STUDY ON THE SOCIAL, ENVIRONMENTAL AND ECONOMIC IMPACTS OF QUINOA PROMOTION IN BOLIVIA

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CHAPTER I

1. Importance of the Quinoa Crop

The importance of Quinoa (*Chenopodium Quinoa Willd.*) is due to its outstanding agronomic and nutritional qualities. With regard to agronomics, its tolerance to freezing, drought and salinity make this species the most suitable one for cultivation on the Bolivian Altiplano [Bolivian high plain]. Its nutritional qualities, in particular its protein content, make this a very important product for nutrition and food security, mainly for the populations of the Andean region.

The nutritional qualities of quinoa are due to the fact that it possesses all the essential amino acids and minerals which are far superior to those of other cereals. It is considered to be a good substitute for milk and meat, which is of interest to the developed countries; this situation is advantageous to the quinoa exporter and, accordingly generates increased income for those involved with the crop. However, there are requirements with respect to quality and competitiveness, which calls for research geared towards satisfying the existing and future requirements of the market (Bonifacio, 1995).

At the present time the prices paid per metric tonne (MT) of organic quinoa in European and US markets are high (US$ 18.9 per quintal (1 quintal = 46 kg), up to five times higher than the international price for soya per metric tonne (Crespo et al. 2001), which provides a very favourable economic advantage compared with many other crops, thus opening up considerable opportunities for being a very competitive and efficient chain of production.

Despite the considerable importance of the quinoa crop in Bolivia, it is cultivated only to a small extent, less than 2% of the total cultivated surface area of the country, and less than 5% of the cultivated surface area for cereals. In addition, it has very little participation in the farming sector. This low expansion of the cultivation of quinoa is attributed to various factors, in particular the lack of state policies in promoting the crop.

Added to this is the fact that around 80% of the countryside units producing quinoa are farmers with scarce economic resources, many of whom are engaged in subsistence agriculture. The quinoa crop in comparison to other crops such as soya**,** maize, wheat, rice, potatoes, sugar cane and grain barley is cultivated on a smaller surface area producing lower production volumes than the other crops (Table 1); however, it is of vital importance for the rural settlers of the Altiplano where it represents a source of food security (Saravia and Aroni, 2001).

According to the Ministry of Agriculture, Livestock and Rural Development, in 1997 the gross production value of quinoa represented $14.6 million, equivalent to 1.6% of the gross value of agricultural production as a whole.

Table 1. The most important crops in Bolivia (1998-1999)

CROP	SURFACE AREA (ha) [hectare]	PRODUCTION (MT)
Soya	632,255	762,200
Corn in grain form	282,306	613,161
Wheat	166,795	140,594
Rice	127,740	189,388
Potatoes	119,757	783,323
Sugar cane	89,629	4,159,869
Barley in grain form	87,265	56,180
Quinoa	34,168	22,027

Source: M.A.G.D.R. Statistics Department 2000.

On the Northern Altiplano the cultivated surface area per farmer does not exceed one third of a hectare, on the Central Altiplano the cultivated surface area does not exceed 10 hectares per farmer, while on the Southern Altiplano, the cultivated surface area varies between 3 and 10 hectares per family. On the Northern Altiplano the production of quinoa is more for self-supply, while on the Southern and Central Altiplano production is intended for the market.

The biggest quantity of quinoa in the country is produced on the Southern Altiplano, around 60%, mainly Royal Quinoa which is predominantly exported and whose trade has positioned Bolivia as the top quinoa exporting country, followed by Peru and Ecuador.

Although the volume of exports is small in comparison with other products, this has increased in recent years. Other countries are expressing considerable interest in quinoa, which will enable Bolivia to open up markets and export added-value products, allowing it to stimulate the processing industry and to create more jobs.

2. General characteristics of quinoa

One of the chief characteristics of quinoa grain, making it very sought-after and appealing for human nutrition, is that it does not contain cholesterol, does not form fats in the organism, does not cause weight gain, is easily digestible and can be organically produced.

Quinoa possesses qualities that are superior to cereals and gramineae, due to the quality of its proteins and the minerals content. Rather than quantity, it is characterised by the quality of its proteins provided by the essential amino acids of which it is comprised, such as isoleucine, leucine, lysene, methionene, phenylalamine, threonene, tryptophan and valine. The appropriate balance of the amino acids in the protein of quinoa is its best guarantee, as it possesses a greater content of minerals than other products, such as phosphorus, potassium, magnesium and calcium, among others.

The need to improve the diet of the Bolivian population gave rise to research on quinoa, which commenced in 1960, for the purpose of establishing its nutritional attributes and the possibilities of genetic improvement. Between 1965 and 1970 at the Patacamaya Experimental Station, located in the Aroma Province of La Paz 3,789 metres above sea level, of the Bolivian Institute of Agriculture (IBTA) existing at that time, the work of research on the genetics, agronomic improvement, phytopathology, entomology, bromatology and use of the grain in human and animal nutrition, was intensified.

Following various genetic improvement works, in 1970 the first sweet variety "Sajama", free from saponin, was obtained, which made it possible for the farmer to have a quinoa ready for use as foodstuff, saving time for the housewife who no longer had to spend time eliminating saponin. This variety is currently cultivated in almost all areas of the Central and Northern Altiplano of Bolivia and has also spread to the high-altitude areas of Peru. Apart from being free from saponin, the Sajama variety has an average yield of 1,500 kilos per hectare at the commercial level, with clear benefits for the producers.

The vegetative period of quinoa varies between 150 and 240 days with a plasticity of adaptation to different environmental conditions. The different varieties present relative indifference with respect to the photoperiod and altitude; they can be cultivated from sea level to 3,900 metres above sea level and can tolerate soils with a wide range of pH from 6 to 8.5.

The variability and diversity of quinoa varieties can be summarised in 5 groups:

> Quinoa of the valleys (2,000 and 3,000 metres above sea level) which are late-ripening and of high stature.
>
> Altiplano quinoa (around Lake Titicaca) which can withstand frosts and a relative scarcity of rain.
>
> Salt land quinoa (the plains of the Bolivian Altiplano) which can withstand salty soils.
>
> Sea-level quinoa (found in the south of Chile) these being small plants without sprigs, producing bitter grains.
>
> Sub-tropical quinoa (inter-Andean valleys of Bolivia) which have small white or yellow grains.

Royal Quinoa is a bitter variety, which is only produced in Bolivia, particularly in the districts of Oruro and Potosí, around the salt flats of Uyuni and Coypaza. These lands and salt flats offer the appropriate context for the production of this type of quinoa.

2.1. Quinoa production areas

In recent years an average surface area of more than 35,000 hectares has been cultivated throughout the Bolivian Altiplano. The main cultivation areas developed in the country are in La Paz, in the provinces of Aroma and Gualberto Villaroel, in Oruro, in the region of Salinas de Garci Mendoza in the province of Ladislao Cabrera, which is one of the most important areas under the communal ownership system, with equitable distribution of the land, and in Potosí, which includes the region of Llica in the Province of Daniel Campos and the Province of Nor Lípez, as one of the areas producing high-quality quinoa.

Bolivia is the biggest producer of quinoa, with 46% of world production, followed by Peru with 42% and the United States with 6.3%. According to the Andean Development Corporation (CAF, CID, CLACDS-INCA, 2001), National production of quinoa during the 1970s amounted to approximately 9,000 metric tons per year, covering a surface area of approximately 12,000 cultivated hectares. In recent years it has increased to an average of 22,000 metric tons per year, produced over an area exceeding 35,000 hectares.

Royal Quinoa is the most sought-after variety in foreign markets due to the large size of its grains, identified as being of first class and reaching 2.5 mm in diameter. This type of quinoa is relatively resistant to frosts and periods of drought, which favours its cultivation in the rigorous climatic conditions of the Southern Altiplano. The grain of Royal Quinoa has a high content of saponin which gives it a bitter taste, and the saponin must be removed before consumption, increasing the cost of its processing. However, this high content of saponin creates a certain amount of protection for the grain against attacks by pests or plagues, mainly against birds (ANAPQUI, 2001; IICA/PNUD, 1991).

2.1.1. Production of quinoa on the Bolivian Altiplano

The Bolivian Altiplano has been divided into three clearly differentiated areas for technical/practical purposes: Northern Altiplano, Central Altiplano and Southern Altiplano, due to their characteristics of climate, soil, and agriculture and livestock possibilities.

In Bolivia quinoa is produced mainly in the three areas of the Bolivian Altiplano. Some 41% of national production is cultivated on the Central Altiplano, amounting to 8,817 metric tonnes and a yield of 591 kg/ha, followed in size by the Southern Altiplano where 31% is produced, amounting to 6,709 MT and the Northern Altiplano which produces 28%, amounting to 6,160 MT.

On the Southern Altiplano 65% of the production of the region during the year is sold in the market of Challapata - Oruro, where every Saturday and Sunday the producers carry between 1 and 5 quintals of quinoa for sale, and with the proceeds they purchase foodstuffs such as rice, noodles, sugar, oil and vegetables, as well as school equipment for their children and occasionally clothing for the family. According to information obtained, transactions of 100 quintals of quinoa sometimes take place between producers and intermediaries. There are many small and large intermediaries; the latter stockpile thousands of quintals of quinoa for transfer to Desaguadero on the border with Peru, and from there it is smuggled into Peru (PROINPA 2001-2002).

During the last 12 years (1990-2001) on a national level there has been no significant change in the evolution of the cultivated surface area, production and yield of quinoa (Table 2).

Notwithstanding the considerable social, economic and cultural importance of quinoa cultivation, mainly in the production systems of the Bolivian Altiplano, it can be seen that there has been no significant improvement in the crop over the years, notwithstanding the investments in the generation and transfer of technology (Table 2).

The crop yield on a national level indicates an average of 571 kg/ha [kilograms per hectare] in 1980, 416 kg/ha en 1990 and 651 kg/ha in 2000. These figures indicate that increases in the national production of quinoa are due to the simple expansion of the cultivated area and not increases in yield. This expansion, without the application of suitable technological alternatives for the crop, could give rise to a gradual reduction in the overall production of quinoa, with a decline in the global productivity of the farmers of the Altiplano.

Table 2. Evolution over time of the surface area, yield and production of the quinoa crop in Bolivia.

Year	Surface area (has)	Yield (kg/ha)	Production (MT)

1990	38,615	416	16,077
1991	40,528	613	24,439
1992	38,765	436	16,898
1993	37,894	531	20,109
1994	38,196	510	19,465
1995	36,790	511	18,814
1996	37,480	627	23,490
1997	40,035	712	28,488
1998	38,248	436	16,682
1999	34,168	645	22,027
2000	35,715	651	23,235
2001	33,928	641	21,739

Source: Agricultural and rural statistics unit – MAGDER

According to the report prepared by the BOLINVEST Foundation (1998), the main districts contributing towards national production are Oruro, Potosí, La Paz and to a lesser extent Cochabamba and Chuquisaca, with, in all cases, a relatively uniform evolution in terms of surface area, yield and production from 1990 to 1997 (Table 3).

Table 3. Evolution over time of the surface area, yield and production of the main quinoa- producing districts in Bolivia

Area	Description	1990	1991	1992	1993	1994	1995	1996	1997
Oruro	Surface area (ha)	10200	10619	9843	9560	9925	9800	9950	10045
	Yield (kg/ha)	421	571	387	510	505	633	690	755
	Production (MT)	4294	6063	3807	4880	5008	6200	6865	7584
Potosí	Surface area (ha)	11966	12551	11673	11600	11914	12150	12000	12323
	Yield (kg/ha)	463	534	391	528	522	412	680	711
	Production (MT)	5538	6706	4564	6119	6217	5000	8160	8766
La Paz	Surface area (ha)	16149	17037	16940	16500	16109	14600	15280	16036
	Yield (kg/ha)	392	676	495	545	504	514	546	615
	Production (MT)	6168	11515	8382	9000	8116	7500	8341	9863
Cbba.	Surface area (ha)	180	191	209	194	216	20	205	215
	Yield (kg/ha)	183	471	431	464	477	460	448	553
	Production (MT)	33	90	90	90	103	92	100	119
Chuq.	Surface area (ha)	120	130	100	40	32	40	39	39
	Yield (kg/ha)	367	500	550	500	656	550	615	615
	Production (MT)	44	65	55	20	21	22	24	24

Source: National Ministry of Agriculture and Livestock - SNAG
Eastern Agricultural Chamber – C.A.O. Prepared by the BOLINVEST Foundation

The fact of allowing greater access to financial services, more specifically to credit, implies that the potential exists to expand the agricultural boundaries and therefore increase production volumes, and that local and export marketing is efficient, allowing the GDP under this heading to be increased.

2.2. Quinoa production systems

On the Central and Northern Altiplano quinoa is cultivated under the conventional production system, in rotation with other crops. On the Southern Altiplano, quinoa is the only crop available for farmers, and it is cultivated in adverse conditions with little rain and the occurrence of frequent frosts.

2.2.1. Central and Northern Altiplano

The quinoa production system is similar on both Altiplanos, where the crop is generally cultivated in rotation, after potatoes and in turn is followed by broad beans or a species of fodder (barley or oats). Quinoa is of less importance on the Northern Altiplano and is cultivated mainly for local consumption; accordingly, it is sown on small areas of land, potatoes and barley being more important crops.

There is more land available per farmer on the Central Altiplano (from 21 to 80 hectares for 70% of the farmers) as compared with the Northern Altiplano (fewer than 10 hectares for 70% of the farmers). This makes mechanisation possible, and therefore more areas are dedicated to the commercial production of quinoa on the Central Altiplano (Risi, 1994).

In production for self-supply, quinoa is generally sown in furrows or scattered at random, on land where potatoes were previously cultivated. Fertilisers are not used and very few farmers carry out pest control so that yield amounts to an average of 500 kg/ha. However, for commercial production quinoa is established on rotovated land under the furrows system, nitrogenated fertiliser is applied (40 to 80 N/ha) and pest control is carried out, so that yield during years when there is a good amount of rain exceeds 800 kg/ha.

On the Central Altiplano the main limiting factors reducing the production of quinoa are attacks by plague insects, including cutworms or ticonas (*Felthia sp.*, *Agrotis sp.* and *Spodoptera sp.*) and the quinoa moth (*Eurisacca melanocampta*) during periods of drought, may cause the loss of the entire crop. Frosts and droughts also have a significant effect on yield; a reduction in temperature to -3°C during the flowering season can lead to the total loss of the crop. On the Northern Altiplano in addition to pests and the climate, mildew (*Peronospora farinosa*) and attacks by birds on the sweet varieties of grain significantly affect the yield.

2.2.2. Southern Altiplano

A specific system for the production of quinoa has been developed in this region, because quinoa is the only important crop and it adapts to the environmental conditions of the area. On this part of the Altiplano, agriculture is not the sole source of income; farmers combine agriculture with temporary migration to the mines or urban centres, remaining in the countryside during the sowing and harvesting seasons when more manpower is needed.

The availability of land for farmers is high (an average of 60 hectares per farmer); this availability of land, combined with the high price of quinoa in the area (between US$ 0.70 and

0.80 per kilogram in the stockpiling areas) and the presence of tractors have caused the crop to expand, occasionally to marginal areas (Risi, 1994).

Farmers have stopped cultivating quinoa on the hillsides, where the crop was traditionally grown, and are cultivating it on the areas of the plain. The rotary ploughing tractor for preparing the soil on the plains is causing serious problems of wind erosion on these soils which are sandy, loose and have low natural fertility. In the traditional rotation system land sown with quinoa is rested for a period of time, following which quinoa is re-established. Due to the said factors, the rest period, which was between 4 to 8 years, has been reduced to fewer than 4 years and in some cases quinoa is being continuously cultivated. This will have the consequence of exhausting the natural fertility of the soil in an area in which, due to low rainfall (an average of 100 to 200 mm per year), the effect of chemical fertilisation is minimal.

The production system is characterised by attempts to use the scarce amount of rain that is available as efficiently as possible, the ground being prepared at the end of the rainy season in the months of February and March. Sowing starts at the end of August and the beginning of September based on the holes method, making use of the rainwater remaining in the soil at the end of the agricultural season. The holes are opened up until the moisture is found in the soil at a depth of 30 to 35 cm, and in each hole 50 to 100 quinoa seeds are placed, the holes then being covered up by approximately 10 cm of soil. When the seedlings emerge they are then covered with straw or thola twigs to protect them from frost or from the sun and to prevent the holes from being filled in with soil swept along by the wind. Once the crop becomes established in the field, no further cultivation work takes place until harvesting.

Climate is the main limiting factor. The scarce rainfall and the frosts seriously affect the crop. On land that has not been properly prepared, a period of prolonged drought may cause the entire harvest to be lost. Among the main factors affecting production it is important to mention the hare. In recent years the population level of this animal has reached a level that is seriously affecting the crop; it feeds by night on the seedlings and several holes devoid of seedlings can be found in a quinoa field. As this is a recent problem, the farmer does not know how to control it. Another limiting factor on the Southern Altiplano is the question of insects, particularly cutting insects or ticonas and the grain moth or kcona kcona. There must be added to these limiting factors the problems of wind erosion and the loss of the natural fertility of the soils described previously.

The varieties of quinoa cultivated on the Southern Altiplano are the large grain type (the grain diameter exceeding 2 mm). The grain of these varieties, once the bitterness has been removed, is called "Royal Quinoa", in reference to the Royal White variety. However, farmers use a diversity of local crops with the "Royal" type grain. The export market demands "Royal Quinoa" due to its size and the price is even more attractive if the product is organic; therefore, the system of organic quinoa production is being developed on the Southern Altiplano.

2.3. Marketing and Transformation

The quinoa grain contains the alkaloid saponin, which is slightly toxic, giving a bitter taste to the grain, and it must therefore be eliminated. The work of removing the saponin involves roasting, scarifying, washing or chemically processing the grain. Other complementary processes to the processing of quinoa grain are: Drying, venting, selecting by size, separating stones and impurities and packing (Galliag, 1995).

For marketing purposes the majority of conventional quinoa is processed using traditional methods, in "processing plants" that are usually owned by the wholesalers themselves. However, all the ecological quinoa for export that is marketed inevitably passes through the "industrial processing plants" (CEDLA, 2001).

From the perspective of the basic producers, marketing takes place according to various methods, depending on organisational capacity, the type of quinoa cultivated and the geographical location. A large number of ecological quinoa producers in Potosí and Oruro sell their products to the National Association of Quinoa Producers (ANAPQUI) and to the Tierra Cooperatives Operation (CECAOT) through their stockpiling centres. The first has seven regional stockpiling centres on the Southern Altiplano (CEDLA, 2001).

Another destination of this production is the processing plants of private companies based in Challapata - Oruro and La Paz, which also have their respective stockpiling centres in the region. These processing plants pack and sell the product directly abroad, and sometimes within the country to the marketing centres (CEDLA, 2001).

The producers of conventional quinoa on the Southern Altiplano - especially those which are not associated - sell their production through the traditional intermediaries, which almost invariably have their own transporter and purchase the product in bulk with no removal of saponin, no cleaning and no classification and they resell the product in Challapata to the wholesalers. These wholesalers carry out the processing by traditional means or send it to "dividers" (packers) and/or retailers, who sell the product in small packages to the final consumer (CEDLA, 2001).

An imperceptible but evident phenomenon is the transfer of conventional quinoa by the wholesalers to the border with Peru; the product then leaves the country as contraband. It is estimated that 60% to 70% of the quinoa of the Southern Altiplano is sold by this means.

The majority of the production of the producers of conventional quinoa on the Northern and Central Altiplano is for self-supply; however, their saleable production takes them to district fairs where traditional intermediaries operate. These engage in the traditional processing operation for the purpose of subsequent sale to dividers or retailers in the cities of La Paz and El Alto.

2.3.1. Processing of quinoa

Industrially quinoa is a problem, as the grains must be subjected to washing or friction operations before they can be used for the preparation of products. This product is called “DE-SAPONISED”, because the saponin has been eliminated from it.

