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A Revision of the introduced species of *Manihot* Miller (Euphorbiaceae) in Malesia

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Abstract

Manihot is a New World genus with a 100 species. Two species have been introduced in Southeast Asia. *M. glaziovii* (distinctly peltate leaves, no ridges on the ovary and fruit), a small tree, was cultivated for its latex, but *Hevea brasiliensis* outcompeted this species. *M. esculenta* (leaves not or hardly peltate, ridges along ovary and fruit), usually a shrub, is a major root crop for humans as well as for animals, it is known worldwide as cassava, manioc, or tapioca.

INTRODUCTION

The very well-known genus *Manihot* was first described by Miller (1754), though this publication has remained obscure for a long time. Adanson (1763) was generally acknowledged as the first author of the genus. The genus name was already introduced by Linnaeus (1753) as an epithet of a species in the genus *Jatropha* (*J. manihot*). The most recent and very extensive revision of the genus is by Rogers & Appan (1973) who recognized 2 genera, the monotypic *Manihotoides* and the much larger genus *Manihot* with 98 species. All species are American except for the widely cultivated type species of the genus, *M. esculenta* Crantz. The latter is only known from cultivation and escapes.

Webster (1994) places *Manihot* together with *Cnidoscolus* in the tribe Manihoteae, subfamily Crotonoideae. Palynology points to a close relationship (read great resemblance) between both genera, which was independently confirmed by Punt (1962) and Miller & Webster (1962). The latter two show that *Cnidoscolus* is quite distinct from *Jatropha*, with which it

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was first classified. Webster (1994) reduced *Manihotoides* again to *Manihot* because of a new intermediary species found in Mexico; this gives *Manihot* the round number of a 100 species. Typical for the tribe are the periporate, 3-nucleate pollen grains with reticulate to clavate sexine, the absence of petals, simple hairs, articulated laticifers, multifid styles, carunculate seeds, starchy endosperm, and chromosome number $x=9$.

Manihot differs from *Cnidoscolus* (Webster, 1994) in its non-stinging hairs, stipellate instead of glandular leaf blades, racemose or racemose-paniculate inflorescences (versus dichasial-paniculate), and staminate flowers with free instead of connate stamens, intrastaminal instead of extrastaminal disc, and yellowish or greenish sepals (versus white). Other typical characters of *Manihot* in Southeast Asia are the palmatifid, usually peltate leaves, absence of glands and stellate hairs, the presence of large sepals, stamens in 2 rows, disc glands, a pistillode, pusticulate fruits, marbled seeds, and a caruncle.

Two species of *Manihot* have been introduced in Malesia, *M. glaziovii* and *M. esculenta*. *M. glaziovii* Müll.-Arg., a tree, was used for its latex and was scheduled to be a competitor for the rubber tree, *Hevea brasiliensis*. However, *Hevea* is favoured and *M. glaziovii* has disappeared or it only plays a minor role in the production of rubber. *M. esculenta*, a shrub, is mainly cultivated for its edible roots, which produce a high quality though cyanogenic starch. The plant has been introduced in several Asian countries by the Portuguese, probably around 1810, and probably by the Spaniards in the Philippines. In Java it was still an unimportant crop plant up to 1880, but then the Colonial Dutch government promoted its cultivation because of the good storage results and failures of rice and maize crops. Presently it is an important food crop in many SE Asian countries for human and animal consumption (after Veltkamp & de Bruijn, 1996).

Because of the fact that *Manihot* has been introduced in Malesia, only a qualitative description of the species is provided. The rationalism for this policy is that introduced species are usually extremely variable due to the many cultivars present and they are hardly collected. This means that it is very likely that the extreme measures are not well represented in herbaria. *Manihot esculenta* is, because of its extreme variability, also a species with many synonymous names. Only those names will be presented which are or have been commonly used in Southeast Asia; for all other names refer to the systematic treatment of Rogers and Appan (1973). Literature references will also be more or less restricted to the major taxonomic treatments for Southeast Asia.

