

Quinoa: A climate resilient crop

for sustainable livelihood security of small and marginal farmers of Odisha

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Government of India has included quinoa under Millet Mission as a pseudo millet crop for its wide adoption. The speciality of this crop lies with the nutritional and medicinal value, and its ability to grow in marginal lands under moderate moisture deficit and salinity stress. The crop can be fitted to rice fallows of eastern India with minimum water and pest management practices. An average yield of 1.0–1.5 t/ha is generally reported under field conditions, though its potential yield is up to 4 t/ha. High market value of quinoa seeds (₹150/kg), low cost of cultivation and stress tolerance of the crop has scope for crop diversification in eastern India. In addition to the local market, the international market should be explored for export of high-quality quinoa grains. This may help in enhancing the profit margin further.

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QUINOA (*Chenopodium quinoa* Willd.) belonging to family Amaranthaceae is a C₃ Andean grain crop. It is cultivated in more than 120 countries worldwide including Peru, Bolivia, Ecuador, Columbia, Chile, Brazil France, England, Sweden, Denmark, Holland, Italy, several African counties, Turkey, Greece, Morocco, China, India, Pakistan, New Zealand, Australia, Canada, United States and the Mediterranean regions in an area of 126 thousand hectares with a production of 103 thousand tonnes. The crop is gradually gaining popularity since it is well adapted to marginal soils, and can be grown under extreme abiotic stress like drought, salinity and temperature. Quinoa grains are rich in protein (14–18%), fat (6%) and minerals, while also being gluten-free and well balanced with essential amino acids. Its nutritional values and ability to grow in marginal land and produces reasonably well under abiotic stress has contributed substantially to food and nutritional security of several regions of world. Considering the scope and prospects of Quinoa

cultivation, the United Nations declared 2013 as the International Year of Quinoa. In India, quinoa is cultivated in an area of 440 ha with an average yield of 1053 tonnes and gaining popularities in Rajasthan, Karnataka, Andhra Pradesh, Tamil Nadu and other eastern Indian states. Government of India has recognised the importance of quinoa as a climate resilient crop in India and included under Millet Mission as a pseudo millet crop for its wide adoption.



Quinoa seeds

Uses of Quinoa

Quinoa grains are rich in carbohydrates, fats, proteins, minerals and bioactive compounds having antioxidant properties with

balanced amino acid. On an average, the seed contains 10–18% protein, 4.5–8.8% crude fat and 54.1–64.2% carbohydrates. Grains are consumed as staple food for pre-Columbian Andean farming communities in South America. Besides, quinoa seed is also used as animal feed. The whole plant can be used as green fodder and crop residues can be fed to the animal. Oil, starch, saponin, protein concentrates and quinoa milk are extracted from quinoa seeds. Dye is extracted from leaf and seed for industrial use. Thus, it is a versatile resilient crop for coming generations.

Quinoa starch is made of uniform and small granules. This property makes its use as a raw material in several industrial applications. Saponins present in quinoa seeds can be extracted and used in insecticides, antibiotics, fungicides, and pharma industries. Quinoa also helps to reduce the risk of various diseases in human beings like cardiovascular diseases, type-2 diabetes, cancer, high blood pressure and obesity. Quinoa as a break crop in crop rotations minimises incidence of

diseases. For its diversified food, fodder, industrial and ecological value, the researchers and policy makers predict that quinoa will emerge as one of the most climate resilient crop for the humanity under the scenario of climate change.