2.3.1.1. Products prepared using quinoa grains (agro-industry)

Quinoa in grain form ('pearled')

Quinoa is subjected to the process called “de-saponisation”, which can be by means of the dry method (friction), wet method (washing) or mixed, whereby the saponin is eliminated. This process produces quinoa ready for direct consumption, for the preparation of soups, ground products, 'pipocas', etc. It also serves for other processes as described below.

Quinoa Flakes

The pearled grains are moistened (with 15% to 16% moisture), and are subsequently subjected to pressure between two rollers causing them to form circular wafers; very fine flakes are thus produced that conserve the majority of the proteins, and the cooking time is shorter. The flakes are used for soups, breakfast cereals, juices and others.

Quinoa Flour

The pearled grains are subjected to milling and sifting, using special milling machines, in order to obtain good-quality flour, though there is a slight reduction in the protein content, especially due to the separation of the germ. The flour can be used as a substitute for wheat flour up to 20% to 25% for making bread, biscuits and pastries, without any adverse effect on the texture and flavour of the final product.

Toasted Quinoa Flour

The pearled grains are subjected to toasting and milling processes. The flour obtained in this way is easily digestible and is recommended for children and adults, including pregnant mothers.

Expanded Quinoa (pop corn)

Also referred to as insufflation, a process whereby the pearled grains are submitted to high pressure and temperature within a chamber to expand the volume. This product can be imbued with different flavours, ready for immediate consumption. The disadvantage is that more than 60% of the proteins are lost.

2.3.1.2. Agro-industry by-products

Quinoa Bran

This is generally used as a raw material for the preparation of balanced foodstuffs for cattle and other animals.

Powder containing saponin

This is the residual product from the scarification process (removal of saponin when dry) of the quinoa grains. It is not recommendable to use it as a foodstuff due to the fact that this glycoside is not tolerated by animals, but it can be employed as a detergent, for which purpose it is traditionally used in the farming populations. This product can potentially be used by manufacturers of soaps, shampoos and toothpaste.

Split quinoa grains

This is generally used as a direct foodstuff in the poultry industry, sometimes being used for preparing balanced foods for cattle, pigs and other animals.

2.4. Nutritional characteristics of quinoa

Quinoa, known as the "mother cereal" in the Quechuan language, was the staple diet of the Incas for thousands of years, along with their religion and culture. With the arrival of the conquistadors its cultivation was replaced by maize and potatoes, and within a short period of time it became a forgotten and underutilised crop.

Quinoa contains a greater content of proteins, calcium, phosphorus, iron and magnesium than other cereals. It also contains all the essential amino acids, it is rich in fibre and group B vitamins and it is gluten free. The grain is soft, very digestive, cooks quickly and has a pleasant taste. It also has nutritive properties and it is very easy to use, being sold in a wide variety of forms: grain, flakes, flour, pasta, bread, biscuits, different beverages, meals and others. It is considered by the UNO and the WHO to be a complete food due to its extremely high nutritional value.

As it is a gluten-free food the majority of the population can consume it, including those who are allergic to gluten. Quinoa maintains its nutritive qualities even during industrial processes, and it is capable notably of substituting proteins of animal origin.

The quinoa grain is the only vegetable food that provides all the amino acids essential to the life of humans and in values close to those published by the United Nations Organisation for Agriculture and Food, which means that its protein is of excellent quality; its nutritive characteristics make it comparable with milk (Villalobos and Espejo, 1997). Although human beings cannot survive on a single food, Duane Johnson of the University of Colorado affirms that if he had to depend on a single food in order to survive, the best option would undoubtedly be quinoa. Table 4 presents the composition of quinoa compared with other cereals.

2.4.1. Food

Once the grain has been washed delicious savoury or sweet dishes can be prepared, in both solid and liquid form. Quinoa flour can be produced, which can be enriched with wheat flours in the preparation of biscuits, 'barritas', pies, whips, cakes, spaghetti, etc, providing high nutritive value. It is also used in the preparation of batters, enriching these, conserving their moistness and providing a very agreeable flavour in addition to a fine and special texture. It is thus possible to prepare highly energy-charged and very agreeable foods that are 100% natural, contain no cholesterol and are gluten free.

It is a food that is highly valued for its chemical nature, due to the transformations which it undergoes when ingested, and the effects that it produces in the consumer. Quinoa represents one of the main components of the diet of the Andean family.

Table 4. Composition of quinoa grain in relation to wheat and oats

Components	Royal Quinoa	Wheat	Oats
Calories	336.0	330.0	405.0
Water	10.8	16.5	9.3
Proteins	12.1	9.2	10.6
Fats	6.1	1.5	10.2
Carbohydrates	68.3	71.6	68.5
Fibre	6.8	3.0	2.7
Ash	2.7	1.1	1.5
Calcium	107.0	36.0	100.0
Phosphorus	302.0	224.0	321.0
Iron	5.2	4.6	2.5
Thiamine	1.5	0.2	0.0
Riboflavin	0.3	0.8	0.0
Niacin	1.2	2.8	0.0
Ascorbic acid	1.1	0.0	0.0

Source: PROCISUR-ICCA, 1997

Table 5. Percentage of amino acids contained in 100 grams of protein in quinoa, wheat and milk.

Amino acids (%)	Quinoa (%)	Wheat (%)	Milk (%)
Histidine *	4.6	1.7	1.7
Isoleucine *	7.0	3.3	4.8
Leucine *	7.3	5.8	7.3
Lysine *	8.4	2.2	5.6
Methionene *	5.5	2.1	2.1
Phenylalanine *	5.3	4.2	3.7
Threonene *	5.7	2.7	3.1
Tryptophan *	1.2	1.0	1.0
Valine*	7.6	3.6	4.7
Aspartic Acid	8.6	--	--
Glutamic Acid	16.2	--	--
Cysterine	7.0	--	--
Serine	4.8	--	--
Tyrosine	6.7	--	--
Argine *	7.4	3.6	2.8
Proline	3.5	--	--
Alanine	4.7	3.7	3.3
Glycine	5.2	3.9	2.0
*Essential amino acids			

Source: PROCISUR-ICCA, 1997

From the standpoint of nutrition and diet, quinoa is a natural source of economic vegetal protein and high nutritive value due to the combination of a greater proportion of essential amino acids. The calorific value is greater than that of other cereals, both grain and flour, reaching 350 Cal/100gr, which characterises it as a food that is appropriate for cold areas and seasons.

The composition of essential amino acids (Table 5), gives it a biological value comparable only with that of milk and eggs, thus making it one of the principal foodstuffs of our region. Likewise, its content of fats, carbohydrates, fibre, calcium and other elements make it a very valuable food (Table 6).

Table 6. Components of quinoa compared with other major foods and products

Comparative table of components of quinoa with those of other major foods (kgs)						
Components (%)	**Quinoa**	**Meat**	**Eggs**	**Cheese**	**Cows' milk**	**Human milk**
Proteins	13.0	30.0	14.0	18.0	3.5	1.8
Fats	6.1	50.0	3.2	-	3.5	3.5
Carbohydrates	71.0	-	-	-	-	-
Sugar	-	-	-	-	4.7	7.5
Iron	5.2	2.2	3.2	-	2.5	-
Calories 100 grs	370.0	431.0	200.0	24.0	66.0	88.0

Table comparing components of quinoa with those of other products (kgs)					
Components (%)	**Quinoa**	**Wheat**	**Maize**	**Rice**	**Oats**
Proteins	13.0	11.43	12.28	10.25	12.30
Fats	6.70	2.08	4.30	0.16	5.60
Fibre	3.45	3.65	1.68	-	8.70
Ash	3.06	1.46	1.49	0.60	2.60
Calcium	0.12	0.05	0.01	-	-
Phosphorus	0.36	0.42	0.30	0.10	-
Carbohydrates	71.0	71.0	70.0	78.0	60.0

Source: Castiñeria and Lozano.

Quinoa, as a vegetal protein, assists the development and growth of the human organism, conserves heat and energy in the body, is easy to digest and forms a complete and balanced diet.

The United Nations Organisation for Agriculture and Food states that a protein is biologically complete when it contains all the essential amino acids in a quantity equal to or exceeding those established for each amino acid in a reference or standard protein. Proteins possessing one or more limiting amino acids, i.e., in a lower proportion than that established for the standard protein, are considered to be biologically incomplete, due to the fact that they cannot be fully utilised.

Another correction factor relating to the biological quality of proteins is digestibility. The digestibility of the protein of eggs, milk and meat is close to 100%. Cereals and leguminous plants, due to their fibre content, have a lower rate of digestibility. It is considered that the digestibility of quinoa is approximately 80%.

The quality of the protein of quinoa improves after thermal treatment (cooking), obtaining a better concentration of amino acids and with the virtual disappearance of the limiting amino acids. Processes using dry heat, such as toasting and expanding (pop-corn), can notably reduce the availability of lysine, which is thermolabile and may also react with other components of the grain (the Maillard Reaction, for example) reducing its bioavailability.

The Institute of Laboratory Services of Health Diagnostics and Research (SELADIS) established that Royal Quinoa is the first food possessing the complete set of amino acids, i.e. 21 amino acids, among the most well-known of which are: lysine, tyrosine, methionine and tryptophan, and the interesting thing is that they are present in appropriate quantities suitable for human consumption.

2.5. Characterisation of consumption of quinoa

The parameters for measuring the consumption and consumption standards of quinoa are: quinoa in the form of washed or unwashed grain, quinoa flakes and quinoa flour. Generally speaking, the main towns of the central area of the country have a lower consumption of quinoa and other cereals per capita than the main towns of other areas. Habits and traditions probably influence the consumption of quinoa. The city that is most closely linked to the consumption of quinoa is Oruro (Table 7), due to the proximity to the production areas and the better prices for the grain, the variety of quinoa and ample supplies (IICA/PNUD, 1991 and 1999).

The demand for quinoa is low due to the relatively low consumption per capita in comparison with other grains (Table 7). This may be attributed to a number of factors; In the first place, the price of the product affects its competitiveness in the market; and in the second place, lack of awareness of the advantages and/or favourable characteristics is a factor limiting its consumption. Likewise, other factors exist that affect demand and are not connected with price but with the mechanisms of distribution to the consumer, characterised by irregular supplies, poor quality of presentation of the products and the absence of promotion for its consumption (IICA0.1991).

Table 7. Consumption per capita (kg/year) of quinoa and other products by districts in Bolivia.

Locations	Quinoa	Wheat	Rice	Barley	Oats	Noodles
Oruro	9.6	7.0	40.2	2.4	3.9	59.7
Potosí	4.8	12.9	31.7	3.3	13.9	30.7
Cochabamba	4.9	4.3	41.2	0.7	1.5	22.0
La Paz	4.4	3.4	37.2	7.5	2.1	12.4
El Alto	3.5	2.5	34.0	4.2	5.9	27.2
Santa Cruz	3.2	4.9	37.8	0.2	3.1	17.2
Sucre	nd	17.8	44.4	3.5	13.3	26.4

Source IICA, 1999

Quinoa is used in different forms, mainly in stews, salads, croquettes and soups. For breakfast it is consumed as a single or mixed cereal. In Bolivia there is an incipient industry of quinoa by-products, which are: pastries; prepared cereal and quinoa bars containing chocolate (IICA/PNUD, 1991; CAF, CID, CLACDS-INCAE, 2001).

The traditional uses of quinoa identify the culture linked with the crop; in turn, the traditional uses practised in the community constitute to a great extent the fundamental reason for its conservation *in situ* and these uses, as they spread to urban centres, contribute towards the conservation of the diversity and reinforce its use by giving an economic significance to the various types of quinoa (Table 8).

Table 8. Traditional forms of consumption of quinoa

Name	Ingredients				Type of food
Pesq'e	Quinoa grain	Fresh milk	Boiled water	Salt	Pure
Kispiña	Quinoa flour	Boiled water	Oil		Steam-cooked
Mocora	Quinoa 'Pito'	Boiled water	Sugar	Cinnamon	'Pito' drink
Phisara	Quinoa flour	Water	Oil	Salt	Ground quinoa
K'usa	Quinoa grain	Sugar			Quinoa chicha
Mukuna	Quinoa flour	Boiled water	Fat	Salt	Steamed tortilla filled with charque [dried meat]

Recent studies have shown that the production of quinoa is used: 66% for self-supply and 34% for sale (Table 9). These figures confirm the role of quinoa as a staple diet for the peasant families of the Altiplano.

Table 9. Average production of quinoa per area and destination (1986 - 1995)

Area	Production		Self-supply		Sale	
	MT	%	MT	%	MT	%
Northern Altiplano	4840	24	3390	70	1450	30
Central Altiplano	8330	42	7080	85	1250	15
Southern Altiplano	6810	34	2720	40	4090	60

Source. MACA, 1986 -1995, SNAG [National Statistics Office]/Sectorial statistics, SETA.-Consultants 1990.

2.6. Medicinal value

2.6.1. Quinoa prevents breast cancer and osteoporosis

According to an article published in Los Tiempos newspaper (12 March 2001), quinoa, the Andean grain which has already been widely discussed, has now brought another surprise as it also contains phytoestrogens, substances that prevent chronic diseases such as osteoporosis, breast cancer, heart disease and other feminine problems caused by a lack of oestrogen during the menopause.

According to scientific studies carried out by international laboratories, phytoestrogens can be found in the majority of cereals, as well as in soya. But up until now no study of this nature has been carried out on quinoa; however, it is presumed to contain high levels of phytoestrogens, which has yet to be proven.

On the Bolivian Altiplano it has been established that women in that region do not present with cases of osteoporosis, but that women do present with this disease in other social segments located in the cities and where consumption of quinoa is low. Everything appears to indicate that the absence of osteoporosis is related to the diet of the Altiplano, which is rich in grains containing phytoestrogens, substances that allow the absorption of calcium, which means that the women of this region do not suffer from osteoporosis.

2.6.2. Quinoa plasters to cure bone fractures

The Varieties of Royal Quinoa Huallata, Mok'o Rosado, K'ellu, Pandela, Achachino, Rosa Blanca, Chillpi Amapola and Chillpi Rosado are used to cure bone fractures, using unprocessed milled quinoa grain.

The quinoa is ground, mixed with wine and simmered until the mixture becomes thick. This preparation is applied directly to the bone fracture, for both humans and livestock, and is dressed with a calico for direct contact (Royal Quinoa Catalogue, 2003).

2.7. Quinoa Chain

The quinoa agro-industry has a small participation in the country's production. Its most characteristic activity is that of subsistence agriculture in poor peasant communities within the Altiplano area. Despite the fact that the relative weighting of quinoa barely amounts to 2.2% of the agricultural GDP of Bolivia, the crop was selected due to its potential important effects on the competitiveness of this activity with a view to rural development on the Bolivian Altiplano.

Due to the economic and social potential of the quinoa agro-industry, the government of Bolivia has included it in the seven economic activities that form a part of the programme of national agreements on competitiveness (National Dialogue, 2000).

2.7.1. Summarised description of the chain

The production chain in the country is very new and is concentrated on five areas of the Bolivian Altiplano: Challapata (the main centre for stockpiling and cleaning), La Paz and El Alto (stockpiling, cleaning and product-processing centre), El Desaguadero (main stockpiling and legal and contraband export centre) and Cochabamba (quinoa-processing centre) (SBPC, 2003).

In the main chain of value creation, the most important stage is primary production. There are also the industrial, intermediary and final consumer stages. The main features of each of these stages are as follows:

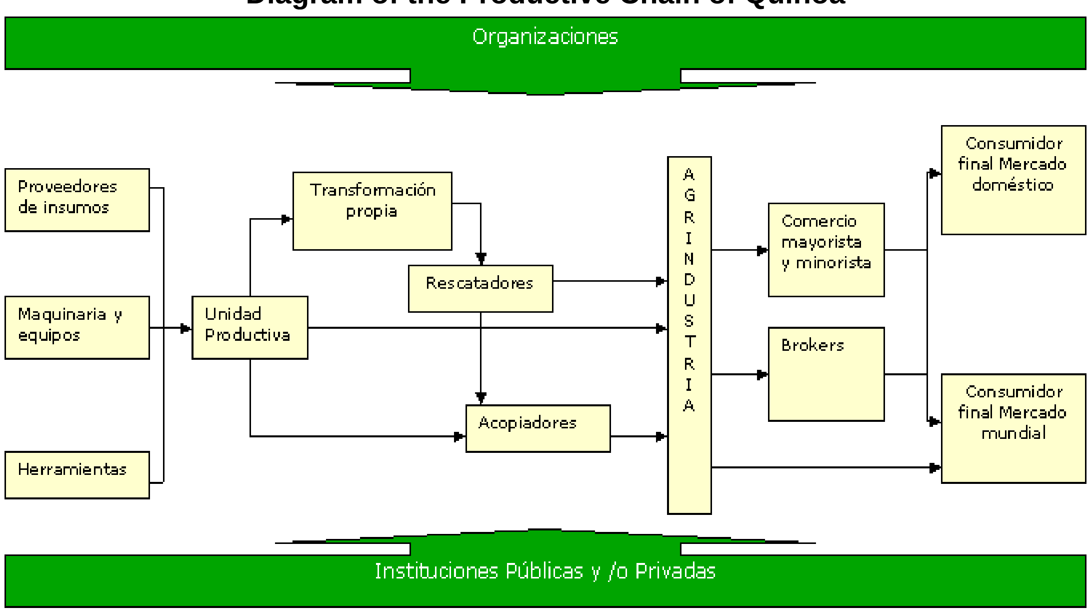
Primary Production: The most developed stage is that of primary production which includes a large number of production units with a given volume of production, which is used mainly for self-supply. These units, which involve 75,000 producers, are dispersed throughout the Altiplano region and use traditional cultivation techniques and little technology.

Industry: This is concentrated in very few actors. Five companies in Bolivia mobilise the major part of the quinoa in terms of stockpiling, cleaning and selection. Although some of these companies are starting to process quinoa in products with more added value, their processes and final product fall short of the degree of quality demanded by the international market.

The Intermediaries: They have an important role to play in the stockpiling of the product, which is difficult due to the dispersed nature of the production units. Some intermediaries only stockpile the product, while others are involved from stockpiling to marketing. The majority of these are informal intermediaries who sell the product to industry for its processing and sale.

Final Consumer: The major proportion of the product is consumed by the farmers on the Altiplano themselves. Quinoa is directed at local, regional and international markets. The local and regional markets are those involving the greatest volume. Peru is the biggest importer of Bolivian quinoa. The international market is important but the volumes are lower and consist in the export of quinoa grain for consumption in that form or as a raw material product (SBPC, 2003).

Diagram of the Productive Chain of Quinoa



3. Critical factors limiting the increased production of quinoa

3.1. Of a technological nature

The technological conditions under which the agricultural production of quinoa takes place are still deficient. No seeds research programmes exist to make it possible to homogenise the harvest season, advance the crop cycle so that it is not adversely affected by frosts, release the cultivation of black grains “ajaras” and in this way optimise the selection and extraction process, among others (SBPC, 2003).

Inappropriate working of soils and their low fertility have had a significant negative impact on increasing deterioration (erosion, desertification, salinisation) and low yield. However, although quinoa does not demand substantial water resources, some studies have demonstrated the feasibility of irrigation systems, which can increase the yield considerably and ensure minimum levels of production, especially in times of drought. Practically no attention has been given to this matter. Due to the fact that water resources on the Altiplano are scarce, it is necessary to investigate the sources of this water and the use of pressurised irrigation systems which have been recommended for the area.

On the question of pest control, as part of the ecological management of the crop, which is a current requirement of the international market, no strategy has been developed and it is therefore necessary to identify technological alternatives which have been shown to be successful with other crops, using renewable energy sources. At the present time the subject of pests is of considerable importance because of the negative effects on the yield, due to occasional losses, (which can often be between 30% and 70% of the production).