Manihot Miller, Gard. Dict. ed. 4, 2. 1754; Adans., Fam. Pl. 2: 356. 1763; Crantz, Inst. Rei Herb. 1: 658. 1766; Pohl, Pl. Bras. Icon. Descr. 1: 17. 1827; Müll.-Arg. in DC., Prodr. 15, 2: 1057. 1866; in Mart., Fl. Bras. 11, 2: 438. 1874; Pax in Engl., Pflanzenr. IV. 147.ii: 21. 1910; Standl., Contr. U.S. Natl. Herb. 23: 642. 1923; Pax & K. Hoffm. in Engl., Pflanzenr. IV.147.xvi: 194. 1924; Croizat, J. Arnold Arbor. 23: 216. 1942; Backer & Bakh.f., Fl. Java 1: 495. 1963; Airy Shaw, Kew Bull. 26: 308. 1972; Rogers & Appan, Fl. Neotropica

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13: 19. 1973; Airy Shaw, Kew Bull. Add. Ser. 4: 174. 1975; Kew Bull. Add. Ser. 8: 172. 1980; Kew Bull. 37: 30. 1982. Type species: *Jatropha manihot* L. [= *Manihot esculenta* Crantz].

Janipha Humb., Bonpl. & Kunth, Nov. Gen. Sp. 2: 84 (folio), 106 (quarto), t. 109. 1817.

Mandioca Link, Handbuch 2: 436. 19831, nom. superfl.

Manihotoides Rogers & Appan, Fl. Neotropica 13: 247. 1973. — Type species: *Manihotoides pauciflora* (Brandege) Rogers & Appan [= *Manihot pauciflora* Brandege]

Monoecious subshrubs, shrubs, trees or vines. *Roots* tuberous and often with large quantities of stored starch. *Stems* with a soft wide pith, usually branching dichotomously, mainly sympodial; latex white, usually abundant. *Indumentum* simple hairs only. *Stipules* persistent to caducous, setaceous, margins entire, serrulate or dentate, leaving well-defined scars. *Leaves* alternate, simple; petioles long (SE Asia), often reddish; blade (SE Asia) palmatifid with (1-)5(-11 or more) lobes, seldom not lobed; lobes usually obovate, usually asymmetric except for the central lobe, papery, base (SE Asia) not to distinctly peltate, margin entire, glabrous (SE Asia), usually glaucous below; venation looped and closed near margin, usually scalariform. *Inflorescences* terminal or pseudo-axillary (due to development of side-branches, then opposite leaf) raceme-like panicles, usually several per node, branching sparingly once (SE Asia) with short branches; lower flowers pistillate, upper ones staminate, seldom flowers of one sex only present; bracts and bracteoles subtending side-branches and flowers, margin entire, serrulate, serrate or laciniate. *Flowers* actinomorphic, 5-merous, pedicelled, abscission zone not visible; staminate flowers smaller than pistillate flowers; calyx in SE Asia campanulate, 5-lobed, lobes imbricate; petals absent. *Staminate flowers*: stamens 10, in 2 whorls of 5, outer larger (SE Asia), more or less outside disc glands, inner whorl among disc glands, filaments slender, anther versatile, subbasally dorsifixed, introrsely opening with longitudinal slits, 2-locular, connective elongated, elongation pilose; disc glands 10, radially arranged; pistillode small. *Pistillate flowers*: calyx lobes 5-nerved; staminodes sometimes present; disc annular, surface wobbly, glabrous; ovary 3-locular, one anatropous ovule per locule; style short, glabrous; stigmas 3, glabrous, apically broadening, often split, at the margin with globose stigmatic glands. *Fruits* capsular, globose to broadly ellipsoid, in Asia septicidal and partly, apically loculicidal; exocarp dry, smooth to warty, sometimes winged or ridged, often dehiscent from mesocarp; column hardly thickened basally and apically, with hardly any remains of the septa, subbasally with one vascular bundle, subapically 3-veined. *Seed* ellipsoid, dorsiventrally flattened, usually marbled with various shades of brown and white, shiny, apically with a caruncle. *Embryo* flat, surrounded by copious endosperm.

