Title: Neglected crops: 1492 from a different perspective...

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Quinoa (Chenopodium quince)

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Botanical name: *Chenopodium quinoa* Wild.
Family: Chenopodiaceae
Common names. English: quinoa, quinua; Quechua: : quinua. kiuna (Ecuador, Peru. Bolivia): Aymara jiura (Bolivia); Mapuche: quinhua (Chile): *Chibcha :* suba (Colombia)

The quinoa is a food plant which was extensively cultivated in the Andean region by pre-Columbian cultures some 5 000 years ago and was used in the diet of the settlers both of the inter-Andean valleys. which are very cold high areas, and of the high plateaus. After maize, it has occupied the most prominent place among Andean grains.

At present, it continues to be grown in Colombia. Ecuador, Peru, Bolivia, Chile and Argentina. Its marginalization began with the introduction of cereals such as barley and wheat, which eventually replaced it. The reduction in its cultivated area in the Andean countries is also due to technical, economic and social reasons. Harvesting and threshing, which in the majority of cases are done by hand, take a great many days and the grain requires a process to remove its bitter ingredients before consumption. The prices received by farmers often do not justify their labour.

Uses and nutritional value

The parts of Chenopodium quinoa used as human food include the grain, the young leaves up to where ear formation begins (the protein content of the ear is as much as 3.3 percent in the dry matter) and, less frequently, the young ears. The plants nutritional value is considerable: the content and quality of its proteins are outstanding because of their essential amino acid composition (lysine, arginine, histidine and methionine); its biological value is comparable to casein and it is especially suitable for food mixtures with legumes and cereals.

Of the Andean grains, C. quinoa is the most versatile from the point of view of culinary preparation: the whole grain, the uncooked or roasted flour, small leaves, meal and instant powder can be prepared in a number of ways. There are numerous recipes on about 100 preparations, including tamales, huancaína sauce, leaf salad, pickled quinoa ears, soups and casseroles, stews, torrejas pastries. sweets and desserts and soft and fermented, hot and colts, beverages, as well as breads, biscuits and pancakes, which contain 15 to 20 percent of quinoa flour.

The whole plant is used as green fodder Harvest residues are also used to feed cattle, sheep, pigs, horses and poultry.

The leaves, stems and grain have medicinal uses and the properties attributed to it include cicatrization, anti-inflammation, analgesia against toothache and as a disinfectant of the urinary tract. It is also used in the case of fractures and internal haemorrhaging and as an insect repellent.

Its production potential is good. Because of this, its cultivation is spreading to other countries. With adequate soil preparation, fertilization and pest and disease control, yields of more than 3 to 4 tonnes per hectare can be obtained. In recent years, it has been introduced on the international market, fetching prices in excess of US$ 1.5 per kg.

Botanical description

C. quinoa is an annual herbaceous plant, measuring 0.20 to 3 m in height, depending on environmental conditions and genotype. It has a racemose inflorescence (a panicle with groups of flowers in glomerules); small, incomplete, sessile flowers of the same colour as the sepals and they may be hermaphrodite, pistillate or male sterile. The stamens have short filaments bearing basifixed anthers; the style has two or three feathery stigmas.

The fruit occurs in an indehiscent achene, protected by the perigonium. The seeds are 1 to 2.6 mm and are white, yellow, red, purple, brown or black. The leaves show pronounced polymorphism: rhomboid, deltoid or triangular. The taproot is densely branched.

Ecology and phytogeography

The cycle varies from 120 to 240 days and is suited to various environmental conditions. The phenological phases are emergence; two, four and six true leaves; branching; start of ear formation; full formation of ear; start of florescence; florescence or anthesis; woody grain; soft grain; and physiological maturity.

The quinoa has the ability to adapt to adverse environmental conditions such as cold and drought. Its seeds do not exhibit dormancy and they germinate when conditions are suitable, even on the plant itself although, in the wild forms, they may remain in the soil for two to three years without germinating.

C. quinoa's traditional cultivation area extends from lat. 8°N to lat. 30°S, as the plant adapts to different conditions of humidity, altitude and topography. Its requirements are:

Precipitation. This depends on the agro-ecological zone and the genotype to which it belongs. It varies from 250 mm (the area of salt deposits in Bolivia) to 1 500 mm in the inter-Andean valleys. Although it shows strong resistance in periods of drought, it requires sufficient humidity at the commencement of cultivation.

Temperature. It tolerates down to -5°C in the branching phase, depending on the ecotype and the duration of the minimum temperature. Its ontogenic resistance to cold and drought is very variable. Ecotypes exist which are resistant to temperatures of down to -8°C and survive for 20 days (mean monthly temperature).

