



Quinoa: The Super Grain For Healthy Lifestyle

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The genus *Chenopodium* (family Chenopodiaceae) comprises about 250 species (Giusti, 1970), which include herbaceous, suffrutescent and arborescent perennials, although most species are colonizing annuals (Wilson, 1990). *Chenopodium* spp. have been cultivated for centuries as a leafy vegetable (*Chenopodium album*) as well as an important subsidiary grain crop (*Chenopodium quinoa* and *C. album*) for human and animal foodstuff due to high-protein and a balanced amino-acid spectrum with high lysine (5.1–6.4%) and methionine (0.4–1.0%) contents (Prakash and Pal, 1998, Bhargava et al., 2003a). *C. quinoa* Willd. is a native of the Andean region and is a member of the subsection Cellulata of the section *Chenopodium* of the genus *Chenopodium*. It belongs to the group of crops known as pseudocereals (Cusack, 1984, Koziol, 1993) that includes other domesticated chenopods, amaranths and buckwheat. The grain has a high-protein content with abundance of essential amino acids, and a wide range of vitamins and minerals (Repo-Carrasco et al., 2003). Recently, there has been growing interest in a number of countries (especially in Europe), initiating introduction and research work on quinoa (Galwey, 1992, Jacobsen, 2003). The aim of the paper is to review the existing literature and explore the potential of this crop for agricultural as well as various industrial purposes, especially for India and other countries having similar agro-climatic conditions.

History

Quinoa has been an important food grain source in the Andean region since 3000 b.c. (Tapia, 1982) and occupied a place of prominence in the Inca empire only next only to maize (Cusack, 1984). However, after the conquest of the region by the Spaniards in 1532 a.d., other crops, such as potato and barley, relegated quinoa to the background. However, the sporadic failure of green revolution in the Andes and enormous destruction of other crops by droughts, once again brought native crops.

Distribution

Quinoa is grown in a wide range of environments in the South American region (especially in and around the Andes), at latitudes from 20°N in Columbia to 40°S in Chile, and from sea level to an altitude of 3800 m (Risi and Galwey, 1989a). The distribution starts from Narino to the Salares of southern Bolivia that includes countries like Ecuador, Peru and northern Argentina (Jujuy and Salta provinces) (Wilson, 1990). The Atacama Desert forms a break in the distribution of the crop, which continues

Cytotaxonomy

The domesticated species of *Chenopodium* are divided into two subsections on the basis of pericarp and perianth morphology, and crossing relationships (Wilson, 1990). The first subsection Cellulata contains diploid allotetraploids ($2n = 4x = 36$) like *C. quinoa* and *Chenopodium berlandieri* subsp. *nuttaliae*. The second subsection Leiosperma

includes domesticated and semi-domesticated forms like *Chenopodium pallidicaule* ($2n = 18$) and *C. album* ($2n = 18, 36, 54$) (Wilson, 1980, Gangopadhyay et al., 2002).

Botanical description

Quinoa is a gynomonocious annual plant with an erect stem, and bears alternate leaves that are variously coloured due to the presence of betacyanins. The plant shows good growth in India with many cultivars reaching upto 1.5 m in height, generally with large number of branches and a big leaf size (Bhargava et al., unpublished results). A well-developed, highly ramified tap-root system is present (Gandarillas, 1979), penetrating as deep as 1.5 m below the surface, which protects against drought

Effect of temperature and photoperiod on quinoa

Bertero et al. (1999b) showed that photoperiodic sensitivity was negatively associated with the latitude of origin of nine quinoa lines and positively associated with minimal time taken from emergence to visible flower buds, when temperature and photoperiod responses were taken as independent (non-interactive). However, photoperiod and temperature parameters when taken as independent (interactive) were not significantly related with latitudes of origin.

Crop production and management

Quinoa can be grown on various types of soils, including marginal soils with a wide pH range (Jacobsen and Stolen, 1993, Tapia, 1979). Although, sowing can be done in rows, groups, mixed, broadcast or by transplanting, row spacing of 25–50 cm is preferable since it allows easy hoeing. A level, well-drained seedbed is most suited for quinoa cultivation. Seeds should be sown 1–2 cm deep in a fine structured, moist seed bed (Jacobsen, 2003).

