Wild Species of *Manihot* Mill. (*Euphorbiaceae*) in the Embrapa Cassava and Fruit Collection, Cruz das Almas, Bahia, Brazil

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ABSTRACT – *Manihot* is a neotropical genus with about 70 species in Brazil. Considered an important source of starch, the wild species are useful in cassava breeding programs. Taxonomic studies on this genus are scarce, and several species are endangered. The Embrapa Cassava and Fruit Collection contain wild cassava species of *Manihot* from different regions in Brazil, although many have uncertain taxonomic identifications. The present study reviewed the taxonomy of these specimens and provides descriptions and illustrations for each collection/species. Thirteen species were identified. The best represented biome in the collection was the Cerrado (eight species), followed by the Caatinga (five species). Four taxa are distributed in more than one ecosystem, while six species are on red lists, indicating the importance of their conservation in germplasm banks.

Key words: Cassava germplasm, conservation, *Manihot esculenta*, pre-breeding

RESUMO – **Espécies Silvestres de *Manihot* Mill. (*Euphorbiaceae*) da Coleção da Embrapa Mandioca e Fruticultura, Cruz das Almas, Bahia, Brasil**. *Manihot* é um gênero neotropical com cerca de 70 espécies no Brasil. Suas espécies silvestres são úteis em programas de melhoramento da mandioca, importante fonte de amido. Apesar disso, o gênero carece de estudos taxonômicos e diversas espécies figuram em listas de espécies ameaçadas. A Coleção da Embrapa Mandioca e Fruticultura abriga acessos de espécies silvestres de Manihot de diferentes regiões do Brasil, com identificação taxonômica pouco precisa. O objetivo deste trabalho foi revisar a taxonomia destas espécies e fornecer descrições e ilustrações de cada uma delas. Foram identificadas 13 espécies. Os ambientes melhor representados na coleção foram o cerrado (oito espécies), seguido pela caatinga (cinco espécies). Quatro taxa apresentam distribuição em mais de um ecossistema, enquanto seis estão incluídos em listas de espécies ameaçadas, o que reforça a importância de sua manutenção nesse banco de germoplasma.

Palavras-chave: conservação, germoplasma da Mandioca, *Manihot esculenta*, pré-Melhoramento

INTRODUCTION

Manihot Mill. is native to tropical regions of the New World, with the largest concentrations of species in Mexico and Brazil (Rogers & Appan 1973; Nassar 1978). Central Brazil is the main center of diversity of this genus (with 38 species), while Mexico, northeastern Brazil, southern Mato Grosso do Sul State, and Bolivia have 17, 16, and six species respectively (Nassar *et al.* 2008).

Manihot has a complex taxonomy (Allem 1979b), and the delimitations of a number of species

are complicated by wide ranges of morphological variations of plant organs such as leaves and flowers that has generated considerable nomenclatural confusion (Allem 1979abc; 1989). Some authors have estimated that there are 128 species in the genus, while others have placed that number between 65 and 70 (Müller 1866, Pax 1910, Allem 2001, Cordeiro *et al.* 2013). There have been relatively few publications in Brazil focusing on the taxonomy of this genus since the beginning of the present century, and the lack of specialists, descriptions, identification keys, and iconographic illustrations has generated taxonomic doubts within many collections (Allem 1979 a, b, c, 1999, 2001, Allem 2002).

Wild species of *Manihot* represent an important gene pool that can be used in cassava breeding programs (*M. esculenta* Crantz) and aid in solving serious problems with this crop – which is a major source of starch for many human populations (Alves *et al*. 2011, FAO 2009, Gomes & Leal 2003). This universe of potentially useful genes is threatened, however, as 65 species have been included in the Red List of Threatened Species (IUCN 1997).

The Cassava Germplasm Bank (CGB) of the Empresa Brasileira de Pesquisa Agropecuária (Embrapa) contains approximately 1800 specimens from a large number of ecosystems, and is considered the largest germplasm bank in the country (and the second largest in Latin America) (Fukuda *et al.* 2005). Associated with the CGB, the Embrapa also maintains a *Manihot* Wild Species Collection, but the species within this collection have not been precisely identified and many of them are known only by their common names or collection numbers; other specimens have been identified by scientists without expertise in the taxonomy of that genus (Ledo *et al.* 2010).

As such, the present work sought to identify the wild species of *Manihot* within the Cassava and Fruit Collection and provide diagnostic characteristics for their correct classification.

MATERIALS AND METHODS

The present work was undertaken between June 2009 and July 2011, when these species were collected and identified. The circumscriptions of the species follow the classification suggested by Rogers & Appan (1973) and Allem (1979abc, 2001). The collections at the ALCB, ASE, CEN, CEPEC, CPAP, CVRD, EAC, ESA, FLOR, FURB, HAS, HB, HPBR, HPUC, HRB, HST, HUEFS, HUFU, HURB, HVASF, IAN, ICN, IMA, IPA, MBML, MG, NY, PEUFR, R, RB, SP, SPF, UEC, UFP, UFMT, UFP, UFRN, UNB, US, VIC, and VIES herbaria were consulted, together with scanned and digitalized specimens and types provided by the B, F, FM, and K herbaria (acronyms follow Thiers 2012).

The cultivated specimens in the collection were prepared according to Mori *et al.* (1989) and deposited in the Herbarium at the Universidade Federal do Recôncavo da Bahia (HURB), Bahia State, Brazil.

Measurements of leaf width and length, as well as evaluations of the shapes of the leaf lobes were made at least 10 samples, seeking more extreme forms, only at the central lobe, and always at the widest location. Plant heights, habits, latex color, and other structures were determined using fresh material. Bracts and stipules wider than 1.0 cm were considered foliaceous; semifoliaceous between 0.5 and 0.8 cm; setaceous < 0.5 cm. The caruncle was considered to be subapical when attached in the ventral region of the seed, although it could extend beyond the seed apex (Fig. 1b).

The diagnoses, identification keys, and species illustrations were based on CGB collection samples and were complemented (when necessary) with data from herbarium specimens maintained in the different collections visited. The distribution data was obtained from the herbarium collections consulted, from the publications cited above, and from Cordeiro *et al.* (2013). Only the most recently collected material from each municipality was considered.

RESULTS AND DISCUSSION

Key to the wild species of *Manihot* in the Embrapa Cassava and Fruit Collection, Cruz das Almas, Bahia State, Brazil.

1.Bracts foliaceous.....2

1'.Bracts semifoliaceous or setaceous.....7

2.Latex creamy to yellow, fruit bacaceous.....2.*M. caerulescens*

2'.Latex white, fruit capsular.....3

3.Stem, leaf, flowers and fruits tomentose.....11.*M. tomentosa*

3'.Stem, leaf, flowers and fruits glabrous or slightly pubescent.....4

4.Lobes foliaceous, short-lanceolate.....10.*M. longiracemosa*

4'.Lobes foliaceous, elliptic, ovoid, obovoid or suborbicular.....5

5.Staminate buds bifusiform, petioles flattened.....9.*M. jacobinensis*

5'Staminate buds ovoid or ellipsoid, petioles cylindrical.....6

6.Inflorescence paniculate, bracts ca. 2.0 cm, capsules orbicular.....6.*M. divergens*

6'.Inflorescence racemose, bracts ca. 1.0 cm, capsules ovoid……..….4.*M. cecropiaefolia*

7.Bracts semifoliaceous.....8

7'.Bracts setaceous.....9

8.Racemes erect, leaves associated with the deltoid inflorescences, buds partially covered by bracts.....1.*M. anomala*

8'.Racemes pendent, leaves associated with the elliptical or orbicular inflorescences, buds totally exposed.....8.*M. irwinii*

9.Inflorescence paniculate.....10

9'.Inflorescence racemose.....11

10.Capsules without ribs, caruncle ventral.....3.*M. carthagenensis* subsp. *glaziovii*

10'.Capsules slightly ribbed, caruncle subapical.....7.*M. esculenta* subsp. *flabellifolia*

11.Capsules without ribs.....13.*Manihot* sp. 2

11'.Capsules ribbed.....12

12.Capsules with undulating ribs, conspicuous.....5.*M. dichotoma*

12'.Capsules with straight ribs, inconspicuous.....12.*Manihot* sp.1

Taxonomic Synopsis

1. *Manihot anomala* Pohl, Pl. Bras. Icon. Descr. 1: 27 (t. 21). 1827.