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Key to the species

- 1a. Mainly shrubs; leaves not or slightly (up to 2 mm) peltate; ovary with 6 longitudinal ridges; fruits with 6 longitudinal wings. (Leaf lobes narrow, c. 2.9—12.5 times as long as wide; central unlobed part usually short, lobes 15—21 times as long; nerves usually not very distinct and differently coloured when dry. Seeds up to 12 mm long. *M. dulcis* form in Malay Peninsula exceptional in these characters and like *M. glaziovii*).
 *M. esculenta*
- 1b. Mainly small trees; leaves distinctly (more than 5 mm) peltate; ovary smooth; fruits without wings. (Leaf lobes broad, lobes 0.9—3 times as long as wide; central unlobed part usually longer, lobes 5.8—12.5 times as long; nerves usually distinct and differently coloured when dry. Seeds 12 mm or longer.) *M. glaziovii*

Manihot esculenta Crantz, Inst. Rei Herb. 1: 167. 1766; Backer & Bakh.f., Fl. Java 1: 496. 1963; Airy Shaw, Kew Bull. 26: 308. 1972; Rogers & Appan, Fl. Neotropica 13: 25. 1973; Airy Shaw, Kew Bull. Add. Ser. 4: 174. 1975; Kew Bull. Add. Ser. 8: 172. 1980; Kew Bull. 37: 30. 1982; Veltkamp & G.H. de Bruijn in Flach & Rumawas, Plant Res. SE Asia 9: 107. 1996.

Jatropha manihot L., Sp. Pl. 1007. 1753.

Janipha manihot Humb., Bonpl. & Kunth, Nov. Gen. Sp. 2: 84 (folio), 108 (quarto). 1817.

Manihot utilisima Pohl, Pl. Bras. Ic. Decr. 1: 32, t. 24, 1827, nom. superfl., see note 1; Müll.-Arg. in DC., Prodr. 15, 2: 1064. 1866; Pax in Engl., Pflanzenr. IV.147. ii: 67, fig. 24. 1910. — Lectotype (Rogers & Appan, 1973): Merian, Dissertatio generatione metamorphosibus insectorum Surinamensium. Fig. 4 & Fig. 5. 1726.

Jatropha dulcis J.F.Gmel., Onom. Bot. 5: 7. 1772-1778.

Manihot dulcis (J.F.Gmel.) Pax in Engl., Pflanzenr. IV.147. ii: 71. 1910. — Type not indicated, no lectotype known.

For a full nomenclature see Rogers & Appan, 1973.

(Herb to) shrub (to treelet), up to 7 m high, dbh up to 20 cm, single to few stems, sparingly branching; branchlets light green to tinged reddish, nodes reddish. *Bark* smooth, light brown to yellowish grey; inner bark cream-green; exudate thin, watery; wood soft, creamy straw. *Stipules* entire or somewhat split. *Leaves*: petiole light greenish to red; blade basally attached or slightly (up to 2 mm) peltate, dark green above, pale light greenish greyish underneath, sometimes variegated; lobes narrow, 2.9-12.5 times as long as wide; central

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unlobed part usually short, lobes 15-21 times as long; nerves 5-18 pairs, usually not very distinct, especially above, usually not differently coloured when dry, veins reticulate to scalariform. *Inflorescences* lax, with 3-5 together in fascicles; pedicels light green to red. *Staminate flowers*: calyx divided to halfway or more, green to white to lobes white to reddish with white median band inside to red purple, glabrous except for apex of calyx tube and inner side of segments finely hairy; filaments white, anthers yellow; disc yellow to light orange. *Pistillate flowers*: calyx green with red margin and midrib, hairy along the margin and on the midrib inside; disc pink; ovary with 6 longitudinal ridges, green (with pinkish stripes) to orange; pistil and stigmas white. *Fruit* subglobose, green (to light yellow, white, dark brown), rather smooth, with 6 longitudinal wings. *Seeds* up to 12 mm long.

