terms of its available nitrogen, phosphorus and potassium content (Table 3). Results are in tune with Shyam[14].

Results suggest that besides medicinal use, bloom of Ak can be successfully used for production of biogas with higher fertilizer value.

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Studies on stem structure of *X Laburnocytisus adamii* (Poit) Scheid

X Laburnocytisus adamii (Poit.) Scheid. is a graft hybrid of *Laburnum anagyroides* Medik. and *Cytisus purpureus* Scop., both belonging to the family Fabaceae. Adam, a nurseryman from Vitry near Paris, inserted a shield from the bark of a low-spreading, purple-flowered shrub *C. purpureus* (purple broom) into a stock of yellow-flowered *L. anagyroides* (golden chain tree). The bud lay dormant for a year and then grew upright and vigorous with larger leaves than is usual for broom. This graft hybrid continued to grow, the main limb producing foliage and long drooping chains of yellow flowers along with clumps of purple flowers on twiggy branches and pinkish flowers on other longer branches.

The yellow and purple flowers produced by *X L. adamii* were similar to those of the parent plants, while the pink flowers had characteristics intermediate between the two originally grafted plants. The pink flowers were associated with somatic fusion of cells of the two graft partners, while the revertant sectors (i.e. branches that formed flowers identical to either of the originally grafted plants) were the result of segregation of the characters back to uniformity. Such a graft hybrid, also called 'chimera', is a bigeneric hybrid, which has originated artificially as a result of grafting of two different genera[1,2].

Here we compare the stem structure of shoots associated with the three different types of flowers found in *X L. adamii*, and see whether the *Laburnum*-type and *Cytisus*-type differed in stem structure from *L. vossii* and *C. purpureus* respectively.

Shoots were selected from the *X L. adamii* tree growing in the Treborth Botanic Garden, UK, having leaf and flower types characteristic of *Laburnum*, *Cytisus* and *X Laburnocytisus*. Shoots were also selected from plants of *C. purpureus* and *L. vossii* (a close relative of *L. anagyroides*). Samples from these shoots were pickled and preserved in formalin–propionic–alcohol (FPA). These samples were washed in tap water before cutting sections, and portions remaining after sectioning were preserved in 70% alcohol.

Sections were cut by hand with a single-edged razor blade, in transverse, tangential longitudinal and radial longitudinal directions. These were mounted in a dilute solution of iodine in potassium iodide (which stains starch grain black and acts as a general differential stain for cellulose and lignin). These temporary mounts were examined and photographed immediately with a transmitted light microscope. Polarized light was also used to show up any crystals present.

The three types of shoot from the *X L. adamii* tree are described here as *Laburnum*-type, *Cytisus*-type and *Laburnocytisus*-type.

Laburnum-type shoots were similar to those of *L. vossii* in having a rounded first-year stem, with slight ridges on each side of the petiole base, but these faded out a short distance below the leaf axil. The young first-year stems of both *Laburnum*-type and *L. vossii* were covered in white hairs closely adpressed to the stem, but these soon disappeared leaving a green stem. Later, in the season the epidermis turned pale brown, then broke up to show a smooth and shiny green periderm below.

In contrast, *C. purpureus* and the *Cytisus*-type stems both had persistent longitudinal ridges on either side of each petiole, continuing up to the petiole above: these ridges became less obvious in third-year stems. The bark of older *C. purpureus* and *Cytisus*-type stems was rougher than in the *L. vossii and Laburnum*-type, with

elongated vertical ridges: that of the *Laburnocytisus*-type appeared intermediate.

The differences in external appearance between the stem types were associated with differences in the rate of change from the original epidermis to production of a periderm. Successive stages in the change from epidermis to periderm are shown in Figures 1 *a–c*, 2 *a*, *b* and 3 *a*, *b*. The multilayered periderm was produced within the cortex, and the epidermis and outer cortex layers subsequently peeled-off. This happened much earlier in *Laburnum*-type and *L. vossii* stems (in the first year) than in *Cytisus*-type and *C. purpureus* stems (in the second or third year).