(Figs. 1A-C)

Shrubs ca. 2 m tall, prostrates, latex white to pinkish, stipules setaceous. Leaves 0-3-5 lobed, those associated with the inflorescences frequently non-lobed and deltoidal, lobes 10.0- 15.0 x 3.0-5.0 cm, elliptic to obovoid, sometimes pandurate, apex acute. Inflorescence racemose or paniculate, erect; bracts semifoliaceous, curved over the floral buds, green. Staminate buds orbicular to ovoid. Capsules orbicular, ca. 1.5 cm in diameter, smooth. Seeds oblong, ca. 1.0 cm long, caruncle subapical.

Examined material: BRAZIL, BAHIA, Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M. Martins et. al. 1414* (HURB); São Félix da Coribe,

road to EBDA, 13º34'27.7''S, 44º18'29.9''W, 26/VII/11, *M. Martins et. al. 1808* (HURB); DISTRITO FEDERAL, Sobradinho, 1 Km after entrance to Fazenda Limoeiro–Pedreira Contagem, 07.II.2001, *A. A. Santos 887* (CEN); GOIÁS, Alto Paraíso de Goiás, near Vale da Lua, 23.I.2005, *J. P. Souza et al. 4480* (HUEFS); Aurora do Tocantins, road to Balneário, 25.I.2005, *J. P. Souza et. al. 4610* (ESA); Minaçu, transmission line São Salvador–Canabrava Fazenda Fortuna, 07.XI.2012, *B. M. T. Walter et al. 5929* (CEN); Uruaçu, 87.5 Km, NE entrance to Rialma on the BR-153 highway, towards Uruaçu 25.I.1995, *A. C. Allem et al. 4413* (CEN); MATO GROSSO, Chapada dos Guimarães, road to Chapada dos Guimarães–Cuiabá and a side road to Cuiabá–Fazenda Ponderoza, 22.II.1997, *A. G. Naves, et al. 1130* (HUEFS); MINAS GERAIS, Cabeceira Grande, forest near escape tunnel, 26.XI.2002, *A. A. Santos et al. 1667* (HUEFS); Matozinho, Fazenda Cauaia – near Lapa do Santo, 07.III.2007, *J. C. F. Mello Jr. et al. 625* (SPF); SÃO PAULO, Itirapina, Forest Institute Experimental Station, 12.II.1984, *H. F. Leitão et al. 15966* (UFMT).

Comments: *Manihot anomala* can be recognized by its erect inflorescences, with semifoliaceous bracts curved over the floral buds, and terminal leaves usually entire and deltoidal, glabrous or variably pubescent. Demonstrates wide shape variations and has an extensive list of synonyms (Allem 1979a).
Geographical distribution: Argentina Bolivia, Paraguay, Peru and Brazil: Distrito Federal, Goiás, Mato Grosso, Minas Gerais, Pará, São Paulo. In Brazil endemic of cerrado.

2. *Manihot caerulescens* Pohl, Pl. Bras. Icon.Descr. 1: 56. 1827.

(Figs. 2A-G)

Trees 4-10 m tall, erects, latex creamy to deep yellow, stipules setaceous. Leaves 3-7 (9) lobed, lobes 8.0-15.0 x 4.0-6.0 cm, usually obovoid, sometimes pandurate, apex acuminate. Inflorescence racemose, pendent; bracts foliaceous, purplish-green. Staminate buds ovoid to oblong. Fruit bacaceous, orbicular to ovoid, ca. 3.5 cm long, smooth to variously ribbed. Seeds ovoid, ca. 1.7 cm long, caruncle ventral, inconspicuous.

Examined material: BRAZIL, BAHIA, Abaíra, road to Catolés–Ribeirão de Baixo–Inúbia, 19.III.1992, *B. Stannard et al. 52711* (HUEFS); Barreiras, Acabavidas waterfall, 11º53'24''S, 45º35'32''W, 28.VII.11, *M. Martins et. al. 1825* (HURB); Serra do Mimo, 14.XII.2006, *B. T. C. Santos et al. 299* (HUEFS); Bom Jesus da Lapa, 14 Km S of the junction to Bom Jesus da Lapa on the road to Malhada, 11.II.2000, *L. P. Queiroz et al. 5864* (HUEFS); Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M. Martins et. al. 1421* (HURB); Lençóis, Lençóis to BR–242 road, 18.V.1988, *L. A. M. Silva et al. 2756* (CEPEC); Mirangaba, 10º56'19.3''S 40º34'45.9''W, 08.III.2010, *M. Martins et. al. 1717* (HURB); Sento Sé, village of Volta da Serra, 10º15'6.8''S, 42º03'32.8''W, 12.III.10, *M. Martins et. al. 1739* (HURB); Xique-Xique, road to Barra, side road to Santo Inácio and Gentio do Ouro, 28.IV.1999, *R.C. Forzza et al. 1408* (SPF); MARANHÃO, Balsas, Gerais de Balsas Project, 21.XI.1995, *G. P. Silva et al. 3248* (CEN); MATO GROSSO, Chapada dos Guimarães, Km 15–25 of the road to Chapada dos Guimarães, 20.X.1995, *G. Hatschbach et al. 63650* (CEN); MATO GROSSO DO SUL, Paraizo–Capim Verde road, 23.I.2001, *J. R. Pirani et al. 4812* (SPF); MINAS GERAIS, Botumirim, Fazenda Serra da Canastra 3.5 Km after the Rio Bananal bridge, 22.XII.2004, *R. C. Forzza et al. 3816* (SPF); Santo Antônio do Retiro, 15º22'23.1''S, 42º41'15.4''W, 16.VIII.2010, *M. Martins et. al. 1662* (HURB); PIAUÍ, Esperantina, Quilombo Olho D'água dos Pires, 08.VI.2003, *E. A. Franco 058* ((HUEFS); SÃO PAULO, Altinópolis, Morro do Forno, 17.XI.2003, *R. B. Oliveira et al. 354* (SPF).

Comments: *Manihot caerulescens* is easily recognized by its yellowish latex, leaves with obovoid lobes with acuminate apices, fruits variably ribbed and indehiscent (rare in the genus) (Allem 1999).
Geographical distribution: Paraguay and Brazil: Amapá, Bahia, Ceará, Goiás, Maranhão, Mato Grosso, Minas Gerais, Pará, Piauí, Pernambuco, Rio de Janeiro. In Brazil in the caatinga, campos rupestres, cerrado and rain forest.

3. *Manihot carthagenensis* subsp. ***glaziovii*** (Müll. Arg.) Allem, Novon 11: 160. 2001.

