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Taxonomic and morpho-anatomical studies on variegated plants I: *Polyscias balfouriana* Bailey (Araliaceae)

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Abstract. Morpho-anatomical studies of leaves of two cultivars of *Polyscias balfouriana* Bailey (Araliaceae) reveal that while the mutation in both the cultivars has occurred in L_2, the detailed pattern of variegation in the two cultivars is quite different from each other due to displacement phenomenon of normal green and mutated colourless layers.

Keywords. *Polyscias balfouriana*; taxonomy; morpho-anatomy.

1. Introduction

Variegated plants are gaining considerable importance in ornamental horticulture as items of indoor decoration, particularly so with the change in the pattern of housing, from individual houses with land around, to flats. There is, therefore, an ever-increasing demand for this group of plants. Tropics and sub-tropics in general have an abundant wealth of such plants which have not been properly studied botanically and horticulturally. The main object of the present work is to fill this lacuna and standardise their taxonomical nomenclature and document morpho-anatomical characteristics with a view to examine the nature and extent of the tissue-recombination prevalent in the variegated plants grown in India.

Essentially, variegated plants arise as spontaneous bud-sports frequently in cultivated plants and have been observed by nursery men, horticulturists and geneticists who have maintained them by vegetative propagation. These have often been given fancy names by nursery men. The bud-sports are somatic mutations which survive as chimeras which among others was demonstrated by Simmonds (1965) in the case of potatoes. More often the bud-sports have been found in clonally propagated plants, particularly, in sterile hybrids (Crane and Lawrence 1952).

2. Observations and discussion

The present account deals with cultivars of *Polyscias balfouriana* Bailey. The nomenclature has been confirmed from *Exotica* (Graf 1973). They belong to the family Araliaceae and are natives of New Caledonia. Although there are many

cultivars under this species only the two most common, viz., *Polyscias balfouriana* cv. 'Marginata' and cv. 'Pennockii' have been studied here. Both are leafy, bushy shrubs with leathery variegated leaves usually with three, orbicular coarsely toothed leaflets. The leaves are dark green or greyish-green in colour. The leaves of cv. Pennockii generally have dark green marginal patches with pale green or chlorotic centres masked with dark green layers of cells and yellowish veins (figure 1), while in cv. Marginata, generally, leaves are dark green having irregular white marginal patches. Occasionally dark green normal leaves are also found; rarely, however, albino leaflets are observed (figure 2).

