Factsheet
Botanical Data: de Maca

Lepidium meyenii Walp.

Project

Drafting botanical monographs (factsheets) for five Peruvian crops

Factsheet – Botanical Data: Maca - Lepidium meyenii Walp.

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I. BOTÁNY

Genus. Lepidium belongs to the Brassicaceae (Cruciferae) family and is the largest genus within that with 150 – 170 species (10, 13, 17). The most widely distributed species is Lepidium sativum L., whose seedlings are edible; it is found worldwide, except for Antarctica, yet restricted to tropical and sub-tropical regions, and these mostly in higher elevations. Lepidium probably originated in the Mediterranean, where most diploids species are found (17, 28). Hitchcock performed the most recent review of South American species and recognized forty-two species (11). It is mainly comprised of annual and perennial herbs as well as subshrubs and small shrubs.

In terms of morphology, it is characterized by dehiscent fruits (thin walled silicles) with normally emarginate tips and strongly cuneiformed valves, hanging seeds with a very mucilaginous seedcover, two or four (sometimes six) stamens, and cone-shaped nectaries (3, 4). There are fourteen species recognized in Peru, including L. meyenii and L. peruvianum (see below) (7). At least six wild species, with L. meyenii, have been reported in the central part of Peru, and, while some of these appear in sympatry L. meyenii, it is unknown whether they might be its closest relatives.

One molecular study (RFLP, RAPD) on samples of three wild species (L. bipinnatifidum, L. kalenbornii, and L. chichicara) from different places of origin did not find sufficient similarities with cultivated forms of L. meyenii (29). Very little to nothing is known about the origin of maca.

Morphology. L. meyenii is biennial (rarely annual) with an underground storage organ and decumbent stems (11, 15, 23). The latter are slightly ramified; shafts are 3 cm – 10 (- 20) cm long and emerge from the basal rosette. Leaves are clearly dimorphous, and rosette leaves are the largest (3 cm – 8 cm long, fleshy, pinnate to bipinnatisect, and frequently, somewhat lirate). Stem leaves on the flower buds are reduced, entire, lobed, or deeply crenate. Inflorescence is a panicle (compound raceme), pauciflorous, 1 cm – 2 (-5) cm long, and often partially covered with leaves.

L. meyenii has two stamens with yellow, longitudinal dehiscence anthers and four greenish nectaries located at the base of the ovary, two on either side of the stamens (1). Fruits are 4 mm – 5 mm long dehiscent silicles with two cuneiform cavities, each holding one seed. These are ovate, 2 mm – 2.5 mm long, and grayish red in color.

2 cm – 5 cm long storage organ is difficult to classify, possibly being a stem (hypocotyl) or taproot, since no ontogenous study has been conducted on the plant; yet it is quite likely the area between stem and root would contain the largest portion of the thickening of the storage organ (16). This organ is also the edible part of the plant and can be white, yellow, pink, and even red.

Taxonomy. Maca is called by two scientific names, but their validity and priority is not clear; older name is Lepidium meyenii Walp (30). The original description is based upon a Peruvian specimen (holotype) from the department of Puno, near Piscoma, at an altitude of nearly 5000 m. Chacon, whose study is as broad as it is unclear, separates the cultivated form, Lepidium peruvianum G. Chacón de Popovici, from the wild, edible species L. Meyenii (8). And while the catalogue of Peruvian flora mentions both names, L. peruvianum is scarcely recognized by other sources or simply not found, until very recently, for example, in the International Plant Names Index (7, 27).

No one has conducted a recent critical revision of Lepidium in the South American Andes, and current definitions are based largely on MacBride and Hitchcock (11, 15). Most recent works from Australia and North America as well as one, older monograph concerning the entire genus do not help much at this point (3, 4, 10, 24, 28). To come to a correct scientific judgment on the validity of the name L. peruvianum requires a systematic, critical review that currently does not exist.

On the basis of available data, to separate L. meyenii into different species with certainty is not scientifically justifiable, and so maca should be called by the scientific name, L. meyenii, in accordance with the principle of priority of the International Code of Botanical Nomenclature.

Variability. Due to its coloring, it is possible to differentiate four to eight "forms" (cultivars or groups of cultivars) (14, 20, 23). As to that, one new study at the Bombon mesa (department of Junin) states six cultivars can clearly be differentiated by the color of their storage organ (yellow, purple, cream, light purple ["red"], black, and gray) and combinations of them (2). The same study also states there are seven different shapes, from flattened circular to amorphous. Two, quite differentiated ecotypes are recognized in Peru: ecotype 1 from the Bombon mesa and ecotype 2 from Huancayo-Huancavelica.

