

Quinoa

A nutritive alternative crop to the saline land of Gujarat

Vineeth T. V.^{1*}, Anil Chinchmalatpure¹, Kailash Prajapat², Shravan Kumar¹ and Parbodh Chander Sharma²

ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch 392012, Gujarat

Soil salinity is one among the major factors responsible for large scale land degradation and decline in productivity. Gujarat alone contributes to a total salt affected area of 2.22 Mha. Conventional crops cannot be grown successfully in these salt affected soils. Biosaline agriculture is gaining fast momentum across the world which demands the cultivation of alternate salt tolerant crops in these barren lands. Quinoa is an edible, annual seed crop, high in protein content and salt tolerance. It can tolerate up to a soil salinity of 15-20 dS m⁻¹ without significant compromise in yield. Introduction and popularization of this crop in the vast tracts of saline land in Gujarat has tremendous potential in safeguarding the income of resource poor farmers.

Keywords: Nutritive alternative crops, Protein, Quinoa, Saline land

Introduction

Cultivable land is decreasing because of vegetation loss, soil erosion, inadequate water management, excessive use of fertilizers, soil and groundwater degradation, urbanization, climate change and poor agricultural practices. One of the major causes of land degradation is buildup of soil salinity as a result of natural and manmade factors. It is estimated that agricultural soils are decreasing about 1-2 % every year especially in the arid and semiarid regions of the World due to soil salinity.

The total cultivable land area of India is 142 Mha. Out of this, 6.74 Mha is degraded due to soil salinity and alkalinity and it is likely to increase to 16.2 Mha by 2050. Gujarat alone contributes to a total salt affected area of 2.22 Mha. Moreover, around 33.5 % of Gujarat's total area is already subjected to varying degrees of soil erosion. The major reasons for increase in salt affected areas in Gujarat are the arid, semiarid climate, sea water intrusion, over extraction of ground water for intensive cropping,

injudicious use of canal water and other unscientific farming practices. Moreover, heavy industrialization has also caused increased discharge of various harmful effluents in to rivers thereby polluting the ground water resource. Rain water scarcity/drought or high intensity rainfall over short period of time is other characteristic features of Gujarat. In general, saline water of TDS (total dissolved solutes) more than 2000 ppm is used for irrigation in many parts of the state, making the soil more and more saline. Moreover, out of the total 8100 km long coastal line of India, 1,600 km passes through Gujarat. It is a State of industries and more and more productive agricultural land is diverted towards industrialization and urbanization. The soil organic matter content is also decreasing rapidly which can lead to further increase in soil salinity. So we are running out of options, and the only option left is to bring this barren, salt affected land in to cultivation to meet the growing food demand and more importantly to address the growing climatic and ecological concerns. But, major agricultural crops and trees

cannot be grown in such soils as they exhibit a low tolerance to salt. So future agricultural production in these saline soils should be based on salt tolerant crops which are edible and/or of economic and ecological significance. This is called as "Biosaline agriculture" which can help small farmers feed their families and livestock.

Quinoa: Origin and distribution

One such crop is "quinoa" which is an edible annual seed crop which is famous for its protein content and high salt tolerance. It is a native of South America where it has been cultivated and consumed for thousands of years. The people of South America are often called as "Andeans" and they have maintained, protected and preserved this food crop using their indigenous knowledge and farming techniques. These people harvest the grain, roast it and made to flour to make various kinds of bread. It can also be used as a cereal, soup and made in to pasta. The total production of quinoa in South America was 70,000 tonnes in 2009. Now, this crop has spread to

more than 70 countries including India and the total global area and production accounts to 126000 ha and 103000 tonnes respectively. In India, it is cultivated in an area of 440 hectares with an approximate total production of 1053 tonnes.

