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FOREST RESTORATION RESEARCH IN NORTHERN THAILAND: 2. THE FRUITS, SEEDS AND SEEDLINGS OF *GLUTA USITATA* (WALL.) HOU (ANACARDIACEAE)

Stephen Elliott[1], *Siriporn Kopachon*[1], *Kitiya Suriya*[1], *Surat Plukum*[1], *Greuk Pakaad*[1], *Puttipong Navakitbumrung*[1], *J. F. Maxwell*[1], *Vilaiwan Anusarnsunthorn*[1], *Nancy C. Garwood*[2] *and David Blakesley*[3]

ABSTRACT

Gluta usitata (Wall.) Hou (Anacardiaceae) is a common, deciduous, native tree species, found mostly in deciduous dipterocarp–oak forest and bamboo deciduous forest 350–1,240 m above sea level. It is usually leafless from March until April. It flowers from December until March and fruits from January until May. Seeds begin to germinate 16–23 days after sowing and continue to do so over about 2 months. Detailed descriptions of the fruit, seed and seedling are presented. *G. usitata* could be a useful tree for inclusion in tree planting programs to restore deciduous forest below 1,000 m elevation. Seeds collected in January–March should be sown in forest soil or compost in individual plastic bags (6.5 cm x 23 cm) with added slow–release fertilizer. Seedlings grown in full sunlight should be ready for planting in about 18 months (i.e. at the beginning of the rainy season of the year following seed collection).

INTRODUCTION

This paper is the second in a series presenting results from the Forest Restoration Research Unit (FORRU) (KOPACHON *ET AL.*, 1996), a joint initiative between Chiang Mai University (CMU) and Doi Suthep–Pui National Park Headquarters (under the Royal Forest Department), where the unit is located. It is generously sponsored by Riche Monde (Bangkok) Ltd. as part of the company's support program for environmental research and education. FORRU's goal is to develop appropriate techniques to accelerate natural forest regeneration on deforested sites to restore biodiversity and maintain watersheds in conservation areas in northern Thailand. The first phase of the project involves gathering descriptive, ecological and taxonomic information on the wide variety of tree species which grow in the region (ELLIOTT *ET AL.*, 1995). This includes data on the seasonal cycles of flowering and fruiting (phenology), seed germination and seedling morphology. This information, when complete, will be published as a handbook to aid recognition of the fruits, seeds and seedlings of native forest trees and advise on the propagation of seedlings for tree planting projects. In the meantime, short papers on individual species, such as this one, will be published as results become available.

[1] Forest Restoration Research Unit, Biology Department, Chiang Mai University, Chiang Mai, Thailand 50200.
[2] Department of Botany, The Natural History Museum, Cromwell Road, SW7 5BD, London, U.K.
[3] University of Bath, School of Biology and Biochemistry, Bath BA2 7AY, U.K.
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Gluta usitata (Wall.) Hou (Anacardiaceae) is a common native deciduous tree, known in English as the varnish tree or red zebra wood and in the vernacular as รักใหญ่ (rak yai, central Thai) or ฮักหลวง (hak luang, northern Thai) (FORESTRY ASSOCIATION OF THAILAND, 1970). It was first described by WALLICH in 1829 under the name *Melanorrhoea usitata* Wall. (Pl. As. Rar. 1 : 9. t.11 & 12., 1829) from specimens collected in Burma, but was later incorporated into the large genus *Gluta* by HOU (1978a). The species name *usitata* is Latin for something that is ordinary or useful. The tree is cultivated in some parts of eastern Asia.

It is perhaps best known for its resinous sap, which is the source of Burmese lacquer (HOU, 1978b). Like other species of *Gluta,* the sap is also highly irritative. Skin contact causes severe dermatitis in some people, whilst others are unaffected. Yet, despite its caustic nature, the sap is used in traditional remedies to relieve toothache, as a purgative and in tonics to promote vigour. When mixed with the sap of *Euphorbia antiquorum* L. (Euphorbiaceae), it is used to treat fungal skin infections and hemorrhoids and mixed with honey, it is used to treat mouth ulcers. Its bark is included in traditional remedies for sexually transmitted diseases, stomach pain and painful joints. The bark of the roots is used to treat skin diseases, intestinal worms and coughs. The leaves and the roots make an antiseptic poultice applied to wounds and its hard wood is used to make furniture, spears, gun stocks, tool handles and umbrella handles and is used as firewood (FORESTRY ASSOCIATION OF THAILAND, 1970). Further details are given by BURKHILL (1966).