Soil. It prefers easily worked, semi-deep soils, with good drainage and a supply of nutrients. It is suited to acid soils with a pH of 4.5 (in Cajamarca, Peru) and alkaline soils with a pH of up to 9.5 (in

Uyuni, Bolivia), depending on the ecotype. Acceptable production is also obtained both on sandy and clayey soils.

Genetic diversity

The nearest wild species to C. *quinoa* are C. hircinum and C. *berlandieri,* which have the same number of chromosomes (2n = 4x = 36), and C. *pallidicaule* with 2n = 2x = 18 chromosomes.

Sympatric wild populations of domesticated populations exist under cultivation, and morphological and electrophoretic similarities can be noted between one and the other in each locality, which indicates that domesticated quinoas are generally accompanied by wild populations in their various distribution areas.

Cultivated quinoas exhibit great genetic diversity, showing variability in the colouring of the plant, inflorescence and seeds, types of inflorescence, protein content, saponin content, betacyanine and calcium oxalate crystals in the leaves, so that a wide adaptation to different agro-ecological conditions may be seen (soils, precipitation, temperature, altitude, resistance to frost, drought, salinity or acidity).

From the point of view of its variability, it may be considered an oligocentric species, with an ample centre of origin of multiple diversification. The Andean region and, within it, the shores of Lake Titicaca, are where the greatest diversity and genetic variation occur. The main varieties known in this region are: in Peru, Kancolla, Cheweca, Witulla, Tahuaco, Camacani, Yocara, Wilacayuni, Blanca de Juli, Amarilla de Marangam, Pacus, Rosada y Blanca de Junin, Hualhuas, Huancayo, Mantaro, Huacariz, Huacataz, Acostambo, Blanca Ayacuchana and Nariho; in Bolivia, Sajama, Real Blanca, Chucapaca, Kamiri, Huaranga, Pasancalla, Pandela, Tupiza. Jachapucu, Wila Coymini, Kellu, Uthusaya, Chullpi, Kaslali and Chillpi; in Ecuador, Inbaya, Chaucha, INIAP-Cochasqui, Tanlahua, Piartal, Porotoc, Amarga del Chimborazo, Amarga de Imbabura and Morada; in Colombia, Dulce de Quitopampa; in Argentina, Blanca de Jujuy; and in Chile, Baer, Lito, Faro and Picchaman.

The risks of genetic erosion are due not only to the loss of viability in gene banks (at present it exceeds 15 percent annually) but also that occurring in the areas of diversification, particularly in places where cultivars and modern varieties are promoted for commercial purposes. The case of wild species is even more delicate, with small, isolated populations which have not been collected in time and which are inexorably vanishing. There are also risks from environmental factors and natural disasters. In *situ* conservation is an alternative, although there are difficulties of a socio-economic nature and also regarding institutional support.

Throughout the Andean region there are several gene banks where over 2 000 accessions are preserved in cold-storage rooms: in Peru, at the experimental stations of Camacani and Illpa (Puno), K'ayra and Andenes (Cuzco), Canaan (Ayacucho), Mantaro y Santa Ana (Huancayo), Baños del Inca (Cajamarca); in Ecuador, at the Santa Catalina station of INIAP (it has a cold-storage room); and in Bolivia, at the Patacamaya station of the IBTA.

The areas of genetic diversity where there are still no collections are the islands of Lake Titicaca: the areas above 3 900 m in Peru and Bolivia; the semi-arid inter-Andean valleys; the salt-pans; the valleys of the eastern slope of the Andes; and the cold zones of Argentina.

Cultivation practices

The traditional cultivation technique consists of sowing under dry conditions in a crop rotation with potato or on strips in maize crops, with little soil preparation and using only the residual organic fertilizers from the preceding crop. Sowing density varies between 15 and 20 kg of unselected seed per hectare. As traditional growers always look for safety in cultivation, they therefore sow several ecotypes at different times and in different locations. Cultivation work is limited to one or two hoeings, with occasional earthing up, particularly in the inter-Andean valleys. There is no pest and disease control. The plants are harvested when they reach physiological maturity and are laid for 30 to 45 days, after which they are threshed on well-trodden ground, beaten with curved sticks *(wajtana)* or trampled by animals. Yields range from 400 to 1 200 kg per hectare, depending on the region.