Soil and climatic requirement

Quinoa requires short day lengths and cool temperatures for good growth. The crop can be cultivated under wide range of temperature (-4°C – 38°C). However, for better crop growth, optimum temperature is 8 – 35°C and it can survive even night frost for few hours. Temperature beyond 45°C tends to cause pollen sterility. Relative humidity of 40 – 88% favours plant growth and can produce substantial grain yield even in low rainfall regions (100 – 200 mm). Quinoa can be cultivated from the sea level to 4000 m altitude. Well drained soil is good to grow quinoa. Quinoa can grow in a range of soils from clayey to sandy including marginal soils with a pH of 4.5 – 9.5 . Quinoa prefers cool soil conditions (25 – 35°C). Germination occurs within 24 – 48 hours after sowing when adequate moisture is present, and seedlings emerge in 3 – 5 days. It can tolerate salinity of 10 – 15 dS/cm electrical conductivity.

Varieties

Quinoa is recently introduced in India and research has been initiated to develop high yielding varieties for different regions. At present land races having different seed colours like black, red, pink, orange, yellow, or white are available for cultivation. The seed colour is due to presence of the alkaloid saponin which has several medicinal properties.

Crop establishment

Direct dry seeding is a common method of crop establishment. However, it can be substituted by transplanting of 20 – 25 days old seedlings in main field. Sowing of seeds by small hand operated seeder or manual method ensures uniform seed distribution and better crop growth. Line sowing of seeds on beds adopting broad bed and furrow



Line sowing on broad beds

method helps in better emergence of seedlings and optimum plant population than sowing on flat beds. Seeds should be sown at a shallow depth of 1 – 2 cm in a homogeneous, fine-structured and moist seed bed. Since seeds are very small, it is better to mix the seeds with a similar volume of dry sand for uniform distribution of seeds.

Seed rate, seed treatment and optimum crop geometry

Sowing is one of the most important activities, because the emergence of seedlings impacts plant density and final yields. Optimum seed rate is 15 – 20 kg seed per hectare. Seeds should be treated with *Trichoderma* dust formulation @ 10 g/kg before sowing. Seed treatment with this biopesticide is useful in avoiding seed borne and some soil borne diseases in an eco-friendly way. A row to row spacing of 25 – 30 cm and plant to plant spacing of 10 – 15 cm ensures optimum plant population for high yield. Excess plant population should be thinned out at early stage of crop growth, preferably within 20 days of germination. Thinned out seedlings can be used as very good green vegetable. In case of surplus, it can be used as fodder.

Optimum sowing time

Mid-October to mid-November is the optimum sowing time of quinoa in eastern India. This sowing time is similar to sowing time of other cool season crops like toria, mustard, wheat, pea, gram, etc. Delay in sowing reduces the crop growing period and adversely affects the yield attributes and grain yield in quinoa.



Line sowing on flat beds

Nutrient management

The crop requires well decomposed FYM @ 5 – 10 tonnes/ha which should be applied 10 – 15 days before sowing during final land preparation. Blanket application of fertilizers at 120 kg N, 50 kg P_2O_5 and 50 kg K_2O /ha in the form of urea, single super phosphate and muriate of potash is recommended for optimum production of quinoa under irrigated ecology. Entire dose of P, K and $\frac{1}{2}$ of N should be applied as basal and remaining $\frac{1}{2}$ dose of N in two equal splits at 20 – 25 and 45 – 50 days after sowing.

Water management

Quinoa is a drought tolerant crop with water requirement of 250 – 325 mm. The crop responds well to irrigation in light textured sandy-loam or loamy-sand soils. The crop coefficient of quinoa varies from 0.5 in the initial growth stage, 1.0 in the mid-season stage and 0.7 at harvest. Excessive irrigation in the seedling stage causes several soil burn diseases which ultimately affect the crop stand establishment. Three to four irrigations during its growing cycle at critical growth stages, viz. vegetative, flowering and grain filling period ensure optimum yield. Irrigation in furrows is superior than check basin method. Drip irrigation scheduled at 1.0 Epan throughout cropping period recorded higher growth, yield attributes and yield and water use efficiency compared to other surface and drip irrigation methods. Under deficit water supply, drip irrigation with 0.5 Epan at vegetative and 1.0 Epan at both flowering and at grain filling stage can be recommended for quinoa



A view of crop at flowering stage



Field view of quinoa under different irrigation treatments

production with minimum yield penalty.