II. DIAGNOSTIC FEATURES AND POSSIBLE CONFUSSIONS

Lepidium meyenii is the only species in the *Lepidium* genus with a thickened storage organ in the shape of a turnip. There are zero possibilities of confusing it with neighboring species, which might happen is *L. peruvianum* were to be recognized.

III. DISTRIBUTION

Lepidium meyenii is distributed in the central Andes of Peru, Bolivia, and northwest Argentina. Its distribution and cultivation in Peru are limited, being for all practical purposes restricted to the departments of Junin and Pasco (2, 6, 14, 19). Largest cultivation areas are in the surroundings of Lake Junin, near Huayre, Carhuamayo, Uco, Ondores, Junin, Ninacaca, and Vicco (21).

Possible wild populations (or naturalized populations) have been reported in the Ichuasi Mountains of Puno and in the sectors of Torata and Carumas in Moquegua (20). It is assumed maca cultivation was widespread in Peru during the 16th and 17th centuries and had most likely been grown earlier, at least in Cusco and the Lake Titicaca Basin.

IV. ECOLOGY AND POSSIBLE CULTIVATION AREAS

Habitat. Maca cultivation is restricted to treeless areas of puna vegetation, between (3700) 4000 m and 4500 m (6, 9, 19, 23) corresponding to relatively infertile steppes on the upper Andes, characterized by strong winds, extreme sunlight, and low temperatures, which can fall to as much as -10º C (26). Average daytime temperature is 18º C, average night time temperature is 8º C, and average relative humidity is 70%, making this species (among useful vegetables) one of the most frost tolerant. It even flourishes at an altitude where only a few other upper Andean gramineae can grow. Cultivation area soils are usually acidic with a pH<5.

Growth. Maca is normally biennial. The first period of growth ends with the development of one visible rosette and the storage organ and lasts nearly seven months (19, 21). During the second year, floral stems appear, first with just a few flowers forming in the center of the basal rosette and some other isolated ones on the leaf axil, which produce very little fruit, though (22, 23). At the same time, productive buds with reproductive flowers begin to form, as do some fruit, at the base and under the leaves

Within the next three months, racemes with 50 – 70 flowers are formed in the secondary productive buds. Maca is mainly self pollinating (autogamous) and cleistogamous, although it does present long flowering periods and the opening of flowers in successive series during its reproductive stage (2). Fruit is formed in a period of five weeks, and then seeds begin to be dispersed. Fruit production has a success rate of close to 85%, and one plant can produce up to 14 gr. of seeds (P1000 ≈ 0,625 g).

Seeds germinate in close to one week, without lying dormant, in warm (25º C), humid conditions. Yet, in good climatic conditions (sufficient humidity, little frost, and optimum temperatures), it can act as an annual plant and complete its life cycle in one year. In laboratories, maca can complete its life cycle in eleven months.

Photoperiod. Crop tests in the United States have shown maca can also be successfully cultivated in winter in California (21, 22). It may also have shown the photoperiod has no influence on growth and development and the species does not need short days to develop the taproot and flowers, reasons why it is considered day neutral.

Cultivation region. On account of low heat yet relatively high soil quality (nutrients and moisture) requirements, cultivation is probably possible throughout most of Peru's upper mountainous regions. Northern departments (Cajamarca, Piura, Tumbes, San Martín, Lambayeque, and Amazonas) do not have extensive highland regions.

Areas that are particularly suitable would be higher elevations in the departments of La Libertad, Ancash, Junin, Huanuco, Apurimac, Ayacucho, Cusco, and eastern Puno.

Western Apurimac, Ayacucho, and Puno might be too dry for cultivation except for their lower, humid regions. It would not be profitable to cultivate maca in nutrient poor soils, for example, sandy rocky ones in the Cordillera Negra (Ancash).

Traditional cultivation areas are in the central Andes and Bombon mesa, departments of Junin and Pasco. In 2003, 75% of national production came from there and the other 25% from the departments of Ancash, Cajamarca, Huánuco, Huancavelica, Ayacucho, Apurímac y Puno (5, 31). Production in the latter group is limited and normally just for self consumption or some degree of local sale (2).

V. CULTIVATION AND USE

Cultivation. Maca is primarily a monocrop, yet there are times when rows of bitter potatoes are sown between the plants, which farmers report lowering pest infestations (23). It is traditionally sown directly at the beginning of the mountain rainy season, between September and October (19, 21, 22). Planting fields tend to be prairies, fallow lands where maca has not been planted for ten years, or others that have been prepared through rotation (for example with bitter potatoes).