Furthermore, although technological packages have been generated in order to reduce post-harvesting losses which are high (24%), there has been no mass adoption of this technology by the producers, and therefore the vast majority still employ traditional methods which cause losses and contamination of the grain, to the detriment of obtaining higher prices for quinoa of better quality.

Training and technical assistance are necessary in order to introduce the technological changes required to improve productivity and competitiveness. At the present time, although the efforts of the institutions providing the services are considerable, there have been very few results due to the limited cover and because the methodologies applied have not always met the expectations of the beneficiaries, and therefore these processes have not been sustainable over time (SBPC, 2003).

With an improvement in production technology and with production being made sustainable in terms of both time and space, the aforementioned negative impacts will be reduced and this will mean better conservation and management of the natural productive resources, and the identification of varieties of quinoa that are resistant to adverse climatic factors, as well as those that are resistant to attacks by pests and diseases. All of this will allow an improvement in the quality of the final product and thus reduce the poverty levels of the quinoa producers.

3.2. Promotion

3.2.1. Deficient internal and external promotion

Although official exports have demonstrated an increasing trend over the years, the annual figure for the last five years has been variable, around 2.0 to 2.5 million dollars, which in terms of volume signifies an average of 1,800 MT per year, a figure which represents only 50% of the commercial organic production and approximately 15% of the total production of the area (SBPC, 2003).

It can be inferred from the foregoing that during the last five years exports have not experienced the same dynamic growth as in previous years.

According to the generalised criteria of the sector, expectations of being able to generate increased volumes of exports and achieve significant growth in this area are frustrated by the lack of promotion of quinoa by the main diplomatic missions abroad, and the official promotion Organisation (CPROBOL), which has insufficient resources to promote quinoa, by participating in international fairs, promoting contact with business missions, identifying customers, among others.

Domestic promotion of quinoa is also identified as a weakness of the State as it does not promote the consumption of quinoa, at least in regard to institutional purchasers (Armed Forces, National Police, etc).

3.2.2. The lack of an appropriate strategy of State financing and access to credit

Many the necessary investments required to improve the technological aspects do not materialise because the current market conditions for financial services do not allow access to sources of finance.

Microcredit exists in the area, through certain rural financial institutions which grant loans small short-term loans and high interest rates, as the risks are also high. This situation means that the farmer cannot finance his basic requirements, being unable to access working capital, much less funds for long-term investments which are required to introduce technological changes to promote productivity. This lack of liquidity on the part of the farmers means that they have to sell their grain at low prices, especially to the intermediaries.

Although in the past many organisations producing quinoa have benefited from credit assistance programmes, they are now ready to become involved in commercial finance schemes, whenever their conditions improve. The improvement of the conditions of access to finance falls within the promotional roles of the State (SBPC, 2003).

3.2.3. Insufficient State investment for basic infrastructure

Based on decentralisation, it is the regional and municipal governments which play a predominant role in investigating the basic support infrastructure for production, such as irrigation systems, electrical energy for productive uses, including the improvement of access roads, among others.

According to Crespo et al. (2001) at the present time the cost of transporting quinoa in the area is 0.0124 $US/quintal-km. In other areas of the country the cost is 0.0062 $US/quintal-km, i.e. on the Altiplano the cost of transport is double. There is also a problem of many regions being impassable in the rainy season, as in the case of Salar on the Southern Altiplano, which causes difficulties in the timely supply of the grain.

It is therefore important for the regional and municipal governments to play a more active role in promoting the development of production, prioritising resources for investment in production support (SBPC, 2003).

3.2.4. Lack of business investment in different links of the chain

Deficiencies in business management and the lack of an entrepreneurial spirit reflect on the performance of the organisations, leading to inappropriate decisions or lost opportunities. It is also known that at the level of the first link in the chain, the producers do not have access to market information (prices, volumes, etc), which limits their negotiating power.

The organisational culture of certain production units belonging to the rural workers have not demonstrated a capacity for innovation, which has given rise to many of them losing their traditional markets. Decision-making in these organisations is very slow, as approval must be obtained at each management level, which results in lost opportunities (SBPC, 2003).

It is therefore necessary to promote a change in the business approach of the actors in the chain.

3.2.5. Lack of integration in different links of the chain

Although several productive organisations are vertically integrated by the production process, as they participate in all the stages (agricultural production, stockpiling, industrial processing and export) their interests are not always consistent with those of similar organisations, and even less so with those of private organisations.

A regional theme in the chain is also apparent. The actors of Oruro consider that they produce the biggest amount and the best quinoa, because Salinas is the Quinoa Capital. In Potosí it is said that the best quinoa is produced within its territory and that it is sold as “Oruran” quinoa in Challapata. Apparently this approach has given rise to the halting of a support initiative by the Japanese government, to implement a high-technology Pilot Processing Plant (SBPC, 2003)

3.2.6. Fragmentation of the productive capacity and legal security of the organisations

Around 70% of the quinoa producers on the Southern Altiplano are independent producers. This trend is seen more in the Region of Oruro than in Potosí, where the producers act in a more associative way.

However, the majority of these associations do not act as formal economic agents, but more as non-profit-making organisations. The said situation prevents these organisations from having a more effective participation in the economy. Some of them have opted for the entrepreneurial card, in order to be able to participate in tenders; however, there are restrictions in their action due to the limited existing quota.

Being part of an association is important for making the best use of the productive resources (e.g. irrigation, machinery, etc); likewise, formalisation may become an incentive for the creation of strategic alliances with other actors in the chain (SBPC, 2003).

3.3. Climate

The climate of the Altiplano is characterised by presenting a relatively humid environment on the Northern Altiplano (RH 58%, Tihuanacu Station, 1973-1992) with a gradual reduction towards the Southern Altiplano where the environment is dry (RH 38%, Salinas GM Station, 1945-1985) (IBTA 1994).

As regards temperatures, these fluctuate from North to South and from East to West, being highest in the Eastern part of the Northern Altiplano and lowest in the Western part of the Southern Altiplano. However, significant differences do not appear to exist.

These environmental conditions allow the development of different ecosystems in the humid North and the dry South. In the North it is possib le to see a greater profusion, vegetal communities of the 'bofedal' and 'pajonal' type *Stipa ichu*. Conversely, in the South the xerophytic type of vegetation is more accentuated; a variety of 'tholar' and 'pajonal' species can be found. In this area it is possible to find large areas of plain with no vegetation whatsoever.

3.4. Socio-economic situation

The peasant families settled on the Altiplano are predominantly of Aymará origin, this being the most accentuated characteristic in the North. In the South there is a greater preponderance of peoples of Quechuan origin. On the Central Altiplano the distribution appears to be balanced.

As regards population density, this is in direct proportion to the climatological environment and pressure on the land. The more arid the climate the lower the population density and pressure on the land, and the more humid the climate, the greater the population density and pressure on the land. Accordingly, on the Southern Altiplano the man/land ratio is 1:5, on the Central Altiplano it is 1:6 and on the Northern Altiplano or it is 1:2.

The population density determines the pressure on the land. On the Northern Altiplano land ownership is atomised. However, on the Southern Altiplano land holdings can be found amounting to tens of hectares. This is the case with the Communities of Igachi (Northern Altiplano), Santiago de Collana (Central Altiplano) and Chacala (Southern Altiplano) (IBTA-SIPAB 1992).

The peasant communities of the Northern Altiplano have strong connections with the large consumer centres, such as the cities of La Paz and El Alto; however, the connection with the market is less intense for the distant communities of the Southern Altiplano.

With regard to crops, these vary on the three Altiplanos. On the Northern Altiplano an average of 16 crops can be found, while on the new Central Altiplano and on the Southern Altiplano 8 crops can be found. In this context, the importance of the quinoa crop, within the family production systems, varies for the three Altiplanos (IBTA-SIPAB 1992).

CHAPTER II

RESULTS PER THEMATIC WORK AREA, CONNECTED WITH QUINOA IN BOLIVIA

Background

Due to its importance and value for food purposes, quinoa has been studied since the decades of the '1940s, 1950s and 1960s in different universities in Bolivia, the research work carried out by Dr Martín Cárdenas at the Autonomous University of Cochabamba, being particularly noteworthy. The establishment of the project “Bolivia OXFAM-FAO” in 1965 gave rise to integrated research on quinoa in Bolivia, the emphasis being placed on research into the origin, botanical and genetic aspects. As a result of this research work after seven years at the Patacamaya Experimental Station, the successful culmination was the identification of the “Sajama” sweet variety, which is now spread throughout the Andean region.

The Sajama variety was released at the Patacamaya Station in the year 1968 with an average yield of 2,000 kg/ha, this having had a considerable impact not only at the national level, but also at the Andean region level. Despite this scientific advance, yield at the national level was still considered low, and therefore in 1976-1977 work was carried out with a view to improving the crop.

In 1975 the Bolivian Institute of Agriculture Technology (IBTA) was created, and the National Programmes for the Generation and Transfer of Technology under different heads was commenced. Among these was the National Quinoa Programme at the Patacamaya Experimental Station, which received the support of the International Centre for Development (CIID Canada) in the year 1977, through the IBTA-CIID agreement.

The support of CIID Canada was programmed in three stages. In the first stage emphasis was given to aspects of conservation of the germplasm, genetic improvement and basic agronomic research into pests and diseases. In the second stage the research was expanded to aspects of crop handling, with the emphasis on mechanisation. The third stage included the study of the quinoa-production systems. After the third stage there were many experimental achievements to the benefit of the producers of this crop.

With the closing of the IBTA in 1998, the National Quinoa Programme was restructured and then formed a part of the PROINPA Foundation for the purpose of providing continuity for the various activities carried out, in the knowledge that there had been useful achievements.

The activities carried out by PROINPA were financed by different organisations supporting productive development, both national and international. The national support included that of the Ministry of Agriculture Livestock and Rural Development (MAGDER), CONTRAVALORES and currently the Bolivian System of Agricultural Technology (SIBTA); among the international organisations support was provided by DANIDA, IPGRI, CIP-DANIDA, PPD/PNUD, PREDUZA, IPGRI/IFAD, McKNIGHT and PEREZ GUERRERO.

The DANIDA Project had a duration of one year, up until December 1999. Work was carried out in connection with the quinoa germplasm collection in order to identify promising material with a greater resistance to drought, frosts and salinity. A contribution was also made to the collection of new accessions of quinoa, multiplication of seed in the collection and the organisation and systematisation of the information existing at the Germplasm Bank.

It was also possible to evaluate, together with the producers, precocious [early-maturing] strains tolerant to frost and drought, and a contribution was made towards forming Local Agricultural Research Committees (CIALs) in the areas of action of the Quinoa Programme.

The IPGRI Project also had a duration of one year, up until September 1999. Work was carried out on monitoring the viability of the seed of the quinoa collection and the agro-morphological characterisation of 183 new accessions of the germplasm. A contribution was made towards determining the immediate or medium-term refreshment of the seed of the collection, in addition to completing the agro-morphological information up to accession 2603.

Likewise, the project made a partial contribution towards the training and initial implementation of the germplasm database under the pcGRIN programme, which activities were considered to be important mainly for the purpose of revitalising the collections and reintroducing part of the material to their places of origin, under the system of participative evaluation.

The CIP DANIDA Project had a duration of one year, up until December 2000. Emphasis was placed on improving quinoa to resist adverse conditions (drought, salinity and frost); in this context research activities were carried out in order to identify resistant genotypes. The project contributed towards identifying material selected by resistance to drought and salinity, based on the germplasm of the Andean zone.

The evaluation of the degree of resistance to drought and salinity was conducted in a glasshouse and in the field. The evaluation criteria were determined on the basis of the genetic material, expressed in terms of yield in conditions of stress and also as a function of the components of resistance. Once the accessions of interest for the improvement had been identified, these were submitted to different improvement processors, including selection according to the agronomic properties and the grain, hybridisation plans, identification of molecular markers to facilitate selection, and others.

The PPD/PNUD Project the title having been “Conservation and Management of the Genetic Variability of Quinoa”. It had a duration of one year, up until May 2001. The objectives were: monitoring the viability of germplasm seeds, multiplying the accessions with a reduced quantity of seed, improving the storage conditions of the active collection of the germplasm, commencing studies on long-term conservation and documenting in electronic form the information generated by characterisation and evaluation.

In the CONTRAVALORES Project work was carried out on the Integrated Management of Insectile Pests in the Quinoa Crop. Doses of baculovirus were studied for the purpose of the biological control of the quinoa moth, as well as tests on the virulence of a new entomopathogen of the 'ticona' complex.

The PREDUZA Project is currently in the second stage of execution; work is being carried out on improving the quinoa crop for durable resistance to mildew on the Bolivian Altiplano, due to the fact that the disease reduces the photosynthetic capacity of the plant, causing complete defoliation in susceptible varieties, and a reduction in the yield of 30% to 50%, in serious cases affecting 100% of the crop.

The principal benefit of this project was to assemble germplasm resistant to mildew, and at the same time to train technicians and farmers (men and women) in techniques of selection and evaluation of progeny having a durable resistance to mildew.

The IPGRI-IFAD Project of three years duration, which is in operation up until September 2004. The project is the result of a close cooperation with a wide range of interested groups, including farmers, ONG's, National Universities and National Programmes of Bolivia, Peru and Ecuador. It is focused on vegetal species such as quinoa, cañahua, amaranth and tarwi, which were selected by the member countries based on their nutritional importance and their capacity to generate income, particularly among the poor in the rural environment.

The objectives of the project are: a) to ensure the genetic resource base and extend the distribution of the target crops by means of the development and application of integrated strategies of preservation and use; b) to reinforce genetic diversity, improve the quality and increase the availability of germplasm of the species and more promising varieties and: c) to increase the demand and use of forgotten and under-utilised species by means of the development and application of appropriate technologies of production, processing, commercialisation and marketing strategies.

The McKnight Project is concerned with the sustainable production of the quinoa crop and it is being executed up until October 2005. It works on the Bolivian Altiplano in different thematic areas, such as genetic resources, genetic improvement, integrated management of pests and diseases, harvesting and post-harvesting technology, socio-economics and training.

The SIBTA-SINARGEAA Project. By mandate of the Bolivian State, through the Ministry of Affairs for Country Workers, Indigenous Peoples and Farmers (MACIA), the PROINPA Foundation covers the administration, management and conservation of the High Andean Grain Germplasm Bank, for which it has received financial support from the MACIA since August 2000 under different Agreements signed between the MACIA, the UCPSA and PROINPA. Following the creation of the National System for the Management, Conservation, Use and evaluation of Genetic Resources of Bolivia for Agriculture and Food (SINARGEAA), PROINPA is the acknowledged leading institution of the High Andean Grains Subsystems, for the conservation of the genetic resources of the country's High Andean grains.

The project is currently in execution and it includes complementary *ex situ* and *in situ* activities to ensure conservation and increase the sustainable use of High Andean grain resources. Also included are activities of relationships and interaction with other systems and banks working within the framework of the SINARGEAA.

The main achievements between the agricultural years 1981-1982 to 2002-2003 are set out below in summarised form in thematic areas.

1. Genetic Resources

The first quinoa germplasm organised in the Andean region was implemented during the decade of the 1960s at the Patacamaya Experimental Station. At the present time, this genetic material forms part of the National High Andean Grains Bank (BNGA) which reports to the PROINPA Foundation; the collection consists of 2,949 accessions, which is considered to be the most important collection in the world. The preserved wide genetic variability includes entries for the entire Andean region, as well as for quinoas at sea level. It therefore makes a relevant contribution towards the stability of the country's crop, largely in the Andean region.

The management strategy seeks to achieve rational and sustainable conservation of the genetic resources of quinoa, combining *ex situ* and *in situ* conservation. According to this approach, the accessions and/or populations of interest are simultaneously maintained at the site of origin, especially in traditional (*in situ)* cultivation systems and in the (*ex situ)* germplasm bank, which also constitutes an effective, safe, durable, economic and biologically sustainable alternative.

1.1 *Ex situ* Conservation

In order to have a well characterised, protected and documented germplasm Bank, in addition to continuing to strengthen it by introducing new accessions collected in different regions of Bolivia, various activities were being carried out as mentioned below.

1.1.1 Acquisition

At the present time 2949 accessions of quinoa are preserved at the BNGA. The ratio as regards the form of acquisition indicates that 85% of the genetic material was obtained by collection, 13.5% by means of exchange and 1.5% by means of donations. The initial collection work was carried out on the initiative of Humberto Gandarillas, who went on collection trips throughout the Altiplano and high valleys of Bolivia, with the financial backing of the “Bolivia OXFAM-FAO" Project and subsequently with the support of the Institute of Andean Crops of the Ministry of Agriculture of Bolivia.

Subsequently the collection was expanded with sizeable donations received from the Technical University of Oruro (56 accessions) and 239 accessions from Peru, donated by the IICA, increasing the collection to 1375 accessions. The results of the evaluations of this material at the Patacamaya Station, gave rise to the establishment and description of 17 quinoa strains (Gandarillas 1968).

Subsequently, at the end of the decade of the 1960s and the beginning of the 1970s a further 446 accessions were received by way of donations and interchange from Peru, among which were included 131 accessions corresponding to mass selections from the National Technical University of the Altiplano of Puno. During this same period the collection of 159 cultivated and wild accessions was reported, on the Central Altiplano of Bolivia (La Paz and Oruro) as well as a reception of 65 accessions collected by the OEA, without any recorded data as to the date of collection.

If the numbers reported are added to those of the mid-1970s, the collection of Andean quinoa and crops should amount to 2045 accessions. However, at that time it was decided to exclude from the collection crops of potatoes, oca and papaliza. There were also losses of the genetic material, and therefore a reassignment was carried out of the numbering of the accessions of the quinoa germplasm, some 1458 accessions having been reported at that time. Subsequently, Waldo Tellería carried out a collection in the region of Oruro thereby bringing the collection to 1472 accessions.

In 1978 there were received in the form of a donation, accessions from the north of Argentina, the collection being expanded to 1487 accessions. In the same year Humberto Gandarillas carried out collections on the Altiplano and high valleys of the country, in addition to reporting on the three accessions from Mexico, the collection thereby being expanded to 1516 accessions. Subsequently, in 1981, Humberto Gandarillas, Gualbeto Espíndola and Florencio Zambrana, went on different collection trips in the country, increasing the collection to a total of 1752 accessions. In 1982 the arrival of eight accessions from Ecuador (INIAP) and one from the north of Chile were accorded, expanding the germplasm to 1761 accessions.

Between 1983 and 1985 several collections took place in the country, in which the following participated: Humberto Gandarillas, Gualberto Espíndola, Raúl Saravia, Alejandro Bonifacio, Emigdio Ballón, Germán Nina and Estanislao Quispe, whereby the collection was expanded to 1985 accessions; during that same period the arrival of varieties of quinoa from Peru, Ecuador, Chile and Mexico were also recorded. Subsequently, in 1987 a donation was received of an accession from the north of Argentina and in 1989 a collection on the Central Altiplano of 15 Accessions by Guillermo Prieto, Raúl Saravia and Alejandro Bonifacio, was reported, expanding the collection to 2001 accessions.

In 1992 some 2012 accessions of germplasm were recorded, the last of which (11 accessions) having no information as to origin. In the same year 20 accessions were added from the Southern and Central Altiplanos, the collectors being Gualberto Espíndola, Genaro Aroni and Juan Tupa.

In 1993 a donation of 54 accessions was received, originating from Cochabamba, via the Wiñay Siway NGO, An Integral Cooperative of Punata Services, Radio Esperanza and Segundo Alandia, and four accessions were received from Ecuador via the INIAP, thus increasing the germplasm bank to 2090 accessions. In the same year, the Mañica Substation, through Severino Bartolomé, carried out a collection of 147 accessions (cultivated and wild). There were also added from the improvement area of the Quinoa Programme 182 accessions (wild material and advanced bitter and sweet strains), expanding the collection to 2419 accessions.