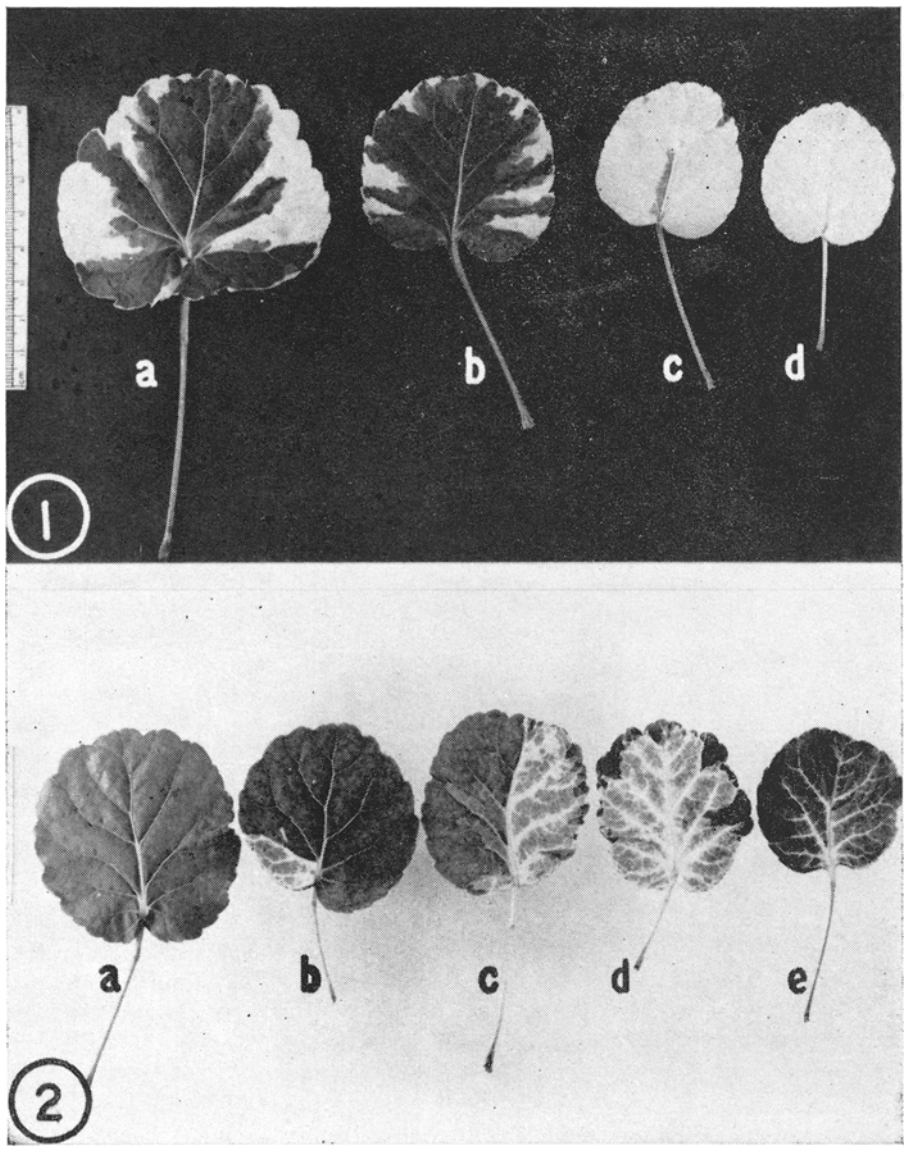
Different type of leaves studied during the present study were normal dark green; variegated with dark green patches on the margin and light green or pale green centre with chlorotic veins; and variegated with white marginal patches and dark green centre. Since both cultivars are pollen and seed sterile, the conclusions have been drawn on the basis of nature of the three germinal layers, i.e., L_1, L_2 and L_3 (Satina *et al* 1940). L_1 gives rise to epidermal and marginal mesophyll tissue, L_2 produces central mesophyll tissue and L_3 gives rise only to vascular tissue or midrib of the leaf.

2.1. *Marginata*

Typical variegated leaves of this cultivar (figures 1a and b) have colourless or yellow irregular marginal patches which sometimes extend up to mid-rib, with green centre in varying shades. The green zone is sharply separated from the colourless margin. More often totally colourless (figure 1d) or entirely normal green leaves are also found, rarely colourless leaves developed dark green patches of varying size near or away from the mid-rib (figure 1c). Since the distribution of green and colourless tissue of leaf is not regular, no two leaves are identical except in the gross pattern of variegation of leaf. The colour density and patterns of variegation on upper and lower surfaces of leaves also do not coincide.

Cross-sections of the leaf show that it is 9–10 celled thick excluding upper and lower epidermides (figure 3). The central green region has different shades of green and the extent of the colour is directly related to the thickness of green portion in the leaf. In figure 3, the rectangles on the upper and lower sides of the diagram represent the cells of the epidermis, and cross marked areas represent green portions in the variegated leaf. A layer of cylindrical cells under the upper epidermis represents the palisade tissue cells of which are generally filled with chloroplasts. The region between the palisade tissue and the lower epidermis is spongy parenchyma in which cells are rounded or hexagonal. Transverse sections of different regions of central green part show irregular distribution of chloroplasts in spongy parenchyma and palisade tissue. As viewed from upper and lower leaf surface, the irregular distribution of green and white tissue accounts for different hues of green colour as also the presence of different patterns of variegation on different leaves.

