

Growing super grain quinoa

in India

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Quinoa, Chenopodium quinoa, a primitive pseudo-grain used for food in the Andean region of South America mostly remains unknown to the world. Its nutritional and nutraceutical benefits has gained global attention in the recent past. A very new crop for our Indian subcontinent, its cultivation is more challenging under diverse agro-climate of the country. Quinoa can perform successfully under almost all climate and environmental conditions of India and is thus considered a very hardy crop particularly for the rain-fed and draught affected zones being a very rich protein diet. FAO celebrated 2013 as the “Year of Quinoa” and since then a number of countries have initiated research and development on its cultivation technologies. Quinoa is an annual crop cultivated mainly as a rabi crop taking about 120-150 days to maturity. Quinoa production has been initiated in a few areas in India but it is un-organized, since scientific agro techniques have still not been standardized. Keeping in view DIBER (DRDO), Haldwani (Uttarakhand) initiated maiden scientific study during the year 2015 at multi locations in various centres of the institute to develop suitable package of practices for cultivation of quinoa. Apart from its cultivation, product formulation and their comparative evaluation has also been undertaken at the institute to standardize the performance of Indian quinoa with Andean quinoa.

Key words: *Chenopodium quinoa*, Cultivation, Quinoa

FAST GROWING population and shrinking of land resources have drastically reduced the per capita availability of cultivable land in India. Crisis of irrigation water, fast climate change, food and nutritional security have put many challenges before us to feed population all over the globe. It is estimated that over 60 % of cultivable land in India is still rainfed and unirrigated. This necessitates for crop diversification to improve our crop productivity with low water and fertilizer inputs, mostly to our drought affected areas. This offers unique opportunity to grow highly productive and nutritious crop quinoa, which is a new crop to the country having tremendous potential to be grown with less water and high nutritive grain yield. Mostly the Indian population has scarcity of protein-rich diet due to common use

of rice and wheat as main diet. Thus, protein rich quinoa can be taken as an important food crop in India for fighting against scarcity of nutritious grain. It can make our diets more balanced against combating silent hunger among poor populations. Besides this, product development by using improved technologies and marketing can open new areas for its diverse applications and entrepreneurship. This crop is very high in demand in food processing industries in many countries of Europe and America, owing to its high nutritive, nutraceutical and health benefits.

Quinoa, a pseudocereal, belongs to genus *Chenopodium* and family Chenopodiaceae, from which the common weed and leafy vegetable *Chenopodium* (*Bathua*) comes. Botanically it is known as

Chenopodium quinoa. It usually grows up to 45 to 300 cm high with a range of colours that vary from white, yellow, pink to darker red, purple and black. It has thick, erect, woody stalk that may be branched or un-branched with alternate, wide leaves usually green but turning yellow, red or purple on maturity. The flower is tiny, incomplete, sessile, without petals, hermaphrodite (both male and female in the same flower) and female or pistillate. Fruit is small dry achene quoted with thin pericarp contains 4% saponin, which gives bitter taste and foam. The saponin can destroy blood cell membrane if consumed without proper washing or removal of the pericarp layer. Quinoa is usually self-pollinated crop but cross pollination also reported at a rate of 10-15%. The seed size is similar to millet (2–3 mm) and with



two flat surfaces can be black, red, pink, orange, yellow or white in colour. Its embryo comprises 60% of the volume within pericarp that results in the higher protein content of the seed in comparison of other cereals. Its well developed taproot system, which can reach up to 180 cm deep in soils, makes the plants strong to face the challenges of water stress conditions.

Origin and distribution

Quinoa is a native of the Andean region particularly to the Altiplano shared by Colombia, Ecuador, Chile, Peru and Bolivia. It is believed to be domesticated 5000-7000 years ago as other chenopods, amaranths and buckwheat crop. Various studies have been conducted by DIBER at Haldwani (470 m above sea level), Pithoragarh (1,600 m above sea level), Auli (3,000 m above sea level), Leh, J&K (3,450 m above sea level), Banda and Lucknow (UP), Patna (Bihar) and Secunderabad (AP) during the year 2015-2017. Based on findings of studies and our observations, growing tips are being discussed in brief, in this article, in order to provide basic information and guidelines to boost the cultivation of this wonder crop in India.