In 1994, Wilfredo Rojas, Nicolás Monasterios and Gualberto Espíndola, carried out a collection of nine accessions from the Southern Altiplano and nine accessions from the Pacajes Province of La Paz; there was also an exchange with the Technical School of Caquiaviri, resulting in the addition of 65 accessions. New accessions were received as a donation from the INIA of Peru, bringing the total collection to 2511 accessions. In 1995 some 24 accessions were added to the collection, mainly improved varieties and strains.

In 1998 12 advanced strains were added, originating from the improvement area, and 56 accessions collected on the Southern Altiplano by Alejandro Bonifacio, were recorded. In 1999 17 accessions were added from world testing of quinoa, originating from Peru, Ecuador, England, Holland and Denmark, and 85 accessions were collected on the Northern, Central and Southern Altiplanos, increasing the germplasm bank to date to a total of 2701 accessions (Rojas et al. 1999).

Subsequently, between the years 2001-2003, with the support of the IPGRI-IFAD project, 248 accessions were collected by means of decentralised collections, where the social institutions, university students and groups of farmers played an important role in increasing the collection of quinoa germplasm to 2949 accessions, covering geographical areas which had not previously been processed (Rojas, 2002a; Rojas et al. 2003).

1.1.2 Storage

The BNGA is kept in La Paz at the Altiplano Regional Office of the PROINPA Foundation. The traditional form of storage that has prevailed is short- and medium-term conservation, taking advantage of the environmental conditions of the Altiplano. However, in the last two years it was possible to implement long-term conservation.

Short- and medium-term storage

The accessions are stored in a dark environment under natural conditions, where the storage temperature during the year fluctuates between 8°C and 16° between the minimum and maximum temperatures, respectively, the average relative humidity of the environment being 45%. Each accession is stored in plastic containers with 500 grams capacity. The packages are semi-hermetic, 0.6 mm in thickness and with a double layer, ideal for preserving germplasm in the short and medium term.

The quantity of seed that is conserved per accession is 300 grams (average), the moisture content of which fluctuates between 9% and 12.8% (Rojas and Maydana, 2001). The packages are duly identified with the accession number, from 0001 to 2949 and are arranged on metal stands with five trays.

Under these storage conditions the quinoa seeds maintain their viability for a period of between 8 and 10 years, with acceptable levels of viability (65% to 85%) in accordance with the standard for the management of gene banks.

Long-term storage

Between the years 2001 and 2003 work was being carried out on the process of standardising a method to reduce the moisture content of the quinoa seed for the purpose of its long-term conservation. By means of a moisture-extraction device it was possible to reduce the humidity content of the seeds without affecting their viability, to levels fluctuating between 5% and 6% in 247 accessions of quinoa forming the collection nucleus.

The quantity of seeds used per accession was between 1500 to 2500 seeds, which were exposed to a temperature of 40°C for 18 hours; the genetic material was then vacuum sealed in tri-laminar aluminium envelopes and finally stored in a freezing chamber at -18ºC. The description of the method for implementing the long-term conservation of the collection of quinoa germplasm includes the protocol of analysis of viability and recovery of the germination to levels above that recommended by the standard for gene banks (Rojas and Camargo, 2003).

1.1.3 Characterisation and evaluation

In the year 1981-1982 the first characterisation and evaluation of the different accessions of the germplasm collection was carried out, using the descriptors developed by the National Quinoa Programme. The growth habit, general vigour and height of the plant, foliage, tolerance to frost, drought, deluge, pests and diseases, flower type, ear type, and yield, seed quality and size of grain were evaluated.

Subsequently, for the purpose of publishing a catalogue of the collection of quinoa germplasm, in the years 1992-1994 the work commenced on the characterisation and preliminary evaluation at the Patacamaya Experimental Station of the former Bolivian Institute of Farming Technology (IBTA), which was completed by the PROINPA Foundation in the years 1998-2001 with the support of the IPGRI and SIBTA-UCPSA (Table 10).

Table 10. Details of characterisation and evaluation of the germplasm collection

Agricultural Year	Accessions		Place	Financier
	Number	Identification		
1992-1993	2032	0001-2032	Patacamaya	IBTA - World Bank
1993-1994	2421	0001-2421	Patacamaya	IBTA - World Bank
1998-1999	183	2422-2603	Belén	IPGRI
2000-2001	99	2604-2701	Choquenaira	SIBTA - UCPCA

In the field work characterisation and evaluation, 45 agro-morphological variables were recorded, quantitatively and qualitatively, from the emergence of the seedlings to physiological maturity. Meanwhile, in the characterisation of the grain 13 variables were recorded quantitatively and qualitatively, making a total of 58 variables.

The information obtained was systematised and the first “Catalogue of the Quinoa Collection Conserved at the National Bank of High Andean Grains" was published. The published material contains information relating to: Passport details, colouration of the shoot, architecture of the plant, characteristics of the stalk, shape and size of the leaf, shape and size of the ear, characteristics of the grain, saponin, yield, phenologic stages and tolerance to abiotic factors (Rojas et al. 2001).

A new list of descriptors has also been proposed, based on that which was published by the IPGRI (CIRF, 1981), this having been standardised at the national level by experts working with the crop. The list of quinoa descriptors contains passport data that includes ethno-botanical variables as well as characterisation and evaluation data (Rojas and Pinto, 2003). The document will be considered as forming the basis for the publication of a new edition by the IPGRI.

From the year 2003 work was being carried out to complete the characterisation study using markers of the micro satellite type, due to the fact that they are numerous, highly variable, co-dominant, well distributed in the genome, relatively easy to use and reproducible.

The expansion of certain regions of the quinoa genome known as “micro satellites” is being carried out with the hope that these differ in size from one individual to another, which would make it possible to reveal differences between the individual specimens analysed, which is what is in fact sought when any type of marker is used in genetic diversity studies (Melgarejo et al. 2004).

1.1.4 Multiplication and regeneration

In the year 1991-1992 the first study on the viability and vigour of the seeds stored in the quinoa germplasm collection was carried out. The results made it possible to determine the existence of a low percentage of germination in the accessions, for which reason in the following year the entire collection was regenerated, and at the same time this opportunity was used to increase the quantity of available seed.

For handling the germplasm collection it has been determined that the critical quantity of seed required for multiplication of the material is 60 grams (Rojas and Bonifacio, 2001), while the managed levels of viability are 85% for cultivated accessions and 65% for wild accessions, in accordance with the Standards for Gene Banks (1994).

For the purpose of implementing a calendar schedule for regeneration of the quinoa collection, viability monitoring was carried out on two occasions. The first analysis took place in the year 1999-2000 following which the germplasm was conserved for 7 years, and the second analysis took place in the year 2000-2001, immediately following the regeneration of the germplasm. Differentiated groups were identified in the maintenance response of the viability percentage: 9 groups in accessions of cultivated quinoa and 5 groups in accessions of wild quinoa (Rojas, 2001). Since that time the germination tests have been carried out every 6 months in the groups identified, in order to quantify the descendency over time.

1.1.5 Documentation and information

Traditionally the manual system of documentation has prevailed for recording the information generated in each of the management stages of the germplasm collection. This system consists of a collection file, a book on passport data, a book on characterisation and evaluation data, as well as a book on data on the viability and size of the sample.

Between the years 1999-2001 the database of the quinoa germplasm collection has been implemented under the pcGRIN programme, with the inclusion of passport data, characterisation and evaluation data, data on collaborators, geographical data and taxonomic data on 2701 accessions, this being the first Andean region equipped with an electronic documentation system (Rojas and Quispe, 2001).

The electronic documentation system has facilitated the search for promising materials to allow the promotion of the use of the potential genetic resource available in the germplasm collection and in accordance with the requirements of the programme for the genetic improvement of the crop. Likewise, it has allowed the analysis of the genetic variability of the germplasm collection, determined the patterns of variation, the most discriminating quantitative variables, and has identified groups of different genetic variability (Rojas, 2003).

Subsequently, the intra-group genetic variability of quinoas in the area surrounding Lake Titicaca and Royal Quinoas of the Southern Altiplano of Bolivia was studied. The genetic variability of the germplasm of wild quinoa was also studied, during which 6 groups were identified, suggesting the presence of 6 different species in the wild quinoa germplasm. Groups 2 and 4 were the most distant between one another and included the most early maturing and the most late maturing quinoas, respectively; in group 4 the semi-late accessions predominated, originating from the high valleys of Chuquisaca, Cochabamba and La Paz, while groups 1 and 3 displayed a certain similarity and originated from the Altiplano shared by Peru and Bolivia.

For the purpose of facilitating the management and increasing the use of the quinoa germplasm, the nucleus collection was formed using multivariate statistics procedures. The nucleus collection comprises 267 accessions which represent 10.6% of the total collection. A comparison of the genetic variability among the total number of accessions considered in the analysis and the collection nucleus reveals that the selection strategy of dissimilar materials was appropriate. The most important correlations between the quantitative variables observed in the entire germplasm collection under the control of various complex genes, were also conserved for the nucleus collection, which demonstrates the representativity of the genetic variability. The details on the origin of the nucleus collection is that 200 accessions are from Bolivia, where a greater number originated from the regions of La Paz, Oruro and Potosí, as compared with Cochabamba and Chuquisaca; 48 accessions are from Peru, with a significant contribution from the region of Puno; 6 accessions are from northern Argentina, 1 accession is from Ecuador and 1 accession is from Europe; 9 accessions report passport data of the OEA and; 2 accessions whose passport data is in the process of recovery (Rojas, 2002b).

Maps of the geographical distribution of the quinoa collection have also been prepared, in which the genetic variability is distributed from 0º 08' on the Equator to 44º 00' Southern Latitudes in the southern region of Chile, and from 64º 19' to 78º 20' Western Longitude, the biggest variability being concentrated in Bolivia, mainly in the region of the Altiplano, in areas bordering the road extending through Lake Titicaca, La Paz, Oruro, Challapata, Sevaruyo and Uyuni. In the case of the Southern Altiplano, also in the areas of Salinas de Garci Mendoza, Daniel Campos and los Lipez. In the Valleys region a greater concentration of accessions is noted in the high valleys of Cochabamba, Chuquisaca and Potosí, in comparison with the high valleys of Tarija. These results assist in the planning of future collection work from geographical areas not yet covered. Those areas that are seen to have a greater concentration of accessions are likewise potential areas for implementing *in situ* programmes of conservation, where the farmers participate as the principal actors (Rojas, 2002c).

1.2 *In situ* conservation

In the year 2001-2002, studies were commenced to design a strategy for *in situ* conservation of quinoa to complement *ex situ* conservation, which takes place at the National High Andean Grains Bank. Plans were laid to study the state of genetic variability of quinoa on the Southern Altiplano and on the Northern Altiplano, in the vicinity of Lake Titicaca, both being considered to be sub-centres of genetic variability of quinoa within the country.

On the Southern Altiplano it was determined that 96% of farmers cultivate between 1 and 4 ecotypes of Royal Quinoa and the remaining 4% sow between 5 and 12 ecotypes. Royal White and Pandela are the ecotypes that are used with the greatest frequency by the farmers, being cultivated by 78% and 63% of the producer population, respectively. The ecotypes that are next in terms of frequency of use are Pisankalla sown by 16% of the farmers, Utusaya White by 15%, Toledo by 14%, K'ellu by 11%, Blanco Puñete by 7%, Chillpi by 6%, and Elva and Roja-Granadina by 5%.

The other ecotypes are being sown by 10 or fewer farmers, equivalent to between 1% and 3% of the producer population. The situation is rather critical for the Challamoco, Mizca, Manzana, Mezcla and Uyuka ecotypes, which are only being sown by one farmer in the sample, equivalent to 0.4% of the population. These ecotypes are clearly in a process of genetic erosion which requires immediate intervention in order to avoid their loss (Rojas et al. 2004).

In regard to the study on the genetic variability of quinoa in the area surrounding Lake Titicaca (Northern Altiplano), it was also determined that the current state of variability is critical, the number of varieties having been reduced to 40, with families most frequently sowing the local variety 'Janko Jupa' (32.3%). 68% of the families sow between 1 and 4 varieties. 74% of the families place the crop in third and fourth place in terms of importance, after potatoes and broad beans/oca. In regard to the sown surface, plots of between 2 m and up to 5000 m are used^2, where 71% of those interviewed sow on plots smaller than 500 m^2. The production of the crop is used as follows: an average of 85.57% for self-supply, 6.13% for sale, 5.94% for seed and 2.36% for barter (Rojas et al. 2003).

In both studies the figures can be considered to be indicators of critical danger, requiring immediate action, for which case and participant studies are being carried out in order to evaluate the reasons for the loss of variability, the preferences of the farmers and the potential for revaluation. It is also necessary to promote the use of the genetic variability available through the National High Andean Grains Bank in order to increase the use and diversity of varieties of quinoa.

For the purpose of promoting the quinoa crop and its genetic richness, a certain amount of revaluation work was carried out. In the production of quinoa for the marketplace, there is a predominant preference for the white-coloured grain of a large size, which is known as commercial quinoa. This market preference is leading to displacement from the Creole varieties, especially those of a dark colour which mainly has varied traditional uses. In this connection, in the year 1999-2000 an agronomic and culinary evaluation was carried out of 32 selections of quinoa of dark-coloured grain originating from the quinoa germplasm, which can be employed in the production and diversification of the uses of quinoa.

Also since the year 2001-2002, a strategy has been applied to promote the use of the genetic variability of quinoa with the active participation of the farmers, who, by means of their participative evaluations, identify the varieties that present the best adaptation to their environmental conditions, in accordance with their selection criteria, which is considered to be good commercial potential.

2. Genetic Improvement

This was the subject area involving the greatest number of works carried out and it involved the greatest initial efforts of the Quinoa Programme, seeking to obtain promising material with outstanding agronomic characteristics that can easily be adopted by the farmers of the Altiplano. A summary of the main activities and results obtained is set out below.

The work of genetic improvement is focused on minimising the effect of the principal factors limiting production, such as drought, frost, pests and diseases, in addition to obtaining early maturing material with varying contents of saponin.

2.1 Improvement by hybridisation

Although in the decade of the 1960s crossing took place in order to obtain the first variety of "Sajama" quinoa, the improvement by hybridisation commenced in 1977, with 18 crossings between strains of the Sajama variety and other large-grain samples, with the support of the International Centre for Development (CIID Canada), through the IBTA-CIID Agreement.

From that year crossings were carried out annually between progenitors of different origin in order to fix in future varieties the genetic diversity existing in the species. The crossings were oriented towards increasing the yield of the crop, obtaining resistance to biotic and abiotic factors, grain size, low content of saponin, early-maturity and others. The efforts were concentrated on obtaining a material for the conditions of the Central and Northern Altiplanos to exceed the yield of the Sajama variety, early-maturing, having a sweet grain and of good quality.

Between the years 1980 and 1984 inter-species hybridisation work was carried out within the Cellulata of the *Chenopodium* genus in order to resolve the origin of the quinoa crop. It was determined that the wild species *Chenopodium petiolare, Chenopodium hicinum* and *Chenopodium sp.* related to the geographical origin of quinoa. The crossings between *Chenopodium petiolare* and *Chenopodium hicinum* produced alotetraploides with 36 somatic chromosomes. One of them had all the characteristics of *Chenopodium quinoa*, such as plant morphology, the shape of the ear, the colour and the size of the seed.

During this same time period, the Samaranti variety was released by means of individual selection based on the Sajama variety. The presence of genetic and cytoplasmatic sterility in quinoa was also determined, these being promising results for the production of hybrids using male sterility in order to increase the yield. Genetic markers were also identified, such as the shape of the ear, the colour and the saponin content, and the type of heredity was determined.

The results of this work was that in the year 1985-1986, Huaranga, Chucapaca and Kamiri were released as new varieties having the characteristics of varieties with a yield better than that of the Sajama variety, sweet, with a large-sized grain and white in colour. In the year 1991-1992 the Sayaña variety was released, this being the variety with the best grain yield, having good characteristics and of the early-ripening type. In the year 1993-1994 the Ratuqui was released as a new variety, this being early-ripening, of large size, sweet and offering a good yield.

In the year 1993-1994, the Robura variety was released, based on individual selection work. The year 1997 saw the release of 7 varieties of quinoa: Jumataqui, Intinayra, Santa María, Patacamaya, Jiskito, Surumi and Jilata, which were registered with the Regional Seeds Board of La Paz, in order to provide them with legal protection for use of the varieties and obtention rights.

In the year 2002-2003 the Jach’a Grano (Large Grain) variety was released by the PROINPA Foundation. This variety has characteristics of producing large, bitter grain, being the first of its type, since all the previous varieties of improvements are of sweet grain; Jach’a Grano therefore has a good option of being adopted in areas where attacks by birds is significant. The participation of the farmers has led to the allocation of importance to native technical terms with respect to agronomic characteristics and use. The evaluation and selection of strains by the farmers coincided to the extent of 40% with those selected by the researchers.

2.2 Mass evaluations and selection

For the purpose of identifying prominent material with desirable characteristics, such as resistance to adverse environmental factors, pests and diseases, precocious and of good yield, various evaluation works were carried out, with the mass selection of advanced strains obtained from the genetic improvement programme of the Creole material of the Andean regions themselves, and of material originating from other countries. This work was carried out year after year, becoming increasingly rigorous in terms of the prioritisation of the material evaluated. The most noteworthy work carried out is indicated below.

In the year 1981-1982 the first yield tests commenced on the crossings done at the start of the Project; it was observed that many strains produced 30% more than the control varieties “Sajama” and “Belén”, at the Patacamaya and Belén Experimental Stations, respectively; they also displayed characteristics of sweet large grain and other favourable agronomic characteristics. The introduction of superior varieties in the short term was thus assured.

The yield components were also studied by means of an evaluation of 36 accessions of the germplasm collection. It was determined that yield is associated with the height of the plant (r = 0.45), the length of the ear (r = 0.66) and the diameter of the stork (r = 0.54). The analyses of cause and effect made it possible to determine that the length of the ear and the diameter of the stalk have a notable direct effect, the values having reached 59 and 38 percent, respectively, followed by the weight of 100 grams which amounted to 12.58 percent.

In the year 1987-1988, tolerance to frost by the Creole varieties was evaluated, these varieties having withstood frosts of up to -7ºC. However, in the year 1988-1989, in another study on tolerance to frosts, exceptional tolerance of quinoa to low temperatures was determined, with seedlings withstanding -12ºC, flowering 7.8ºC and grain ripeness -10.4ºC, though in the latter case with a physiological reaction of reabsorption of grain in formation.

In the year 1997-1998, under the management conditions of the farmer, an evaluation was carried out on the agronomic performance of 7 precocious strains in three localities of the Northern Altiplano, in addition to determining their range of adaptation in terms of their precociousness and grain quality. On average for the three localities the Sayaña variety and the 26(85)DD strain were those which showed the best performance.

For the purpose of having material resistant to drought, in the year 1998-1999, the selection of gene types took place at the Experimental Stations of Belén and Choquenaira, 18 selected accessions and varieties originating from research programmes of the Andean Area and Europe, having been evaluated. The evaluation took place in irrigated and non-irrigated conditions. The results of the localities of Belén show that in general terms the varieties of Peru displayed the best yield, while the varieties selected in Europe recorded a lower output; finally, the varieties from Bolivia fall between the indicated limits of higher and lower yield.

With the implementation of the PREDUZA project, in the year 1998-1999 in the locality of Choquenaira (Northern Altiplano), a total of 950 accessions from the germplasm collection were evaluated, for the purpose of identifying partial resistance to the mildew disease (*Peronnospora farinosa*). 90 accessions were selected having characteristics of resistance to mildew, from which 291 individual plants were selected. Meanwhile, in the locality of Belén, based on the same 950 accessions, 60 accessions were selected with a total of 198 individual plants. The large quantity of selections was subsequently reduced, based on the characteristics of the grain.

In the year 1999-2000, a regional survey of advanced strains resistant to mildew was carried out, which consisted in the evaluation of 9 strains selected due to their partial resistance to the disease, which was replicated in two localities of the Northern Altiplano of Bolivia. The variables evaluated were incidence and severity as well as certain variables of an agronomic type, such as precociousness, harvesting rate, weight in hectolitres, size of grain and yield.