The foregoing observations indicate that the cultivar is a periclinal chimera with white over green constitution. L_1 is genetically green because stomatal guard cells contain chloroplasts both in white and green portions of the variegated leaf. L_2 is white or colourless while L_3 is green. The genetic make-up of the three germinal layers (L_1, L_2, L_3) is, therefore, GWG, where G stands for normal green and W for mutated colourless or white chloroplasts. In a typial variegated leaf, the



Figures 1–2. Leaves of *Polyscias balfouriana* cultivars: **1.** cv. ' Marginata ': ab—Leaves with white margin and green centre; c—White leaf with green patch on mid-rib; d—Albino leaf. **2.** cv. ' Pennockii ': a—Normal green leaf; b—Leaf with chlorotic patch at the base; c—half green and half chlorotic leaf; d—Variegated leaf with dark green marginal patches and chlorotic centre; e—Green leaf with chlorotic veins.

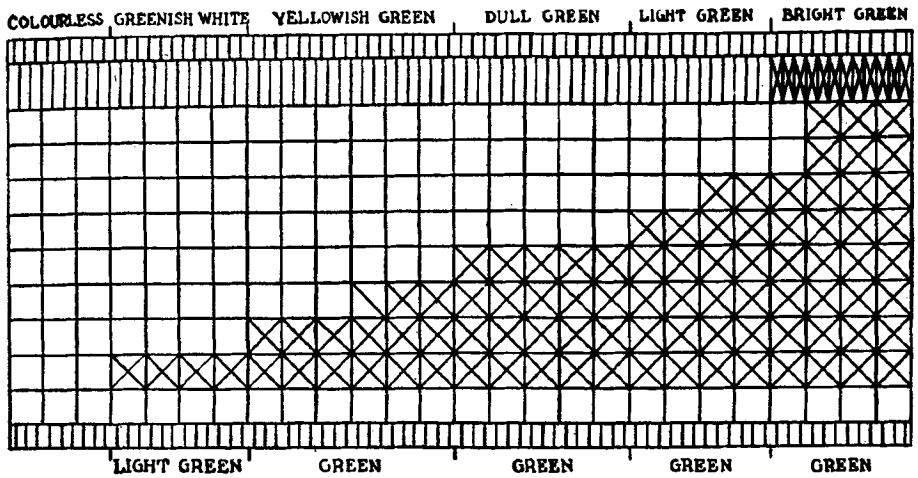


Figure 3. Semi-diagrammatic representation of a variegated leaf of cv. Marginata showing white and different shades of green colour.

white marginal patches are of GWW type and the central green portion with different green colour intensities have a mixture of cells having different genetic make-up. Irregular involvement of normal and mutated cells give different hues of green colour to the central regior. Similar observations have been reported by Dermen (1960) in fruit-sport of peaches and in the case of variegated leaf of Poinsettia. Due to irregular distribution of normal and mutated cells, the pattern of variegation on upper and lower surfaces of leaf differs (figure 3). Rarely total green leaves emerge in this cultivar, which are GGG in constitution. Perhaps these might have originated from genetically green L_3 or, from a single cell derived from genetically green L_1 which by repeated divisions gave rise to the entire tissue of the leaf along with epidermis. This has also been observed by Derman (1960) in his cytochimeras of peach where a pure diploid type of branch (2–2–2) originated from a diploid-tetraploid-tetraploid (2–4–4) chimeral peach tree. Often, total white or albino leaves appear in cv. Marginata with a GWW type of constitution. Probably these leaves originated through displacement phenomenon of genetically normal green L_3 by mutated L_2 as observed by Howard (1959, 1967) and Simmonds (1965, 1969), in their potato mutants.

2.2. *Pennockii*

This cultivar (figure 2) has marginal patches of green tissue with pale green or chlorotic centre. There are also some leaves which are green with chlorotic veins. Some entirely green leaves are also present. The pattern of variegation in this sport varies from leaf to leaf. There are some leaves which are completely green but have chlorotic patches on one side of the leaf at the base, or half of the leaf is green and the other half pale green having chlorotic condition along the veins and veinlets with dark green marginal patches.