Before planting, seeds are cleaned or mixed with the remains of flowers, fruits, and dirt. During the mornings, when there is less wind, they are planted by hand in prepared fields. They are also mixed with sand or manure to assist in distribution. 100 gr. of seed are used for 200 m^2 – 300 m^2 or the

equivalent of 1.5 kg – 2 kg/ ha (25). Tree limbs or rakes or even the quick passage of sheep herds over the land are used to cover them. A more technical system for planting could include furrowing, yet it is not widely employed. Sometimes seedlings are thinned out after two months to obtain uniform “tubers”.

Depending on the case, weed control needs to be done manually. Hilling is not often done, but thinning and weeding are recommended so plants will develop correctly. Minimum distance between plants should be 8 cm – 10 cm (26). Soil should be fertilized with poultry manure (3 tons – 5 tons/ ha). Maca does, however, respond well to 60 – 60 – 60 fertilizing, yet storage organ quality is affected; previous experiences cite chemical fertilizer use changing organ flavor and making it more spongy, hence of lower quality. Ash is at times mixed in to improve soil.

Ideal daytime temperature is 18º C and nighttime is 8º C (see above). Higher temperatures (22º C / 12º C) limit growth, especially in the storage organ (22).

Soil. Maca seems to exhaust relatively poor soils quickly, i.e. it frequently consumes nutrients on an unequal basis so it is necessary to let fields lay fallow and/ or rotate crops for at least five years (14, 18, 26). Plants tested in short and long days grow better in almost neutral soils (pH 6,6) than in acidic ones (pH 5,3) (22). Cultivation methods, or in other words, soil pH neutralizing applications, would probably increase productivity.

Propagation. Since maca does not normally produce seeds in the first year, larger, superior plants are chosen during the harvest to be seed producers. These are then placed in 50 cm – 60 cm deep holes (In Peru, called “pozas”) and completely covered with dirt (21, 23). Storage organs selected for botanical seed production can be kept in moist towels or plastic crates, the latter primarily used with greater volumes (2).

Twenty-five to forty-five days later, organs are transplanted to cultivation beds and then planted in nutrient rich, fertilized earth or in pure animal dung. Yet, before transplanting organs, it is necessary that most of them have sprouted leaves. Also, since plants need sufficient moisture, they are normally planted at the beginning of the second rainy season.

Some plants can simply be left in the ground and transplanted when their aerial parts have been killed by frost (14, 18). Whole plants are then harvested when silicles start to turn yellow (just before dehiscence). Infructescences (branches with silicles) are allowed to mature in “ champas “ (sections of prairie grass mixed with animal dung) or in bags for seven to twelve days (2).

They are then sun dried, making certain no water falls on them. Once completely dry, they are threshed, rubbing them together by hand to eliminate vegetative parts. What remains is the “pita”, which can be stored in bags in a cool, dry place for a maximum of three to four years. Seed production process lasts 190 to 210 days after plant has grown, which takes one year (25).