In surface view, the epidermis included stomata in all shoot types, plus hairs in *Laburnum*-type and *L. vossii* (or hair base where the hairs had broken-off), but not in *Cytisus*-type or *C. purpureus*.

In surface view, the periderm had thick-walled polygonal cells in *Laburnum*-type, *Laburnocytisus*-type and *L. vossii* (Figure 4 *a*). In sections, the periderm cells appeared to be thinner-walled in *Cytisus*-type and *C. purpureus* (Figure 4 *b*) than in *L. anagyroides*, *Laburnocytisus*-type and *L. vossii* (Figure 5 *a–c*). The periderm cells were arranged in neat rows (radially and longitudinally), with the outer periclinal walls particularly thickened (Figure 5 *a* and *c*).

Beneath each bark ridge there was a group of gelatinous fibres (Figures 1 *a*, 2 *a*), which appeared to originate as cap cells to vascular bundles from the leaf petiole. The gelatinous bark fibres were in blocks in the outer bark of all stem types: these blocks appeared to be more

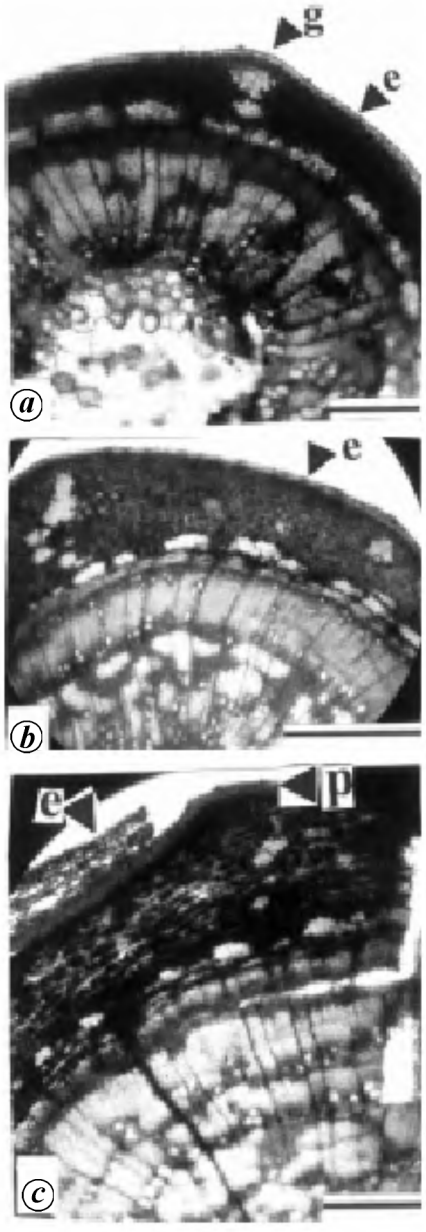

Figure 1. Transverse sections of *Cytisus purpureus* stems. Scale bar 1 mm. ***a***, One-yr-old stem. g, Group of gelatinous fibres beneath ridge on bark and e, Epidermis. ***b***, Two-yr-old stem. e, Epidermis. ***c***, Three-yr-old stem. e, Epidermis and outer cortex beginning to strip-off and p, Periderm exposed where outer tissue stripped-off.

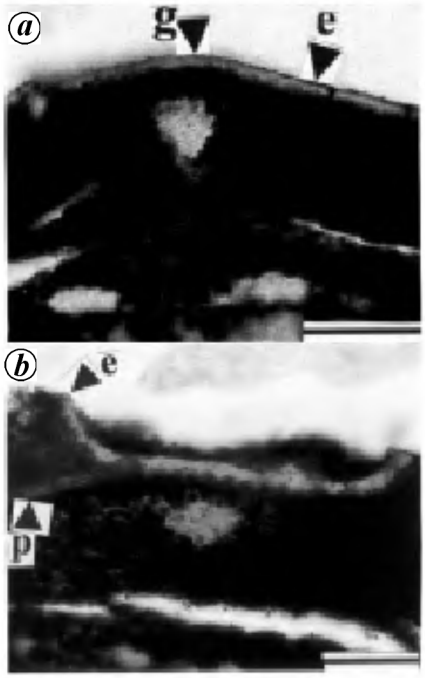

Figure 2. Transverse section of *Cytisus*-type shoots from *X Laburnocytisus adamii*. ***a***, Scale bar 0.3 mm. g, Group of gelatinous fibres beneath ridge on bark and e, Epidermis. ***b***, Scale bar 0.2 mm. e, Epidermis beginning to break up and p, Periderm developing in cortex.