Experimental results show that yields can be increased by preparing the soil well, applying 80-40-00, applying fractionated nitrogen during sowing and earthing up. It is recommended that the crop be sown in furrows spaced 40 to 80 cm apart, using 10 kg per hectare of selected seed and hoeing during the first phenological phases, with earthing up particularly in the case of valley-growing quinoa and control of the main pests. The crop can be harvested using either combine harvesters or stationary harvesters. Yields of up to 5 000 kg per hectare of grain can be achieved and a by-product of harvesting is 5 to 10 tonnes per hectare of chaff for feeding livestock. These yields can be produced under suitable climatic conditions (rain and temperature), which do not always prevail in the different agroecological areas of the Andes.

Prospects for improvement

One of the main current limitations of cultivation stems from the fact that almost all the traditional varieties contain saponins in a greater or lesser quantity, which give the grain a bitter flavour However, varieties with a low saponin content do exist, for example Blanca de Junin as do some which are almost free of saponin, such as Sajama and Nariño.

For centuries the quinoa has been considered a food of low social prestige, although this prejudice is slowly changing. There needs to be a greater awareness of its nutritional value.

Prospects for improving propagation and cultivation techniques are fairly encouraging. Agroindustrial processing is a decisive factor for the present and future development of the crop. It enables quality and use to be optimized and aggregate value increased and it makes marketing easier, thus encouraging growers not only to improve productivity but also to increase the area sown.

Experiments in projects such as that of COPACA (1990) in publicizing knowledge about the quinoa, among other crops, open up prospects of the crop spreading on a very large scale, in view of its strategic importance in feeding populations, especially the rural population.

It may also be extended to the urban and peripheral populations and be of interest in food security programmes.

There are possibilities of its being introduced into the market economy and of its contributing to the generation of adequate incomes. However, there are still an excessive number of intermediaries in the marketing process and quality parameters still have to be determined in terms of the market and exports.

Potential areas for introduction and cultivation. The rate of distribution and cultivated area attained with the quinoa before the sixteenth century could be recovered and its cultivation in arid and semi-arid or marginal areas increased. In Venezuela, good results have been produced by trials carried out in the Merida and Maracay areas with a view to its future introduction in the Departments of Merida, Trujillo and Lara. In Colombia, these trials included the savannah of Bogota and the Departments of Boyaca, Cundinamarea, Valle, Huila, Nariño, Santander and Antioquía.

In Ecuador it has been introduced throughout the Andean region, mainly in the provinces of Carchi, Imbabura, Pichincha, Cotopaxi, Chimborazo. Loja and Tunguragua. Its cultivation is being promoted by private firms in low, warmer agro-ecological areas for export.

In Peru, it has been introduced throughout the Andean region from Piura to Tacna. although on the coast its potential is good, particularly as regards export. In Bolivia, it has also been introduced into the Andean region. Its yield can be increased in the area of the salt-pans and it can he incorporated in the yungas.

It would be feasible to introduce the crop into Honduras and Guatemala as well as the central states of Mexico (Mexico, Puebla, Guerrero. Tlaxcala and Oaxaca). It has been researched in the United States and is now sown in Colorado.

Uses and nutritional value

The Andean lupin is not only an important source of` protein (42.2 percent in the dry grain, 20 percent in the cooked grain and 44.5 percent in the flour), but also of fat which in the dry grain is 16 percent and in the flour 23 percent. It is used for human consumption after the bitter taste has been removed. a process for which there are several methods. Preparation varies according to the region and the occasion on which it is eaten: cebiche serrano, soups (cream of Andean lupin); stews *(pipián* a kind of fricassée); desserts (mazamorra custard with orange) and soft drinks (papaya juice with Andean lupin flour).

Industrially, flour is obtained which is used in a proportion of up to 15 percent in breadmaking - it has the advantage of considerably improving the protein and calorific value of the product. It also allows the bread to be kept longer because of the retrogradation of the starch, a greater volume being obtained owing to the emulgent properties of the sweet lupin's lecithin. The alkaloids (sparteine, lupinine, lupanidine, etc) are used to control ectoparasites and intestinal parasites of animals.. Occasionally, farmers use the Andean lupin's cooking water as a laxative and to control pests and diseases. In the flowering state, the plant is incorporated into soil as green manure and effectively improves the quantity of` organic matter and the structure and moisture retention of the soil. Because of its alkaloid content, it is frequently sown as a hedge or to separate plots of different crops, preventing damage which animals might cause. Harvest residues (dry stems) are used as fuel because of their high cellulose content which provides an appreciable calorific value.