The results display a high incidence between 70.4% and 100% and a severity between 72.5% and 100%. The strains produce grains of medium and large size. The material was highly homogeneous, and 5 outstanding strains were selected.

In the same year, gene types resistant to drought selected in the Andean area were evaluated, in addition to the degree of resistance to frost, agronomic performance and yield in the localities of Choquenaira, Jalsuri, Letanías and Belén, on the Northern and Central Altiplanos. The material evaluated consisted of two groups, the first of varieties and accessions able to escape frosts, and the other group made up of accessions selected due to their resistance to frosts in Puno, in which materials of Bolivian origin were included. The system of precipitation was more or less regular for the Altiplano, so that there was no opportunity to precisely evaluate resistance to drought. The majority of the material evaluated performed as precocious and very precocious, completing their maturity cycle between 130 and 150 days. The decrease in temperature occurred when the plants were in the flowering and grain ripeness stages. The majority of the material was affected, between 40% and 60% of the plants, very few of the accessions having tolerated a frost of –6ºC.

In the year 1999-2000, the extent of the genotype interaction was estimated on the basis of the environment and the geographical stability of the yield of 15 varieties in three locations of the Northern Altiplano. It was determined that the varieties Jilata, Robura and Chucapaca, displayed similar yields, in the case of Jilata and Chuacapaca comparatively higher than the average for the varieties studied, while Robura was slightly lower. The said characteristics define these varieties as being of high productive capacity in a stable and predictable form in a wide range of environmental conditions, irrespective of the system of production. Therefore, the varieties Jilata, Robura and Chucapaca can be recommended for the conditions studied, although the absence of the yearly effect did not allow the seasonal stability of the varieties to be estimated.

In the year 2001-2002, the tests on yield continued, including the 5 advanced lines with partial resistance to mildew, and one control line, in three locations of the Northern Altiplano of La Paz (Jalsuri and Letanías in the province of Ingavi, and Belén in the Province of Omasuyos). The farmers participated in the evaluation, laying emphasis on the general performance of these strains, the vigour, height and population of the plants, the quality of the grain and their ability to be processed by the consumer for The incidence of disease in different genotypes recorded values of up to 100%. The genotype with the lowest percentage of severity was the Púrpura strain, with 10.1% severity, followed by the Sayaña variety, with 12.9% severity. The contrary occurred with the 320 strain, which recorded higher values of attack by the disease, reaching 40.1%.

3. Agronomy

Work was carried out in this area to generate technologies that made it possible principally to improve the production of the crop, and for these to be adapted to the different socio-economic conditions of the farmers of the Southern Altiplano and the Central and Northern Altiplanos. The main technologies investigated included the following:

3.1 Land preparation

Land preparation is a technical and mechanical process designed to condition the land to provide it with a good seed-bed. The quality of preparation of the soil land determines to a large extent the success of the harvest, and therefore this work must be carried out with the greatest possible care. Land preparation is a process that involves several stages.

For the conditions of the Central and Northern Altiplanos, it is recommended that the land be prepared with a rotary plough or 'scooper', depending on the type of soil. This work should be done in February or March, taking advantage of the last rains of the season. It may also be possible to till the land during the snowfalls at the end of the winter. This technology is generally applied for commercial production on both Altiplanos, though land used for subsistance farming is still prepared with a yoke plough on plots that were sown with potatoes in the previous year.

In the decades of the 1970s and 1980s, on the Southern Altiplano the agricultural boundary was extended due to increased demand for quinoa. The crop is becoming more extensive and it is spreading towards the plains, the use of the rotary cultivator being introduced there. But its excessive use has caused problems because of the erosion of the soil due to its fragile texture. This also resulted in an ecological problem in the region due to marginal land being taken over. In view of this situation, it is recommended that the preparation work be carried out according to a set of practices such as the rotation of plots, the use of living hedges of thola, and the tilling of the soil without turning over the arable layer.

The National Quinoa Programme of the IBTA developed a technological alternative for the Southern Altiplano, consisting in the use of a rotovater in the first ploughing, that is to say on virgin land, in order to introduce the organic material, but from the second ploughing the use of the chisel plough, known in the region as the “Qhulliri”, is recommended. However, on the hill slopes the land is still prepared manually, which is characterised by localised processing, that is to say in the physical space where the seed is deposited.

3.2 Sowing

Sowing is a very important initial step for the establishment of quinoa; this task must be carried out correctly and at the right time. The moistness of the soil at the time of sowing is a decisive factor for good germination and to obtain an adequate population of plants per plot.

On the Central and Northern Altiplano, the traditional form of sowing consists in scattering the seed at random and then passing with a yoke plough or leading animals (sheep) over the plot once the seed has been scattered. However, technologies have been developed, including sowing in furrows, which consists in initially opening up the furrows with the yolk or mechanical traction plough and then distributing the seed in a continuous stream. The mechanised system makes the furrows, carries out the distribution and tops off the seed simultaneously.

The implements used for the sowing of quinoa were adapted from those designed for smaller cereals and grasses. It is possible to obtain seed distributors manufactured within the region according to the technical specifications suggested by the National Quinoa Programme. This implement has four ploughshares which open up the furrows, two hoppers which distribute the seed, and wheels coupled to each ploughshare, which plug and compact the seed. Rainfall of 12 to 15 mm in less than 24 hours is the minimum required to start the seeding process. The mechanised system makes it possible to take advantage of a small amount of moisture and to cover the greatest possible surface area.

In the year 1983-84 important discoveries were made on improving the quinoa-production technology. The first relates to the increase in the number of furrows per hectare, maintaining the same density of sowing in each furrow, which resulted in a consistent increase in yield. The second relates to the positive influence of ridging to increase production. These results show that by combining the use of the improved variety, with the seed in a smaller space, and ridging between 30 and 45 days, increases the yield from 3,000 to 4,000 kg/ha, although this is under the management conditions of the Patacamaya Experimental Station.

In the year 1997-1998, a quinoa seed distributor was designed for manual pushing/traction operation by a single person. The implement is currently being evaluated on the plots of the farmers, with good performance of the equipment and good acceptance by the farmers, having been initially observed.

Traditional sowing on the Southern Altiplano is done in holes one meter apart, the depth of which must reach the moisture accumulated in the soil. This work is carried out with human effort, using a tool which is called a “taquiza” in the region. However, from 1980 a prototype was constructed for the mechanised sowing of quinoa, called “Satiri I” which, driven by motorised traction, maximises the moisture in the soil, with a performance of 2.5 hours per hectare in comparison with manual sowing, which requires 56 hours per hectare, representing 7 working days.

3.3 Application of organic and inorganic fertilisers

Due to the need to identify the doses and the seasons for the addition of nutrients to the quinoa crop, studies were carried out on the use of organic and inorganic fertilisers.

In the years 1981-1985, at the Patacamaya Experimental Station, for the conditions of the Central and Northern Altiplanos independent tests were carried out on the effect of different doses of organic fertiliser, a favourable response having been observed in the crop in comparison with the independent addition of each of them, a small increase having been noted in the yield by the application of sheep and llama manure. Furthermore, the protein content of the grain increases with increased volumes of sheep and llama manure.

Continuing with the studies, in the year 1986-1987 doses of nitrogenised and phosphorised fertilisation were tested, a good response in the crop having been observed solely in respect of the application of nitrogen, both on the Northern Altiplano and on the Central Altiplano, Levels of 40-00-00 and 80-00-00 being recommended to generate increased production and rate of return. No clear response was observed with the addition of phosphorus.

Following several research campaigns on the subject of fertilisers or compost in the year 1992-93, it was possible to provide a precise recommendation with respect to the fertilisation of quinoa on the Central and Northern Altiplanos, which consists in the application of nitrogen in a dose of 80 kg/ha, applied in split form, 50% during the topping of the ears and 50% during the pre-flowering stage, preferably after rainfall in excess of 15 mm, to facilitate absorption by the plant and to avoid losses due to volatisation. The use of sheep, cattle or llama manure (organic fertiliser) is recommended in the application of 5000 kg/ha, distributed randomly before the soil is rotovated, to assist its decomposition.

Due to the fact that on the Southern Altiplano, there has been an increase in the demand for the production of organic quinoa, the greatest efforts in this region have been concentrated on organic fertilisers. The technological alternatives are: a) The introduction of the manure in holes after rotovation, in an amount of between 300 and 500 grams per hole, leaving a mound of earth to identify the place at the time of sowing. By means of this method of application between 3 and 5 MT of manure per hectare are used. b) Random introduction before the soil is rotovated (January to February) in a quantity of 10 MT per hectare, which should be spread uniformly over the entire surface area.

3.4 Harvesting and post-harvesting

There could be an increase in the volumes of national production of quinoa if losses attributable to management deficiencies, particularly at the time of harvesting and post harvesting, could be reduced. These deficiencies result in the poor quality of the final product, grains being observed that are split, contaminated with impurities, and other aspects that result in the rejection of considerable quantities of the production.

Harvesting and postharvesting are important stages with regard to the quality of quinoa grain. Management, from cutting to final processing is costly, and for this reason small stones and impurities can often be found in the final product, which are castigated by a low market price. In the majority of cases this work is done in traditional form, the plants being uprooted by hand, dried on stacks or heaps, and once the plants are dry threshing takes place manually.

On the Southern Altiplano from the year 1995-1996, efforts were intensified on evaluating different methods of cutting, stacking and threshing, complementing a physical analysis of each treatment. The results demonstrate that the cutting of the quinoa reduces the probability of the incorporation of impurities and small stones in the grain, that drying is accelerated with the "arches" system, and that this method offers a relative degree of protection against attacks by rodents. The mechanical thresher makes the threshing process easier and reduces the percentage of unthreshed grain.

In the year 1996-1997, mechanical cutting was introduced with the use of harvesters, acceptance having been achieved within the region. Cutting with harvesters and sickles has spread throughout 13 communities of the Southern Altiplano, some 253 hectares having been cut, benefiting 153 quinoa producers. With effect from the following year (1997-1998), the use of sickles and harvesters in quinoa production became widespread.

During the period 1999-2000, the technologies of drying and threshing quinoa with a view to reducing the contamination of the grain were validated, which process is normally done using traditional technology, consisting in the uprooting of the plants (it having been observed that earth, sand and small stones were attached to the roots, which contaminated the quinoa grain) as well as the stacking process. Despite the efforts of several institutions such as IBTA, CORDEOR, PAC, ANAPQUI, CECAOT, MAGDR/FAO HOLANDA and progressive farmers who participated in partially resolving this problem and these new technologies were adopted by a reduced number of producers.

In the year 2000-2001 research work was carried out, established on a farmer's plot on the Southern Altiplano, which consisted in testing different alternatives of harvesting, drying and threshing, in order to reduce the rates of contamination in the harvested grain. It was observed that the best alternative was cutting by sickle and direct threshing, because this significantly reduces the contamination of the grain with inorganic impurities, thus producing a grain of better commercial quality. Mechanised threshing with the “Vencedora” Thresher achieved outputs of 10 to 12 quintals per hour.

For the production of quality grain, in the year 2001-2002, harvesting and post harvesting technologies were tested, executed on the Central Altiplano(Jalsuri Community) and on the Southern Altiplano (The Sajsi and Villa Pucarani Communities). On the Central Altiplano it was observed that there are no differences in the number of days required to harvest a hectare of quinoa using the manual method of lifting the plants and cutting with a sickle; it was also determined that the percentage of loss of grain using the traditional method was 0.9% and using the sickle it was 1.3%. On the Southern Altiplano, participative evaluation was carried out of two cutting methods (cutting with the sickle and cutting with the mattock), in addition to using the “Vencedora” thresher. There were better results using the sickle, and the use of the thresher improved the quality of the grain.

During the same year, a manual airing device developed by the FAO-Post Harvesting Project received considerable acceptance by the producers of the Southern Altiplano. In the Chacala Community, the PROINPA Foundation, together with groups of interested farmers, carried out demonstrations with the venter and -the results were highly favourable, several families in the region having adopted this technology.

In the year 2002-2003, manual venting continued, in addition to motorised venting and the application of direct threshing. The grain obtained was cleaner (containing no rodent or bird excrement) and therefore the product achieved a better price at market. A negative aspect pointed out by the farmers was the cost of the machinery. Other comments were added, such as the technique of cutting with a sickle has not been adopted by the farmers as these are not very practical when the stalks are thick, and it strains the back of the operator.

4. Integrated management of pests and diseases

The production potential of the quinoa crop is constantly limited due to attacks by pests and diseases, which restrict its normal development and production. Among the main diseases is the mildew disease, caused by the fungus *Peronospora farinosa*, and among pests there is the quinoa moth or kcona kcona (*Eurisacca melanocampta*) and the 'ticona' (*Copitarsia turbata*). For this purpose the National Quinoa Programme carried out research with a view to controlling the incidence of the said pests and diseases.

4.1 Chemical control

From the year 1981-1982 tests were carried out on the chemical control of mildew and the kcona kcona and ticona pests, results having been found that encourage the continuation of the research. On the Central Altiplano, for the control of mildew the chemical products Antracol (0.357 kg/ha), Manzate 200 (0.5 kg/ha), Polyram (0.25 kg/ha), and Miltox (2 kg/ha) were tested. In general there was a good response, with yields of 2,570 to 3,141 kg/ha being achieved.

In the year 1987-1988, the efficiency of different chemical products was tested, including the fungicides Benlate and Ridomil, these having been applied according to the different rates of severity of the mildew, and subsequently an economic analysis was carried out. Among the products evaluated, Ridomil was shown to provide the most efficient control and the best season for application was when 30% severity of the pathogen existed. This alternative technology is currently being applied on commercial plots on the Central and Northern Altiplanos.

For the control of insects, chemical products were studied (insecticides) which rapidly reduced the population density of the insects. It is recommended that the following insecticides be applied: Ambusch (4-6 cc/20 litres), Karate (3-5 cc/20 litres) and Baytroid (15-20 cc/20 litres). However, with frequent use the insects can become resistant, and therefore variation is recommended, alternating with other control methods.

4.2 Biological control

In the case of controlling the main crop pests, various activities were carried out, including the identification of biological controllers, the use of natural extracts and the validation of bio-insecticidal products.

In the year 1987-1988, work was carried out on the identification of biological controllers of quinoa pests, with a view to identifying forms of parasites and depredation. In this connection, there were identified as the main bio-controllers of the kcona kconas and the ticonas, certain large wasps commonly known as chinca-chinca and nina nina.

In the year 1993-1994, studies were carried out on the use of bio-insecticides and entomopathogens. The entomopathogens for controlling the pests, were the *Beauveria bassiana* fungus, the *Bacillus thuringiensis bacteria*, and the granulosis virus. On the Southern Altiplano (Salinas de Garci Mendoza), the best results were obtained with the granulosis virus (baculovirus) and the Dipel (*Bacillus thurigiensis)* in high doses. On the Central Altiplano (Caracollo), the greatest efficacy was achieved by use of the baculovirus in a high dose. Using the identified results, a programme of Integrated Pest Control was introduced. Based on these studies, preliminary recommendations are now already in place with respect to the use of piretroides insecticides.

During the period 1994-95, mainly for the purpose of controlling kcona kconas and ticonas, Dipel and Baculovirus were tested, in comparison with a chemical controller (Ambusch). It was observed that the bio-insecticides can control pests up to a rate of 70%, but only in the 1st and 2nd larvae stages and not in the 3rd and 4th stages. The best results were achieved with Ambusch, which provided 91% control. Despite these results, good acceptance was achieved in the communities of the Southern Altiplano for the bio-insecticides

During the year 1995-1996, on the Southern Altiplano, three species of parasitoids of the quinoa moth were identified. The species are of the *Deleboea sp* complex 'Ichneomonido' and *Copidosoma* sp., which remain in diapause in their cocoons (in the soil). Significant advances were also achieved in the biological control of pests using natural extracts: Muña blanca, Muña negra, Molle, Chachacoma, Uma thola and Ñak'a thola, which displayed gradual efficiency in controlling the pests of the quinoa crop. The residual effect of the extracts does not remain for a prolonged period in the crop; it is biodegradable and has no effect on benign insects, although it is necessary to identify the optimum doses in order to reduce the cost of using these natural extracts.

In the year 1996-1997, studies were carried out on the Central and Northern Altiplanos to identify the best bio-controllers of the main quinoa pests. In the area of integrated management of pests, the efficiency of the extracts of 'muña' in controlling pests has been demonstrated, although the costs are high. It was also determined that defoliating pests and grain crushers can be controlled with the use of pyrethrum, provided that the two pests are in the initial larvaeal stages

In the year 1998-1999, on the Central and Northern Altiplano field tests were carried out on the efficiency of two doses of Matapol (20 and 40 larvae/litre of water) for the biological control of the quinoa moth, as compared with the product Ambusch. Treatment with Ambusch was the most effective, recording an average control efficiency rate of 87%. This was followed successively by the treatments 20 and 40 larvae per litre of water, which recorded averages of 64% and 50% efficiency, respectively. The results obtained show that the chemical treatment is the most efficient in controlling the quinoa moth.

In the year 1999-2000, on the Northern Altiplano, for the purpose of controlling the moth tests were carried out with four doses of Matapol (5, 20, 35 and 50 larvae/litre of water) and one dose of the product Ambusch (0.25 ml of Ambush/litre of water). The Ambusch product was the most efficient, providing 87% control, and the doses of Matapol of 35 and 50 larvae per litre of water recorded efficiency rates of 55% and 56%, respectively, evaluated 21 days after application, clearly demonstrating that the percentage of efficiency is increased with the increase in the concentration of the spray.

In the same year, on the Central Altiplano, tests were carried out on the efficiency of 4 doses of Success (a bacteria metabolism product), as an alternative in the biological control of the quinoa moth and its effect on the benign fauna, compared with a chemical treatment. The treatments of 50 and 60 cc of Success per 100 litres of water and the chemical treatment achieved efficiencies of 88%, 93% and 97%, respectively, clearly demonstrating that the bio-controller could be another important alternative in the biological control of the moth.

The tests were carried out on the efficiency of three doses of Tracer (a new biological product considered to be highly ecological as it is selective and non-toxic for beneficial insects and man) in the control of the quinoa moth. The work was carried out on the Central Altiplano (Jalsuri) on plots of the Sayaña variety and the L-26 strain. The results showed that Tracer is a highly efficient product in controlling the quinoa moth, recording efficiency rates from 96% to 98% between the lowest dose and the highest dose, respectively, for the Sayaña variety, and from 89% to 91% for the L-26 strain.

Based on the results obtained, in the year 2001-2002, on the Central Altiplano an evaluation was carried out of the bio-insecticides Success, Probione and Probiovert, for controlling the quinoa moth. An efficiency rate of 92% was recorded for Success, while the performance of the other two bio-insecticides remained within the ranges of 7% and 40%, which are considered low in preventing losses due to the effect of the pest. Meanwhile, on the Southern Altiplano, an evaluation was carried out on the bio-insecticide Success for controlling the larvae of the ticona complex (Spodoptera sp., Feltia sp.y Agrotis sp.) the results having shown an efficiency rate in excess of 92% on the third day following application in commercial plot conditions.

4.3 Economic damage

Several studies were carried out in order to determine the economic damage caused by the different pests affecting the quinoa crop. In relation to the percentage of loss of grain due to attacks by birds, it was determined that the sweet varieties are the most susceptible, for which the losses are enormous, even amounting to the total loss of the grain when the attack is severe, as is the case around Lake Titicaca (Northern Altiplano) where flocks of lakeside birds attack the quinoa fields. In the past this fact was one of the main arguments of the farmers for rejecting the introduction of sweet varieties, such as Sajama, IBTA-Belén and others, as they preferred to continue to cultivate the bitter varieties.

