



QUINOA - Research and Development at the International Potato Center (CIP) ¹

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Quinoa is a highly nutritive food product, being cultivated for more than 7000 years in South America, due to an outstanding protein quality and a high content of a range of vitamins and minerals. Other characteristics are saponins in the seed hull and lack of gluten. Quinoa is one of the main food crops in the Andean mountains, but during recent time has also arised interest for the product in the United States, Europe, and Asia. Quinoa has been selected by the Food and Agriculture Organisation (FAO) as one of the crops destined to offer food security in the next century.

The Quinoa Project CIP-DANIDA has been very active and creating results, which has added valuable activities to CIP's agenda (see next chapter). The project has been built up and consolidated in only three years, presently consisting of 3.25 scientists in CIP and a large number of national partners (universities, NARS, NGO's etc.) in the three Andean countries Peru, Bolivia and Ecuador, in addition to collaborators in the rest of South America, in the USA, Europe, Africa and Asia. It is positive when considering the biodiversity aspect that not only the major crops (potato and sweetpotato), but also the minor Andean crops are included into CIP's agenda, positioning CIP as an international center working with underutilized species of high potential, such as the Andean roots and tubers and quinoa.

Through collaboration with FAO the project is coordinating the Quinoa Test, where a range of quinoa cultivars are sown all over the world. The first results indicate that quinoa has a potential in several new locations, such as in Africa and Asia. 71 students from the Andean countries have had the opportunity to perform their thesis work in the project, and these investigations have resulted in a large number of publications, presenting new knowledge and new uses of quinoa. An international workshop was arranged in 1999. New project applications are steadily developed with both the traditional and new partners, and several proposals have been approved. A formal agreement with the Royal Veterinary & Agricultural University, Copenhagen (KVL) is being established, which will imply exchange of students and professors. Collaboration and support to national institutions in South America has been considerable, through research work, student theses, field days etc.

The primary beneficiaries of the work have been the small-scale Andean farmers (improved seed material, Field Days), NARI's (student thesis, collaboration, teaching), small enterprises

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(specific products from specific cultivars), and consumers (new products, improved quality, lower price). The enrichment of the research capacity of national researchers through the scientific cooperation with national institutions should secure a positive effect in the long term, and also more directly when focusing on participative research in farmers communities, which is being built up at present. The key term is sustainable production of quinoa, including organic production for export, to help solving the problems of malnutrition, and to increase food security and farmers income.

This is what we have obtained.

NEWS ABOUT QUINOA

- **Quinoa has an extremely high nutritive value**

Quinoa is the most complete seed product existing, due to a high protein quality, explained by a high content of the essential amino acids, such as lysine, threonine and methionine, which are of shortage in the cereals and legumes. The content of vitamins (A, B₂, and E), and of minerals (calcium, iron, copper and zinc) is high. Only 11% of the fatty acids are saturated, the most common of the unsaturated being linoleic, oleic and linolenic acid with 54, 22 and 7%, respectively.

- **Quinoa can grow almost anywhere in the world**

The Quinoa Test has shown that quinoa can be grown in large parts of Latin America, Africa and Asia, providing high quality food products for improving food security. Yields of up to 4 t/ha were obtained in Kenya.

- **New, promising products, based on quinoa, elaborated**

Quinoa milk and tempeh (alternative to gene modified soybean, of much consumer attention), protein concentrates (based on the embryo, 30-40% protein, for intensive rehabilitation programmes for undernourished), and natural colorants (betalains, for use in food).

- **Quinoa can grow in seawater**

It has been demonstrated that in general the salt tolerance of quinoa is very high, being able to grow and produce in salt concentrations similar to sea water (40 mS/cm). 4 salt tolerant lines identified, with even better tolerance, which will form base of breeding programmes.

- **Quinoa can grow under extremely dry conditions**

Quinoa can grow with only 200 mm rainfall in pure sand. 9 drought resistant lines identified, which will form base of breeding programmes. All drought mediating mechanisms found. Quinoa may be a potential alternative crop for growing in drought-prone areas of Africa and Asia.