Botanical description

L. mutabilis is an annual plant varying in height from 0.4 to 2.5 m, depending on the genotype and environment in which it is grown. It has a taproot with a thick main stem, reaching up to 3 m. The ramified secondary roots have symbiotic nodules with bacteria of the Rhizobium genus. The stems are cylindrical and woody. The leaves are palmate and digitate. It has racemose inflorescences with several flower verticils, each with five flowers, whose colours range from blue, purple, sky blue, pink to white. The androecium is formed by ten dorsifixed and five basifixed stamens. Because of flower abscission, 50 to 70 percent of the flowers do not form fruit, especially on secondary and tertiary branches. The fruit occurs in a pubescent, indehiscent pod in the cultivated species, with some dehiscence in the semi-cultivated and wild species. It is elliptical or oblong, pointed at both ends, with approximately 130 pods per plant. The seed is lenticular, 8 to 10 mm long and 6 to 8 mm wide. Its colour varies between black and white, through bay, dark grey, light grey and greenish yellow. A hardened integument, containing alkaloids, accounts for 10 percent of the seed. The weight of 100 seeds is between 20 and 28 g.

The growing cycle varies between 150 and 360 days, depending on the genotype and whether ripening of the central stem alone is taken into account or that of other branches. The various phenological phases are: emergence; first true leaf; formation of the raceme on the central stem; flowering; podding; pod ripening; and physiological maturity. The seeds exhibit dormancy through immaturity, since they require a post ripening phase before germinating. In wild species of Lupinus, dispersion is spontaneous through dehiscence and may extend as far as several metres.

Ecology and phytogeography

L. mutabilis is grown in temperate cold areas (Venezuela, Chile and northern Argentina), in inter-Andean valleys and on high plateaus, from 2 000 to 3 850 m, although good yields have been obtained in experiments at sea level. The requirements of L. *mutabilis* are:

Photoperiod. It is apparently unaffected by this factor, although it is grown more under short-day conditions.

Precipitation. Its requirements are between 350 and 800 mm and it is grown exclusively under dry farming conditions. It is susceptible to excessive humidity and moderately susceptible to drought during flowering and podding.

Temperature. It does not tolerate frosts during the raceme formation and ripening phase, although some ecotypes grown on the shores of Lake Titicaca have a greater resistance to cold.

Soil. It prefers loamy-sandy soils, with an adequate balance of nutrients, good drainage and a pH between 5 and 7; on acid soils, *Rhizobium* nitrogen-fixation is very low.

Cultivation continues in the traditional way in Ecuador. Peru and Bolivia, although introductions have now been made with good results in Venezuela, Colombia, Chile, Argentina, Mexico and European countries.

Genetic diversity

The Andean lupin displays a wide genetic diversity, with great variability in its architecture, adaptation to soils, precipitation, temperature and altitude. This is also the case with earliness, protein, oil and alkaloid content and disease tolerance. The colour of the seed, plant and flower varies. Its centre of origin would seem to be located in the Andean region of Ecuador, Peru and Bolivia, since the greatest genetic variability is found there. In this region, 83 species of the *Lupinus* genus have been identified.

Known varieties and cultivars are numerous: in Peru, Andenes 80, Cuzco, K'ayra, Carlos Ochoa, Yunguyo, Altagracia, H6, SCG-9, SCG25, SLP- 1, SLP-2, SLP-3, SLP-4 and SLP-5; in Bolivia, Toralapa and Carabuco; and in Chile, Inti.

Several working collections are kept in universities, at research institutes and in technical cooperation projects throughout the Andean region. More than 1 600 accessions are kept in cold storage rooms at several experimental stations. The main ones are in Peru (K'ayra in Cuzco, Santa Ana in Huancayo, Illpa and Camacani in Puno, Banos del Inca in Cajamarca and Canáan in Ayacucho), Bolivia (Patacamaya, Toralapa and Pairumani) and Ecuador (Santa Catalina).

The high fat content of the seeds reduces germination times; losses may be as much as 20 to 25 percent annually, hence continuous regeneration of the material is required.

No genetic erosion has yet been observed in the field, since the introduction of improved varieties is not significant. In *situ* conservation would be a good alternative, particularly for the wild species.

The areas of genetic diversity of cultivated or wild species which need to be collected are situated above 3 800 m in semi-arid regions, in deep inter-Andean valleys, on the eastern slope of the Andes, on the low ridges of the Peruvian coast, at the foot of the Venezuelan mountains, in the Colombian savannah, in northern Argentina, in the yungas of Bolivia and in Chile, in Concepción and Chiloé in the south, and in the northern areas.