Distribution: Probably originally cultivated in NE Brazil, nowadays only known from cultivation, and found throughout SE Asia and Malesia.

Ecology and Habitat: Cultivated or found in waste places of mainly abandoned gardens and along road sides, probably not escaped; locally common. Soil: clay, limestone, red loam, peaty soil, usually well-drained. Alt.: sea level up to 1700 m.

Flowering and fruiting: Whole year through, though less so in Sep. and Oct. See also Veltkamp & de Bruijn 1996.

Uses: The roots constitute one of the world's largest stock crops for starch. It is mainly used for human consumption, less for animal consumption and (far less) for industrial purposes, though this may be very different per country. The roots can rarely be eaten fresh and are usually cooked, steamed, fried or roasted when fresh or after drying or fermenting. It is advisable to peel, grind or cut, and dry the roots in order to diminish the contents of cyanogenic glucosides (mainly linamarin). Only sweet cassava can be eaten fresh in small quantities, because the peel contains most HCN; the bitter ones have to be treated due to a much higher HCN content. The leaves are also eaten, they contain reasonable amounts of carotene and vitamin C, though they too have to be cut into pieces and they have to be cooked. Food poisoning hardly occurs, because most people know how to prepare the roots and leaves. See also Veltkamp & de Bruijn (1996). Plants, especially with variegated leaves, are also used in horticulture.

Vernacular names: English: Brazilian arrowroot, cassava, tapioca. French: Manioc. Thailand: man-sampalang (general), man-samrong (Central), mam-mai (Peninsular). Malay Peninsula: Hubiq khan (Semelai); ubi belanda, ubi benggala, ubi kayu. Sumatra: Oebi, oebi kajoe, oebi paid. Java: Katela djendral, pohon, pohon abang, telo markan, telotengkor (Javanese); ketela pohon (M.); sampen (Sundanese); ubi dangdur, ubi pongger (Malay); singkong, singkot pahit, ubi kaju. Borneo: Sabah: Ubi kayu (Malay); ubi kayu puteh (Brunei); Sarawak: Bandung kapok (Bidayuh); jabang (Iban). Philippines: Balangay, kamoting-kahoy (Bisaya); balanghoy (Samar-Leyte Bisaya); kahoy, kahoy patata (Ifugao); kamoting-kahoy (Tagalog);

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kasaba (Ilokano); sang-laykayo (Tagbanaua). Lesser Sunda Islands: Alor: Anti, batakong kika, batakong koeli, batakong liking, batakong kang. Moluccas: Halmahera: Inggris; Soela Sanana: Kasbi. New Guinea: Irian Jaya: Baundo taindi (Kuman); wateni (Kebar); Papua New Guinea: Hofa hagaya (Okapa); kawara (Taisora); cassava, mandioca, tapiagose, tapioc, timango heme.

Notes: 1. Rogers & Appan (1973) cited a type specimen for *Manihot utilissima* Pohl. However, in Pohl's description he referred to the Linnaean name *Jatropha manihot*, which makes it either a superfluous name when it really is a new species (like Rogers & Appan interpreted it), or it is superfluous because Pohl was not the first to create a new name under *Manihot* as Crantz did so already in 1766. The latter interpretation is favoured here. 2. Many cultivars of *M. esculenta* exist but no satisfactory classification of them exists. 3. Several specimens of the Malay Peninsula and, to a lesser extent, from New Guinea have broad lobes, a long central leaf part and very distinct, differently coloured venation. This form can be referred to as the '*M. dulcis*' form. They strongly resemble *M. glaziovii* but they lack the peltation and they still possess ribs or wings along the fruits.

