A Unique Stem Structure in Bedstraw or Cleavers (Galium aparine)

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Abstract

Bedstraw or cleavers (Galium aparine L.) is a widespread weed of wet places and roadsides and is distinquished by a unique trailing or vining habit. Although the stems of bedstraw do not twine or produce tendrils as do true vines, bedstraw is able to ascend above the canopy of other plants by using its barbed stem tissue to crawl up and over neighboring vegetation. Scanning electron microscopy of stem segments revealed that bedstraw has a unique stem structure with four prominent ridges, and with repeating barb-like structures along the ribbed surface. These barb-like structures enable the stem to anchor in other objects, allowing the bedstraw to ascend above other plants. The internal anatomy of the stem of these plants is also unique. The mature stem pith is hollow and is surrounded by a dense layer of fiber cells. A broad ring of xylary fibers is found in the mature bedstraw stem that are involved in both support and water uptake. Photosynthetic parenchyma is restricted to a few cell layers at the stem periphery and more prominently in the ridges. Immunocytochemistry indicates that the walls of the ridged tissues and the barbs are highly enriched in pectins compared to the other tissue, perhaps enhancing the ability of these structures to stick to foreign objects. This unique stem structure allows bedstraw to act as a pseudo-vine without twining or producing tendrils.

Introduction

Bedstraw (or cleavers, catchweed, and numerous other common names) is a common weed of pastures, waste ground, meadows, and fence rows. Despite its nearly ubiquitous occurrence, bedstraw is a rather unusual weed in that, although not a vine in the strictest sense of the term, it can ascend over other plants in the canopy much in the way as do true vines. In many ways, the stems of bedstraw are much like Mother Nature's version of Velcro! One might call this habit "clinging" rather than vining. Little is known about the anatomy of bedstraw, aside from one rather sketchy publication, which would allow it to perform these functions.

In this study, we examined the internal and external anatomy of this unique weed by light and scanning electron microscopy and their wall composition by immunocytochemistry. These data indicate that the presence of distinct barbs along the stem and leaf surfaces allow the bedstraw to attach to portions of other plants, akin to a plant version of Velcro.

Material and Methods

Plant Materials

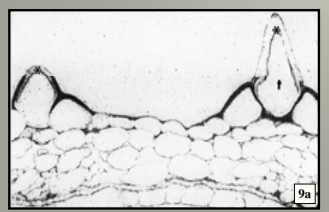
Bedstraw tissues were collected at several sites in Greenville, Stoneville, and Leland, MS and were fixed in 6% glutaraldehyde in 0.05 M PIPES buffer (pH 7.4) for at least 2h.

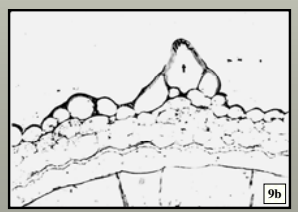
Light Microscopy

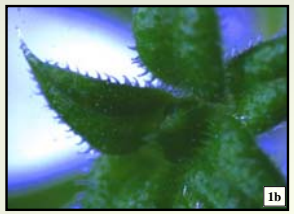
Samples for light microscopy and immunocytochemistry were dehydrated in an ethanol series and then embedded in LR White resin in 25% increments each day at -20C. The samples were transferred to room temperature after samples had spent one day in 100% plastic and rocked on a rotating shaker for 24h. Samples were transferred to flat bottom BEEM capsules and polymerized in a vacuum oven at 50C for approximately 2h. Light microscopic sections (0.35µm) were cut with a Reichert Ultracut Ultramicrotome and were stained with Toluidine blue on a warming tray. Sections for immunocytochemistry were serial sections from these same block faces, but were not stained with Toluidine blue. For immunocytochemistry a number of polysaccharide monoclonal antibodies were used to probe the sections and sites of antibody reaction detected by immunogold with silver intensification (Vaughn 2003).

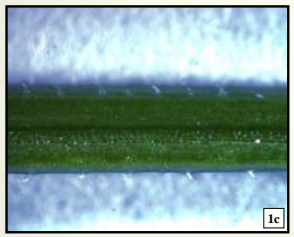
Scanning Electron Microscopy

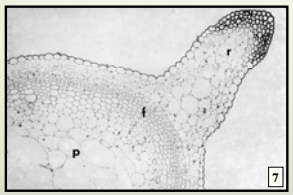
Samples for SEM were dehydrated in an ethanol series and critical point dried and coated with gold-palladium before observation with a JEOL 840 scanning electron microscope.