Cultivation practices

The traditional cultivation practice consists of sowing after minimum tilling, particularly on thin soils and in high areas because of the sparse growth of weeds and the need to conserve humidity. The crop is generally cultivated in rotation with potato or cereals, without the use of fertilizers or manures. Sowing density varies from 100 to 120 kg per hectare of unselected seed, which is broadcast. Cultivation work is limited to hoeing. Harvesting takes place when the plants have reached full maturity. The seeds are separated from the pod by blows from a curved stick or they are trampled by livestock. Threshing is completed by winnowing. Using this technique, yields range between 500 and 1 000 kg per hectare. depending on the region and ecotypes used.

FIGURE 14 A) Andean lupin *(Lupinus mutabilis);*A1) flower; A2) legume; A3) seed; B) kiwicha *(Amaranthus caudatus);* B1) flower; B2) fruit

The improved cultivation technique consists of sowing on pre-prepared soil that has been fertilized with the formula 0-60-00 or 0-80-60, depending on soil fertility. The requirement is 80 to 90 kg of selected seed per hectare, disinfected against Colletotrichum sp. Two or three seeds at a time are put into furrows spaced 60 to 80 cm apart. Weeding is done in the branching phase, together with control of the seed weevil (Apion sp.) and *Epicauta* sp. Harvesting takes place when the central stem (high plateau of Peru and Bolivia), or primary and secondary branches (inter-Andean valleys) are mature.

The usual method of harvesting is reaping, laying, threshing, winnowing and storage - laborious and labour-intensive activities. Stationary soybean and kidney bean threshers have been used with good results, and prototype stationary threshers with a 0.5 to 1 h.p. motor have even been designed. However. the efficiency of the latter equipment is still not adequate (processing 500 to 600 kg per day). Yields reach 3 500 and 5 000 kg per hectare.

Cultivation is being developed with greater interest in Peru. Bolivia and Ecuador (the agronomic situation of Andean lupin utilization in Ecuador has been described). The alkaloid-free variety, Inti, bred in Chile by von Baer, is currently available.

Prospects for improvement

Cultivation of the Andean lupin, like other crops of Andean origin, is limited by the lack of continued support for research and promotion. The main limitation is the alkaloid content of the seed and plant itself: Alkaloids give them a sharp, bitter taste and have to be removed by way of various laborious processes. The traditional and best-known method is cooking, followed by rinsing for several days. The harvest residues cannot be used as fodder until alkaloid-free varieties are available. Although. at present, there are ecotypes with a low alkaloid content and one variety which is tree of them, these still show adaptation difficulties, low resistance to pests and diseases, a long vegetative period and little growth vigour. Its nutritional value and forms of use are not widely known, which is why its consumption is not more widespread among the population. Moreover, market supplies of Andean lupine which have had their bitter flavour removed are temporary and limited to producer areas.

Processing methods are still unsophisticated and not very efficient. With advanced agroindustrial techniques. the crop could be extended and promoted and its prices improved. It has production potential and prospects for use as an oilseed plant, source of protein, nitrogen-fixer and producer of alkaloids, with applications in animal and plant health.

Cultivation could be extended to marginal areas: to do this, more genetic research is needed on resistance to drought. frosts. hail and soil acidity. Through selection and crossing, there is potential for the development of varieties that are free of alkaloids and have desirable agronomic and productive characteristics.

Potential areas for introduction and cultivation

Cultivation could be increased in the Andes of Ecuador, Peru and Bolivia, troth in traditional areas where it was abandoned or displaced and in new areas. by introducing varieties with a low alkaloid content or free of alkaloids. As an oilseed plans, it could contribute to alleviating the oils and fats deficit in the Andean countries. Its use has even been considered as fodder in the cold areas of Europe. Early varieties (150-day growing period) can be sown in rotation with cereals in the mountain ranges or with other industrial crops on the coast of Peru.

In Colombia, the experience of its introduction in to Boyacá, Cundinamarca, Nariño and Antioquia has been favourable, as it has also in Trujillo, Merida and Lara in Venezuela. In northern Argentina, Uruguay and Paraguay, it could be introduced into high cold areas. This needs further research, particularly in Uruguay and Paraguay. In Argentina, there are gene banks with a limited amount of material, and research has been carried out at the Universities of Cordoba and Buenos Aires and at

INTA.

In Chile, the species L. *lutеus*. *L. albus* and *L. angustifolius* are grown; these are used for making flour for bread, in the oil industry and as a supplementary food for schoolchildren and hospitals. Production areas are concentrated in Concepción, Valdivia and Gorbea. The early and sweet varieties could be grown in the country's high areas.