Manihot glaziovii Müll.-Arg. in Mart., Fl. Bras. 11, 2: 446. 1874; Pax in Engl., Pflanzenr. IV.147. ii: 89, fig. 31. 1910; Backer & Bakh.f., Fl. Java 1: 496. 1963; Rogers & Appan, Fl. Neotropica 13: 17. 1973; Airy Shaw, Kew Bull. Add. Ser. 4: 174. 1975; Kew Bull. Add. Ser. 8: 173. 1980. — Type: *Glaziou 1022* (G, n.v.; photo at F, n.v.), Brazil, near Rio de Janeiro.

(Shrub to) tree up to 13 m high, dbh up to 20 cm. *Bark* pinkish grey to dark brown, scaly, c. 0.6 cm thick, *Raucaria*-like; inner bark brown, thin; exudate thick, white latex; wood white. *Stipules* entire. *Leaves:* petiole green with reddish tinge; blade peltate, inserted 5-15 (-20) mm from the margin; dull to shiny dark green above, green to pale bluish green below, latex present; lobes 0.9-3 times as long as wide; central unlobed part relatively long, lobes 5.8-12.5 times as long; nerves 7-17 pairs, venation very distinct, usually differently coloured when dry, veins scalariform. *Inflorescences* lax, usually single or few together. *Staminate flowers:* calyx divided to more or less halfway, green to greenish white to dark purple inside at base, glabrous; filaments white, anthers yellow. *Pistillate flowers:* calyx green tinged dull reddish to inside pinkish, glabrous; ovary smooth, yellow. *Fruits* globose, green with yellow sutures, warty, without wings. *Seeds* 12 mm or longer; caruncle yellow.

Distribution: Native to N-Brazil. Sparsely cultivated throughout SE Asia.

Ecology and habitat: Cultivated, often left behind and therefore found in scrubs, secondary forest and waste places along roadsides and rivers, near paddies, old cultivated fields; locally common. Often associated with *Pterocarpus* when growing along water. Soil: sticky red soil, may be water logged. Alt.: sea level up to 1200 m.

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Flowering and fruiting: Flowering whole year through, fruiting probably also, though no data available for Aug.-Dec.

Uses: Cultivated all over Malesia for its latex which can be turned into rubber. However, *Hevea brasiliensis* outcompeted this species and presently it is hardly cultivated. The leaves can be eaten as vegetable, but must be chopped and cooked due to the HCN content of the leaves. The plant is often used in Java as a scion in *Manihot esculenta* roots to improve their production.

Vernacular names: English: Ceara rubber. Java: Oebi kajoe, oebi karet. Borneo: Kalimantan: Singkang tahunan; Sarawak: Bandong tujuh (tahun) (Selakau); ubi jipon, ubi tahun (Malay).

Note: See note 3 under *M. esculenta*.

Identification list of specimens

The numbers cited behind the collections refer to the species, the herbaria are abbreviated (BO = Herbarium Bogoriense, Indonesia; L = Rijksherbarium, Leiden, The Netherlands):

- 1 = *Manihot esculenta* Crantz
2 = *Manihot glaziovii* Müll.-Arg.