(Fig. 3A-F)

Trees or shrubs 2-10 m tall, erects or prostrates, latex white, stipules semifoliaceous, laciniate. Leaves 3-5 (7) lobed, lobes 5.0-10.0 x 1.5-2.0 cm, elliptic to obovoid, sometimes pandurate, apex acute, petiole with basal or peltate insertion. Inflorescence paniculate, erect or pendent; bracts setaceous or semifoliaceous, greenish or purplish. Staminate buds ovoid. Capsules orbicular, 1.0-2.0 cm in diameter, smooth or rough. Seeds elliptic, ca. 1.2 cm long, caruncle ventral.

Examined material: BRAZIL, BAHIA, Casa Nova, BR–235, 9º25'6.6''S, 41º51'22.0''W, 10.III.10, *M. Martins et.*

al. 1730 (HURB); Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M. Martins et. al. 1420* (HURB); Jacobina, BR–324, Roncador Bridge, 11º12'22.7''S, 40º25'51.1''W, 8.III.10, *M. Martins et. al. 1721* (HURB); Jaguarari, BR–407, 19 km after Senhor do Bonfim, 10º17'46.4''S, 40º10'11.9''W, 9.III.10, *M. Martins et. al. 1725* (HURB); Juacema, BR–407, 10º08'57.2''S, 40º13'51.5''W, 9.III.10, *M. Martins et. al. 1726* (HURB); Riacho de Santana, BR–430 towards Bom Jesus da Lapa, 10 km after Riacho de Santana portal, BR–430, towards Bom Jesus da Lapa, 13º37'34.5''S, 42º35'0.6''W, 18.IV.10, *M. Martins et. al. 1647* (HURB); Pindobaçu, Pindobaçu/Senhor do Bonfim road, km 6, 10º41'42.3''S, 40º20'40.4''W, 9.III.10, *M. Martins et. al. 1724* (HURB); Remanso, BR–235, 9º34'51.1''S, 42º7'36.2''W, 10.III.10, *M. Martins et. al. 1731* (HURB); Santa Teresinha, BR–493, towards Itatim, 12º42'26.2''S, 39º41'05.9''W, 18.IV.10, *M. Martins et. al. 1632* (HURB); Sento Sé, Volta da Serra village, 10º03'51.5''S, 42º12'51.5''W, 12.III.10, *M. Martins et. al. 1736* (HURB); CEARÁ, Aiuaba, Aiuaba Ecological Station, 6º44'35''S, 40º19'19''W, 27.V.04, *J. R. Lemos 214 & P. Matias* (SPF); MINAS GERAIS, Janaúba, BR–122, Km 16, 15º25'S, 43º33'W, 08.XI.84, *A. C. Allem et al. 2888* (CEN); Descoberto, Represa da Grama Biological Reserve, 24.I.01, *R. C. Forzza et al. 1766* (SP); PERNAMBUCO, Buíque, Vale do Catimbau, 12.II.08, *D. N. Silva et al. 16* (SPF); Petrolina, 5 km after airport, towards Casa Nova, 9º22'3.1''S, 40º34'33.6''W, 9.III.10, *M. Martins et. al. 1727* (HURB); PIAUÍ, Monsenhor Gil, 14 km SW of city, 5º42'S, 42º36''W, 01.II.95, *A. C. Allem 4482 & V. S. Silva* (CEN); RIO GRANDE DO NORTE, Serra Negra do Norte, Seridó Ecological Station, 17.IV.99, *R. G. V. Camacho 21* (SPF).

Comments: *Manihot carthagenensis* subsp. *glaziovii* has as diagnostic characters semifoliaceous stipules with dentate margins, paniculate inflorescences, orbicular fruits with elliptical seeds and ventral caruncle. This extensive list of diagnostic characters is necessary due to the wide morphological diversity seen within this species. These characteristics, allied to its ample distribution, resulted in a series of specific epithets now considered to be synonyms (Allem 1979c, 2001). Allem (2001) differentiated two subspecies of *M. carthagenensis*, based principally on their geographical distributions and leaf margins. *Manihot carthagenensis* subsp. *carthagenensis* is distributed from Argentina to Venezuela and has pandurate leaf margins, while *Manihot carthagenensis* subsp. *glaziovii* is found in the semiarid region of Brazil between Minas Gerais and Piauí and has entire lobes (Allem 2001). Analyses of herbarium specimens indicated that plants with both type of leaves can be found in northeastern Brazil – indicating that this characteristic is not sufficient to distinguish between these subspecies and that their circumscriptions must be reviewed.

Geographical distribution: Brazil **(**Minas Gerais and the northeastern states of Brazil, except Maranhão). Occurs in the caatinga and rain forest.

4. *Manihot cecropiaefolia* Pohl, PI. Bras. Ic. et Descr. 1: 49. t. 42. 1827.

(Figs. 4A-D)

Shrubs ca. 1.0 m tall, prostrates, latex white, stipules setaceous. Leaves 3-5 lobed, coriaceous, veins and margins purple, lobes 8.0-15.0 x 3.0-6.0 cm, ovoid to obovoid, lateral lobes slightly recurved. Inflorescence racemose, pendent; bracts foliaceous, purplish. Staminate buds ovoid-ellipsoid. Capsules ovoid, ca. 1.0 cm long, smooth, dehiscence lines purple. Seeds ovoid, ca. 0.9 cm long, caruncle subapical.

Examined material: BRAZIL, BAHIA, Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M. Martins et al. 1425*, (HURB); DISTRITO FEDERAL, Brasília, CENARGEN Introduction Field, 23.XII.1981, *J. G. A. Vieira 277* (CEN); GOIÁS, Abadiânia, Km 86 BR-060 BSB-Anápolis, 15.IV.1980, *A. C. Allem et al. 2644* (CEN); Itapurunga, 24 Km NE of Caiçara along the Morro Agudo de Goiás road, 21.XII.1987, *A. C. Allem et al. 3759* (CEN); Jaraguá, Serra de Jaraguá, 2 Km on the TV tower road, 17.IV.1980, *A. C. Allem et al. 2660* (CEN); Niquelândia, Região da Serra Negra – left margin of the Bagagem river, 15.IV.1992, *B. M. T. Walter et al. 1357* (RB); São João de Aliança, GO-118, 40 Km N of São João de Aliança-Alto Paraíso Goiás, 01.IV.1981, *J. G. A. Vieira 48* (CEN).

Comments: *Manihot cecropiaefolia* differs from *M. violacea* by the shapes and sizes of the leaf lobes, and inflorescences normally longer (although with large variations in lengths).

Geographical distribution: Brazil **(**Goiás). Occurs in the cerrado.