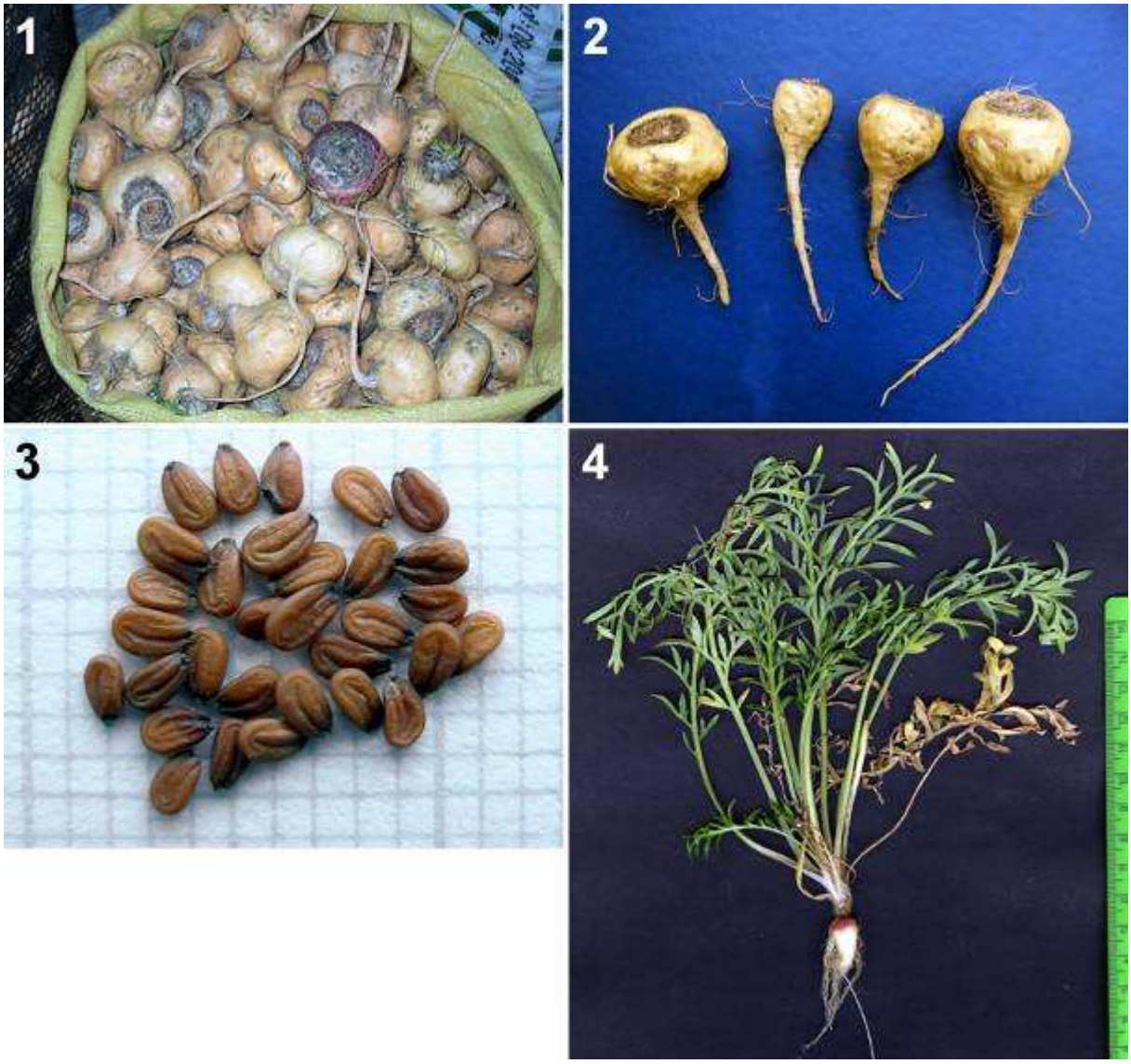
Pests and diseases. Very rarely is maca attacked by pest or disease. Root borers (*Premotrypes* spp.) and mildew (*Peronospora parasitica*) will eventually appear (21, 26).

Harvesting and yield. Plants are usually harvested between May and July, seven to nine months after planting. They are individually dug up with a simple curved implement (locally called “cashews”) (26). Leaves are still growing at this time, and roots and hypocotyls have reached their maximum diameter (nearly 5 cm) (14). Yield varies widely. When directly sown with no tending, fresh weight yield is just 2 tons – 3 tons/ ha. When more sophisticated cultivation methods and tending procedures are used (planting rows, fertilizing, and weeding), fresh weight yield can reach 14 tons – 15 (-20) tons/ ha, translating into a dry weight of 4.4 tons/ha (18, 23, 26).

VI. POST HARVEST

Post harvest, leaves are separated from storage organ, or whole plants are often left out in the sun for ten to fifteen days to dry (14, 21). Leaves are not normally removed from storage organ since farmers believe they produce sweeter, higher quality tubers. At night, plants are covered to protect them from moisture and frost. This drying method loses 30% - 50% of the harvest since leaves wither and overheat, causing damage to the storage organ.

After drying is complete, leaves are removed and organs sold or stored. Organs are stored in dark, well aired sheds in piles no taller than 10 cm. In the department of Junin, farm communities have set up drying facilities, much like greenhouses: wooden structure covered with transparent plastic. Ten days post harvest, leafless organs are stored inside on top burlap or beds of arrow grass. This structure concentrates and optimizes the sun's heat within, thus rapidly and uniformly drying the tubers. Purpose of these greenhouse-like drying facilities is to reduce drying time and labor requirements and to increase sugar content (12).



1) Maca on sale at an Arequipan market

2) Maca storage organs

3) Seeds

4) Habit

Photos: 1, 3: Nicolas Dostert; 2: Jose Roque; 4: Maximilian Weigend

VIII. LITERATURE

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