Nutritional values

Quinoa is termed as super grain and said to be future crop because of its nutritional, nutraceutical and health potential. It is very rich source of protein (13.81-21.9%) and reasonable amount of all essential amino-acids, which are rare in other food crops, with high lysine (5.1–6.4%) and methionine (0.4–1.0%) contents, and a wide range of vitamins and minerals (Table 1).

All essential amino acids, minerals like (potassium, phosphorus, calcium, magnesium, manganese, zinc) oils, vitamins (B₁, B₂, B₃, C, E) and flavonoids, give it highly nutritional and antioxidant qualities retained even after processing under high temperatures. About 6% of dietary fibres of total grain is very useful for intestine, cholesterol regulation and preventing colon cancer. It is an important source of gluten free

Table 1. Nutritional profile of quinoa pseudograins

Nutrients	Quantity
Carbohydrates	60-74%
Protein	12.5 -16.7%
Fat	5.5-8.5%
Fibre	1.9-10.5%
Calcium	874-1487 mg/kg
Phosphorus	1400-5300 mg/kg
Magnesium	260-5050 mg/kg
Iron	14-168 mg/kg
Zinc	28-48 mg/kg
Potassium	75-12000 mg/kg
Ascorbic acid	4.1-6.4 mg/kg
α-tocopherol	2.6-5.37 mg/kg
Thiamin	0.38-0.40 mg/kg
Riboflavin	0.39 mg/kg
Niacin	1.06 mg/kg

pseudocereal grain which is a rich source of various dietary fibres. Quinoa seeds contain a layer of saponin in its outer layer which is a water soluble glycoside, a mildly laxative compound with bitter taste. It can be washed off from quinoa before consumption or removed through mechanical abrasion. Saponin is useful in protection of crop from insects and birds. The higher digestibility (95.3%) was observed in quinoa formulated baby food which was higher than that of commercially available other famous infant foods derived from milk and soya (Table 2).

Uses

Quinoa is primarily grown for its super nutritious seed which can be used as flour, rice, flakes etc. (Table 3). The leaves, seeds, stems and ash of the plant is used to cure more than 20 ailments, viz. liver ailments, liver abscess, angina, toothache and fever etc. Quinoa is used for dressings or poultices, as soothing and anti-

inflammatory for urinary tract catarrh. It has healing properties against wounds, sores, bruises, sprains, shocks, internal bleeding. It is also useful as diuretic, lactiferous, digestive, emetic, insect repellent and vermifuge etc.

The leaves are cooked as vegetable, panicles as a delicacy and grains cooked as cereals. Quinoa can be processed through extrusion process. Flour of its grain is useful to enrich vegetarian diets with amino acids. NASA (USA) has also recommended quinoa to feed its astronauts. The remaining plant material can be used as valuable fodder for the animals or converted into ash for medicinal use.

Climate and adaptability

Quinoa has a remarkable adaptability to different agro-climatic zones and it can withstand temperature range from –4 °C to 38 °C and relative humidity from 40% to 88% but it can be ideally cultivated under temperature ranging between 15 and 20° C. Quinoa is one of the few crops that grows in extreme climate and soil conditions due to its wide range of adaptability. Our multi-location trials showed that quinoa can successfully be cultivated in high altitude conditions of Ladakh in Jammu and Kashmir, middle hills of Uttarakhand in Pithoragarh region and foot hills of Haldwani (Nainital) in Uttarakhand, besides its cultivation in drought affected regions of Bundelkhand (Uttar Pradesh) and Secunderabad in Telangana etc. Quinoa reported to have grown successfully under various abiotic stress conditions like poor soils or excessive drainage, low fertility or very acidic (pH 4.8) to

Table 2. Comparison of nutritive value of quinoa with other cereals (per 100 g)

