Both Vines and Tendrils Utilize Gelatinous Fibers To Cause Twining and Coiling.

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Abstract

Previous studies on the coiling of tendrils in redvine strongly indicated that gelatinous (G) fibers were responsible for the coiling of these organs. However, the universality of these observations is currently unknown. In this study, we surveyed a number of twining vines and coiling tendrils for the presence of G fibers, using both microscopy and immunocytochemistry. All tendrils produced copious G fibers, although the extent and position varied tremendously between taxa. In species with tendrils that are touch-sensitive on all surfaces, G fibers were present as a cylinder external to the vascular tissue. In contrast, tendrils that are touch-sensitive on only one surface have G-fibers only on the touched side. Even in species with adhesive tendrils, G fibers were present, possibly involved in contractile and/ or pressure-related roles. In twining stems, G fibers appeared after stem circumnutation had ceased and appear to be involved in the fixing of the stem to a certain position. When vines were challenged with increasing diameter supports (which require more force from the vine), the number of G fibers also increased, although there was a limit in size above which the vine could not climb and no further increase of G fibers was noted. These data strongly indicate that G fibers are critical structures in both coiling vines and twining stems, causing the same kind of radical structural changes that they cause in righting tree trunks and branches.

Introduction

Previous work in our lab on redvine tendrils (Meloche et al. 2007) has established a strong correlation between the presence of gelatinous (G) fibers and the ability of these tendrils to coil about other objects. Although this observation is of significance, we don't know whether this G fiber based mechanism of coiling is in fact operating in other tendrils or is something that is unique to the G fibers in redvine.

Material and Methods

Plant material was collected and fixed in 3% glutaraldehyde, dehydrated in graded ethanol, and embedded in LR white. Specimens were sectioned at 0.35 microns and collected on chrome-alum slides. Sections were either stained with toluidine blue or processed for immunocytochemistry. Anti-polysaccharide antibodies were purchased from Plant Probes, UK and the Complex Carbohydrate Research Center, GA. The secondary antibody was 15 nm colloidal gold, silver-enhanced for observation by conventional light microscopy. For more details, see (Meloche et al., 2007).

Results and Discussion

Tendrils

We observed three patterns of G fibers in tendrils and this was highly correlated with the type of tendril examined.

1) Species with tendrils that are touch sensitive on all surfaces, such as redvine, develop a cylinder of G fibers (Fig 1).

2) Species belonging to the genus cucurbitaceae possess tendrils that are touch-sensitive on one surface. These tendrils develop G fibers only along the touch-sensitive surface (Fig 2).

3) Species with adhesive tendrils that coil post-adherence (to assist in guying the vine to the support) develop G fibers only in the center of the tendril (Fig 3).

In all cases these G fibers react with antibodies that label xylans (LM10 and LM11) except for the G layer itself, which occupies the most internal zone and that reacts strongly with antibodies to arabinans and rhamnogalacturonans.

Vines

Vines go through stages in the process of twining about an object. The first phase involves a rapid circumnutation of the stem tip as it searches for an object about which to twine. At this stage the stem is still supple and can be re-positioned easily. No G fibers are present at this stage. However, as the vine begins to fix its position around its support, G fibers develop in the area between the epidermis and the vascular tissue and additional fibers (non-G fibers) develop near the vascular tissue. Thus, in the case of twining vines, the G fibers appear at the stage at which the vine sets its final shape (Fig 4).

Morning glory was challenged with supports having a range of diameters. Plants climbing supports with a larger diameter were found to have more G-fibers than plants that climbed supports with a smaller diameter (data not shown). This direct correlation between the number of G-fibers present in the stem of the morning glory and the diameter of the support provides further support in favor of the critical role of G-fibers in twining vines and coiling tendrils.

Conclusion

Both vines and tendrils utilize G fibers to exert or fix a coiled morphology, although the arrangement of the fibers and their extent vary tremendously between the different tendril types. In vines, the G fibers appear to fix the stem in a coiled position.