Weed management

Crop-weed competition in quinoa severely reduces the grain and stover yield. Growth and development of quinoa crop is very slow during the first two weeks after emergence. Integrated approach like use of weed seed free quality seeds, well decomposed organic manures, early sowing with pre-sowing irrigation enable quinoa to have a head start over weeds. Initial 16 days from sowing are critical for crop weed competition. If sown at a row spacing of 25–50 cm, mechanical hoeing for weeding can be performed, and then the plants can suppress the weeds. If mechanical weeding is not possible, one hand weeding at 20–25 days after sowing followed by top dressing of fertilizers minimises the crop weed competition in quinoa. Application of post emergence herbicide as an alternate to hand weeding severely affects the crop yield. This requires further investigation for establishment of herbicide selectivity in quinoa.

Insect pest and disease

Insect pests attacking quinoa cause damage ranging from 8–40%. However, presence of saponins in grains offers resistance against damage due to insect pests and birds. Mildews, damping off, blight and mosaic viruses are known to infect the crop. Amongst these, downy mildew causes a yield reduction of 33–58%. High humidity and warm conditions favour development of downy mildew.

Cropping system

Being a short duration, deep rooted and low water requiring crop, quinoa can be well fitted to various cropping systems as pure and inter crop. Due to its ability to grow in marginal soils and adverse ecologies, it is best suited for climate-smart cropping system. Inclusion of quinoa in cropping system will ensue agro-ecological intensification of rice fallows and upland irrigated ecologies.

Harvesting and yield

The yellowing and shedding of leaves followed by drying of plants indicates maturity of quinoa crop. Threshing can be done by sticks, bullock or by threshers. At optimum level of farm management practices, potential yield of 4 t/ha of grain can be harvested. Average yield of 1.0–1.5 t/ha is generally reported under field conditions. Winnowing and cleaning should be done by fanning mill and gravity separator. After cleaning, seeds should be dried under sun for 1–2 days for reducing moisture content to 10% for prolonged storage. International Rice Research Institute (IRRI) super bags may be used for safe storage and for fetching good market price.

Economics

Under optimum level of management, quinoa produces 1.5–2.0 t/ha of grains along with bhusha (straw) of 1.8–2.5 t/ha. The results of experiment conducted at ICAR-Indian Institute of Water Management (IIWM) research farm revealed that sowing on broad bed and furrow methods with 4 irrigation resulted in crop

productivity of 20.34 kg/ha/day. The cost of cultivation was ₹44300/ha. Net computed income based on prevailing local market price and demand was ₹60000/ha with B:C ratio of 2.37.

Way forward

Quinoa is a new crop to the farmers of Odisha. Development of location specific and farmers friendly varieties and establishment of seed production system will ensure the availability of quality seeds to the farmers for cultivation in appropriate time. More research is required for development of integrated crop management practices with special emphasis on irrigation schedule and methods of sowing for higher water productivity and net farm income.

SUMMARY

The food and nutritional value along with well accepted agronomic characters of quinoa crop has opened opportunities to cultivate in various states of India. The crop can be fitted to rice fallows of eastern India with minimum water and pest management practices particularly true for Odisha. During wet season, rice is leading cereal crop in Odisha. About 2.1 million hectares rice fallows are underutilised due to lack of assured irrigation facilities. Short duration and low water requirement crop like Quinoa can be taken with minimum effort in rice fallows of several districts of Odisha. With adoption of improved varieties and package of practices, quinoa can be cultivated on sustainable basis in both rainfed and irrigated ecologies. The role of policy makers, research institutions, farmers, and supply chain are important for its production, use and consumption. In addition to the local market, the international market should be explored for export of high-quality quinoa grains matching the consumer demand with good branding for enhancing the farm income and ensuring food and nutritional security of small and marginal farmers under climate change scenario.

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