Diseases and pests

Quinoa is infected by a variety of pathogens, which cause several diseases like mildews, damping off, blight, mosaic, etc. (Table 1). Viruses are known to infect the plant, but reports of significant damage are absent. Downy mildew is the most severe pathogen on quinoa and is known to cause yield reduction of 33–58%, even in the most resistant cultivars (Danielsen et al., 2000). Danielsen and Munk (2004) tested seven disease-assessment methods to measure downy mildew severity on quinoa and

Economic uses

Quinoa is highly nutritive and is being used to make flour, soup, breakfast and alcohol. It is sold either as whole grain that is cooked as rice or in combination dishes. It can be fermented to make beer, or used to feed livestock (Galwey, 1989). Whole plant is also used as green fodder to feed cattle, pigs and poultry. In Peru and Bolivia, quinoa flakes, tortillas, pancakes and puffed grains are produced commercially (Popenoe et al., 1989). The use of quinoa for medicinal purposes has been

Leaves

Quinoa leaves contain ample amount of ash (3.3%), fibre (1.9%), nitrates (0.4%), vitamin E (2.9 mg α -TE/100 g) and Na (289 mg/100 g) (Koziol, 1992). Prakash et al. (1993) reported that leaves have about 82–190 mg/kg of carotenoids, 1.2–2.3 gm/kg of vitamin C and 27–30 gm/kg of proteins. Study on fresh leaves (Bhargava et al., unpublished results) revealed abundant moisture (83.92–89.11%), chlorophyll a (0.48–1.82 mg/g), chlorophyll b (0.25–0.07 mg/g) and much higher amount of leaf carotenoid

Saponins

Saponins are the principle antinutritional factors present in the seed coat of quinoa. The saponin content in seeds of sweet genotypes varies from 0.2 to 0.4 g/kg dry matter and in bitter genotypes from 4.7 to 11.3 g/kg dry matter (Mastebroek et al., 2000). Saponins in quinoa are basically glycosidic triterpenoids with glucose constituting about 80% of the weight. Saponin content is affected by soil-water deficit, high water deficit lowering the saponin content (Soliz-Guerrero et al., 2002).

Breeding approaches

The basic objective of breeding in quinoa is the development of a variety with high grain yield accompanied with high protein and low saponin content. However, it is not so easy due to self-pollinated nature of the crop. The problem is compounded, since the flowers are very small, as a result of which emasculation and hybridization is very tedious and difficult. In spite of these difficulties, mass selection and hybridization has been practiced in quinoa (Risi and Galwey, 1984). Various

Tolerance in relation to stress conditions

Quinoa exhibits high level of resistance to several predominant adverse factors, like soil salinity, drought, frost, diseases and pests (Jacobsen et al., 2003). It can tolerate soil pH from 4.8 to 9.5 because of mycorrhizal associations, thus maximizing the use of scarce nutrients (Tapia, 1979, Mujica, 1994) and also resists frost before the flower-bud formation stage (Jacobsen et al., 2005). Moreover, it accumulates salt ions in tissues, which adjusts leaf water potential, enabling the plant

Quinoa in Indian perspective

India, located between 8° and 38°N and 68° and 93.5°E, exhibits enormous diversity for agro-climatic regions and edapho-climatic conditions. An increasing population in this region of the world demands not only an increase in food grain production but also a shift towards environmentally sound sustainable agriculture. Quinoa can play a major role in future diversification of agricultural systems in India, not only in the Himalayan region, but also in the North-Indian Plains. Trials at N.B.R.I.

Concluding remarks

Quinoa's ability to produce high protein grains under ecologically extreme conditions makes it important for the diversification of future agricultural systems, especially in high-altitude area of the Himalayas and North-Indian Plains. The high nutritional quality and multiple uses in food products make quinoa ideal for utilization by the food industry. Other potential uses reviewed by the industry include use of quinoa as a flow improver in starch flour products, fillers in plastic industry.