Thin sections of the leaf were also examined. The leaf is 9–10 celled thick excluding upper and lower epidermides (figure 4). Palisade tissue is thickly packed with dark green chloroplasts at places but sometime it is completely devoid of chloroplasts. Some mesophyll cells below the upper epidermis or just above the lower epidermis contain chloroplasts. The number of cells or cell layers containing chloroplasts varies from place to place. Sometime these chloroplast-containing cells form a pyramid like figure in the mesophyll tissue. At some places it is observed that chloroplasts are completely absent from all the tissues of leaf. This type of irregular distribution of mutated and normal cells in the leaf tissue are responsible for the chlorotic pattern of variegation of leaf. Often the frequency of distribution of chloroplasts in the cells and their colour varies which also give different hues of green colour. Actually it is very difficult to show correctly the frequency of distribution and colour of chloroplasts in the cell layers through the given diagram. It can give only an idea about the actual number of cell layers and presence and absence of chloroplasts in the tissues of the leaf.

This cultivar is also a periclinal chimera. Generally apart from typically variegated leaves on the plant, there are leaves half green and half chlorotic with green marginal patches, and rarely normal leaves are also found. The type of variegation in this cultivar gives chlorotic appearance. According to the concept of chimeral development (Dermen 1960), it can be concluded that variegation in cv. Pennockii is due to mutation in L_2 in which chlorophyll development of plastids is suppressed. Therefore, the genetic nature of the chimera is GWG where L_1 is originally genetically normal green, which is responsible for dark green marginal patches and also for the emergence of some total green leaves. It might also be assumed that total green leaves have originated from a deeper layer, i.e., L_3 which is also genetically normal green. Due to involvement of mutated and normal germinal layers, mesophyll and palisade tissues have a mixture of colourless and normal green cells. Thus the irregular distribution of normal green and mutated colourless cells in the leaf is responsible for the chlorotic type of variegation in this cultivar. The presence of yellowish veins and veinlets in some leaves support the concept of displacement of normal L_3 by mutated L_2.

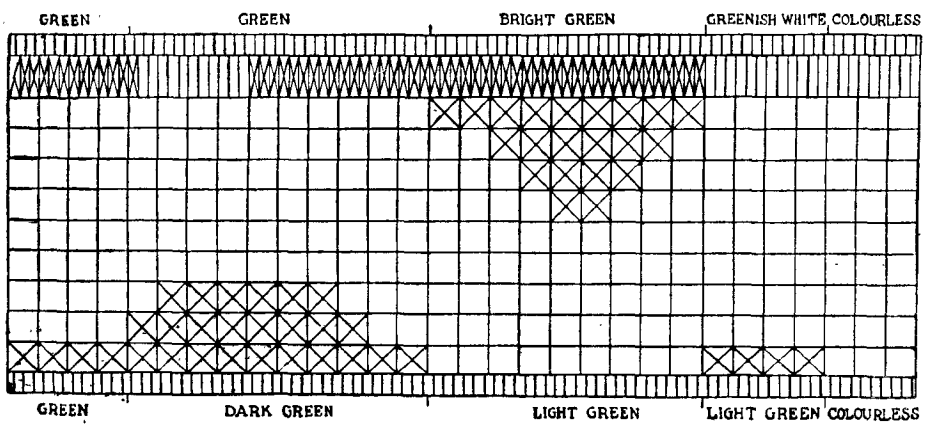


Figure 4. Semi-diagrammatic representation of a variegated leaf of cv. Pennockii showing different shades of chlorotic pattern.

On the basis of above observations it has been established that chlorotic nature of variegation in this cultivar is due to mutation in one of the three germinal layers (L_2) of leaf.

It is very difficult to establish the nature of variegation in these cultivars through genetic analysis because the material is pollen as well as seed sterile. Conclusions could be drawn only after studying the pattern of variegation of the leaf. The differences in variegation pattern of upper and lower surfaces of the leaf supports the genetic origin of variegation. Dermen (1960) is of the opinion that differential colouring almost consistently on the two surfaces of a variegated leaf is considered as a useful diagnostic point in judging whether a variegation is of genetic origin.

3. Conclusions

According to Dermen (1960) duality in colour of leaves due to gene or cytoplasmic mutation is termed as variegation. These are mostly permanent changes which take place in the growing point of the shoot. Due to mutation, normal chloroplast development is inhibited at places. The nature of mutation in these cultivars cannot be ascertained with any certainty, because both are pollen and seed sterile.

While the details of variegation pattern in the two cultivars, Marginata and Pennockii are quite different from each other, their genetic constitution is perhaps the same being GWG.

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