In the year 1991-1992, the agronomic damage and economic loss due to attacks by moths on the Central Altiplano (Patacamaya) was determined, a percentage loss of 44.6% having been recorded. Meanwhile, in the same year on the Southern Altiplano, losses of 20% were recorded at Tunupa Vinto, 28% at Ancoyo, 38% at Mañica and 35% at Calcha. With regard to the optimum seasons for applying the insecticides, these are when the pest is in the 1st and 2nd lavae stage (Mañica), in the 1st and 3rd stage (Calcha), and in the three stages in Tunupa Vinto.

In a study on the Central and Northern Altiplanos concerning the levels of economic damage caused by ticonas, it was determined that the Ratuqui variety requires only the presence of one larva per 0.7 m2 of crop to cause economic damage. Obviously the greatest reductions in yield are due to the increased population of the pest. In a study on the determination of losses caused by mildew on the quinoa crop, it was determined that the disease can cause losses in yield of more than 50%.

5. Seed production

Seed production is a specialised activity involving a number of technical and logistical aspects designed to guarantee varietal identity, genetic purity, health, viability and performance potential. For the conditions of the Central and Northern Altiplanos, technology has been developed which is regulated and is subjected to official monitoring by the corresponding authorities of the Regional Seeds Office. The technology involves the following procedures:

5.1 Selection and preparation of the land

This should be done as a function of the location and the characteristics of the soil. Isolated plots should preferably be selected in order to avoid possible mixtures with other varieties. In regard to the land topography, this should be flat or may have a slight gradient. The land should be located in areas that are relatively well protected from frosts; the soil should preferably be of a thick or thick-sandy texture, deep and with good drainage conditions.

For the production of good-quality seed, it is necessary to prepare the land adequately. This should be done when the soil contains sufficient moisture, which generally occurs in February or March with the last rains of the season. This means having the land prepared in advance for sowing in September to November.

5.2 Selection of the variety

This depends on the area, the time of sowing and the demand for the variety. For the Central and Northern Altiplanos, the use of the improved varieties obtained by the ex IBTA and the PROINPA Foundation is recommended. However, some of these varieties could have a greater harvest option depending on the sowing season, which is determined basically by the frequency of rainfall. For the first sowing in September, the use of the Chucapaca, Surumi and Robura varieties is recommended; for the middle sowing in October, the Sajama, Camiri, Sayaña and Ratuqui varieties are recommended; and finally, for late sowing, that is to say from November to the first fortnight in December, the Ratuqui, Jisquito, Patacamaya and Santa María varieties are recommended.

5.3 Sowing

It is recommended that sowing be carried out when the soil has field capacity moisture. The most appropriate sowing system for seed production is in rows or furrows; this can be done by means of animal traction or mechanised ploughing and the seed can then be distributed manually or in a continuous stream. The distance between furrows should be 50 cm and the quantity of seed from 8 to 10 kilograms per hectare.

5.4 Isolation

This is a necessary procedure to avoid cross-pollination between varieties and the occurrence of mixtures during harvesting work. Isolation by space consists in establishing the plots of different varieties with a separation of at least 30 metres; this distance can be increased by 50% towards the side from which the wind predominantly blows. Isolation by time relates to the separation of the sowing seasons; this means that the different varieties to be produced on neighbouring plots should be sown with a separation of 15 days between sowing operations. Isolation by cycles consists in taking advantage of the differences in the reproductive cycle of the varieties. Under this system, two varieties differing in terms of cycle (15 days) can be sown in adjacent fields and during the same season.

5.5 Vegetal purification

This consists in the elimination of those plants which do not adhere to the standards described for the variety. Varietal mixtures can be identified by the colour of the plant, the shape of the ear, the colour of the grain, the type of grain, the presence of saponin and others. The work consists in uprooting plants that do not conform to the production variety; more emphasis should be given to wild quinoas that spoil the presentation of the product. It is recommended that this be done in two seasons, the first before flowering, observing the colour of the plant and the type of ear, and the second on physiological maturity, observing the colour of the grain, the type of grain and the presence of saponin.

5.6 Harvesting and threshing

In regards to seeds, the harvest should be done according to a suitable method and using the appropriate system. Reaping should take place when the plants reach physiological maturity; some indicators of maturity are: Complete yellowing of the plants on the entire plot and resistance of the grain to pressure. Late harvesting reduces the viability of the seed. In addition, threshing and selection must be done appropriately, using suitable equipment in order to obtain high-quality seed.

5.7 Categories of seed and certification

The Regional Seed Office recognises two categories of seed, basic and certified. The production of basic seed is the responsibility of the improvement programmes and seed production certified by the Experimental Centres and the seed producers.

The certification of seed is a process that involves carrying out a number of official formalities designed to guarantee the production of high-quality seed. The procedures are: Registration of the production batches, field inspection during the productive period of the crop, store inspection and laboratory analysis. Once the requirements have been met, the producer obtains the official certificate.

For seed production, chemical fertilisation and control of pests and diseases is very important. The technical recommendations used were described in the section on agronomy.

6. Organic production

With the opening up of the international quinoa market, the demand for organic quinoa has become significant. The necessary research was commenced in this connection in the year 1992-1993, which was intensified in the year 1995-1996, with all its environmental connotations and the sustainability of the crop, in order to be in a position to recommend technological alternatives for the production of organic quinoa.

In the year 1996-1997 the producer organisations of the Southern Altiplano, such as CECAOT and ANAPQUI, started organic production taking advantage of the natural developmental conditions of the quinoa crop on the hillsides, this production amounting to only 8% of the total cultivated surface area in the region. Subsequently, due to market requirements for biological products and expected prices, the production of biological quinoa was promoted on the plain of the Southern Altiplano.

Notwithstanding the efforts made in relation to biological production by some of the organisations and institutions, 90% of the total quinoa production is of the conventional type, involving the use of chemical pesticides and fertilisers and the intensive use of agricultural machinery in preparing the soil, thus leading to a deterioration of the fragile ecosystem of the Southern Altiplano.

All these problems indicate that it is necessary to seek long-term sustainable production, by identifying agronomic alternatives that do not damage the ecosystem, such as the addition of manure, green fertilisers, minimum tilling, pest control with natural extracts and vegetal cover. Based on the results obtained it was seen that the production of organic quinoa on the plain is feasible if the quantity of organic material (manure and vegetal residues) is increased, thus inducing increased yield.

7. Training

7.1 Training courses

In the year 1994-1995, a course was held for technicians on production technology and marketing of quinoa, as well as 6 courses on fertilisation, pest control and quinoa seed production, in which 170 farmers participated.

In the year 1995-1996, several training courses were held for farmers, with 100 participants. The work of promotion and diffusion of technological alternatives for the cultivation of quinoa received 90% acceptance by the farmers; however, its adoption depends on the producers obtaining machinery and equipment (seeders, sowers, harvesters, fumigators and threshers) either by direct purchase, loan or donation.

In the year 1997-1998, training was provided to 259 quinoa-producing farmers in 13 communities belonging to 4 provinces on the Southern Altiplano, concerning mass selection processes, which generated 5,978 kg of selected seed. A further 5 training courses were also conducted on the rational management of pesticides, with 230 participants, and support was provided in controlling the Tunku-tunku (*Anacuerma centrolinea*) pest in three communities of the Daniel Campos province.

In the year 2001-2002, farmers and technicians of other institutions were trained in the Integral Management of the quinoa crop. The training of farmers and technicians was done using the methodology of the Country Schools (ECAs). The training sessions were held fortnightly, and the farmers proposed and prioritised the subjects treated, which were: yellowing of quinoa caused by the mildew disease, control of pests and grain quality of quinoa. In total, 13 training sessions were held relating to the integral management of pests and diseases of the quinoa crop.

During 2002-03, training was provided to 194 farmers on subjects such as the integrated management of the quinoa crop, the use of quinoa and the preparation of foods through the methodology of Country Schools and training courses. 7 training courses were also conducted on the integrated management of quinoa, with the emphasis on seed production, on the Northern, Central and Southern Altiplanos, with a participation of 224 farmers (33 percent women and 67 percent men).

7.2 Participative research

During all the stages of the generation and transfer of technology, the participation of the producers had to be active and voluntary, in order for the selected technologies to have serious prospects of being fully accepted by the producers, and for mass adoption to benefit the development of an eco-region. Prior experience with the participation of farmers has demonstrated the importance of involving the farmer in the production technologies research process.

In the year 1998-1999, Local Agricultural Research Committees (CIALs) were formed, consisting of 4 to 5 farmers selected by the community, having the responsibility of conducting research on a prioritised problem. CIALs were trained in Jalsuri (Central Altiplano) and Chacala (Southern Altiplano), for which several visits were made for the purpose of contact and rapprochement with the local organisations according to a methodology developed by IPRA (Participative Research in Agriculture).

In the year 1999-2000 participative research work was carried out with the CIAL of Jalsuri, where the farmers decided to study two sowing systems; 'furrows' and semi-mechanised, and to compare these with the random-scattering system traditionally used in the community. The results demonstrated that it is possible to harvest up to 26.5 quintals of quinoa with the semi-mechanised system, 16.7 quintals with the furrows system and 13.7 quintals with the random-scattering or traditional system. As a recommendation, the CIAL itself decided to continue to study the semi-mechanised sowing system but on land surface areas bigger than 1000 m2, in addition to studying its influence on early and late maturing varieties of quinoa.

8. Agro-feeding chain

8.1 Processing and marketing

The quinoa crop on the Bolivian Altiplano is considered to be important, because according to the National Institute of Statistics there are 85,000 agricultural units producing this grain; annual production in Bolivia exceeds 20,000 MT, of which at least 77.5 percent is used for self-supply and the remainder for the national and export markets.

A relevant aspect is the various studies on the marketing of the product, either national or international marketing, taking into account price fluctuations, trade flows, existing limiting factors and requirements relating to the quality of the product. It is also important to give added value to the product so that the chain is more efficient and competitive, mainly for the benefit of the producers.

In this connection in the year 1992-1993, studies were commenced with a view to understanding the dynamic of national and international market prices and the problems encountered in quinoa processing. It is also important to emphasise that the promotion of quinoa consumption commenced in the municipalities, in some cases with the cooperation of the World Food Programme, and the participation of producer organisations, resulting in the provision of quinoa flakes for school breakfasts.

According to estimates of PROINPA (2000), on the Southern Altiplano the cultivated surface area amounts to 12,400 hectares with a production of 7,000 MT and an average yield of 580 kg/ha. Part of the said production is processed at the regional plants of ANAPQUI, such as: APQUINQUI, SOPROQUI, APROQUI, COPROQUIR, COPROQUIRY and the Salinas Plant, for processing and export as pearled quinoa (1,000 MT) and for the preparation of finished products of quinoa destined for the national market.

It is also emphasised that 65% of the production of the Southern Altiplano is sold during the year in the main market of Challapata - Oruro, where transactions of more than 100 quintals take place. The intermediaries (large and small) play an important role and that it is they who determine the price of the product. The large intermediaries are those which stockpile thousands of quintals of quinoa for transfer to Desaguadero, Peru, this being contraband quinoa which enters Peru from that point.

At the present time all members of the family in the quinoa-producing areas on the Southern Altiplano participate in production work; however, the current price of 80 to 120 Bolivars per quintal does not recompense the family effort.

The losses and costs of processing sweet and bitter quinoa at the plant level are well known. According to tests carried out at the plant level it was determined that the losses (spoilage) for bitter quinoa amount to 10.1% in comparison with sweet quinoa which amount to 8.5%. The plants specialising in the processing of quinoa, process some 1,500 MT per year, but there is a need to improve the processing technology, and to diversify the finished products of quinoa in order to offer a broader range of products to the national and export markets.

A participative characterisation of quinoa was carried out, concerning uses, restrictions and opportunities at the level of communities and at other levels in the chain, giving great attention to the gender aspect. The purpose of the activity was to collect information on forms of consumption, sale and participation by women in the production and processing of quinoa in communities on the Southern Altiplano; likewise to identify and categorise the different economic and agro-technical elements intra and extra families that condition the current functioning and evolution of the subsystem of quinoa cultivation on the Northern Altiplano, and to determine price fluctuations by means of visits to marketing centres.

In general, it was possible to verify that it is necessary to train the rural and urban population on the diversified preparation of foodstuffs based on quinoa, an aspect which is being dealt with by the PROPINPA Foundation, though on a small scale.

8.2 Added value of quinoa

In order to increase the added value and income based on the marketing of quinoa, culinary aptitude tests were carried out in the year 2001-2002 on the Northern Altiplano on promising varieties and with a substantial participation by the farmers. For this, the characteristics of the grain of 5 promising strains of quinoa were evaluated, associated with improvement, processing and preparation of recipes. The quality of the raw material is related to the size and uniformity of the grain. Large grain is directly related to the size of the flakes; when the grains are large and of greater consistency, they produce bigger flakes for the agro-industry. A better flavour is achieved with black grain quinoas, though it does not have much penetration in relation to white quinoa, a characteristic which could be utilised to develop new forms of consumption, using grain which, up until now, has not been of commercial value.

Quinoa is a multipurpose crop for agro-industrialists in the Andean countries, and what is sought is to characterise it and have a better knowledge as to its commercial use, in order to be able to increase the level of income of the producers. The work in the agronomic field is complemented with part of the agro-industrial tests for which there is a committed participation by the entities dedicated to the Agro-industry.

In the year 2002-2003, in conditions of the Southern Altiplano, an evaluation was carried out of the agro-morphological characteristics and the yield of 6 ecotypes of royal quinoa: Achachino, Lipeña, Toledo, Pandela, Kellu and Pisankalla, which fluctuated between 644 and 915 kg/ha. After the material had been processed it was studied in a laboratory to determine its transformation potential. The Achachino ecotype has an exceptional balance in regard to protein (18.3%), fat (3.1%) and fibre (6.3%). The degree of expansion for the preparation of pastas and noodles was measured, the Achachino ecotype having displayed better qualities for this purpose, followed closely by the Kellu and Pandela ecotypes. The percentage of invert sugar was also measured, in order to determine the degree of fermentation for the purpose of bread making and the preparation of beverages, the Pandela and Toledo varieties having shown the best aptitude. For grainy food products and snacks Pisancalla is the most suitable strain for this purpose, as it has smaller granules of starch (0.004 mm).

8.3 Demand by the agro-industries

There is a continuous demand on the part of agro-industries engaged in the processing of various products, including quinoa. However, the volume of demand, quality requirements, fluctuations in demand etc. is not known in detail. Activities for determining the current situation of this demand are therefore being commenced.

In the year 2001-2002, characterisation of the demand for quinoa by agro-industry destined for the local market and export was carried out, in order to have information on the criteria for the evaluation of quinoa required by the two types of agro-industries, and to quantify the annual and monthly demand by these agro-industries.

Preliminary information was collected on the location of the agro-industries engaged in the processing of quinoa, and subsequently a series of visits to the same was scheduled, during which a survey was carried out that included information on location, the characteristics of the processing plant and the type of processing carried out. This was for the purpose of standardising the type of product offered to the market and to be in a position to make comparisons.

The cooperating companies supplying the required information were Fideos La Coronilla, Planta Procesadora Andina, Irupana and Andean Valley. Talks were held with the four companies with a view to commencing the work of approaching farmers producing quinoa, interested in generating new business opportunities. In addition, the companies indicated their agreement to the characterisation and analysis of the costs of transforming the raw material to the final product.

In the year 2002-2003, the characterisation of eight agro-industry companies was carried out in order to obtain information on the demand for quinoa in grain and processed form for agro-industry, destined for the national and international markets. In general terms, the demand for the raw material amounted to 2,310 MT per year.

8.4 Articulation of the agro-food chain

The quinoa production chain will be made increasingly efficient and competitive as its components are better articulated, and equity exists in regard to the profits achieved from the business.

Therefore, on the Central and Northern Altiplanos in the year 2001-2002 the first links between farmers producing quinoa and the processors were promoted, as in the case of the Irpa Chico Agricultural Cooperative consisting of farmers from the Jalsuri Community of the Ingavi province of La Paz, which signed an Agreement with Procesadora de Cereales Andina, of mutual benefit to both links in the chain, based on the increased surface area cultivated by the farmers, whose production will be acquired by Procesadora Andina.

Continuing with the activity of articulation of the components of the chain, during the 2002-03 period the signing of a Business Agreement between the communities of Pomposillo and Vitu Calacachi, which belongs to the province of Aroma in the district of La Paz, was promoted with Procesadora de Cereales Andina, which will allow articulation of the demand for quinoa between both links in the chain for the production of the year 2003-2004.

In the same agricultural context, contacts were encouraged between the producers of San Pedro San Pablo (Ingavi) and the Andina e Industria Irupapa processors, for the purpose of identifying demand and supply, and following an approach between these parties, points of coincidence were identified and certain business agreements were established favouring both sides.

A bottleneck between the producer-processor links is the lack of mechanisms for fair raw material transactions. The marketing of quinoa is not organised and it does not have well-defined or permanent channels, which situation makes relations between the said actors in the chain difficult.

9. Promotion

Quinoa is a crop with considerable nutritional potential, but because it is not universally known it is underutilised by the Bolivian population itself. For the purpose of publicising the nutritional qualities of quinoa at a national and international level, steps are being taken through the IBNORCA to include it in the list of standardised foods of the Codex Alimentarius, in order to increase consumption and demand for this crop and thus contribute towards improving the quality of life of all those involved in the food chain for this crop.

In the year 2002-2003, the promotion of the nutritive value of Andean grain and information generated within the project was commenced. Summaries were prepared by thematic areas of the general project, accompanied by photo shoots, reports, reports from national and regional workshops, and training events which are being incorporated in the web page of the project. The nutritional value of Andean grain has been promoted through advertising spots and micro documentaries broadcast on TV and radio.

The recovery and revaluation of this grain has awakened the interest and concern of academic and research institutions, country organisations and also municipalities, all being conscious of the contribution that this type of food can make towards food security.

In the year 2002, in coordination with the Tiahuanaco Country Academic Unit of the UCB and the Faculty of Agronomy of the UMSA, in Tihuanacu the first quinoa and cañahua fair was held. In the year 2003 the second quinoa and cañahua fair was held. Both events had the participation of farmers from the municipalities of Viacha, Achacachi, Desaguadero, Guaqui and Tihuanacu, in addition to the Southern Altiplano, research institutions and companies engaged in the transformation of these products, having been able to observe panels specialising in the area of genetic variability, nutritional and medicinal uses of quinoa, agro-industry and technological innovation, and machines for producing flakes that could allow the industrialisation of quinoa.

Other events are also being organised, such as the Expo-Feria of Science, Production and Technology (La Paz), Fexpo Quinoa 2003 (La Paz) and the International Fairs of Cochabamba and Santa Cruz, which are important venues for promoting quinoa in its various forms of consumption.

Workshops were organised for identifying technological requirements and possible alternative solutions, with the participation of various institutions involved in this field, agro-industries, countryside authorities and quinoa producers. With the results of this workshop proposals were prepared with project profiles which were presented to the Municipalities, which, depending on the characteristics of the prioritised subject matter, could be included in the Municipal Development Projects (PDM), or alternative forms of finance could be sought abroad.

CHAPTER III

SOCIAL IMPACT

Quinoa is cultivated mainly on the Bolivian Altiplano, in the areas of La Paz Oruro and Potosí, but also in the inter-Andean valleys of Cochabamba, Chuquisaca and Tarija. Therefore, the producing population is distributed throughout the Northern, Central and Southern Altiplanos and the Inter-Andean Valleys, and are therefore of Aymaran and Quechuan origin, with the existence of mixed communities also. The family economy of the settler of the Altiplano is based on agricultural activities, with the cultivation of potatoes (sweet and standard), quinoa, broad beans, cañahua, barley oats, Andean root crops and vegetables where irrigation is available. The livestock activities include the rearing of sheep, llama, cattle and other smaller animals.

The socio-economic characteristics in which the farmers are developing on the three Altiplanos and Inter-Andean Valleys are different; it is therefore necessary to make a clear differentiation between them. (According to Montes de Oca, 1998, Atlas de Bolivia 1997, interviews conducted in 2003).