Compositions (%)	Quinoa	Rice	Oats	Barley	Rye	Maize	Wheat
Protein	13-44	7-69	8-2	10-4	9-5	10-67	11-72
Fibre	3-36	0	8-7	3-4	1-7	1-68	2-65
Unsaturated-fat	6-96	0-16	5-6	1-2	1-6	4-3	2-08
Carbohydrate	77-29	81-3	62-6	68-9	73-8	69-58	70-75

Table 3. Uses of quinoa

Uses	Values	Plant part used
Edible and drink	Vitamins and protein	Seeds and leaves
Animal feed	Vitamins and protein	Whole plant
Medicines	Resistance, skin and breathnig problems	Seeds and leaves
Insect replent	Against insect and pest	Leaves and seed coat



alkaline (pH 8.5) conditions. It also has excellent ability to tolerate moisture stress conditions.

Soil and field preparations

Quinoa can be grown on a wide range of soils, from sandy loam to clay loam but it gives best results on sandy loam soils. It can be raised successfully to low rainfall regions than irrigated land. A clean and well pulverized and weed free land of good tilth is needed for better germination. The land should be well prepared first by deep ploughing with soil turning plough, followed by one or two cross harrowing. Each ploughing should be followed by planking. There should be proper moisture at the time of sowing for sufficient/ proper germination.

Seed rate and time of sowing

Quinoa requires cool conditions (temperature 20-23°C) for its seed germination and plant growth like wheat and barley. It is a 130 to 150 days crop in plain conditions. Seeds of quinoa are very small in size and weight of thousand mature seeds comes around 2.06 to 2.09 g. It requires light moisture in soil at the time of sowing. Germination starts quickly within 24 hours after sowing in moist soils. Seeds are sown in rows in well prepared fine tilth fields. Sowing should be done at 60-75 cm in rows and 30-40 cm plant to plant distance to be maintained. Depth of seed sowing should be kept around 2 cm, as small tiny seeds may not germinate when sown beyond 2 cm deep. For commercial cultivation of quinoa seed rate of 4 to 5 kg/ha is required. Thinning should also be done after germination to maintain proper distance between the plants. The best time of sowing of quinoa is mid May to mid June in high altitude conditions, however, it should be sown in November in the Indo-Gangatic regions. Sowing is recommended in October in middle Himalayan regions.

Water management

Quinoa is a very hardy crop and can tolerate acute draught conditions, hence has immense potential to be produced in rainfed and draught

affected areas of the country. However, light irrigations at crucial stages of growth boost the crop growth and yield. Sufficient soil moisture is required for fast germination. First irrigation 25-30 days after sowing helps in faster vegetative growth of the crop. Water stress at the time of flowering affects the yield quality of the grains. Thus light irrigation is recommended just before the flowering. High moisture and water logging at any stage of crop growth damage the crop.

Manures and fertilizers

There is no sufficient knowledge on nutritional requirement of the crop. Thus systematic studies need to be conducted. Quinoa responds well to nitrogen fertilizer and about 80 q N, 60 kg P and 40 kg K/ha seem to be sufficient to obtain maximum crop yield. About 100-150 q/ha farm yard manure can be added in the soil before sowing for obtaining better results.

Intercultural practices

Quinoa can be grown like other *Chenopodium* species without much care. Thinning of crop after emergence at around 2 to 4 leaf stage is an essential operation to maintain plant to plant distance. Weeds is other challenge, which affects crop growth and yield. It should be removed in appropriate manner as soon as possible. Earthening of individual plant before flowering is considered necessary to support the plant to bear the panicle load and avoid breaking hollow stems.

Crop protection

Quinoa may be infected by pathogens like mildews, damping off, blight, mosaic etc. Viruses can also infect plants. However, no report on severe damage of the crop in India has been noticed. Downy mildew, damping off, stalk rot fungi of stem, stem gothic spot fungi, gray mould fungi, leaf spot fungi, bacterial blight bacteria, false nodule, chlorotic mosaic virus, *Chenopodium* mosaic virus and false nodule nematode etc. are some common diseases reported in quinoa from different parts of the globe. Birds also damage

considerably to quinoa seeds thus an average of 8-40% of damage was estimated in the certain quinoa growing countries. A wide variety of insects also damage quinoa during seed germination and up to harvest and seed storage. A variety of caterpillars (insect larve), beetles, aphids may cause damage to the crop. Quinoa plant bug (*Melanotrichus* sp.) and beet armyworm (*Spodoptera exigua*) etc. are other damaging insects reported world wide.