In Central America. its introduction could result in an encouraging spread of the crop because of the suitable agro-ecological conditions. In Mexico, good results have been obtained experimentally, reaching the point where the tertiary branches are harvested. Its cultivation could spread to Oaxaca and Guerrero and part of other states such as Mexico (Toluca), Tlaxcala and Puebla, as well as to Honduras, Guatemala and Nicaragua. The possibilities are more limited in the United States and Canada because of the technological progress of other crops such as soybean and sunflower.

Lines of research

Lines of research and technological development to promote the crop are as follows:

· *Germplasm:* completing the collection, evaluation, documentation and exchange of genetic material.
· *Genetic and agronomic improvement:* obtaining alkaloid-free varieties, incorporating earliness, resistance to *Colletotrichum gloeosporioides,* resistance to drought, frost and soil acidity; breeding high-yielding varieties, uniformity in ripening of the main stem and side branches, as well as architecture with basal branching; studies on integrated pest and disease control; formation of genetic nuclei; and obtaining basic and certified seed from the main varieties.
· *Postharvest and industrialization* carrying out studies on grading, cleaning and adaptation to agro-industry; introducing techniques to remove alkaloids, while avoiding any loss of nutritional value; research on obtaining processed products for human use; promoting consumption, methods of preparation and biological value.
· *Marketing and consumption*. studying marketing channels and costs and the potential of domestic and foreign markets; providing information on prices and quality parameters; suggesting ways of stimulating demand and establishing social programmes for mass consumption.

Love-lies-bleeding (Amaranthus caudatus)

Botanical name: *Amaranthus caudatus* L.
Family: Amaranthaceae
Common names. *English:* love-lies-bleeding, Inca wheat, cat-tail, tumbleweed; *indigenous languages:* kiwicha (Peru), achita (Peru [Ayacucho, Apurímac]), achis (Peru [Ancash]), coyo (Peru [Cajamarca]), coimi, millmi (Bolivia), sangoracha, ataqo (Ecuador)

Love-lies-bleeding is a grain originating in South America, where it was also domesticated. The chronicler, Cobo, wrote in 1653 that, in the city of Guamanga (Ayacucho), delicious sweets were prepared from bledos *(Amuranthus caudatus*) and sugar. A similar species, the haautli *(A. hypochondriacus)*. was extensively grown in Mesoamerica and is frequently mentioned by writers in connection with Aztec customs and ceremonies.

Since the colonial era, the cultivated area of love-lies-bleeding has decreased considerably. However. it is still grown in Ecuador, Peru, Bolivia and Argentina because of the persistence of Andean farmers, and continues to be important because of its excellent nutritional quality. It is efficient at fixing carbon dioxide, does not have photorespiration and requires less water to produce the same amount of biomass as cereals

The grain's nutritional value is high and can be as much as to 12 to 16 percent protein, while the balance of amino acids is very good, with a fair proportion of these containing sulphur: lysine, methionine and cysteine It does not contain saponins or alkaloids and the leaves are edible. In the human diet it is preferably eaten split or after the split grain has been ground, giving a very agreeable flour.

The grain is also cooked whole. Over 50 ways of preparation are known: the leaves are eaten in salads and the grains are also used to make soups, custards, stews, desserts, drinks, bread and cakes.

Agro-industry makes flour which is used up to 20 percent as a wheat substitute in breadmaking. It is also used to make an instant chocolate powder, syrups and sweets. A study has been made of the use of vegetable colouring matters, which are found up to 23 percent in the ear and are highly water-soluble and unstable in light.

Harvest residues are used for livestock feeding because of the protein content and suitable digestibility. The ground grain is used to control amoebic dysentery.

Botanical description

A caudatus is an annual plant of 0.4 to 3 m. It has a taproot and numerous, very ramified side roots. The leaves are petiolate, oval, opposite or alternate and green or purple. The particulate, monoecious inflorescence ranges from erect to decumbent, with attractive colours - green, yellow, orange, pink, red, purple and brown. The flowers are small, unisexual, staminate or pistillate; the males have three to five stamens and the females have a monospermous superior ovary. The fruit is in a pyxidium; the seeds are small (from 1 to 1.5 mm in diameter). generally white, smooth, shining, slightly flattened, although sometimes yellowish, golden, pink, red and black; and there are 1 000 to 3 000 seeds per gram.

The percentage of allogamy ranges between 10 and 50 percent, even within individuals of the same population. Crossing depends on the wind. the number of pollinating insects. pollen production, etc. Generally, the seeds do not exhibit dormancy and, as they contain moisture, they may even germinate on the plant. Dehiscence occurs at intervals and is a common characteristic among the wild species. Seeds are dispersed over great distances from the parent plant.