The Northern Altiplano covers the provinces surrounding the area of La Paz, which are influenced by the thermal-regulating effect of Lake Titicaca, at an altitude of 3,828 metres above sea level. The approximate total surface area is 18,475 km2. The predominant crops are high-growing corn, wheat, tarwi, broad beans, barley, quinoa, cañahua and forage crops. Despite the climatic conditions, the poor quality of the soil and the scattering of plots, the areas close to the lake have livestock potential (the rearing of dairy cattle). The settlers indicate that the quinoa crop is not the most important one, occupying third or fourth place. More than 95% of the production is destined for self-supply. The phenomenon of migration is an important problem.

The Central Altiplano is located in the provinces of the southern part of the district of La Paz and a large part of the district of Oruro. The altitude fluctuates between 3,600 to 3,850 metres above sea level. The approximate total surface area is 16,500 km2. The important crops are potatoes, quinoa, barley, cañahua and vegetables. In the livestock activity area (breeding of cattle and llama) in many cases more important than the agricultural activity, which contributes towards national production, this region producing meat fibre and abundant guano; however, there are potential areas for the production of quinoa.

The Southern Altiplano comprises the south-western part on the outskirts of Uyuni and Coipasa (Provinces of Oruro and Potosí), at an altitude of 3,600 to 3,950 metres above sea level, with a surface area of 80,600 km2, the crop of most economic relevance being quinoa. They also sow for self-supply, potatoes, broad beans, barley and vegetables in places where there are sources of water. This region is the biggest producer of quinoa in Bolivia. It has unique characteristics for the production of the quinoa ecotypes called "Royal Quinoa", for which there is a demand on the international market. However, the area is also highly suitable for the rearing of llama, which for some settlers is a complementary activity. Other activities are the export of sulphur and other salts. Recently the tourist sector has become a relevant activity for certain communities.

3.1. Migration

The phenomenon of migration in the rural area of Bolivia in recent decades has been accentuated due to various reasons such as: inclement weather conditions (drought, floods), high underemployment of local labour, excessive distribution of plots, especially on the Northern Altiplano, process of desertification due to the degradation of the structural characteristics of the soil on the Southern Altiplano (both water and wind erosion).

On the Northern and Central Altiplanos, the population migrates especially to the main cities of La Paz, Cochabamba and Santa Cruz, the closeness of road links allowing a constant flow between the countryside and the city. In the nuclear family the one who mainly migrates is the male who, after the sowing tasks (September -- November) leaves the community to seek alternative income to sustain the family, returning only for the harvesting work (April -- May). The woman is the one who undertakes the work of rearing the animals, caring for the crops and of course looking after the children of the household, assuming the role of both producer and reproducer.

On the Southern Altiplano, notwithstanding that a specialised production system has been developed for the quinoa crop, because this is the only crop of economic importance that is adapted to the region, the settler combines livestock activities with temporary migration to mines and the main cities of the country, as well as to the borders of the neighbouring countries of Chile and Argentina in the search for better living conditions.

The phenomenon of migration in general has increased with the introduction of non-traditional agricultural practices (mechanisation). The cultivation of quinoa has also had some effect, having become a single crop in the region, degrading cultivable land due to indiscriminate over-exploitation and poor conservation of the soil, which consequently leads to many families having insufficient cultivable land to be able to continue in their communities and subsist as they had done traditionally.

Other factors are under-employment, difficult living conditions (health, education, housing), inadequate road communication systems and restricted access to stable markets. Accordingly, rural settlers are seeking new means of livelihood in order to improve their living standard and satisfy their basic needs.

3.2. Change in the traditional system of cultivation

In Bolivia the systems of agricultural extension, by means of the introduction of technological packages were always intended to achieve a radical change in the traditional production systems. However, the modernised systems usually never took into account the economic, social, cultural, ritual and mythical factors of the farmers within the communities. Consequently, much of the traditional knowledge and know-how has been lost over time.

On the Northern and Central Altiplanos the cultivation of quinoa is a traditional and family decision, determined by ancestral heritage within the area. The management of the crop has to do with the family and the role of each of its members, who interact during the production process, to such an extent that the whole family participates in the entire production process (from sowing to harvest). The work is distributed in the same way as with other crops. For example, during the sowing process the women distribute the seed while the men work with the yoke. During harvesting the men uproot the plants and the women collect them. Both then deal with the threshing of the grain and finally the women handle the 'venting'.

It is important to emphasise that for this crop cultivation work is not normally carried out, so that during development the family engages in the rearing of livestock. It is the females who look after the livestock while the males obtain temporary work outside the farming environment (PROINPA, 2001-02). On the Northern Altiplano the production is used for self-supply, while on the Central Altiplano the quinoa producers sell the excess production in the main weekly fairs.

On the Southern Altiplano up until the decade of the 1940s, the cultivation of quinoa was undertaken for self-supply, according to the traditional production system, with cultivation areas of 0.5 to 1 hectare per family, where the rational management of soils, natural pest control and crop resting and rotation processes enabled the farmers to obtain yields of between 1500 and 2000 kg/ha. The surplus production was used as barter for other products.

From the decade of the 1960s there was an increase in the rate of cultivation, due to a growth in market demand for exports (USA and Europe). Therefore, there has been a sudden change to the new system of "modern" production, with an increase in the farming boundaries, bringing about negative effects on the structure of the soil due to over-exploitation, which translated into desertification (loss of vegetal cover, increased water/wind erosion, salination of soils) and an increase in pests affecting productivity.

From 1983 yields reduced considerably, notwithstanding that there was better use of the technology packages introduced, especially an increase in the use of agrochemicals such as pesticides, and the introduction of agricultural machinery, with yields of 511 kg/ha on average in the year 1995 (Ramos, 2000).

3.2.1. Impact on the cultural traditions

The quinoa crop constitutes an ancestral heritage of the Altiplano dwellers, and since the time of the Incas it has had multiple uses and applications, quinoa also having been involved in religious ceremonies. The Incas themselves commenced the sowing process with a golden plough and after the harvest quinoa was offered in a gold dish to the God Inti. It was and still is also used as a medicinal plant, but is mainly a source of food for the Altiplano dwellers who cultivate it; they use the various parts of the plant from the tender leaves to the grain as a principal source of protein, minerals and vitamins, as well as by-products such as dry leaves and the remains of the stems.

According to the producers of the Southern Altiplano, in bygone days quinoa grain was used as barter in exchange for products from the valleys of Cochabamba, Chuquisaca and Tarija. For this purpose the producer of this marvellous grain had to go on long trips across the salt flats to transport on the back of his llama quinoa grain, salt, and dried llama to barter for other products, mainly corn and wheat.

The custom of using quinoa in religious ceremonies has been gradually disappearing, although in communities specialising in quinoa production they mention that older people still preserve the tradition of making offerings to the gods personified in Pachamama “Mother Earth” and the mountains “Aphus”, from whom they implored good harvests for the crop, the absence of drought and pests, and that the land would produce sufficient in return for their efforts.

Because of its own medicinal properties, quinoa was greatly appreciated by the ancient Andean dwellers for treating various complaints and illnesses. For liver abscesses and hepatic problems of various kinds, as a dental analgesic, for treating angina, as an anti-inflammatory aid, to treat inflammation of the urinary tract and for healing scar tissue. Milled black quinoa grain “ajara” mixed with herbs such as “thola” are used as dressings for treating bone fractures.

Quinoa was in the past, and still is today, an important food, especially for the Andean dweller. The grain is used for human consumption in various forms: Soups (mazamorras, lawa or “allphi”), stews (graneados, “phisara”, pesq’e). The flour is used in the preparation of steamed bread rolls known as K'ispiñas, muk’unas, phiri, pies and pastries. Beverages are also prepared with quinoa, such as chicha or “Q’usa”, soft drinks or “Ullphi”, juices, etc. In addition, the tender quinoa leaves are used as vegetables (llipccha or cchiwa). Quinoa is also used for feeding poultry and other animals.

3.2.2. Effect of the urbanisation culture

The management of the crop involves the entire family. The crop has become a part of their food security and in some cases generates economic income. It is, however, important to emphasise that the feeding of the family is the decision of the woman of the household, who at the present time is inclined towards acquiring food products such as rice and noodles due to their simplicity of preparation it having been noted that many forms of preparation and consumption are being forgotten, and that these are related to the lack of customs and consumption habits among the new generations.

At the present time with the implementation of quinoa-processing plants, it is possible to acquire pearled quinoa in the city markets, for preparing soups and graneados, as well as quinoa flakes, semolina, puffed products, sweets, etc., although national per capita consumption of quinoa continues to be very low in comparison with other foodstuffs, because it is not the staple diet of the family, even in the rural areas, where it is produced, and much less so in the cities. Socio-economic and cultural conditions therefore exist which limit the size of this market.

Although there are migrants from the rural areas who could increase the general market in the cities, the urbanisation process has an influence on the change of diet and consumption habits of people migrating from the rural areas to the urban areas, who begin to consume non-traditional foodstuffs in the new city context. In addition to this, the urban factor involves new lifestyles, new material aspirations and a food system that provides an ample variety of attractively packaged and prepared foods, backed by advertising.

The traditional preparations at risk of being forgotten on the Altiplano, are the consumption of wild quinoa 'pito' and various dishes or stews such as pesk’e huari, pesk’e with lime, etc.

3.3. Improved technologies for crop management

Different institutions and projects made numerous efforts to generate and transfer technologies, to guarantee the improved handling of the quinoa crop in relation to traditional technologies, which to some extent were not the best ones, generating low yield in terms of the quantity and quality of the grain, which does not necessarily meet the requirements of the agro-industries or processors.

Among the principal institutions or organisations that began to train the farmers producing this crop, is the IBTA, a government institution which, through the National Quinoa Programme, successfully began the transfer of various technologies to different communities on the Northern, Central and Southern Altiplanos, though on a very small-scale in the form of demonstration plots for the purpose of spreading the technologies generated, reaching a small number of beneficiaries, in the hope that the technologies would be expanded or would irradiate from farmer to farmer.

Probably the general hypothesis with the transfer of technologies was that the benefiting families acquired the necessary knowledge to cultivate quinoa in a more efficient way. To date there have been no reports affirming the hypothesis presented, and therefore it is not possible to verify with precision, the achievements or the impact of the technologies transferred by the IBTA, their degree of take-up or application, replicability, etc. Despite the fact that the impact that has been achieved with the transferred technologies is not known, mention can be made of some activities that were carried out with a view to achieving the general planned hypothesis.

Technology transfer activities commenced in 1990, the fundamental factor being to obtain the opinions of the farmers in order to be able to validate the evaluated technologies. This process allowed the farmer to start to become involved in resolving the problems on his plots.

Training courses were conducted on:

- Technology concerning the production and marketing of quinoa
- Fertilisation (chemical and organic)
- Integrated handling of pests
- Seed production
- Pesticide management and
- Harvesting and post-harvesting technologies.

From 1999 the PROINPA foundation employed the methodology of the Farmers' Country Schools (ECAs) as an element in the process of technology transfer for the quinoa crop. The Methodology of the ECAs was shown to adapt very well to the crop and to the small farmer on the Altiplano, in addition to satisfying the demands and expectations of the producers for technical assistance. The positive effect of this technology is that it encourages or motivates group participation in the entire training process, improves skills in decision-making, consequently promoting the future creation of a small association of producers.

A relevant aspect is the participation of the farmers in the evaluation of the generation of technology as a way of providing access to improved varieties or sowing, harvesting and post-harvesting technology, and the use of external products such as biological insecticides.

3.3.1. Importance for the rural population of the Altiplano

The production chain on a national level involves approximately 70,000 producers, 55,000 of which are small farmers, many of them subsistence farmers cultivating irregularly for self-supply (with little surplus for trade) on surface areas not exceeding one third of an acre. Some 13,000 farming units permanently produce for sale in the market and for self-supply, 2,000 farming units produce specially (principal crop) for the market. These two groups of farmers are especially located on the Southern Altiplano, 80%, the remaining 20% being located on the Central Altiplano where Royal Quinoa is produced.

However, it is necessary to point out that for the great majority of small farmers (Northern Altiplano and part of the Central Altiplano) it is a crop of vital importance because it represents in many cases the basis of the food security of an increasing population, which is marginalised socially as well as economically, and not coverîng their basic nutritional requirements. Furthermore, the grain, in certain seasons of the year, is sold by the rural settler because it represents a source of cash, so that when family requirements need to be met, the excess production is sold in the main weekly fairs that are held in the townships.

3.4. Changes in the role of the women

The role of the woman in the household, and changes within it, are the factors having most influence in the consumption of food, though this is often overlooked. A context for analysing the role of the woman is based on Becker's economic model of the household, where the demand by a family for particular goods depends on the market price itself and of other goods, the value of the time of the family members, and the total income of the family.

The traditional role of the rural woman is manager of the family food, in addition to being the one who preserves and transfers the alimentary culture. She especially develops the family consumption strategy, the selection and preparation of foods for the nutrition of the family. She is in charge of the traditional transformation processes, which form a part of her responsibility in relation to the family's food security.

It is important to emphasise the family participation in all processes of quinoa production, particularly that of the woman, who is responsible for the production when her husband goes on temporary migrations in search of additional income for the household. The woman is the one who undertakes the work of rearing the animals, caring for the crops and of course looking after the children of the household, assuming the role of both producer and reproducer.

3.5. Organisation and agreements

For the purpose of providing greater encouragement in the promotion of quinoa, the PROINPA Foundation promotes the organisation of the producers, and also facilitates connection between links in the production chain. These connections are translated into firm agreements between raw materials producers and local agro-industry. Although there is experience between a group of producers and a small agro-industry (case: Farmers of the Irpa Chico Cooperative of Jalsuri and Procesadora de Cereales Andina) this process should be consolidated and strengthened in order to aspire to sustainability.

In order to continue with the coordination of the chain, talks have been commenced with a view to a rapprochement between farmers in the various areas of the Altiplano, and companies specialising in the transformation of Andean grains, such as Industrias IRUPANA, AGRONAT, Taller de Alimentos la Chapaquita, ANDEAN VALLEY and QUINOABOL, which are interested in and need quinoa and cañahua grain and are prepared to sign agreements for purchasing these products.

In the search for partners in the industrial sector for the promotion of the local quinoa products, one participant that became involved is the Society of Quinoa Producers (SOPROQUI) of the Nor Lipez Province of the area of Potosí, which has a quinoa-processing plant in the city of Uyuni. The plant processes and offers pearled quinoa for soups and graneados; semolina, flakes, quinoa-coa, puffed products, turrones, etc.

From the social standpoint, quinoa is an extremely important crop for the farmers of the Altiplano, because it involves a significant number of production units, it possesses excellent nutritional characteristics for food security as it can replace any kind of meat, and in regard to its digestibility by humans it is more akin to milk than traditional cereals; it also represents a source of income mainly for families categorised as very poor. The impact which it generates is therefore of vital importance to social well-being.

Its production does not require great effort and the grain can be preserved, without much infrastructure, for a year or more.

CHAPTER IV

ENVIRONMENTAL IMPACT

Any extractive production process on a commercial basis that does not have an appropriate plan for managing the natural resources, involves an accelerated deterioration of the environment; consequently, it has a powerful environmental impact on the ecosystems which are certainly too fragile throughout the Bolivian Altiplano.

At the present time the environmental impact on the principal quinoa-producing areas in the country is not known with precision. However, evidence does exist that there is a process of permanent imbalance, especially in relation to natural productive resources such as soil, water and vegetation.

The main negative elements of the deterioration of the environment, principally relating to erosion and the desertification of the soil are:

Reduction of natural vegetal cover due to indiscriminate felling.
Inadequate soil-tilling systems.
System of soil resting without vegetal cover.
Poor management of the irrigation system, which causes salinity problems.
Little addition of organic material to the soil.
Permission for the development of marginal areas for agriculture.
Excess pasturage.
Increasing division of land.

In order to prevent, mitigate or eliminate the foregoing negative effects, which impact on the environment, regulations exist within the country in relation to the improved conservation and management of productive resources, such as Law 1333 on the Environment, the basic purpose of which is to protect and conserve the environment and the natural resources, regulating the action of man in relation to nature and promoting sustainable development, the purpose of which is to improve the quality of life of the population (SBPC, 2003).

4.1. Traditional production of quinoa

The standard system of pre-Colombian agriculture was not the maximisation of yield, but rather management, conservation and improvement of the fertility of the soil in the long-term, with social relations expressed in medium- and short-term practices.

In past years the traditional cultivation of quinoa only involved sowing and harvesting. The incidence of pests was greatly reduced and did not cause economic damage, apart from exceptional years. Some farmers used natural extracts based on muña, tholas, etc. In addition, the form of use of the soil and of the crop did not favour the proliferation and multiplication of pests.

Losses due to abiotic factors, such as drought, frost, hailstone and wind, gave rise to the knowledge of the use of appropriate varieties for given areas, where there was a greater incidence of such factors. The means of avoiding these factors was to sow a selection of varieties on the same plot, and to vary the sowing dates.

In the traditional production system no types of agro-chemicals were used, as these were unknown by the farmers. Furthermore, the products used were of natural origin and did not cause contamination and damage to the environment.

In soils management, one of the priorities was the preservation of the soils, so that practices were oriented towards avoiding processes of erosion and degradation of the soils within the Southern Altiplano, such as minimal or no ploughing, manual work using proper tools for the different areas, work in restricted areas, the construction of terraces, management of river courses for the formation of alluvial soils, the rotation of plots with resting periods of 4 to 6 years, and grazing on the stubble of previous crops. All these practices reduced the levels of erosion and desertification, as they continued for thousands of years from pre-Colombian times, with sustainable production.

In this connection, concerning the traditional cultivation of quinoa in the past, the production area remained almost constant, due to the fact that the use of the production was self-supply and the remainder was used as barter in exchange for other products.

4.2. Increase in the demand for quinoa

With the commencement of exports of quinoa, pressure is created to increase the production of quinoa and the producers find it necessary to utilise modern technology in fragile ecosystems which have been shown to have had devastating effects on the environment due to the over-exploitation of the soil, the expansion of the farming boundary and the sustainability of production (Liberman, 1987).

4.2.1. Impact on natural resources

Aroni (2001) mentions that the mechanical rotovation of the soil on the Southern Altiplano for the past three decades has been done with the use of the rotary plough. The soil in these areas is characterised by having low stability of aggregates and reduced fertility. The excessive use of agricultural machinery has caused the destabilisation of the ground cover, its degradation and consequently the abandonment of these areas, which were previously quinoa-producing areas. Cossio et al. (1994) estimate that the soil losses caused by Rotary ploughing amount to approximately 70 MT/ha/year.

As a result of the production of quinoa in sandy soils, as is the case on the Southern Altiplano, there has been over-exploitation to such an extent that at the present time large stretches of marginal land can be observed that has been abandoned, containing extensive sand dunes, with negative effects on the ecology of the area.

It is planned to analyse, within the framework of sustainable development, the environmental impact of the quinoa crop on the Southern Altiplano of Bolivia, specifically in the Ladislao Cabrera Province of the District of Oruro and in the Daniel Campos, Nor Lipez, Antonio Quijarro and Enrique Valdivieso Provinces of the District of Potosí, where the transfer of technology to the countryside communities has transformed the traditional use of the land, leading to overuse and environmental deterioration, which is reflected in a reduction in agricultural productivity, increased countryside migration and a sense of frustration due to the products being less competitive, and finally the desperation of people residing in this specific Andean ecosystem.

4.2.1.1. Desertification of the soil on the Southern Altiplano

Desertification is a phenomenon that involves a set of dynamic processes (physical, chemical and biological) which affect the productivity of the ecosystems of arid, semi-arid and sub-humid areas of the world, which can become irreversible and have social, economic, ecological and political consequences. It is synonymous with the degradation of the land, and is connected with the inappropriate use of the resources of soil, water, flora and fauna. When the causes of this degradation are natural one speaks of desertification.

