direction, and a very few are able to twine in both directions. As in humans, right-handed dominance in twining has yet to be explained. Two mechanisms of twining determination were proposed and tested: that handedness is determined by components of the cell structure, and that handedness is determined by external stimuli. The handedness of xylem helices and cell wall microfibril arrays were examined to see if the twining of a vine would mirror cellular helical morphology. Seedlings of Solanum dulcamara*, a local weed displaying variable twining direction, were exposed to varying degrees of light, different orientations of climbing support, and thigmotropic stimuli to observe the effect of environmental forces on twining. Finally, the evolution of the twining habit was studied by mapping the character on an angiosperm phylogenic tree and by comparing the fitness of twining with non-twining in* S. dulcamara*. No correlation was found between xylem handedness and vine handedness, and the study of microfibrils will continue to be refined. The chosen external stimuli did not influence the choice of twining direction in* S. dulcamara, *but counter-clockwise twining was found to provide greater climbing support, and the twining habit was shown to yield plants of greater fitness than those that did not twine.*

Summary

The bean family, Fabaceae, contains more than a hundred twining vines. All of these vines consistently twine to form a right-handed spiral, corresponding to counter-clockwise motion. If all of the vines known to twine are considered, this trend continues – nearly 98% of vines display a fixed twining direction, meaning that all stalks produced by the vine will wind around a support in the same direction. Over 90% of these vines twine counter-clockwise (Ornduff, 1991). The uncompromising preference for unidirectional twining suggests both an evolutionary preference as well as a possible internal determinant of this growth habit. While a few theories have been offered, none have ever been proven.

Investigation of an internal determinant of twining handedness was focused on two structural components of plant cell walls, ligno-cellulose tracheary elements and cellulose microfibrils. The helical array of microfibrils in plant cell walls potentially provides the basis of directional growth in roots, but these observations have not yet been extended to twining vines (Thitmadee *et al.,* 2002). Tracheary elements in xylem tend to form double helices, and their deposition has been attributed to the microfibril array (Barlow, 2000). These structural foundations of growth were hypothesized to influence vine morphology. Helical tracheary elements in xylem were observed through light microscopy of longitudinal sections. The handedness of these helices did not always correspond to the handedness of the vines, but do display right-handed dominance. Reliable measurements of microfibril angle with polarized-light microscopy have not yet been obtained.

Solanum dulcamara (Solanaceae), is a local weed that displays indefinite twining. It is able to twine clockwise or counter-clockwise, or remain a non-twining bush. Seedlings of *S. dulcamara* were exposed to various external stimuli to discover whether the vine environment would determine growth morphology. Plants were grown in varying amounts of sun and shade, with randomly oriented supports. *S. dulcamara* seedlings were also exposed to thigmotropic stimuli, to determine if twining of the stalk could be dependent on the availability and positioning of support. None of these were found to influence the twining direction, but a fitness study of these plants provided information on the impact of growth habit on *S. dulcamara*. It was found that counter-clockwise twining affords tighter coils, and thus greater support, for the climbing stalk, and also that twining plants grew taller than their non-twining neighbors.

References

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