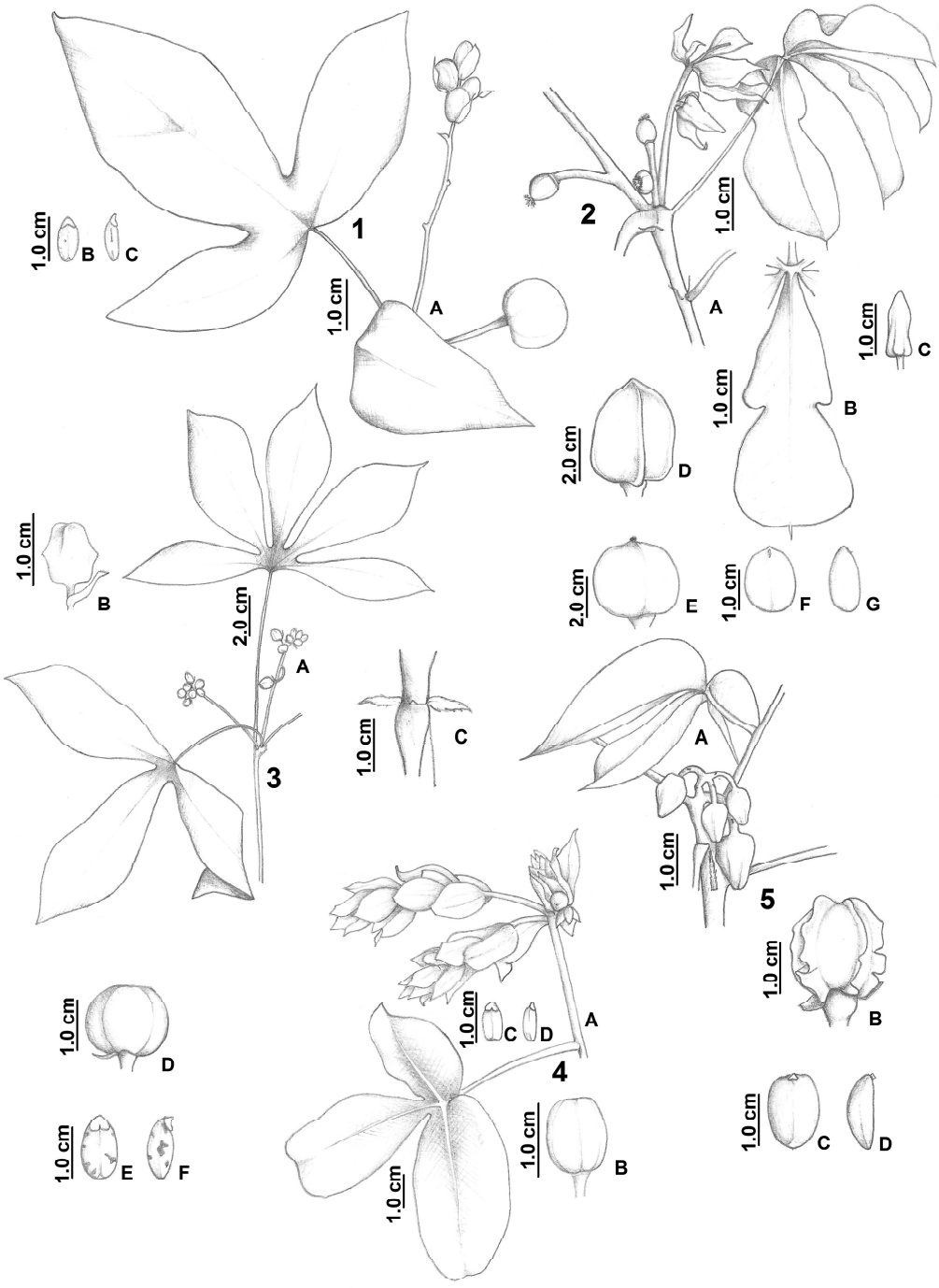
5.***Manihot dichotoma*** Ule, Notizbl. Königl. Bot. Gart. Berlin. 5: 2, 1907, & 5: 19, pl. 1. 1908.

(Figs. 5A-D)

Trees 3-12 m tall, erects, latex white, stipules setaceous. Leaves 3-5 lobed, lobes 7.0-15.0 x 3.0-5.0 cm, oblong, usually pandurate. Inflorescence racemose, pendent; bracts setaceous, greenish.

Staminate buds pyramidal. Capsules orbicular, ca. 3.0 cm in diameter, typically with undulated ribs. Seeds elliptical, ca. 1.8 cm long, caruncle ventral, sometimes inconspicuous.

Examined material: BRAZIL, BAHIA, Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M. Martins et al*. 1417, (HURB); Jequié, Morro da Torre, 13.IV.2007, *L. P. Queiroz et al. 12904* (HUEFS); Manoel Vitorino, Manoel Vitorino/Caatingal road, 19.II.1979, *L. A. M. Silva et al.* (CEPEC); Rio de Contas, Boa Sentença road to Jataí, 21.IV.2003, *A. M. Giulietti et al. 2434* (HUEFS).



Figs. 1-5. 1 A-C. *M. anomala* Pohl. **A.** Detail of branch; **B.** Ventral view of seed; **C.** Lateral view of seed. **2A-G.** *M. caerulescens* Pohl. **A.** Detail of branch; **B.** Detail of the central lobe of a leaf; **C.** Staminate bud; **D.** Ribbed fruit; **E.** Smooth fruit; **F.** Ventral view of seed; **G.** Lateral view of seed. **3A-F.** *M. carthagenensis* subsp. *glaziovii* (Müll.Arg.) Allem. **A.** Detail of branch; **B.** Staminate bud; **C.** Stipules; **D.** Fruit; **E.** Ventral view of seed; **F.** Lateral view of seed. **4A-D.** *M. cecropiaefolia* Pohl. **A.** Detail of branch; **B.** Fruit; **C.** Ventral view of seed; **D.** Lateral view of seed. **5A-D.** *M. dichotoma* Ule. **A.** Detail of branch; **B.** Fruit; **C.**Ventral view of seed; **D.** Lateral view of seed.

Comments: *Manihot dichotoma* can be recognized principally by its large and orbicular capsules, with undulating ribs. Additionally, its seeds are typically elliptical, large, and dark.
Geographical distribution: Brazil **(**Bahia and Pernambuco). Occurs in the caatinga.

6. *Manihot divergens* Pohl, P1. Bras. Ic. et Descr. 1: 41. t. 33. 1827.

(Figs. 6A-D)

Shrubs ca. 1.5 m tall, prostrates, latex white, stipules setaceous. Leaves 0-3 lobed, lobes 7.0-12.0 x 4.0-7.0 cm, ovate to elliptic, lateral lobes usually recurved. Inflorescence racemose, pendent; bracts foliaceous, green-purple. Staminate buds ovoid. Capsules orbicular, ca. 1.0 cm in diameter, smooth, green. Seeds ovoid, ca. 0.6 cm long, caruncle apical or subapical.

Examined material: BRAZIL, BAHIA, Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M.L.L. Martins et al. 1424* (HURB); GOIÁS, Água Fria de Goiás, cerrado in downtown area, 08.I.2012, *M. Martins et al. 2025* (HURB).
Comments: *Manihot divergens* can be recognized by its strongly recurved lateral lobes and by its small size, normally growing prostrate along the ground.
Geographical distribution: Brazil **(**Distrito Federal, Goiás and Minas Gerais). Occurs in the cerrado.

7. *Manihot esculenta* subsp. ***flabellifolia*** (Pohl) Cif., A*rch. Bot.(Forlì). 18: 31. 1942.*

(Figs. 7A-F)

Shrubs ca. 2 m tall, prostrates, latex yellowish, stipules semifoliaceous. Leaves 3-7 lobed, lobes 8.0-15 x ca. 2.5 cm, ovoid to lanceolate, pandurate when young, usually glaucous on the abaxial surface. Inflorescence paniculate, erect or pendent; bracts setaceous, purplish-green. Staminate buds ovoid. Capsule orbicular to ovoid, ca. 2.0 cm long, smooth or rough, slightly ribbed. Seeds ellipsoid, ca. 0.8 cm long, caruncle subapical.