Nutritive and health benefits of Quinoa

The year 2013 was declared as the “International year of quinoa” by the United Nations General Assembly which indicates the potential of this crop. This crop can be grown in marginal to highly saline soils under *rainfed* condition or irrigation with saline water. Quinoa is unique, in that it is a seed eaten as a grain. It is a rich source of protein, dietary fiber, polyunsaturated fats and minerals. The protein content of quinoa ranges from 12-17% depending up on variety, climate and cultivation practice. This is significantly higher than the protein content of rice (6-7%), wheat (10-14 %) and barley (8-14%). As we know, cereals like rice and wheat protein are deficient in the aminoacid lysine and pulse protein is deficient in methionine, but Quinoa protein contains both lysine and methionine and therefore is often called as complete protein. Quinoa does not possess gluten type of protein and hence is a very safe source of protein to diabetic patients who are gluten sensitive. The nutritive value of quinoa is summarized in Table 1. The oil content is 1.8 to 9.5 % and rich in essential fatty acids. It also contains natural antioxidants like β -tocopherol (5.3 mg/100 g seed), β -tocopherol (2.6 mg/100 g seed), polyphenols and phytoestrogens that prevent heart diseases, osteoporosis and breast cancer. Moreover, because of its low glycemic index and digestibility of 80 %, quinoa can be used to replace common cereals in a diabetic diet.

Morphology, yield potential and preliminary package of practices

This plant belongs to Amaranthaceae family which includes other major food crops like beet root, spinach and sugar beet. Duration of the crop is 70-200 days depending up on variety. It has a deep, fibrous root system which is often ramified and robust that helps to cope up with

Table 1. Comparative analysis of nutritive value of quinoa and major cereal crops

	Quinoa	Rice	Wheat	Maize
Energy (Kcal/100g)	399	372	392	408
Total carbohydrate (g/100g)	69	80.4	78.4	81.1
Protein (g/100g)	16.5	7.6	14.3	10.2
Fat (g/100g)	6.3	2.2	2.3	4.7
<i>Vitamin (mg/100g)</i>				
Thiamin	0.2-0.4	0.06	0.45-0.49	0.42
Riboflavin	0.2-0.3	0.06	0.17	0.1
Folic acid	0.0781	0.02	0.078	0.026
<i>Minerals (mg/100g dry weight)</i>				
Calcium	148.7	6.9	50.3	17.1
Iron	13.2	0.7	3.8	2.1
<i>Aminoacid (g/100g protein)</i>				
Lysine	6.0	3.8	2.6	2.9
Methionine	5.3	3.3	3.7	4.0

Source: Adopted and modified from FAO, 2013

drought and provides increased stability. Quinoa is efficient in water use despite being a C3 plant as it possesses physiological mechanisms that enable it to avoid moisture deficit and tolerate drought. The ideal temperature for its growth is 15-20 °C, although it withstands temperature extremes ranging from 38 °C to -8 °C. It withstands intense solar radiation enabling it to gain the hours of heat needed to complete its life cycle. Its robust character is due to a high tolerance level of frost and soil salinity up to 40 dS m⁻¹.

Stem is cylindrical at base may or may not be ramified depending on the variety. Leaves consist of calcium oxalate crystals which help the plant to absorb moisture during night, reduce transpiration and warming from solar radiation. Flowers are very small in size and without petals and may be bisexual, female or male sterile. It may be self pollinated or cross pollinated. The inflorescence is called as panicle which consists of a loose or compact central axis and number of seeds per panicle ranges from 100-3000. Seeds are of varying colours like white, yellow, red and black depending on the variety (Fig. 1) (<http://www.fao.org/quinoa-2013/what-is-quinoa/plant/en/>). The seed yield of the crop ranges from 2-7 tonnes/ha depending on variety, soil and climatic conditions. In India, only very few research attempts has been done on screening of quinoa genotypes, adaptability to our climate and package of practices. The genotypes originated from Inter-

Andean valleys of Bolivia whose grains are small and white or yellow in colour are more suited to Indian climate.