- **Quinoa survives night frost**

High degree of frost resistance (-8 C for 2-4 h).

- **New varieties are on the way**

Within the next three years new at least three varieties might be released for each of the countries, with improved resistance characteristics to drought, frost and disease, and improved commercial value, for enhancing food security and create income from national and international market.

- **Quinoa demand for export increasing**

The demand for organic quinoa to be exported to the USA, Europe and Asia seems to be increasing, estimated to at present 3000t/year, a production which does not exist.

MEETINGS FOR FARMERS AND SCIENTISTS

- **Field Days (1/y.*country)**

Total attendance 2500 farmers, students, university staff, authorities etc., discussing the progress in the work with quinoa, evaluating cultivars and breeding material from the Andean region and Europe, and receiving seed material and a leaflet on the growing of quinoa.

- **Postgrade Course on Stress Physiology, 1-6 December, 1997, Puno, Peru**

42 participants learning from theory and practical exercises about this important subject for crop production in the Andes, under the harsh climatic conditions existing.

- **The Quinoa Test, 1998-2000**

87 institutions in 25 countries have sown a range of cultivars, representing the variability in the species, demonstrating the adaptability of quinoa to a large range of climatic conditions and countries all over the world.

- **I International Workshop on Quinoa, 10-14 May, 1999, Lima, Peru**

140 participants from 14 countries presented results with quinoa and exchanged ideas, proving the interest for the crop.

- **III Festival Internacional de la Quinoa, 8-10 September, 2000, Puno, Peru**

Presentation of products, dishes, and seeds.

PUBLICATIONS

- **Books**

- Field book from American and European Test of Quinoa:

Mujica, A., S.-E. Jacobsen, J. Izquierdo & J. Marathee. 1998. Field Book of the American and European Test of Quinoa. FAO, UNA-Puno. Editor CIP, Lima, Peru, 37 pp.

- Drought stress physiology in quinoa:

Jacobsen, S.-E. & A. Mujica, eds. 1999. Fisiología de la Resistencia a Sequía en Quinoa (*Chenopodium quinoa* Willd.). I Curso Internacional sobre Fisiología de la Resistencia a Sequía en la Quinoa, 1-6 December, 1997, Universidad Nacional del Altiplano, Puno, Peru, 79 pp.

- Proceedings of First International Workshop on Quinoa, CIP, Lima:

Jacobsen, S.-E. & A. Valdez, eds. 1999. Libro de Resúmenes, Primer Taller Internacional sobre Quinoa – Recursos Genéticos y Sistemas de Producción, 10-14 May, UNALM, Lima, Peru, 131 pp.

- Human nutrition based on Andean crops:

Mujica, A., J. Izquierdo, J.P. Marathee, C. Moron & S.-E. Jacobsen (eds.). 1999. Reunión Técnica y Taller de Formulación de Proyecto Regional sobre Producción y Nutrición Humana en base a Cultivos Andinos. Arequipa, Perú, 20-24 julio, 1998, 187 pp.

- **Scientific papers and proceedings**

Presenting the results mentioned above

- **Leaflets**

Growing of quinoa

In total have been performed 71 experiments for thesis (M.Sc. + B.Sc.), creating valuable results, which have been presented in 78 publications (scientific papers, books, book chapters, proceedings, leaflets).

- **External funding proposals**

Successful project applications to complement the core budget have enabled us to initiate important programmes on disease and disease resistance in quinoa, and on integrated pest management (IPM) strategies, important components in an organic production scheme. The demand for organic quinoa is increasing, but a production manual does not exist. Hence the proposals under preparation regard organising of farmers and linking them closer to the agroindustry, in order to increase export of products with an added value; introducing modern

molecular techniques in the breeding (marker assisted breeding); and a gap-filling collecting, characterization, conservation and use of native and wild quinoa species (see Annex).