Examined material: BRAZIL, ACRE, Rio Branco, 26 km at NW of Rio Branco, BR-364, towards Serra da Madureira, 14.VI.1993, *A. C. Allem et al. 4148* (CEN); AMAPÁ, Santo Antonio waterfall, near Jari river, 00º40' S 52º30' W), 06.III.1969, *N. T. Silva 1784* (IAN); BAHIA, Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05. VI. 2009, *M. Martins. et. al. 1413* (HURB); GOIÁS, Nova Roma, Fazenda Junqueira, 12 km from the municipal center, margin of the Paranã River, 2.II.1999, *J. W. B. Machado et al. 304* (CEN); MATO GROSSO, Comodoro, BR-364, between Pontes and Lacerda/Vilhena-RO, V.90, *L. A. Skorupa et al. 771* (CEN); Aripuanã, Andorinhas Waterfall, 3.VII.1997, *G.F. Árbocz et al. 4080* (HUEFS); Rondonópolis, BR–364, 2.5Km after Rondonópolis, towards Serra da Petrovina, 16º31'21.4''S, 54º35'52.6''W, 08.III.2012, *M. Martins, et al. 2066* (HURB); MINAS GERAIS, Juiz de Fora, Morro do Imperador, 1. III. 2012, *D. S. Pifano et al. 313* (CESJ); PÍAUI, Bocaína, near Barragem, 17.II.2000, *M. R. A. Mendes et al. 268* (HUEFS); RONDÔNIA, Jarú, 28 Km NW of Ouro Preto do Oeste, along the BR-364 highway towards Jarú, 26.V.1992, *A. C. Allem, S. K. Hahn 4005* (CEN); TOCANTINS, Barrolândia, 14.9 Km from the city, along the BR-153 road towards Miranorte, *A. C. Allem, V. S. Silva 4424* (CEN).

Comments: *Manihot esculenta* subsp. *flabellifolia* can be recognized by its leaves with elongated, numerous, and glaucous lobes, paniculate inflorescences, and slightly ribbed capsules. These characteristics are also encountered in the cultivated subspecies *M. esculenta* subsp. *esculenta*, which can be differentiated by its production of tuberous roots and by the dilated nodes on its stems.
Geographical distribution: Brazil **(**Acre, Amapá, Amazonas, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Pará, Piauí, Rondônia, São Paulo and Tocantins). Occurs in the cerrado and rain forest.

8. *Manihot irwinii* Roger & Appan, Flora Neotropica 13: 137-139, f. 59C-D, 60A. 1973.

(Figs. 8A-F)

Shrubs or subshrubs, erects or decumbents, up to 1 m tall, latex yellow, stipules setaceous. Leaves 0-3 lobed, margins purplish and veins usually clear, lobes 5.0-8.0 x 4.0-6.0 cm, elliptic to orbicular, apex acute. Inflorescence racemose, pendent; bracts semifoliaceous, purplish. Staminate buds ovoid. Capsules subglobose to slightly elongated, ca. 2.0 cm long, smooth, with distinct dehiscence lines, sometimes slightly ribbed. Seeds ovoid, 0.8 cm long, caruncle apical or subapical.

Examined material: BRAZIL, BAHIA, Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M. Martins. et. al. 1415* (HURB); DISTRITO FEDERAL, Brasília, 17.V.1989, *L. B. Bianchette et al. 765* (HUEFS); GOIÁS, Alto Paraíso de Goiás, 39 Km NE of Alto Paraíso de Goiás, along the GO–118 road towards Cavalcante, 28.V.1993, *A. C. Allem et al. 4092* (CEN); Cavalcante, Bolsa dos Paulistas road, Carmo River, km 4, *G. P. Silva et al. 5601* (CEN); Campinaçu, Buriti, 05.X.2000,

T. B. Cavalcante et al. 2668 (CEN); Cocalzinho, access road to Serra de Pirineus ca. 8 Km from Cocalzinho, 28.II.1988, *M. C. Assis et al. 588* (SPF); Colinas do Sul, Ilha no Lago, 14.XII.1999, *A. A. Santos et al. 581* (CEN); Corumbá de Goiás, 24 Km NW of Corumbá de Goiás–Serra dos Pirineus, 19.III.1982, *A. C. Allem et al. 2832* (CEN); Pirenópolis, Serra dos Pirineus, 18.XI.1987, *L. A. Skorupa et al. 63* (CEN); Teresina de Goiás, 4.1 Km NW of Teresina, along the GO-241 road, towards Cavalcante, 12.I.1995, *A.C. Allem et al. 4385* (CEN).

Comments: *Manihot irwinii* can be recognized by its yellowish latex, rounded leaf lobes with clear and evident veins, and fruits slightly ribbed.
Geographical distribution: Brazil **(**Distrito Federal and Goiás). Occurs in the cerrado and campos rupestres.

9. *Manihot jacobinensis* Müll.Arg *Linnaea 34: 205, 1865*.

(Figs. 9A-D)

Shrubs 1-2 m tall, erects, latex white, stipules setaceous. Leaves 0-3 lobed, lobes 5.0-8.0 x 3.0-5.0 cm, suborbicular, petioles dorsal-ventrally flattened. Inflorescence racemose, erect, bracts foliaceous, purplish. Staminate buds bifusiform. Capsules ovoid to orbicular, ca. 1.0 cm long, smooth, dehiscence lines purple. Seeds ovoid, 0.7 cm long, caruncle apical or subapical.

Examined material: BRAZIL, BAHIA, Andaraí, along the road to Mucugê, near Xique-Xique, 14.II.1977, *R. M. Harley 18674* (SPF); Bela Vista, Tabuleiro de Areia Branca, 25.III.2004, *M. V. Moraes 641* (HUEFS); Campo Formoso, Morro do Cruzeiro, 15.V.1999, *F. França et al. 2936* (HUEFS); Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M. Martins et. al. 1419* (HURB); Igatu, along the Andaraí/Igatu road, 12º53'26.7''S, 41º18'48.8''W, 18.IV.10, *M. Martins et. al. 1643* (HURB); Jacobina, Serra do Tambor ca. Km 25 along the Jacobina/Morro do Chapéu highway, 20.II.1993, *M. V. André et al. 4181* (CEPEC); Lençóis, BR-242-Lençóis road, 20.VII.2006, *J. P. Souza et al. 6268* (HUEFS); Morro do Chapéu, 15 Km from Morro do Chapéu, towards Jacobina, 11.III.1996, *R. Lima et al. 2240* (CEPEC); Mucugê, 1 Km from Mucugê, 10.X.1987, *L. P. Queiroz et al. 1861* (CEPEC); Palmeiras, Pai Inácio, 21.XI.1994, *E. Melo et al. 1143* (CEPEC); Saúde, Morro da Antena, 14.VII.1997, *P. Fiash et al. 2409* (CEPEC); Umburanas, Serra da Empreitada, 09.IV.1999, *L. P. Queiroz et al. 5150* (HUEFS).

Comments: *Manihot jacobinensis* can be recognized by its shrub habit, petioles dorsal-ventrally flattened, and erect racemes.
Geographical distribution: Brazil **(**Bahia). Occurs in the cerrado and campo rupestre in the Chapada Diamantina range.

10. *Manihot longiracemosa* P. Carvalho & M. Martins, Syst. Bot., 39(2): 485-489, 2014.

(Figs. 10A-B)

Shrubs ca. 4.0 m tall, erects, latex white, stipules setaceous. Leaves 3-5 lobed, lobes sinuous, 10.0-20.0 x 3.0-4.0 cm, short-lanceolate. Inflorescence racemose, 15.0-40.0 cm long, erect or, rarely, pendent; bracts foliaceous, curved over the flowers. Staminate buds bifusiform. Capsules ovoid to orbicular, ca. 1.5 cm long, smooth, dehiscence lines purple. Seeds ovoid, 0.8 cm long, caruncle apical or subapical.