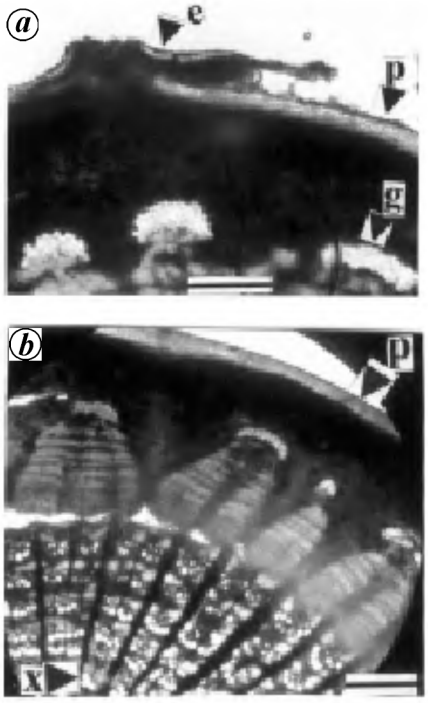

Figure 3. Transverse section of *Laburnocytisus*-type shoots from *X L. adamii*. Scale bar 0.3 mm. e, Epidermis beginning to break up and g, Cap of gelatinous bark fibres. ***b***, Scale bar 0.3 mm. p, Periderm and x, Xylem with clusters of vessels, group of gelatinous fibres and multiseriate rays.

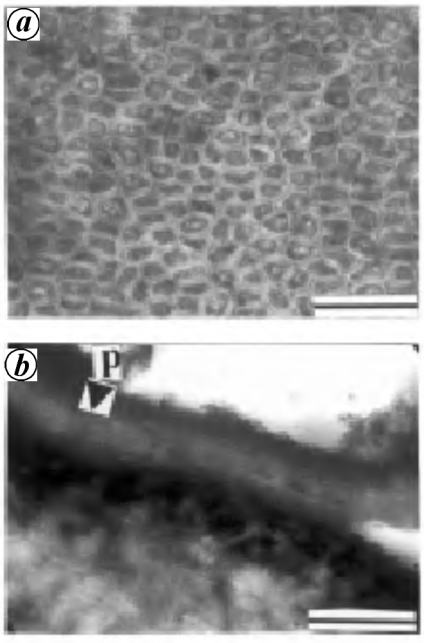

Figure 4. ***a***, *Laburnocytisus*-type shoots from *X L. adamii* showing surface view of periderm cells with thick walls. Scale bar 0.1 mm. ***b***, Transverse section of *C. purpureus* stem. Scale bar 0.1 mm. p, Periderm with thinner cell walls than in *X L. adamii* or *L. vossii*.

conspicuously crescent-shaped in *Laburnocytisus*-type and *L. vossii* (Figure 3 *a* and *b*) than in *Cytisus*-type or *C. purpureus* (Figure 2 *a*, *b*). Gelatinous fibres have been reported in other species of Leguminosae like Black Locust, *Robinia pseudoacacia* as a result of tension wood[3]. The presence of gelatinous fibres in reaction tissue of family Leguminosae has also been reported[4].

Large groups of stone cells were found in the cortex of *Laburnum*-type and *L. vossii* (Figure 6 *a* and *b*). In *Laburnocytisus*-type, *Cytisus*-type and *C. purpureus*, the stone cells appeared to be less frequent with scattered individual cells or small groups in the cortex (Figure 6 *c*).

Rays inflated in the bark in all stem types (Figures 1 *c* and 3 *b*), so that the phloem tended to be in triangular blocks.