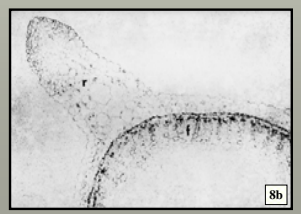






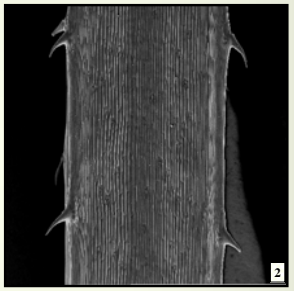


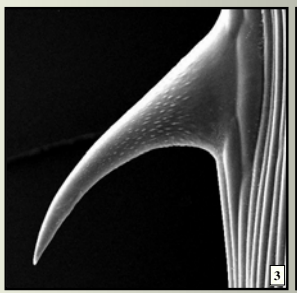


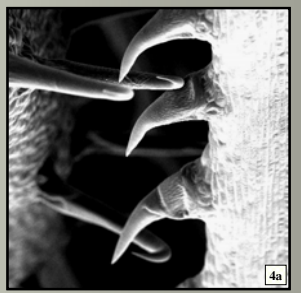


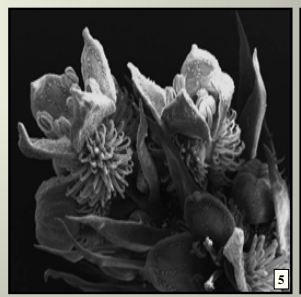
Results and Discussion

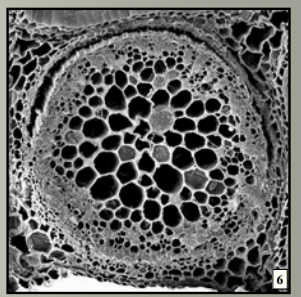
Bedstraw plants are rather lax in appearance with leaves clustered along rather widely separated areas of stem (Fig. 1a,1b,1c). The stem is rough to the touch and when stem pieces are detached they will attach to pieces of clothing or skin. In field situations, the bedstraw plants ascend above the other plants, despite their lax/prostrate nature apparently by using this rough stem surface to adhere to stems and leaves of neighboring plants. Both leaves and stems of bedstraw are covered with prominent barbed trichomes. On the stems, the majority of the trichomes occur on the four corners of the stem in a row, with their ends pointing basipetally (Figs. 2 & 3). In the leaves, in contrast, the trichomes are predominantly on the edges, have a distinct twist to the tip, but are oriented up with the exception of the barbed tip (Fig. 4). Extensive series of barbed trichomes are also found around flower buds (Fig. 5). Internally the stem of the mature bedstraw is quite unique as well. The stem at maturity is essentially a hollow cylinder, with an extensive layer of xylary fibers that provide support and water conduction (Fig. 6 & 7). Parenchyma tissue in the center of the stem expands and then collapses, creating a hollow tube. Photosynthetic parenchyma occupies a narrow band around the periphery of the stem although it is more extensive towards the four corners of the stem associated with the barb. Immunocytochemical probes reveal that the central core of xylary fibers and tissue in the ridges is highly enriched in xylans, which provide the mechanical strength to the tissue (Fig. 8a). Areas around the barbed trichomes were enriched in both highly de-esterified (Fig. 9a) and esterified pectins (Fig. 9b). These sticky molecules might enhance the ability of the barbs to stick to other objects, facilitating the ability to ascend over other neighboring plants.











Conclusion

Bedstraw has a unique combination of a highly barbed stem with a very light internal composition resembling a soda straw that allows it to attach to virtually any object in its path and successfully ascend above them. Essentially, bedstraw has become the plant version of Velcro, allowing it to stick to numerous objects. This strategy essentially gives the bedstraw all the advantages of typical vines with perhaps less cost to the plant in terms of producing tendrils or twining stems. Moreover, this strategy would also help in dispersing seed of the bedstraw as pieces of the plant stick onto the fur of animals and ensuring their wide dispersal.