Examined material: BRAZIL, BAHIA, Andaraí, Serra do Sincorá, 05.VIII.2001, *F. R. Nonato et al. 998*, (HUEFS); Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M. Martins et al. 1423* (HURB); Igatu, between Smoke Valley and Sucupira Valley, 22.I.2010, *B. R. Russ 36* (HUEFS); Lençóis, Afloramento do Veneno, 02.X.2005, *S. P. S. Neves et al. 51* (HUEFS).

Comments: *Manihot longiracemosa* has short-lanceolate and sinuous lobes, bifusiform staminate buds, and long inflorescences with foliaceous bracts that cover the flowers.
Geographical distribution: Brazil **(**Bahia). Occurs in the campo rupestre in the Chapada Diamantina range.

11. *Manihot tomentosa* Pohl, Pl. Bras. Icon. Descr. 1: 50 t. 43. 1827.

(Figs. 11A-D)

Shrubs ca. 1.5 m tall, prostrates, tomentose, latex yellowish, stipules setaceous. Leaves 3-7 lobed, lobes 8.0-12.0 x 3.0-5.0 cm, elliptic to oblong. Inflorescence racemose, pendent; bracts foliaceous, ca. 2.0 cm long, greenish. Staminate buds pyramidal, greenish. Capsules orbicular, lobed and pubescent, ca. 1.5 cm long, smooth. Seeds ovoid, ca. 0.9 cm long, caruncle subapical.

Examined material: BRAZIL, BAHIA, Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009,

M. Martins. et. al. 1426 (HURB); DISTRITO FEDERAL, Brasília, 7.7 Km after EMBRAPA/CPAC along the dirt road to the left, 28.V.1993, *A. C. Allem et al. 4087* (CEN); GOIÁS, Água Fria de Goiás, Cerrado in the downtown area, 16.XII.2005, *T. B. Cavalcante et al. 3593* (CEN); Formosa, Itiquira Waterfall, 35 Km NW of Formosa, along the GO–444 road, 3.II.1987, *A. C. Allem et al. 3684* (CEN); Planaltina, District of Boa Vista–Brasilinha, 16.II.1982, *J. G. A. Viena 029* (CEN); São João D'Aliança, 10 Km from São D'Aliança/Alto Paraíso, margin of the GO–118 road, 25.XI.1994, *M. A. Silva et al. 2426* (SPF); MINAS GERAIS, Piuí, 6.XII.77, *H. F. Leitão-Filho et. al.* (SP).

Comments: *Manihot tomentosa* can be distinguished from the other species of its genus by the tomentosity all of its structures. It is similar to *M. gabrielensis*, which is also tomentose but a subshrub with glabrous capsules (Allem 1989).
Geographical distribution: Brazil **(**Distrito Federal, Goiás and Minas Gerais). Occurs in the Cerrado.

12. *Manihot* sp. 1.

(Figs.12A-D)

Trees 2.0-8.0 m tall, latex white, stipules setaceous. Leaves 3-5 lobed, lobes 5.0-14.0 x 1.5-3.5 cm, elliptic to obovoid, usually pandurate. Inflorescence racemose, pendent; bracts setaceous, greenish. Staminate buds ovoid. Capsules ovoid to oblong, apex acute or truncated, commonly purplish, 2.0-3.0 x ca. 1.0 cm, ribs slightly prominent and straight. Seeds oblong, ca. 1.3 cm long, caruncle subapical.

Examined material: BRAZIL, BAHIA, Abaíra, Abaíra/Jussiape road, 13º23'50.5''S, 41º36'39.3''W, 20.IV.10, *M. Martins et. al. 1644* (HURB); BAHIA, Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 05.VI.2009, *M. Martins et al. 1422* (HURB); Euclides da Cunha, Sítio do Jaime, 21.III.2004, *M. L. Guedes et al. 10845* (ALCB); Filadélfia, 5 Km along the road to Pindobaçu, 28.II.2000, *A. M. Giulietti et al. 1879* (HUEFS); Irecê, Lapão-Morro Pelado, 27.X.2009, *M. L. Guedes et al. 16171* (ALCB); Itaberaba, 25 Km S–SE of Itaberaba, 20.XI.1986, *L. P. Queiroz et al. 1338* (HUEFS); Itiúba, EPABA Experimental Farm, 27.V.1983, *H. P.Bautista et al. 775* (RB); Jeremoabo, Raso da Catarina, 15.I.1981, *L. M. C. Gonçalves 58* (CEPEC); Livramento de Brumado, 3–5 Km from the city along the road from Rio de Contas, 12.XII.1988, *R. M. Harley et al. 27144* (CEPEC); Monte Santo, near the town, 18.IV.2010, *R. P. Oliveira et al. 440* (HUEFS); Morro do Chapéu, Joel Modesto street, exit to the BA–052 highway, 24.V.1993, *A. C. Allem 4079* (CEN); Piemonte da Diamantina, Miguel Calmon – near the Parque Sete Passagens, 23.XII.2006, *M. L. Guedes et al. 13196* (ALCB); Poções, 2–4 Km from Poções-Bom Jesus along the Serra Village road, 05.III.1978, *S. A. Mori et al. 9503* (CEPEC); Queimadas, BA–120 between Cansanção and Queimadas, 17.XI.1986, *L. P. Queiroz et al. 1147* (HUEFS); Rio de Contas, Real Road, lowest part, 1.I.2000, *A. M. Giulietti et al. 1614* (HUEFS); São Gabriel, road to Jussara, 25.X.2009, *E. Melo et al. 6932* (ALCB); Saúde, Paulista Waterfall, 23.II.1993, *A. M. A. Amorim et al. 1061* (CEPEC); Uauá, Serra do Jerônimo, 30.II.2000 *M. R. Fonseca et al. 1356* (HUEFS); MINAS GERAIS, Mato Verde, 6.7 Km NE of last access to Mato Verde along the BR–122 highway to Monte Azul, 14.II.1995, *A. C. Allem et al. 4566* (CEN).

Comments: *Manihot* sp. 1 has small and pandurate leaves, elongated and variably ribbed capsules. The shapes of the leaves and fruits are generally similar to those of *M. diamantinensis* Allem, but differences in the sizes and prominence of their ribs clearly distinguish these species.
Geographical distribution: Brazil **(**Alagoas, Bahia, Ceará, Sergipe, Pernambuco and Rio Grande do Norte). Occurs in the Caatinga.