Package of Practice

Preliminary results showed that October 15 is the suitable planting date in south Indian conditions with spacing of 15 × 10 cm that can fetch an average yield of 15-20 quintal/hectare. The seed rate varies with variety and it ranges from 1.25 to 5 Kg/ha. Seed rate of 8-10 kg ha⁻¹ may be used under saline conditions for optimum plant stand. In black cotton soils (*Vertisols*), nursery preparation followed by transplanting of 25-30 days old seedlings can be practiced for better establishment of the crop. Preliminary fertilizer recommendation is 100 kg N, 50 kg P₂O₅ and 50 kg K₂O ha⁻¹ in the form of urea, single super phosphate and muriate of potash, respectively.

Half of the N and full dose of P and K should be applied as basal, While half dose of N may be top dressed at flowering stage through urea. Under rainfed conditions with no irrigation facility it can be grown with half or even without fertilizers with only application of organic manure. There should be proper moisture at the time of germination. Seed should not be shown below 2 cm depth otherwise germination will be poor. Water soaking of seed for 6-8 hrs followed by shed drying and shallow showing depth in moist soil may be adopted for proper germination.



Fig. 1. Picturesque vies of quinoa plant and grain at ICAR-CSSRI, Karnal.

Uses and market potential of Quinoa

Quinoa has the potential to replace or complement rice, wheat and maize as a major source of energy and protein. It is a potential breakfast item to school going children along with pulses like mung and chickpea. Moreover, products made out of quinoa can be sold and exported as gluten free products. The major uses of quinoa are summarized in Table 2. Processed and semi processed packed food made out of quinoa is available in the market, but it is highly expensive. So, farmers groups/associations can become small entrepreneurs by starting a quinoa based value addition set up.

Salinity and quinoa

Quinoa is a facultative halophyte with very high salt tolerance (15-20 dS m⁻¹). Existing quinoa germplasm in India has been reported to display very high variability in salt tolerance. ICAR-Central Soil Salinity Research Institute (CSSRI) has initiated a network project on morpho physiological characterization and standardization of agronomic practices of quinoa (*Chenopodium quinoa*) for salt affected agro-ecosystems. Quinoa germplasm is

being screened at various salt stress levels by irrigating with saline water of different electrical conductivities (Fig. 2).

The preliminary results showed that some of germplasm gave

satisfactory grain yield of about 6.2 to 7.0 g/plant under high irrigation water salinity of 24 dS m⁻¹. Under field conditions, grain yield of 35 to 40 q ha⁻¹ was obtained in the saline soil of 6-8 dS m⁻¹ EC₂, however the

Table 2. The potential economic uses of quinoa.

Plant part	Uses/remarks
Whole grain or seed	Direct consumption as cereal.
Tender leaves	Direct consumption (33 % protein/g dry weight).
Grain flour	Products like raw or roasted flour, flakes, semolina, breads, sauces, noodles, desserts, sweets.
Grain	Baby foods; consumed by mixing with hot water.
Grain flour	Added to different products like bread, noodles and biscuits at 40, 40 and 70 % respectively.
Seed embryo	45 % protein; can be separated from the seed incorporated in to baby food and other sources as very high protein source for pregnant women and children requiring quick nutritional recovery.
Leaves and stem	Potential source of green and dry forage for cattle, goat, sheep, poultry, pigs and horses.
Whole plant	Medicinal uses: wound healing, reducing swelling, toothache, disinfecting urinary tract, bone setting, stopping of internal bleeding and as insect repellants.
Grain	Starch granule extraction; Starch is very small in size and highly stable making it a potential candidate for use in aerosol production, pulp, talc, plastic industry, paper industry etc.
Bran	Extraction of saponin which has high demand in pharmaceutical industries for developing medicines for increased intestinal permeability, high cholesterol and antibiotics.
Whole plant	Bio-insecticide
Whole plant/grain	Industrial uses: Food, cosmetics, pharmaceuticals. Saponin production which is needed in manufacturing of toothpaste, shampoo, detergents, beer, pesticides and antibiotics.

Source: Adopted and modified from FAO, 2013



Fig. 2. Evaluation of Quinoa germplasm under different salt stress levels.