Ecology and phytogeography

A. caudatus extends from Ecuador to northern Argentina, growing in temperate areas and inter-Andean valleys from sea level to 3 000 m. Its main requirements are:

Photoperiod. It prefers short days, although it shows great adaptability to different environments and can flower with 12- to 1 6-hour days.

Precipitation. Water requirements range from 400 to 800 mm. However, acceptable production levels are obtained with 250 mm. Although it requires reasonable precipitation for germination and flowering, it can tolerate periods of drought after the plant has become established. Crops have been observed in areas with 1 000 mm of annual precipitation.

Temperature. It is sensitive to cold and can tolerate only 4°C in the branching state, with 35 to 40°C as the maximum temperature.

Soils. It prefers easily worked, sandy soils with a high nutrient content and good drainage. although it can adapt to a broad range. The ideal pH is 6 to 7, although crops have been found in acid soils and at a pH of 8.5. It shows tolerance to aluminium toxicity. In the wild form, and tolerated within crops, there are many wild species of Amaranthus as well as species tolerated among cultivated crops. In the Andes, the most important are: A. hybridus A. spinosus. A. dubius A. palmeri. A. viridis A. blitum and A. tricolor which are found growing with maize and other crops. They generally have dark seeds and, under suitable conditions of fertility can develop great vigour and size, to the point of teeing confused with the cultivated plant. The leaves are used for human consumption.

Genetic diversity

A. caudatus has a wide genetic variety and diversity of plant forms, ranging from erect to completely decumbent. It shows great variation in seed colour; earliness; protein content; types of ear; adaptation to soils, climates, precipitation and temperatures; disease resistance; and colouring content. The greatest genetic variation is noted in the Andes (Ecuador, Peru, Bolivia and Argentina).

The Kiwicha [love-lies-bleeding] Research Programme, carried out by the University of Cuzco, Peru, has selected among others the varieties Noel Vietmayer and Oscar Blanco, while INIAA in Cajamarca has selected the varieties Roja de Cajabamba and San Luis.

Over 600 accessions are stored in the gene banks. In Peru, they are found at the experimental stations of K'ayra (Cuzco), Canáan (Ayacucho). Baños del Inca (Cajamarca), Santa Ana (Huancayo) and Tingua (Huaraz); in Ecuador, at the Santa Catalina Experimental Station; in Bolivia, at the Pairumani Experimental Station; and in Argentina, at the University of Cordoba.

There are many areas of genetic diversity which need to be scoured for collecting, mainly the tropical and subtropical valleys of the eastern range of the Andes of Peru, Bolivia and Ecuador as well as the western valleys of the Andes and semi-arid areas of Peru and Bolivia (Ayacucho and Cochabamba. respectively).

Cultivation practices

A. caudatus cultivation is maintained in the traditional way in the Andes of Peru. Bolivia. Ecuador and Argentina. Different forms and systems of cultivation are observed, including: direct sowing: transplanting, with irrigation or ten dry land; growing together with maize; interplanted, to separate fields from other crops; as a border; sowing as a horticultural plant close to houses and plots on small farmsteads; and extensive cultivation.

It is traditionally sown under dry conditions, on pre-prepared ground, often together with maize and, in the case of single sowing, in furrows spaced 80 cm apart and fed with a constant stream of wafer. When the plant reaches 20 to 25 cm, the first weeding is done, and also thinning if the seedlings are clustered together or need to be moved to spaces with a greater availability of water. The plants are also sown in seed beds for subsequent transplanting to irrigated land. Harvesting takes place before the plant is fully mature so as to forestall seed fall. It consists of cutting the plants 20 cm from the soil with sickles and forming small sheaves which are left to dry above the furrows. To remove the seeds, they are beaten with sticks on sheets spread over the ground or on well-trodden earth and then silted or winnowed to separate the grain from the chaff. Using this technique, farmers can obtain from 500 to 1 500 kg per hectare.

Crop improvement consists of adequate preparation of` the soil' direct sowing. with a density of 4 to 6 kg of` selected seed per hectare, in furrows set 80 cm apart, and the application of` fertilizers according to the quantity of nutrients available in the soil (50-60-20 or 80-80-20 in Peru). Cultivation work consists of one or two weedings, light earthing up to prevent collapse from the weight of` the inflorescences and control of` the main pests and diseases.

Without waiting for the plant to mature completely, harvesting is done when its lower leaves show signs of yellowing and there is some basal dehiscence and dry seeds. The plant is cut and left to dry in piles before being beaten with curved sticks (in which case it takes 20 to 25 days' work per hectare), or using stationary wheat threshers in which the size of the sieves, air blast and motor revolutions have been modified. Yields obtained vary between 2 000 and 5 000 kg per hectare in Peru and 900 and 4 000 kg per hectare in Ecuador.