Little difference was detected between stem types in overall wood structure. All types were ring porous (Figure 7 *a*). These results are in conformity with the findings of Werner *et al.*[5] in *L. anagyroides*. Latewood vessels clustered in groups, tending to dendritic or tangential in arrangement (Figure 7 *a*). Scattered parenchyma was present around the vessel groups, and storied tissues were also present. Axial parenchyma has been reported in *Laburnum* and *Cytisus* by Cutler *et al.*[6].

In all stem types, vessels appeared similar in structure: round in transverse section, thick-walled and well-pitted. In all types the bordered pits were alternate, and round, oval or slightly elongated (Figure 7 *b*). Spiral thickening was present in some vessels (Figure 7 *b*).

Rays were possibly wider in *Laburnum* than in *Cytisus*-type (though this may be age-related). In all stem types ray cells were rounded in tangential longitudinal section (Figure 8 *a* and *b*). In radial longitudinal section of all stem types, the ray

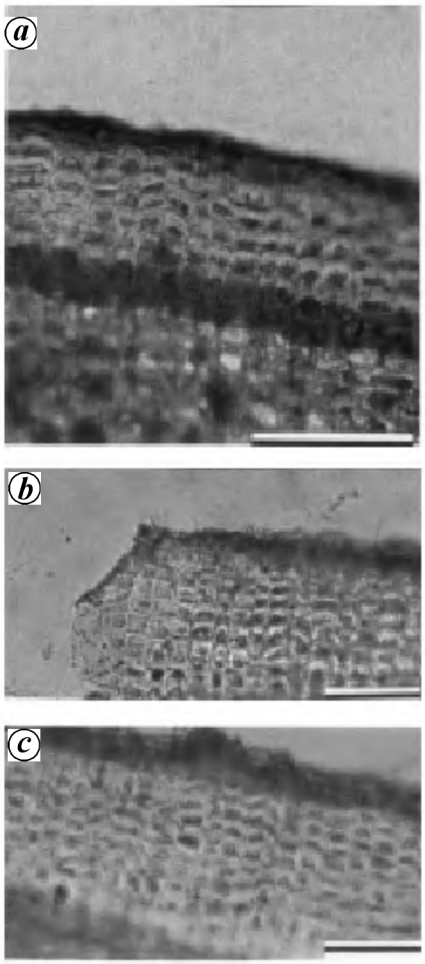

Figure 5. ***a***, Radial longitudinal section of *Laburnocytisus*-type shoots from *X L. adamii* showing multilayered periderm with cell thickened on their outer periclinal walls. Scale bar 0.1 mm. ***b***, Transverse section of *L. vossii* stem showing multilayered periderm in regular rows. Scale bar 0.1 mm. ***c***, Transverse section of *Laburnum*-type shoots from *X L. adamii* showing multilayered periderm. Scale bar 0.1 mm.