Harvesting and threshing

Quinoa can be harvested at the time of physical maturity when leaves become yellow and the seeds become harden, generally after 130-150 days (in plains) or even more 180-200 days (in hilly regions) depending on the variety and environmental conditions. Harvesting is done manually by cutting the plants from the base. After that plants are piled with panicle inward and the centre elevated so that water runs off and maintained there for 7-15 days. Pre-drying causes a reduction in the water content of the plant and protect them against rain and frost which also helps in fast and easy threshing. For threshing panicles are hit against the hard surface or rubbed with the hand to separate seeds. Quinoa plants are threshed in stationary mechanical threshers which can be operated by a tractor or by self-propelled motors. The seeds are cleaned by separating soil, stones, excrement and small and broken seeds from the material. In traditional winnowing the threshed material may fall on ground from hand or to a cloth or plastic in the afternoon wind currents. Clean seeds are exposed to the sun for 3-4 days, for removing excess moisture and reducing the chances of infection of pathogens. The dried seeds are then stored in dry and cool conditions, in appropriate storage containers and bags like wheat and barley.

Yield

A fully mature quinoa plant may yield 100 g to 300 g of seeds which may vary under different environment and soil conditions. Commercially 16 to 20 q/ ha grain is



harvested from a well managed crop depending upon soil, climatic conditions and other managerial practices of the crop.

Removal of saponins

Saponin is a water-soluble bitter soapy compound present in the seed hull, the outer seed cover, and cannot be recommended for direct processing and consumption. The cleaning of quinoa can be done by applying 30 min soaking and 20 minute agitation at 70°C that can reduce saponins satisfactorily to 0.04–0.25%. The wet method is traditionally used by peasants and housewives by successive washing of the grain and rubbing by hand or a stone to remove epispem, which contains saponin. At the industrial level, the humid method is not used due to high drying cost of seed and the formation of foam. The seeds are mechanically abraded against rough walls. The grain is then rubbed

against sieves to separate the next layer, and residues and saponin dust are eliminated. In another method preheated quinoa seeds are brushed for saponin removal. Dry methods are economical, simple, and do not lead to contamination, but they are relatively eliminating 80% of the saponin only.

Commercial products of quinoa

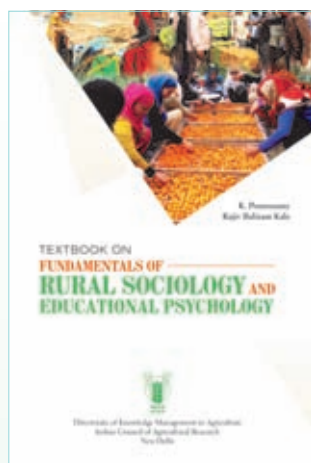
There are approximately 100 recipes reported worldwide in various preparations. Commercial quinoa products are such as pasta, bread, cookies, muffins, cereals, snacks, drinks, flakes, baby food, and diet supplements. Mostly these products have approximately 20% quinoa content. In India certain products prepared at Hyderabad situated institute. Quinoa rice, flour, cookies, bread, pasta, porgies, flakes are commercially available.

Properly cleaned, dried quinoa seeds can be packaged in polybags,

hard paper bags, small gunny bags and also in metal containers for selling and supplying purpose as similar to that of other cereal grains. Quinoa seeds having saponin layer intact may fetch little lesser cost, however, seeds without having saponin layer may fetch higher prices in the market. Being a high protein crop it may be used for self and family purpose before market search. There are lots of markets possibilities are now developing in India at different cities and malls with high demand of quinoa based costly products. Therefore, it can be concluded that the demand of quinoa and quinoa based product is increasing day by day and farmers of drought affected areas and hilly region of our country can grow this crop easily and exploit the diverse utilities of quinoa in near future.

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Textbook on Fundamentals of Rural Sociology and Educational Psychology



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TECHNICAL SPECIFICATIONS

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