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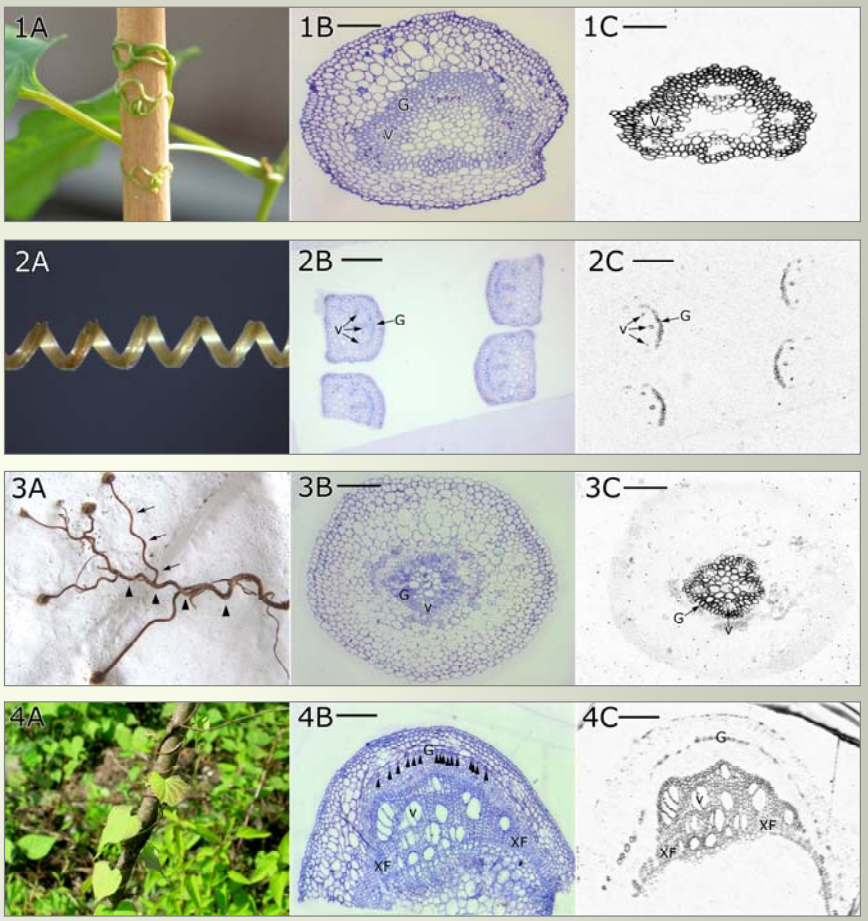

Figure Legends

Figure 1. Redvine tendrils. A. View of tendrils encircling a stake. B. Light microscopic cross-section of tendrils stained with toluidine blue revealing a ring of gelatinous (G) fibers. V = vascular bundle. C. Serial section of B probed with a monoclonal antibody (LM10) to low-substituted xylans. Bar = 100µm.

Figure 2. Wild cucumber tendrils. A. Dissecting microscope image revealing tight coiling. B. Light microscopic section stained wiith toluidine blue through two wraps of a tendril coil. G fibers (G) are found on the inside (touch-sensitive surface) of each coil. C. Corresponding serial section to B probed with an anti-xylan antibody (LM10). The G fibers are restricted to the touch-sensitive surface. V = vessels; Bar = 250µm.

Figure 3. Virginia creeper adhesive tendril. A. Photographic image of tendrils attached to a wall by adhesive. Note the coiling of the tendril stem which pulls the main vine stem closer to the wall after adhesion of the tendril is established (arrows and arrowheads). B. Light microscopic cross section through the coiled tendril at a position similar to that indicated by the arrows. Note the presence of G fibers (G) in the center of the tendril compared to its more peripheral position in the wild cucumber or redvine. C. Serial section labeled with an anti-xylan antibody (LM10) reveals the G fibers and xylem elements. V = vessels; Bar = 100µm.

Figure 4. Morningglory vine. A. Photographic image of plant showing its twining nature. B. Light microscopic cross-section stained with toluidine blue of coiled morningglory stem. G fibers (G) occur as a ring in the cortex (arrowheads) and a band of xylary fibers (XF) occurs adjacent to the xylem. Both of these structures occur as the coiling starts and fixes the stem in the coiled position. C. Serial section labeled with the anti-xylan antibody LM10 reveals heavy labeling of both the G fibers and the xylary fibers. V = vessels; Bar = 250µm.