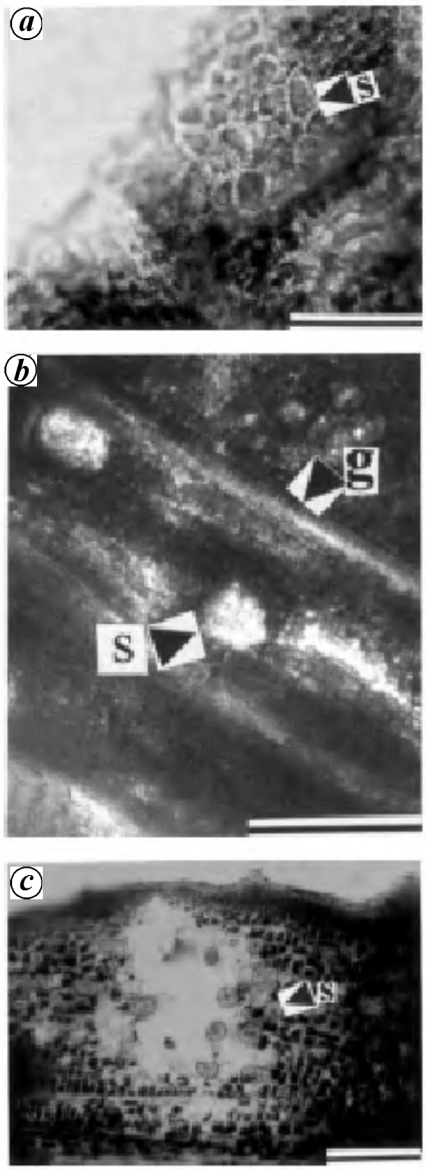

Figure 6. ***a***, Tangential longitudinal section of *L. vossii* stem. Scale bar 0.1 mm. s, Group of thick-walled stone cells in bark. ***b***, Tangential longitudinal section of *Laburnum*-type shoots from *X L. adamii*. Scale bar 0.3 mm. g, Gelatinous bark fibres and s, Group of thick-walled stone cells. ***c***, Radial longitudinal section of *C. purpureus* stem. Scale bar 0.1 mm. s, Individual thick-walled stone cells.

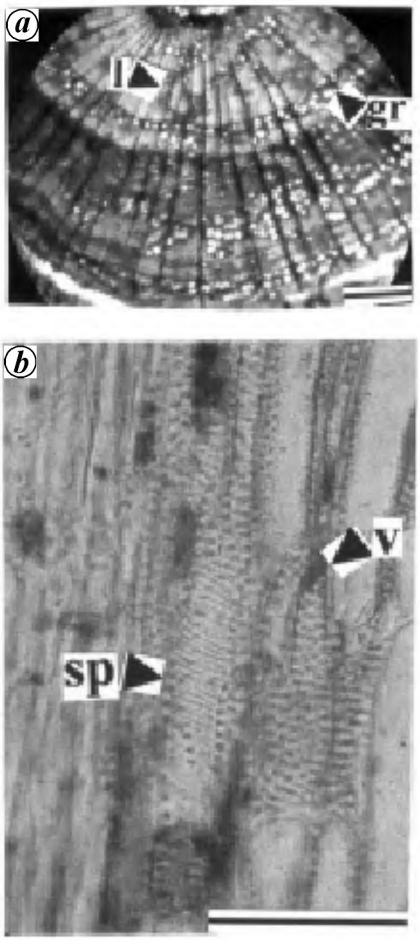

Figure 7. ***a***, Transverse section of *Cytisus*-type shoots from *X L. adamii*. Scale bar 0.3 mm. gr, Growth ring boundary showing ring of earlywood vessels and l, Latewood vessels in dendritic arrangement. ***b***, Radial longitudinal section of *Laburnum*-type shoots from *X L. adamii*. Scale bar 0.05 mm. sp, Spiral thickening in vessel, and v, Alternate pitting in vessel.

cells had thick, well-pitted walls (Figure 9 *a* and *c*). Rays were heterogenous, but there appeared to be a higher proportion of procumbent cells in *Laburnum*-type and *L. vossii* (Figure 9 *a*), compared to *Cytisus*-type, which had more upright cells (Figure 9 *b* and *c*), though this could also be related to the age or width of the rays.

Thus the main differences detected between the three different shoot types on *X L. adamii* were: (i) Presence of hairs on young shoots in *Laburnum* but not *Cytisus*-type and presence of bark ridges with longer persisting epidermis in *Cytisus*- than *Laburnum*-type. (ii) Crescent-shaped caps of gelatinous fibres in the cortex of *Laburnum*-type and *Laburnocytisus*-type; less obvious in *Cytisus*-type. (iii) Stone cells in groups in *Laburnum*-type; present as isolated cells in *Cytisus*-type and *Laburnocytisus*-type. (iv) Rays heterogenous in all specimens, but there appeared to be more procumbent than square or upright cells in *Laburnum*-type compared with more square and upright cells than procumbent in *Cytisus-type.* This needs conformation with further samples.

In all these features, the *Laburnum*-type stems appeared identical to those of *L. vossii*, and the *Cytisus*-type stems were indistinguishable from those of *C. purpureus*. The *Laburnocytisus*-type stems appeared to be intermediate, veering towards the *Laburnum*-type in having crescent-shaped caps of gelatinous fibres, but towards the *Cytisus*-type in frequency of stone cells.