13. *Manihot* sp. 2

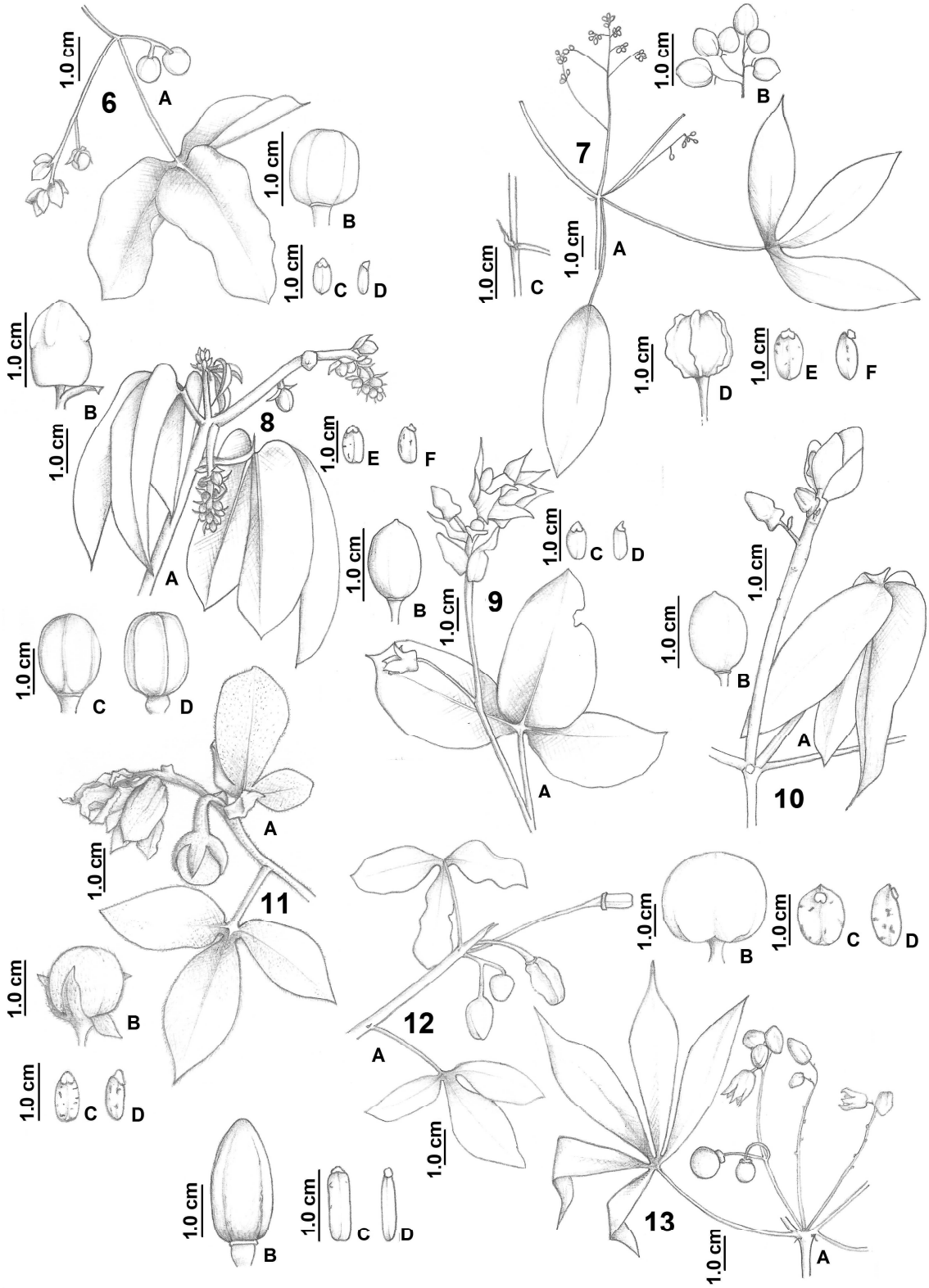
(Figs. 13A-D)

Shrubs ca. 1.5 m tall, erects, latex white, stipules setaceous. Leaves 3-7 lobed, lobes 7.0-10.0 x ca. 2.0 cm, oval-lanceolate. Inflorescence racemose, erect or pendent; bracts setaceous, greenish. Staminate buds ovoid. Capsules orbicular, 2.0-3.0 cm in diameter, smooth. Seeds ellipsoid, ca. 1.5 cm long, caruncle ventral.

Examined material: BAHIA, Cruz das Almas, Embrapa, *Manihot* Wild Species Collection, 17.III.2011, *M. Martins et al. 1791* (HURB).

Comments: *Manihot* sp. 2 is distinguished by its lanceolate foliar lobes and rounded, smooth and large fruits. These characteristics are distinct from other described taxon, which indicates it as a probable new species. However, there are no records of its origin and no similar material was found in the herbaria visited – making it probable that this material represents a hybrid. It will therefore be necessary to undertake additional studies to evaluate its true taxonomic position.

Thirteen species of *Manihot* were identified (Figs. 1-13), eight were exclusive to the "Cerrado"



Figs. 6-13. 6A-D. *M. divergens* (Pohl) Müll.Arg. **A.** Detail of branch; **B.** Fruit; **C.** Ventral view of seed; **D.** Lateral view of seed. **7A-F.** *M. esculenta* subsp. *flabellifolia* (Pohl) Cif. **A.** Detail of branch; **B.** Staminate buds; **C.** Stipule; **D** .Fruit; **E.** Ventral view of seed; **F.** Lateral view of seed. **8A-F.** *M. irwinii* D.J.Rogers & Appan. **A.** Detail of branch; **B.** Staminate bud; **C.** Smooth fruit; **D.** Ribbed fruit; **E.** Ventral view of seed; **F.** Lateral view of seed. **9A-D.** *M. jacobinensis* Müll.Arg. **A.** Detail of branch; **B.** Fruit; **C.** Ventral view of seed; **D.** Lateral view of seed. **10A,B.** *M. longiracemosa* P.Carvalho & M.Martins. **A.** Detail of branch; **B.** Fruit. **11A-D.** *M. tomentosa* Pohl. **A.** Detail of branch; **B.** fruit; **C.** Ventral view of seed; **D.** Lateral view of seed. **12A-D.** *Manihot* sp.1. **A.** Detail of branch; **B.** Fruit; **C.** Ventral view of seed; **D.** Lateral view of seed. **13A-D.** *Manihot* sp.2. **A.** Detail of branch; **B.** Fruit; **C.** Ventral view of seed; **D.** Lateral view of seed.

biome (Brazilian savanna) and five to the "Caatinga" biome (dryland). Four taxa occurred in more than one ecosystem. One species was exclusive to the "Campos Rupestres" (open, rocky field) vegetation of the Chapada Diamantina range; the origin of one taxa could not be determined.

Two species could not be fully identified. *Manihot* sp. 1 (Fig. 12) was identified as *M. dichotoma* Ule, but analyses of the *Opus Principes* of this species (Ule 1907) and herbarium collections indicated that it was in fact a new species with wide distribution throughout the semiarid region of northeastern Brazil. *Manihot* sp.2 (Fig. 13) demonstrated characteristics with no similarities to other species, However, it is of unknown origin and no similar materials were encountered in the other herbarium visited. More detailed studies will be necessary to define the precise taxonomic status of this material.

Manihot esculenta subsp. *flabelifolia* (Pohl) Cif. is considered to belong to the primary genetic pool of the cultivated species *M. esculenta*, and one of its direct ancestors, thus offering promising possibilities for improving cultivated cassava stocks (Allem *et al.* 2001, Ledo *et al.* 2009, Tavares-Filho *et al.* 2009). In addition to this species, *M. dichotoma* Ule, *M. anomala,* and *M. carthagenensis* subsp. *glaziovii* (Müll. Arg.) Allem are also considered to be closely related to *M. esculenta* (Nichols 1947, Bai *et al.* 1993) and should therefore be examined for possible contributions to genetic improvement programs. Other species, such as *M. brachyloba* Müll. Arg., *M. pilosa* Pohl, *M. pruinosa* Pohl, *M. tristis* Müll. Arg., and *M. triphylla* Pohl, which belong to the secondary genetic pool of *M. esculenta* (Allem *et al.* 2001), were not present in the CGB collections and should be targets for future collections and incorporation into maintenance and cultivation programs (e.g. Ledo *et al.* 2010).