HABIT

G. usitata is a large, deciduous, canopy tree, reaching a height of 15–25 m and a diameter at breast height (dbh) of 40–60 cm. It has distinctive grey to pinkish brown, flaky bark (Fig. 1A) which often has darker patches where the resinous sap has oozed out and turned black on exposure to air (Fig. 1B). The sap is milky white or faintly pinkish, at first. The wood is dark red and hard.

Its mature leaves are arranged spirally, notably around the branch tips. The blades are thick, 15–35 cm long by 8–14 cm wide, obovate in shape, obtuse at the apex, acute or attenuate at the base, with entire margins (i.e. no indentations). Both surfaces and all veins are densely covered in very short, fine, simple, white or light brown hairs, giving a downy feel to the leaves. The upper surface is a darker green than the lower surface. Veins on the upper surface are yellow and sunken; those on the lower surface are also yellow and prominently raised. Venation is pinnate and alternate. There are 34–42 looping, secondary veins per side, alternately arranged along the central, primary vein. Many secondary veins have a characteristic y–shaped fork towards the leaf margin. Minor veins form a reticulate pattern. Leaf stalks (petioles) are about 2–4.5 cm long, densely covered in short, light brown hairs on the upper flat surface. The lower surface is convex with 7 longitudinal, parallel ridges and is slightly less hairy than the upper surface. For descriptions of the species, under the name *Melanorrhoea usitata* Wall., see WALLICH (1829 : Pl. As. Rar. 1 : 9. t.11 & 12.), HOOKER (1879) and TARDIEU–BLOT (1962).

A

B

Figure 1. Bark and resin of *G. usitata*, near Wang Bua Bahn, Doi Suthep–Pui National Park, 550 m above sea level: A. fresh wound 7/8/97; B. same wound with blackened resin (Burmese lacquer) 18/8/97 (photos P. Navakitbumrung).

Figure 2. Foliage and immature fruits of *G. usitata,* c. 380 m elevation, Doi Suthep–Pui National Park, Chiang Mai, November 1991 (photo S. Elliott).

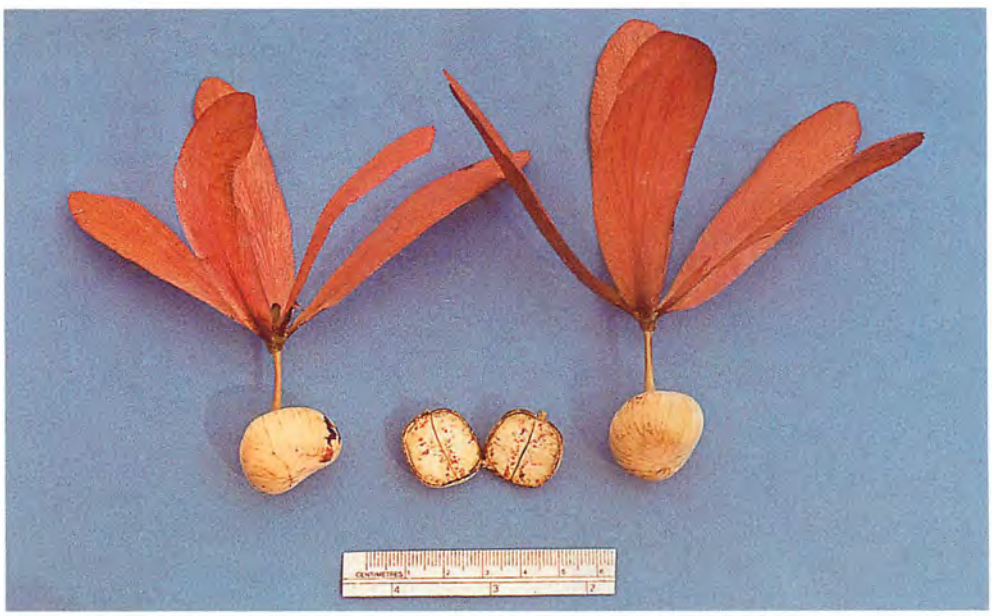

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Figure 3. Fruits and seeds of *G. usitata,* from *S. Kopachon–s091b1,* Doi Suthep–Pui National Park, 550 m elevation. Fruits are orientated in this picture as they would fall from the tree with the drupe below the wings. The drupes are derived from a superior ovary (photo S. Kopachon 29/3/95).