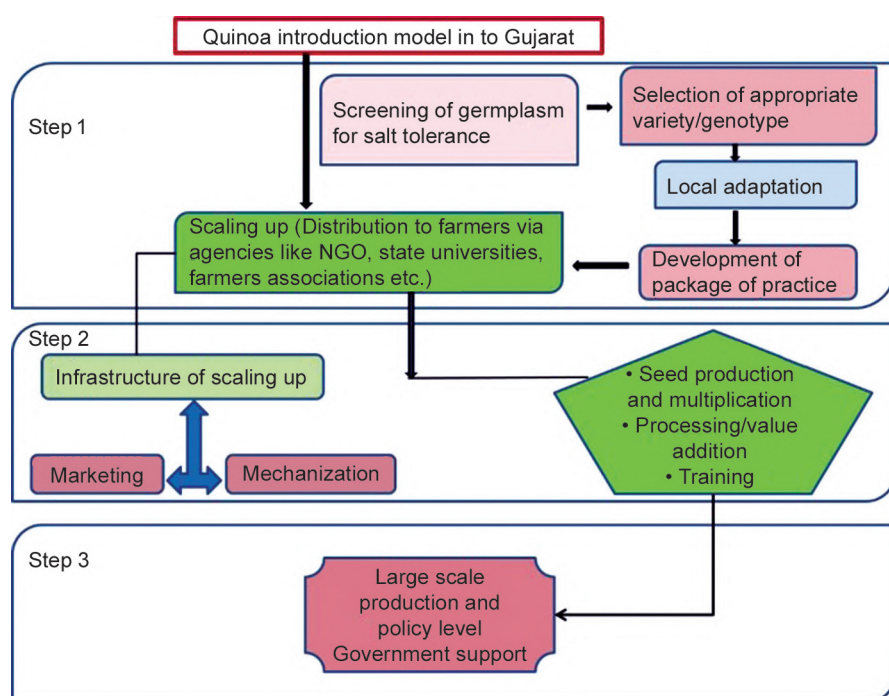


Fig. 3. The flow chart showing the predicted model of introduction of quinoa in to a new area.

crop received good amount of winter rainfall and no irrigation was applied. Field germination was the main problem experienced due to its small seed size. Efforts are being made to explore the more genetic variability for salt affected agro-ecosystem of the country with standardization of agronomic practices.

The genetic variability for salt tolerance shows that it can be cultivated in highly saline soils which hitherto remain barren due to high salt and thereby improve the economic status of resource poor farmers of such areas. It is a hardy crop and has been successfully cultivated in saline soils. It has

specialized structures called Epidermal bladder cells (EBCs) on its leaves, stems and flowers which can capture the excess sodium (Na), retain more potassium (K) and beneficial metabolites, thereby reducing crop damage due to salinity. Researchers across the world have also found out various other ways by which this crop survives high dose of salts in soil. Altogether, quinoa can grow and yield seeds with relatively stable protein content over a wide range of salt affected soils.

CONCLUSION

ICAR-CSSRI imported improved

varieties of wheat from Mexico which in turn brought green revolution in the 1970s. Similarly, it is high time, we introduce alternate crops like quinoa which has the potential to grow and yield in degraded barren saline soils of India. Malnutrition of our children and pregnant women (45 % and 70 % respectively) can be addressed by such highly nutritive crops with quality protein. It is also a possible remedy to the huge fraction of diabetic patients in India (52 %) due to overdependence on rice and wheat. Quinoa can play a major role in future diversification of agriculture system in Gujarat. The predicted model for introduction of quinoa in to a new area is shown in Fig. 3.

However, the adoption rate is very slow in India due to absence of potential market, value chain and inability of people to change their long standing food preferences. The genetic variability of quinoa is immense and further field studies are needed to find out varieties suitable to our soil and climatic conditions. So, let us be the whistle blowers, the change makers towards an altered food preference for enhanced nutritional security.

¹ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch 392 012, Gujarat; ²ICAR-Central Soil Salinity Research Institute, Karnal 132 001, Haryana; *Corresponding author's email: vinee2705@gmail.com / vineeth.tv@icar.gov.in