There had been reports of hybridization between *M. anomala* Pohl and cassava that produced fertile hybrids (Nassar 1980); *M. carthagenensis* spp. *glaziovii* (Müll. Arg.) Allem has been cited as being resistant to African mosaic virus and root rot, while *M. dichotoma* Ule is resistant to drought conditions (Nassar *et al.* 2008).

There are other species that do not demonstrate characteristics currently considered useful for genetic improvement but are in worrisome states of conservation. Six species are listed as threatened with extinction, four as rare, and two as vulnerable (IUCN 1997), indicating the importance of their conservation in germplasm banks.

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REFERENCES

Allem, A.C. 1979a. Notas taxonômicas e novos sinônimos em espécies de *Manihot* - III (Euphorbiaceae). Revista Brasileira de Biologia 39(3): 545–550.

Allem, A.C. 1979b. Notas taxonômicas e novos sinônimos em espécies de *Manihot* - IV (Euphorbiaceae). Revista Brasileira de Biologia 39(4): 735–738.

Allem, A.C. 1979c. Notas taxonômicas e novos sinônimos em espécies de *Manihot* - V (Euphorbiaceae). Revista Brasileira de Biologia 39(4): 891–896.

Allem, A.C. 1989. Four new species of *Manihot* (Euphorbiaceae) from Brazil. Revista Brasileira de Biologia 49: 649–662.

Allem, A.C. 1999. A new species of *Manihot* (Euphorbiaceae) from the Brazilian Amazon. International Journal of Plant Sciences 160: 181–187.

Allem, A.C. 2001. Three infraspecific taxa of *Manihot* (Euphorbiaceae) from the Brazilian Neotropics. Novon 11(2): 157–165.

Allem, A.C., Mendes, R.A., Salomão, A.N. & Burle, M.L. 2001. The primary gene pool of cassava (*Manihot esculenta* Crantz subspecies *esculenta*, Euphorbiaceae). Euphytica 120: 127–132.

Allem, A.C. 2002. Cassava: biology, product and utilization. *In* The origins and taxonomy of Cassava (Hillocks, R.J.; Thresh, J.M. & Bellotti, A.C., eds.). Natural Resources Institute, Greenwich. p.1–16.

Alves, A.A.C., Dita, M.A., Noronha, A.C.S. & Mendes, R.A. 2011. Pré-melhoramento da mandioca – utilização de espécies silvestres como fonte de resistência a fatores bióticos. *In* Pré-melhoramento de plantas – estado da arte e experiências de sucesso (Lopes, M.A. *et al.*, eds.). Embrapa Informação Tecnológica, Brasília. p. 525–547.

Bai, K.V., Asiedu, R. & Dixon, A.G.O. 1993. Cytogenetics of *Manihot* species and interspecific hybrids. *In* Proceedings of the First International Scientific Meeting of the Cassava Biotechnology Network (Roca, W.M. & Thro, A.M., eds.). Centro Internacional de Agricultura Tropical, Cali. Working Document 123, p. 51–55.

Cordeiro, I., Secco, R., Silva, M. J. da, Sodré, R. C. & Martins, M. L. L. 2013. *Manihot.* Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro. http://floradobrasil.jbrj.gov.br/2010/FB017591. Accessed 04.11.2013.

Food and Agriculture Organization 2009. http://faostat.fao.org/site/616/default.aspx#ancor. Accessed 21.10.2013.

Fukuda, W.M.G., Costa, I.R.S., Silva, S. de O. 2005.

Manejo e conservação de recursos genéticos de mandioca (*Manihot esculenta* Crantz) na Embrapa Mandioca e Fruticultura Tropical. Embrapa, Circular Técnica 74.

Gomes, J. de C. & Leal, E.C. 2003. Cultivo da mandioca para a região dos tabuleiros costeiros. Embrapa Mandioca e Fruticultura, Sistemas de Produção, 11. Versão eletrônica. s/n.

International Union for Conservation of Nature 1997. Red List of Threatened Plants. Magnoliopsida. Compiled by the World Conservation Monitoring Center. IUCN - The World Conservation Union, Gland, Switzerland and Cambridge, UK. 862 p.

Ledo, C. A. da S., Tavares-Filho, L.F.Q., Oliveira, M.M. & Silveira, T.C., Santos, A.S., Alves, A.A.C. & Gonçalves, L.S.A. 2009. Análise de agrupamento utilizando variáveis quantitativas e qualitativas para o estudo da diversidade genética em genótipos de mandioca silvestre. *In* Anais XIII Congresso Brasileiro de Mandioca, Botucatu. Unesp, Botucatu, p. 591–595.

Ledo, C.A.S., Silveira, T.C., Carvalho, P.C.L., Martins, M.L.L. & Tavares-Filho, L.F.Q. 2010. Coleta e conservação de germoplasma de espécies silvestres de *Manihot* no estado da Bahia para ampliação da coleção de trabalho da Embrapa Mandioca e Fruticultura. Embrapa Mandioca e Fruticultura. Comunicado Técnico 146. 5p..

Martins, M. L. L., Carvalho, P. C. L., Ledo, C. A. S. & Amorim, A. M. 2014. What´s New in *Manihot* (Euphorbiaceae)? Systematic Botany. 39(2): 485–489.

Mori, S.A., Silva, L.A.M., Lisboa, G. & Coradin, L. 1989. Manual de Manejo de Herbário Fanerogâmico. Centro de Pesquisas do Cacau, Ilhéus. 103 p.

Müller, A. 1866. Euphorbiaceae. *In* A. de Candolle. Prodromus, 15(2): 189–1261; 1269–1286.

Nassar, N.M.A. 1978. Conservation of the genetic resources of cassava (*Manihot esculenta* Crantz): Determination of wild species localities with emphasis on probable origin. Economic Botany. 32: 311–20.

Nassar, N.M.A. 1980. Attempts to Hybridize Wild Manihot Species with Cassava. Economic Botany. 34(1): 13–15.

Nassar, N.M.A., Hashimoto, D.Y.C. & Fernandes, S.D.C. 2008. Wild *Manihot* species: botanical aspects, geographic distribution and economic value. Genetics and Molecular Research. 7 (1): 16–28.

Nichols, R.F.W. 1947. Breeding cassava for virus resistance. East African Agricultural Journal 12: 184–194.

Pax, F. 1910. *Manihot* Adans. *In* Pflanzenreich IV. Euphorbiaceae–Adrianeae (Engler, A., Org.). Leipizig, Konigl Preuss Akademie der Wissenschaften. 147. p. 21–111.

Pohl, J. 1827. *Manihot. In* Plantarum Brasiliae icones et descriptions. Vienna, Antonii Strauss. 1. p. 17–56.

Rogers, D. & Appan, C. 1973. *Manihot* and *Manihotoides* (Euphorbiaceae): a computer- assisted study. Flora Neotropica. (Monograph nº 13) Hafner Press, New York.

Tavarez-Filho, L.F.Q., Ledo, C.A.S., Alves, A.A.C., Santos, A.S. & Gonçalves, L.S.A. 2009. Diversidade genética entre cultivares de mandioca e espécies silvestres de *Manihot* mediante caracterização morfológica. *In* Anais XIII Congresso Brasileiro de Mandioca, Botucatu. Unesp, Botucatu, p. 697–701.

Thiers, B. 2012 [continuously updated]. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/ Accessed 25.10.2013.

Ule, E. 1907. Vorläufige Mitteilung über drei noch unbeschriebene Kautschui liefernde *Manihot*-Arten in Bahia.Notizbl. Königl. Bot. Gart. Berlin 5(41): 2.