HABITAT

In northern Thailand *G. usitata* is a common species in fire-prone deciduous dipterocarp–oak and bamboo deciduous forests (*sensu* MAXWELL *ET AL.* 1995), 350–1,240 m above sea level, commonly associated with other tree species such as *Dipterocarpus obtusifolius* Teijsm. ex Miq. var. *obtusifolius, D. tuberculatus* Roxb. var. *tuberculatus, Shorea obtusa* Wall. ex Bl., *S. siamensis* Miq. var. *siamensis* (all Dipterocarpaceae), *Quercus kerrii* Craib var. *kerrii* (Fagaceae), *Buchanania lanzan* Spreng. and *B. glabra* Wall. ex Hk. f., (both Anacardiaceae), *Eugenia cumini* (L.) Druce (Myrtaceae), *Dalbergia fusca* Pierre (Leguminosae, Papilionoideae) etc.

DISTRIBUTION

The species is found throughout the north and northeast of Thailand, as far south as Chanthaburi. It was collected throughout northern Thailand (Doi Suthep, Kampaeng Phet, Chiang Dao etc.) by A. F. G. Kerr (specimens 933, 4505, 10135 & 19879, BMNH herbarium) in 1910–1931. The CMU Herbarium contains reference specimens from Doi Suthep–Pui National Park (*S. Kopachon s091b1, Maxwell 87-1391 & 94–192*) and Doi Chiang Dao Wildlife Sanctuary (*Maxwell 90-233, Gardner T522*) and the species has also been recorded in Doi Khuntan National Park (where it extends into the lower areas of evergreen forest) and Obluang National Park (*Maxwell 97-67,* CMU HERBARIUM DATABASE). CHAYAMARIT (1994) also records it in Chiang Mai Province at Omkoi, Li and Mae Klang, in Mae Hong Sorn Province near Mae Sariang, in the southeast at Chantaburi and in the northeast at Mukdahan. It is also found in India, Burma and Laos (TROUP, 1921; TARDIEU–BLOT, 1962; CHAYAMARIT, 1994).

PHENOLOGY

In northern Thailand *G. usitata* is deciduous, being mostly leafless from March until April at the hottest, driest time of the year. It flushes with new leaves at the end of April. Small white flowers have been observed from December to May and fruiting occurs from January to March (MAXWELL, pers. obs. and CMU HERBARIUM DATABASE) (Fig. 2).

FRUITS AND SEEDS

The fruits (Fig. 3), which develop from superior ovaries, are produced in cymes (a broad flat–topped inflorescence with the central flowers opening first). The fruit stalks are round in cross section (terete), 2–3.5 cm long below each fruit, green when the fruits are unripe, turning brown–green or brown as the fruits ripen. The fruits are slightly fleshy, indehiscent, irregularly spherical, drupes (stony inner fruit wall enclosing the seed; pyrene). Each fruit has 5 membranous wings (enlarged petals) 4–8 cm long, encircling the fruit stalk about 2 cm below the drupe, pink to reddish when the fruit is unripe, turning

red–brown and drying out as the fruit ripens. The drupes (the globose part of the fruit, not including the wings) are 17–28 mm long and about 15–26 mm wide. There is one seed in each fruit. The outermost and innermost layers of the fruit wall (exocarp and endocarp, respectively) are thin, but the middle layer (mesocarp) is even thinner. The outer fruit wall is very fibrous, creamy-green turning reddish-brown or dark brown and covered with longitudinal veins.

The seeds are smooth, hidden within the fruit walls, turning from light brown to brown upon ripening. Each seed is irregularly spherical, 16.6–27.7 mm long, 14.7–25.1 mm wide and 10.7–18.0 mm thick (means ±SD: 21.82±3.51, 18.71±3.50 and 15.04±2.41 respectively, n=10). Seed fresh weights and dry weights were 1.308–6.862 g (mean ±SD: 3.48±1.81) and 0.658–4.687 g (mean ±SD: 1.85±1.21). Moisture content ranged from 31.7 to 54.52 % (mean ±SD: 48.61±6.52). The embryo is composed of a small rudimentary shoot (plumule) and two large seed leaves (cotyledons). The cotyledons are partially fused together. They are pushed apart at one end by swelling of the seed leaf stalks (cotyledonary petioles).