- A 2713: 1; 2779: 1 (L) — Ambri & Arifin AA357: 2 (L) — ANU series 5742: 1 (L) —
Atmodjo 102: 1 (BO); 422: 1 (BO, L).
Backer 1085: 2 (BO); 1215: 1 (BO); 20320: 1 (BO); 25179: 1 (BO); 26934: 1 (BO);
27300: 1 (BO); 36329: 1 (BO, L) — Bakhuizen van den Brink 6781: 1 (BO) —
Bakhuizen van den Brink jr. 2322: 1 (BO); 3693: 2 (BO) — Beguin 1933: 1 (BO, L)
— Bloembergen 4410: 1 (BO, L) — Boerlage 217: 2 (BO) — Bogor Botanical Garden
IX.A.15: 2 (BO, L); IX.A.113: 2 (BO); IX.A.122: 2 (BO); IX.A.122a: 2 (BO) — du
Bois 1: 1 (BO); 2: 1 (BO); 3: 1 (BO); 11: 1 (BO) — Boschma 53: 1 (BO) —
Branderhorst 102: 1 (L) — Bruinier 188: 2 (BO) — BS series 368: 1 (BO); 11461: 1
(BO); 15430: 2 (BO) — Bünnemeijer 3808: 1 (BO, L) — Buwalda 2893: 1 (BO, L) —
Buysman 60: 1 (L) — BW series 12813: 1 (L).
Docters van Leeuwen 11175: 1 (BO) — Dornstreich NDD-56: 1 (L).
Eggers 15156: 1 (L) — Elbert 2517: 1 (L); 2737: 1 (L); 3914: 1 (L); 4569: 1 (L) —
Elmer 9939: 1 (BO, L).
Fallen, Wiakabu & Lelean 345: 1 (L) — Feuilletau de Bruyn 432: 1 (BO) — Forsten 118:
1 (L).
Gianno, R. 123: 1 (L); 330: 1 (L) — Grashoff, C.W.F. 339: 1 (L).
Hallier 4482: 1 (L) — Harini 46: 1 (L) — van Harreveld 4444: 1 (BO); 6488: 2 (BO) —
Hartley 10128: 1 (L) — van Heurn 6: 2 (L).

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- Irsan 8: 1 (BO, L)— Iwatsuki, Murata & Gutierrez P-1336: 1 (L).
 Jaag 344: 1 (L).
 Kadim & Mahmud K.58: 1 (BO, L) — Kalkman 4552: 1 (L) — Karta 195: 1 (BO, L);
 405: 1 (BO) — Kaudern 6: 1 (L) — Kjellberg 802: 1 (BO) — Koorders 32960: 1
 (BO); 32965: 1 (BO); 35122: 1 (BO); 35123: 1 (BO); 35423: 1 (BO); 35424: 1 (BO);
 35425: 1 (BO); 35659: 1 (BO); 36043: 1 (BO); 36044: 1 (BO); 38078: 1 (BO) —
 Kuschel 9164: 1 (L).
 LAE series 50173: 1 (BO, L); 73631: 1 (L) — Lakshnakara 587: 1 (L) — Lauterbach 803:
 1 (BO, L) — Lörzing 3972: 1 (BO); 6560: 1 (BO); 14012: 2 (BO).
 Maxwell 75-25: 1 (L); 88-1239: 1 (L) — Mayr 96: 1 (BO) — Merrill. 832: 1 (BO, L); 5010:
 2 (BO, L) — Murata, Fukuoka & Sukasdi J-1238: 1 (BO) — Murata, Iwatsuki & Kato B-
 629: 2 (BO, L); B-3099: 1 (BO) — Murata, Iwatsuki & Kato J-1605: 1 (BO).
 NGF series 13135: 2 (BO, L); 20712: 1 (L); 26312: 1 (BO, L); 29883: 1 (L); 29888: 1 (L) —
 van Niel 3698: 1 (L); 3881: 2 (L); 3886: 1 (L).
 PNH series 37895: 1 (L); 72718: 1 (L); 79522: 1 (L); 87819: 1 (L); 91498: 2 (L); 117076: 1
 (L) — Poilane 18598: 1 (L) — Popta 713/126: 2 (L); 774/124: 2 (L); 774/124a: 2 (L).
 Ramlan 49: 1 (L) — Robinson 336: 1 (L) — van Romburgh 260: 2 (BO); 261: 2 (BO) —
 Rubber Research Institute of Malaya 760: 1 (L); 761: 1 (L); 762: 1 (L).
 S series 16430: 2 (L); 33466: 1 (L); 34110: 1 (L); 34111: 1 (L); 34575: 2 (L) — Schiffner
 18: 1 (L) — Shah 7: 1 (L) — Sterly 1720: 1 (L).
 UPNG series 2090: 1 (L); 4128: 1 (L).
 Vidal y Soler 589: 1 (L).
 Yates 2057: 1 (L) — Yoshida 62168: 1 (L).

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