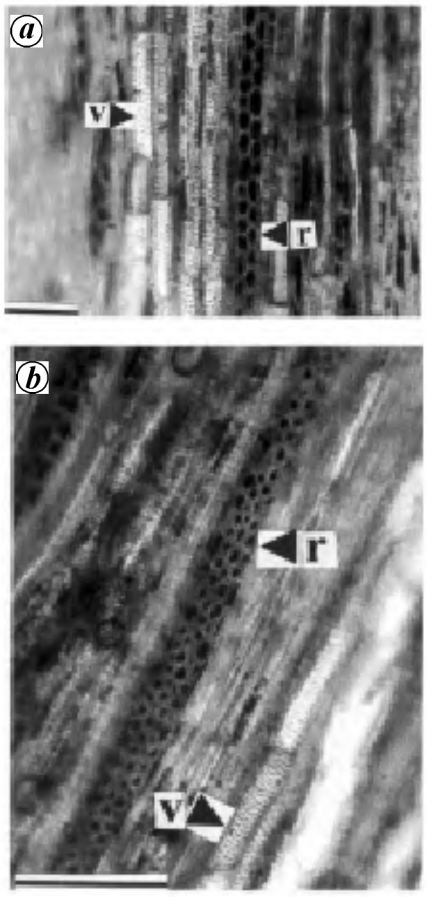

Figure 8. ***a***, Tangential longitudinal section of *C. purpureus* stem. from *X L. adamii*. Scale bar 0.05 mm and r, Ray and v, Alternate pitting in vessel. ***b***, Tangential longitudinal section of *Laburnocytisus*-type shoots from *X L. adamii*. Scale bar 0.05 mm. r, Multicelluar ray with cells rounded in TLS and v, Alternate pitting in vessel.

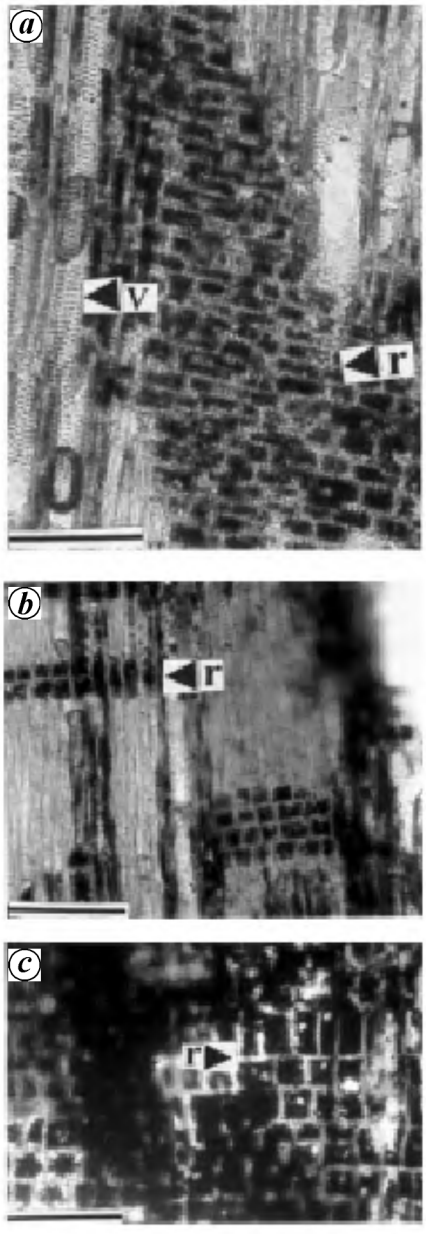

Figure 9. ***a***, Radial longitudinal section of *Laburnum*-type shoots from *X L. adamii*. Scale bar 0.05 mm. r, Ray cells predominantly procumbent and v, Alternate pitting in vessel. ***b***, ***c***, Radial longitudinal section of *C. purpureus* stem. Scale bar 0.05 mm. (***b***) r, Ray cells either square or upright. (***c***) r, Ray cells with thick, well-pitted walls.

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