DISPERSAL

Fruits are initially wind-dispersed. The 5 wings cause the fruits to rapidly revolve, slowing their descent and increasing their chances of being dispersed away from the parent tree before landing. Secondary dispersal by floods and gravity on steep slopes might also occur. Due to the heaviness of the fruits, wind gusts of considerable force are required to ensure their dispersal over a significant distance. It is notable that dispersal occurs mostly in March–April when maximum wind gust speeds are at their highest, during powerful gales preceding onset of the monsoon (data from nearby Chiang Mai Airport). Other species in the same forest type with heavy, winged fruits (e.g. *Dipterocarpus tuberculatus* and *D. obtusifolius*) also disperse their fruits at the same time of year.

No observations of seed predation have yet been made, but the fruits contain the same caustic sap present in the rest of the tree, which might provide some degree of protection against predation. TROUP (1921) noted that the seedling is "immune from damage by grazing owing to the acrid juice in its leaves".

SEED GERMINATION

Ripe fruits were cut from a single *G. usitata* tree 13 m tall, 44 cm diameter at breast height near the scenic spot called Wang Bua Ban on Huaykaew stream 550 m above sea level in Doi Suthep–Pui National Park, on 29 March 1995. The whole fruits, with the wings removed, were planted on 2 April 1995 at the FORRU nursery, 1,050 m above sea level, under two shade treatments: partial shade (about 40% of full sunlight, similar to conditions in partially regenerating gaps) and deep shade (less than 1% full sunlight, similar to conditions under a forest canopy). Seed trays in partial shade were placed on top of concrete benches, beneath a transparent plastic roof, paired with trays in deep shade placed immediately underneath the same bench and screened with black plastic shade

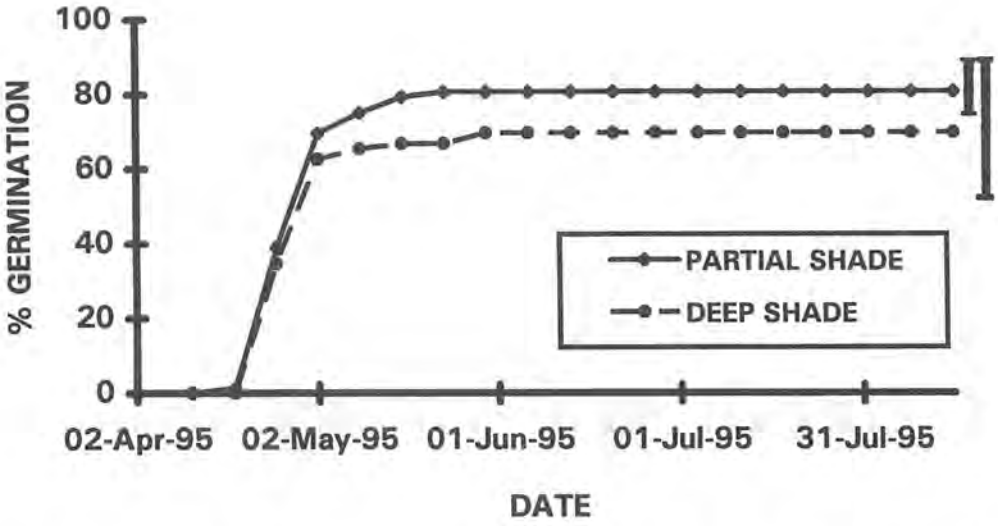

Figure 4. Germination curves of *G. usitata* seeds in partial and deep shade at the FORRU nursery, Doi Suthep–Pui National Park 1,050 m above sea level. Bars indicate standard error of the final germination percentages (n=3).

netting. For each of the two treatments, 72 fruits were randomly divided into three replicate batches of 24. Each replicate consisted of 24 adjacent compartments (3.5 x 3 x 7 cm) in one seed tray containing forest soil. The paired trays were randomly assigned to different benches in the FORRU nursery and watered daily.

The first seed germinated 16 days after planting in partial shade and after 23 days in deep shade. Seeds continued germinating until up to 58 days from the planting date (Fig. 4). The final germination percentage was higher in partial shade (81% ±SD6.36) than in deep shade (69% ±SD10.41), but the difference was not statistically significant (paired t-test, $t=2.22$, $p<0.05$, $n=3$). In addition, for those seeds that germinated, the number of days between sowing and germination did not differ significantly between treatments ($p=0.05$, Kolmogorov–Smirnoff 2-sample test, SOKAL and ROHLF, 1981). Fifty per cent of all seeds that germinated had done so 3–4 weeks after sowing in both treatments.