Prospects for improvement

An increase in production indices, followed by support for industrial processing in rural areas which would increase producers, incomes would stimulate local consumption and. if there was a surplus. exports. The standards achieved in research. evaluation and characterization of the germplasm available, together with the advances in its genetic, agronomic, biochemical and industrial improvement constitute a sound basis, so that technological progress is encouraging as far as the utilization of this plant's productive potential is concerned. The plant needs to be spread more widely among both producers and consumers: its nutritional value and the uses and ways in which it is consumed are not very well publicized in Andcan countries. The advantages of loveliesbleeding are the low cost of the unprocessed grain' the absence of any special treatments being required and the fact that it is willingly accepted by consumers.

Lines of research

The main aspects of research which need to be completed are:

Germplasm and improvement: completing the collection of germplasm in certain areas of the Andean region, as well as evaluation, characterization and documentation breeding varieties with less dehiscence, greater uniformity of ripening, resistance to drought, frosts and soil alkalinity. tolerance of the main pests and diseases and greater colouring content; promoting the establishment of basic and certified seed beds of the main varieties.

Postharvest and industrialization developing prototypes of` machines which enable harvesting to he done effectively, as well as cleaning and selection; developing industrial processing technologies to obtain new products. particularly to boost the supply of foods for mothers and infants.

A publicity campaign also needs to be launched in urban areas. As far as marketing is concerned studies must be carried out on outlets and costs. on the potential of domestic and foreign markets and on quality standards.

Bibliography

Cano, V.J. 1973. El cultivo de la cañihua. Boletín Fac., Ing., Agrícola, 2. Puno, Peru, Universidad Nacional Técnica del Altiplano.

Cárdenas, M. 1 989. *Manual de plants económicas de Bolivia*. 2nd ed. La Paz. Editorial Los Amigos del Libro.

Congreso Internacional sobre Cultivos Andinos. I Ayacucho, 1977; II Riobamba, 1979; III La Paz, 1982; IV Pasto, 1984: V Puno, 1986; VI Quito, 1988; VII La Paz. 1991.

Convención de Quenopodiáceas Quinua-Cañihua. I Puno, 1968: II Potosi, 1976.

FAO. 1982. *El cultivo y la utilización del tarwi Lupinus mutabilis Sweet*. Plant Production and Protection Paper No. 36. Rome.

FAO.1990. *Los* cultivos *andinos subexplotados* y su aporte a *la alimentación* Santiago.

Gandarillas, H. 1967. Observaciones sobre la biología reproductive de la quinua. *Sajama* 5(2): 16-18.

Hunzinker, A.T. 1952. *Los pseudocereales de la agricultura indígena de América*. Buenos Aires, ACME.

León, J. 1964. Plantas alimenticias andinas. IICA *Boletín Técnico. 6*.

Mújica, A.1977. *Cultivo de la quinua*. Universidad Nacional del Altiplano. Puno. Peru.

Mújica, A.1990. Investigación y producción *del tarwi* (Lupinus mutabilis Sweet *en el Perú*. Lima, INIAA, PICA.

National Research Council. 1989. Lost crops *of the Incas: Little known plants from the Andes with promise for worldwide cultivation*. Washington, DC. National Academy Press.

Nieto, C.1989. *El cultivo de amaranto (Amaranthus spp.) una alternativa agronómica para Ecuador* . Publ. Misc.52. E.E. Santa Catalina, Ecuador, INIAP.

Sauer, J.D.1967. The grain amaranths and their relatives: a revised taxonomic and geographic survey.

Ann. Missouri; Bot. Gard. 54: 103-137.

Sumar, L. 1983. *Amaranthus caudatus, el pequeño gigante*. Lima, UNICEF.

Tapia, M., Gandarillas, H., Alandia, S., Car dozo, A. & Mújica, A.1979. *Quinua andinos*. Bogotá, IICA.

Torres, F. 1976. *Lupinus mutabilis Sweet*. A potent food source from the Andean region. Am. J. *Clin. Nutr.* 25: 833.

Vallenas, M. & Carpio, F. 1974. *La cañihua y su cultivo Boletin No.25*. Puno. Peru, Ministry of Agriculture, Agrarian Zone XII.

Wilson, H.1990. Quinua and relatives *(Chenopodium Sub*. Sect. *Cellulata)*. *Econ. Bot*.. 44(3 Suppl.): 92-110.

Zevallos, J. & Mújica, A.1977. Tarwi (Lupinus mutabilis Sweet Puno, Peru. Ministry of Food, Zone XII.

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