Annex

Project title	Partners	Funding	Start	Duration
Successful				
Characterization of downy mildew (<i>Peronospora farinosa</i>) and identification of resistance in quinoa (<i>Chenopodium quinoa</i>) from the Andean highlands	KVL	RUF, DANIDA	Feb. 98	2y.
Resistencia horizontal del mildiu (<i>Peronospora farinosa</i>) en quinua	UNAP, INIA	PREDUZA, Wageningen	Jan. 99	3y.
Uso y conservacion de germoplasma de quinua	PROINPA	Danish embassy, La Paz	Jan. 99	1y.
The biology of the q'hona q'hona – IPM components for the quinoa production in Peru and Bolivia, with special emphasis on the ecology of the main insect pest	KVL, UNAP	RUF, DANIDA	Feb. 00	10m.
Chemical analyses of quinoa, maca and maize	UNAP, CARE-Peru	Limagrain	Sep. 00	1y.
JPO – Late blight and downy mildew	KVL	DANIDA	Jul. 00	2y.
Produccion organica de quinua	INIAP	PROMSA	2000	3y.
Submitted/to be submitted				
Quinoa (<i>Chenopodium quinoa</i> Willd.), a multi-purpose crop for agroindustrial uses in the Andean countries	UNAP, PROINPA, UNB (submitted via CONCYTEC)	PGTF (United Nations)	2000	1.5y.
The genetic base of salt tolerance in quinoa	NIAB	IPEN/IAEA	2000	8m.
Quinoa – A new crop for Africa	CIP-SSA, MAWRD	EENESA	2000	1y.
Climate and agro-ecosystem: The role of biodiversity to face climatic constraints	IRD, PROINPA	IRD	2000	3y.
Improving sustainable productivity of quinoa (<i>Chenopodium quinoa</i> Willd.), an under-utilized species of the Andean region	PROINPA, BYU	McKnight	2001	9y.
Manejo y uso de la diversidad genética de quinua (<i>Chenopodium quinoa</i> Willd.), una especie sub-aprovechada de la región Andina	IPGRI, PROINPA, UNAP, UNB, INIAP, UAP	To be defined	2001	3y.
Rural life strategies under different degrees of drought and frost risk in the high Andean region	ICARDA, PROINPA	US Foundation	2001	3y.
3 UK projects: Genetic diversity, saponins etc.	NIAB, US, CAZS, JIC	BBSRC, DFID	2001	3y.
Others	UNAP, PROINPA etc.	CARE-Peru, CARE-Bol.	2000	Sev. y.
Quinoa as a commercial export crop	CIP-Quito, NGO's	FECD	2001	2y.

Abbreviations:

KVL: Royal Veterinary & Agricultural University, Copenhagen, Denmark
 UNAP: Universidad Nacional del Altiplano, Puno, Peru
 CONCYTEC: Consejo Nacional de Ciencia y Tecnología, Peru
 PROINPA: Fundacion para la Promoción e Investigación de Productos Andinos, Cochabamba, Bolivia
 INIAP: Instituto Nacional de Investigaciones Agropecuarias, Quito, Ecuador
 NIAB: National Institute for Agricultural Botany, Cambridge, England
 MAWRD: Min. of Agriculture, Water and Rural Development, Windhoek, Namibia
 IRD: Institute de Reserche y Developpement, France
 IPEN: Instituto Peruano de Energia Nuclear, Lima, Peru
 EENESA: Environmental Economics Network for Eastern and Southern Africa
 UNB: Universidad Nacional de Bogotá, Bogotá, Colombia
 UBA: Universidad de Buenos Aires, Buenos Aires, Argentina
 UAP: Universidad Arturo Prat, Iquique, Chile
 BYU: Brigham Young University, Utah, USA
 US: U. Sussex, England
 CAZ: Center for Arid Zone Studies, Bangor, Wales
 JIC: John Innes Center, Norwich, England
 BBSRC: Biotechnology and Biological Sciences Research Council, UK
 FECD: Fondo Ecuatoriano Canadiense de Desarrollo, Quito, Ecuador