SEEDLINGS

Seedlings were raised from seed collected from one parent tree. They were initially grown in partial and deep shade (as described above), then transferred to a shaded nursery bed (15–20% full sunlight) and grown to larger sizes. Descriptions are based on about 45 seedlings less than 35 cm tall, 13–15 months old and dried specimens of eight seedlings of various sizes and ages (*Suriya s091b1h1, Navakitbumrung s091b1h3*) deposited at the CMU Biology Department Herbarium and the Natural History Museum, London (*Kopachon s091b1h2*). Various stages of development are illustrated in Figures 5–6.

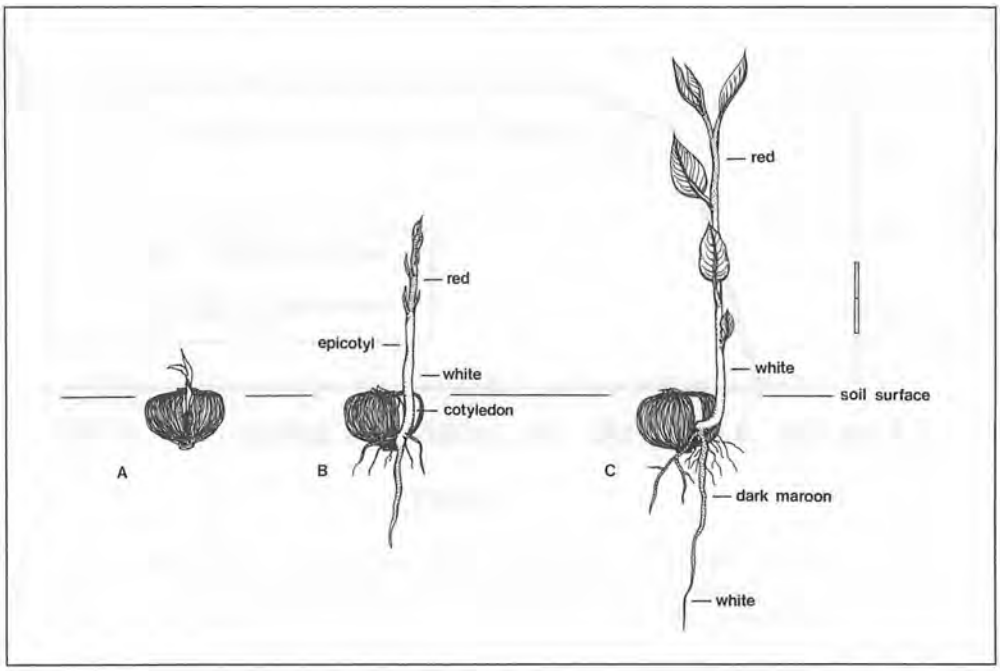

Figure 5. Young seedlings of *G. usitata:* A) 7 days old; B) 10 days old and C) 13 days old (*Suriya s091b1h1* deposited at the CMU Biology Department Herbarium). One division of the scale bar is 1 cm. (drawings K. Suriya & P. Navakitbumrung).

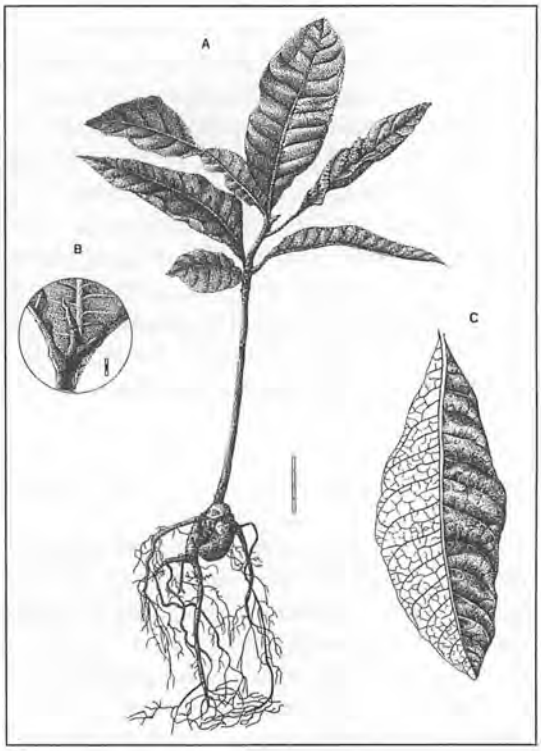

Figure 6. A) seedling of *G. usitata* aged 75 days; B) apical bud (27th node) and C) leaf venation (20th node) (drawing S. Plukum). Root spiraling, seen on this specimen, can be avoided by sowing seeds directly into plastic bags.

Seedling type: cotyledons remain on or below the soil surface (hypogeal), enclosed within the fruit wall (cryptocotylar).

Development: the stalks of the seed leaves (cotyledonary petioles) swell, pushing apart the seed leaves (cotyledons) on one side. The fruit wall splits open and a small tap root emerges downwards. A much faster growing shoot emerges upwards from between the cotyledonary petioles and emerges through the same opening as the root.

Roots: Primary root thick, fibrous, young parts dark maroon turning dark red-brown with age, apex white. **Secondary roots** sparse along the tap root and a few around the point at which the primary root and hypocotyl meet (collet); sinuous, thin, short, light maroon, branching. Tertiary roots same as secondary roots but thinner and shorter.

Stems: Hypocotyl (the part of the stem immediately below the cotyledons) almost non–existent, not enlarging. **Epicotyl** (the part of the stem immediately above the cotyledons) very pale green in very young seedlings, becoming white. In older seedlings (6–8 nodes) the epicotyl becomes light brown or reddish brown. Epicotyl length when the first scale leaf is fully expanded is 15–30 mm. **Internodes:** first internode 11–20 mm long, light maroon when young, becoming white and then light brown and lignified with age. Later internodes become progressively shorter towards the apex (the same pattern is observed on the twigs of adult trees). They are light maroon or reddish green when young quickly becoming light brown–grey (but they have no white phase as in the lowest 2–3 internodes). Tiny raised pores (lenticels) occur densely, especially on the lower parts of the stem. **Stems** of larger seedlings erect, slender. **Axillary buds** (in the upper angle between the stem and the dorsal base of the petiole) minute, green-yellow, sometimes not visible.

Cotyledons (seed leaves) two, opposite, hemispherical, fleshy, creamy white, concealed within the fruit wall, hairless (glabrous), 21–23 mm wide, 10–12 mm long and 7–10 mm thick. Persistent until at least 13 nodes have developed. **Petioles** (cotyledon stalks) about 1 mm long, swollen, flattened on inner side.

Leaves simple, spirally arranged. Leaves at the lowest 5–10 nodes are very small, almost scale-like. Normal sized leaves above the tenth node have blades 45–130 m long x 16–40 mm wide. They are thick, elliptic to ovate–lanceolate, apex acute, base acute to acuminate, margins entire, light maroon and slightly hairy when young, darker green above than below and hairless when fully expanded. **Venation** pinnate; primary veins pale yellow, sunken above and prominently raised below; secondary veins also yellowish, with a characteristic y–shaped fork towards the leaf margin, looping. Secondary veins 8–15 on each side of midnerve, alternate.

Petioles (leaf stalks) red when young, becoming green, swollen towards the axil, 2–3 mm long, 1–2 mm thick, hairless.

Stipules (appendages near the base of the petiole) absent.

Branches can occur from the base of the stem upwards on seedlings more than about 1 year old. Multiple branches from the stem base can occur especially when the seedling is damaged or stressed, a characteristic which could enable seedlings to survive ground fires which are common in the habitats where the species grows. Branches are maroon when young turning brown and then grey with age.

Odour not distinctive.

Sap white, turning black on exposure to air.

CONCLUSIONS

G. usitata could be a useful tree for inclusion in tree planting programs to restore deciduous forest below 1,000 m elevation. It grows well in degraded, fire-prone areas with poor, shallow soils. Due to its many and varied uses, it would be especially appropriate for community forestry, where some kind of financial return is desirable from the trees planted. However, due to the caustic nature of its resin, some caution is necessary in deciding where to plant it. Some people develop an allergic reaction to the resin, whilst others are entirely unaffected. As a precaution, rubber gloves should be worn when handling the seeds or seedlings. If a rash develops within 12 hours to five days after handling the species, seek medical attention. Persons who have experienced a previous allergic reaction to this species or to others in the same family, e.g. mangoes or cashew nuts, should not handle the species at all (MITCHELL, 1990).

Seeds should be collected in March–April and sown immediately into individual black plastic bags (6.5 cm x 23 cm) in forest soil or compost mix. Seeds quickly loose viability during storage. Plant about 25–30% more seeds than the desired number of seedlings, to allow for germination failure. Addition of a slow release fertilizer (e.g. Osmocote) is advisable. Seedlings grown in full sunlight or very light shade should reach a height suitable for planting by the beginning of the rainy season of the year after seed collection.

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