The desertification of the Southern Altiplano of Bolivia, presents connotations both at socio-economic and ecological levels as the problem is constantly increasing and affecting a larger number of inhabitants and surface areas in these marginal regions of the Altiplano (Aroni, Terceros, IBTA Report 1995-96).

At the present time pressure exists on the Southern Altiplano as a consequence of quinoa production, principally for export, which in general is having devastating effects on the environment due to over-exploitation of the soil and the expansion of the agricultural boundary.

The impacts of the foregoing are low productive output in harvesting, a reduction in the grazing areas, drought, frosts, anthropic migration and finally increased poverty rates, as activities in certain sectors are limited to the level of family subsistence, because the conditions created no longer allow anything more than this. As a result the production activities are tending to become solely extractive.

The main factors fuelling these processes are both natural and anthropic, such as aggressive rainfall, strong winds, salination/'sodification', scarce and strongly impacted vegetal cover, drought, high solar radiation, large thermal amplitude, frequent frosts, inappropriate over pasturage, intensive use of the soil (over-exploitation without any contribution), wind and water erosion, mining activities (contamination of soil and water), urban activities without ecological criteria, and poverty, are the main factors contributing towards the loss of productivity of these ecosystems.

In the different communities of the Southern Altiplano, there is a tendency to blame the ecological problems and degradation of the land on natural phenomena, in particular climatic phenomena. However, these have always existed since pre-colonial times and the impacts such as those we are currently observing were never experienced in the past. Therefore, a degree of responsibility must be attributed to poor agricultural techniques used by the communities solely for profit motives, without taking into account the sustainability of the environment over time, perhaps because the possibility of migrating and abandoning the land, due to its acquisition by possession, is deeply rooted in their subconscious.

The demand for quinoa in the export market has led farmers to expand the cultivation area and to intensify it indiscriminately, using systems that are threatening its sustainability, such as the use of ploughing techniques and tools having negative effects, because the land is becoming increasingly less fertile. Alternatives to the mechanical rotovation of the soils should be sought, given that rotary ploughing is very negative for the environment, having an effect on erosion by wind and leading to the loss of moisture from the soil.

When organic agriculture was promoted 20 years ago, initially there was little interest on the part of producers, because at that time the yield of quinoa was relatively high. With the passage of time the soil has become gradually impoverished throughout the quinoa-growing area, leading to misuse , as profit is no longer being generated.

With the traditional rotation system on the Altiplanos on the Southern Altiplano serious problems of wind erosion are being caused due to a high predominance of sandy soils. The resting time for the land, which used to be between 4 and 8 years, has been reduced to less than 4 years and in some cases quinoa is being cultivated continuously. The consequence of this is the exhaustion of the natural fertility of the soil in an area where, due to low rainfall (100 a 200 mm average per year), the effect of fertilisation is minimal.

To this there must be added the fact that in Bolivia, agricultural soil is also affected by the processes of desertification, with serious and very serious erosion problems over an area of 275,544 km2, representing 61% of the region in the process of desertification, with an erosion rate of 50 to 200 MT/ha/year. According to the Ministry of Sustainable Development and Planning (MDSMA), out of the country's 1,500,000 hectares of agricultural land, some 1,800,000 MT of soil are lost annually due to erosion, meaning that the productive capacity is gradually reducing (MDSMA, 1996).

4.3. Effect on the genetic diversity of quinoa

By means of appreciations based on adaptation characteristics and certain morphologies of high hereditability, the genetic diversity available in the Andean region was grouped into 5 groups, which are: 1) Altiplano quinoas, 2) Salt flats quinoas, 3) Inter-Andean Valley quinoas, 4) Warm valleys quinoas and 5) Sea-level quinoas (Lescano, 1989).

Of the proposed groups, the first three classified in Bolivia are Group 1, which represents the Central and Northern Altiplano quinoas, Group 2, which represents the Southern Altiplano, and Group 3, which represents the quinoas of the High Valleys of Bolivia. The three geographical areas are considered to be important sub-centres of variability. It is also important to mention that the greatest genetic variability of the Andean region is to be found in Bolivia, whose germplasm collection consists of more than 2950 accessions of quinoa and is kept at the High Andean National Grain Bank. This quinoa germplasm has been collected since the decade of the 1960s, and at the present time is considered to be one of the most important germplasm collections in the world.

In the year 2001-2002, studies were commenced to verify the state of genetic variability of quinoa on the Southern Altiplano and the Northern Altiplano. The results are of concern, as the genetic variability in both sub-centres is reducing notably.

On the Southern Altiplano it was determined that 96% of farmers cultivate between 1 and 4 ecotypes of Royal Quinoa per family and that the remaining 4% of the population of producers sow between 5 and 7 ecotypes per family, with one family, exceptionally, having been found to be cultivating 12 ecotypes. The total number of ecotypes still sown in the region amounts to 31 different types of Royal Quinoa, equivalent to 7% of the variability conserved at the High Andean National Grain Bank of the PROINPA Foundation, which signifies that more than 90% of the genetic variability would be in the process of erosion.

The Royal White and Pandela ecotypes are those managed most frequently by farmers, being cultivated by 78% and 63% of the population of producers, respectively. The ecotypes following in terms of frequency of management are Pisankalla, sown by 16% of farmers, White Utusaya sown by 15%, Toledo sown by 14%, K'ellu sown by 11%, Blanco Puñete sown by 7%, Chillpi sown by 6%, and Elva and la Roja-Granadina sown by 5%.

The other ecotypes are being sown by 10 or fewer farmers, equivalent to between 1% and 3% of the population of producers. The situation is rather critical for the Challamoco, Mizca, Manzana, Mezcla and Uyuka ecotypes, which are only being sown by one farmer out of the sample, equivalent to 0.4% of the population. These ecotypes are clearly in a process of genetic erosion which requires immediate intervention in order to prevent their loss (Rojas et al. 2004).

The reason mentioned by the farmers is the selective pressure of the quinoa market which is demanding white quinoa with large grains.

In regard to the study on the genetic variability of quinoa on the Northern Altiplano (the area surrounding Lake Titicaca) it was also determined that the current state of variability is critical, the number of varieties having been reduced to 40 compared with the germplasm preserved in *ex situ* form, representing 27% of the variability conserved at the National High Andean Grain Bank, indicating that more than 70% of the variability of this sub-centre would be in the process of erosion.

The surveys indicate that the families sow the local variety 'Janko jupa' with most frequency (32.3%). 68% of the families sow between 1 and 4 varieties. 74% of the families categorise the crop in third and fourth place of importance after potatoes and broad beans/oca. In regard to the sowing area, they use plots from 2 to 5000 m^2, where 71% of those surveyed sow on plots smaller than 500 m^2. The production of the crop is used as follows: an average of 85.57% for self-supply, 6.13% for sale, 5.94% for seed and 2.36% for barter (Rojas et al. 2003).

In the region of the Northern Altiplano, the reasons mentioned by farmers referred to the fact that the quinoa crop has been substituted by fodder crops due to the suitability of the region for intensive livestock rearing, and this change has displaced local varieties of quinoa, with the consequent genetic erosion. Likewise, although to a lesser extent, the introduction of improved varieties has had an effect on the displacement of the local variety.

In both studies the figures can be considered to be indicators of critical danger, requiring immediate action, for which purpose case and participative studies are being carried out in order to evaluate the reasons for the loss of variability, the preferences of the farmers and the potential for revaluation. It is also necessary to promote the use of genetic variability available at the National High Andean Grain Bank in order to increase the use and diversity of quinoa varieties.

4.4. Extent of ecological agriculture

Since 1992 the National Association of Quinoa Producers (ANAPQUI), has been promoting conversion from the conventional production system to the ecological production system. Initially, this was only applied to production on mountain ranges or hill slopes, but areas of production located on the pampas are now being gradually taken into account, where the crop is extensive, and due to the characteristics of being a single crop there is a greater incidence of pests specific to the crop, in addition to the already well-known desertification of the soil.

In order to be able to sell ecological quinoa, the markets of the USA and Europe require certification of the product by a competent institution. The certifiers of ecological products in Bolivia are: Bolicert - Bolivia, Biolatina - Peru, IMO Control – Switzerland and Ecocert – France, which ensure that the ecological production standards of the IFOAM are met, including all the processes connected with control, from the preparation of the soil, sowing, cultivation work, harvesting, stockpiling, processing, package and sale to the final consumer.

Year after year the registration and preparation of areas having this purpose has been increasing, as the different producers' associations and the companies requiring the product and which control the product on the international market are becoming increasingly demanding and in some cases are subsidising producers by paying for the certification of the product. Accordingly, in Bolivia there are approximately 5000 to 6000 hectares with organic certification for the production of quinoa, with around 3500 MT of quinoa being certified for export as ecological product.

The agricultural terms "ecological", "organic" and "biological" are considered to be equivalent. They refer to ecological methods of production, with the exclusion from this category of all products that are not produced under the said standards, thus contributing towards environmental balance.

4.4.1. Production of organic quinoa

Both in the USA and in Europe, quinoa is sold mainly in the health products or ecological products markets. For this reason, exported quinoa must meet certain quality requirements, i.e., be free from impurities, stones, saponin, split grains, grains of a different colour, moisture content below 12%, etc. However, the most important factor for export to these international markets is the condition of being an organic product.

The socio-economic importance of organic quinoa production translates into the need to seek pest control alternatives that arrest or mitigate the negative effects of the use of inorganic commercial toxic pesticides on the environment. Accordingly, bio-insecticides and biological pest controllers are used in the cultivation of quinoa, which are specific to certain pests, without causing biological imbalances within the agro-ecosystem. On the other hand, they are relatively cheap and can easily be integrated within an integrated pest-management scheme to ensure compatibility with other control methods. The bio controllers include *Bacillus thuringiensis* and the granulosis virus, which are being used with promising results in the control of lepidopterans (Sánchez and Marquez, IBTA 1994-95).

For the purpose of strengthening the organic production of quinoa, certain institutions such as the Ecology Institute and the ex - IBTA, through the National Quinoa Programme, have carried out research work into the biological control of the quinoa moth. Research into the biological control of certain quinoa pests was carried out by the Ecology Institute. In an initial stage the parasitoids controlling the quinoa moth *Eurisacca melanocampta* were identified, and in the second stage the percentage of parasitism and the population dynamics of each of these parasitoids were determined, thus establishing the basis for continuing with the Integral Management of Pests in quinoa cultivation.

In addition to the use of parasitoids, there is experience with the bio-insecticides *Baculovirus phthorimaea* and *Bacillus thuringiensis* developed successfully by PROINPA. Another serious quinoa pest is *Copitarsia turbata* commonly known as the Ticona. In research carried out by

PROINPA, a poliedrosis nuclear (VPN) virus was detected, found in laboratory conditions in larvae of *Copitarsi turbata,* which serves as an alternative form of control of this pest.

The use of entomopathogens such as the *Bacillus thuringiensis* and *Baculovirus phthorimaea*, have demonstrated 55% efficiency in controlling pests such as *Copitarsia sp, Feltia sp*. and *Eurisacca Melanocampta*. A favourable characteristic of these entomopathogens is their selective property, acting on the pest and not on benign insects. Bio-insecticides are considered to be environmentally safe and do not cause imbalances in the agro-ecosystem. Furthermore, farmers are not exposed to dangers of inhalation and contact, as occurs when working with inorganic insecticides. The preliminary studies of the population fluctuations of quinoa pests will allow the appropriate use of bio-insecticides, leading to favourable results in the reduction of attacks by these pests. In addition, this practice should essentially be complemented by the use of light snares. (Ethological and Biological Alternatives for Controlling Pests in Quinoa Cultivation, Cochabamba, 1999).

CHAPTER V

ECONOMIC IMPACT

In recent decades sustained microeconomic reforms have been implemented, though growth in Bolivia has not been sufficient to combat poverty. In 1995 the rate of growth of the GDP was 3.7%, the fiscal deficit was reduced to 2% of GDP and the 'money supply' was reduced. However, annual inflation increased from 8.5% to 12.6%, due mainly to the increases in the international prices of basic imported products. These percentages are below the average of other countries in Latin America during the same timescale, and represent a fraction of the achievements of the economies of East Asia in terms of per capita growth. With these low rates, it is not surprising that there has only been a slight impact on the absolute poverty level. Half of all Bolivians continue to live on less than US$ 2 per day, and the infant mortality rate, a key poverty indicator, continues to be high (94 per 1000 live births, rural area and 58 per 1000 live births, urban area).

According to the National Population and Housing Census of 1992, 70% of 1,322,512 Bolivian households were considered to be poor (51% of urban households and 94% of rural households) and they did not have adequate access to basic services of education, health and housing; 37% are in a situation of extreme poverty (32% in abject poverty and 5% social exclusion), 13% were on the threshold of the poverty line, with a minimum level of satisfaction of basic needs, and only 17% were able to satisfy their needs. At the present time these breaches of differentiation between rich and poor have become more accentuated.

5.1. The current situation of quinoa on the international markets

Bolivia is the biggest producer of quinoa, with 46% of world production, followed by Peru with 42% and the United States with 6.3%. According to the Andean Development Corporation (CAF, CID, CLACDS-INCA, 2001), the National production of quinoa in the 1970s was approximately 9000 MT/year on a surface area of approximately 12,000 cultivated hectares.

In recent years this has increased to an average of 22,000 MT/year, produced on an area of around 36,000 hectares. The most frequently quoted variety of quinoa at the international level is "Royal Quinoa", which is only produced on the Southern Altiplano and part of the Central Altiplano, and it has not been possible for it to be adapted to other regions in the world. As this is a ‘highland quinoa’, its flowering depends on a well-defined number of daylight hours (Villalobos and Espejo, 1997). It is important is to clarify that “Royal Quinoa” responds to a conglomeration of ecotypes of different colours, which, after the grain has been processed, are all white, which allows quality products to be obtained when the grain is transformed by agro-industry.

At the present time the most important markets for quinoa are the United States, Germany, France, Holland, Peru and Japan. Of these markets, distributed by geographical areas, the European market is mainly representative for Royal Quinoa, and the sweet grain that has acceptance as a specific product. Following this is the North American market, which is the most advantageous for Bolivia and the Andean region.

Without a doubt, the breach achieved by exporters in the Asian market is important, as this is a high-consumption market particularly for products of natural origin, as is the case with quinoa. At the Latin American level, the target markets are Peru, Chile and Colombia, which offer comparative advantages in terms of customs duty, proximity and ease of marketing. In the case of the Peru market it is necessary for the product to have a formal system of sale, as more than 2,500 MT/year is presumed to be transferred in contraband form, and this may even be as high as 4,500 MT/year. According to some authors, approximately 60% is exported illegally or in the form of contraband, especially Royal Quinoa to Peru.

Although this background information is but an indication of the significance of the demand for quinoa, aspects are dealt with below relating to the comparative advantages for some of these points of sale, which are of importance.

5.1.1. North American Market

The United States is one of the main buyers of quinoa. In 1997 the use of quinoa in this market amounted to approximately 1500 tonnes per annum, with ANAPQUI, CECAOT, SAITE and others being the main suppliers of the product, and which offer "ROYAL QUINOA" characterised basically by the size of the grain exceeding 2.3 to 2.5 millimetres in diameter. Subsequently, Peru and Ecuador are involved in this market niche with quinoa grain having a diameter smaller than 2 millimetres (small-grain quinoa).

Exports of quinoa to the North American market began in 1986, the year in which the Quinoa Corporation exported 108 metric tonnes. Since that time the exported volumes have been gradually increasing at prices fluctuating around 1000 US$/tonne.

Due to the high nutritional value of quinoa, attempts have been made to cultivate quinoa in the USA, specifically in the state of Colorado, the attempts having failed as the quality of the quinoa grain produced in the Andean region was not achieved, and even less so that of Bolivia which, out of the three countries is the quinoa of the best quality.

5.1.2. European and Asian Markets

At the present time the European market (France, Germany, Holland and other countries) is recording the biggest demand for the product; however, this market offers fewer advantages compared with the American markets in regard to tariffs. In 1994 the use of quinoa in Europe amounted to 1300 tonnes/year. At the present time exporters of Bolivian quinoa, such as Jatari, Quinoa Bol and ANAPQUI, are the main suppliers of this product.

In 1998 Japan had imported sizable volumes of quinoa amounting to around 100 tonnes without any promotion of the product in that country, which demonstrated its interest in consuming quinoa (generally mixed with rice) and therefore that country represents an interesting market for selling quinoa to more than 124 million inhabitants who have the highest purchasing power in the world (Sakamoto, 2002).

5.2. Competitive capacity of Bolivian quinoa

Bolivia has the greatest genetic diversity of this Andean grain, which is distributed throughout the Altiplano, and the Inter-Andean Valleys. At the present time the quinoa-production activity involves 70,000 small, medium and large producers, with potential areas for its production easily in excess of 75,000 hectares. Historically some 47,393 hectares were worked, with an average production of more than 21,000 MT in 1985. However, the average over the last 20 years was between 30,000 and 35,000 cultivated hectares with 23,000 MT of grain production.

The characteristics of “Royal Quinoa” are unique for its type, due to the extraordinary size of the grain, which is one of the most relevant competitive advantages. For this reason the international markets frequently demand Bolivian quinoa of high commercial quality.

In the quinoa-production chain, it is necessary to emphasise the important role played by the producers of the Southern Altiplano. In addition to specialising in the management of this crop, they are organised in associations and cooperatives. The companies engaged in processing, transforming and marketing this product have considerable installed and technological capacity developed by agro-industry, especially in regard to machinery for transforming the grain (pearled quinoa).

However, competition has recently been noted in other neighbouring countries such as Peru and Ecuador, which are gradually making inroads into Bolivian quinoa markets. The existence of "potential" companies or possible competitors which in many cases re-export the product they purchase in Bolivia (markets of Challapata or Desaguadero) and pass it off as Peruvian or Ecuadorian quinoa.

Despite all this, Bolivia is the indisputable leader in recorded exports of quinoa on a world level, controlling the world supply of this product (85% to 90%) of total sales.

5.3. The importance of quinoa to the Bolivian economy

According to CAF (CAF/CID/CLADS, 2001) the country’s annual GDP is 8,250 million dollars, of which 15% corresponds to the agricultural sector. 52% of this sectorial GDP originates from the country workers' activity (the remaining 48% corresponds to business). Within the country workers' contribution, 2.3% corresponds to the contribution of the production and sale of quinoa which is sold both locally and externally. In figures, this translates into exports in 1997 equivalent to US$ 1.6 million (PNUD/FNUDC, 1998) and at the present time it is equivalent to US$ 5 million (3 millions official and the remainder unofficial (Laguna 2002, Brenes *et al*, 2001).

According to the same author, when exports of Bolivian products of countryside origin are analysed, the importance of quinoa increases because legal or official exports alone represent 4.5% of this volume of exports.

Another aspect that should not be lost sight of is that these volumes of exports are achieved by only 21% of the producers, which produce for self-supply and allocate very little surplus for sale. Therefore, there is production potential here which should be utilised. If we compare quinoa with soya, for example, it is obvious that the export of the latter product records better profits for the country. However, the potential and rural developmental nature of quinoa means that these two chains are the first to be studied in Bolivia (Crespo, 2001b).

The quinoa-production chain lays emphasis on the Southern Altiplano, an area where production generates between 55% and 85% of the income of the families residing in that region, the poverty level of which is close to 90%. Likewise, the Southern Altiplano of Bolivia provides the biggest quantity of quinoa production (60%) for commercial purposes, though quinoa is also important in the region from the point of view of nutrition and food security, as part of the production is for self-supply.

On the Southern Altiplano there are 55,000 cultivable hectares, of which an annual average of 22,000 hectares is used for the crop. The average annual production of quinoa in the region amounts to 13,500 MT, which is developed in not very efficient production conditions, giving rise to low yield and with primary production being deficient in quality (the presence of impurities), which translates into lower prices for the producer. Furthermore, only 25% of the total production responds to one of the preferred characteristics in the external market, the organic aspect.

5.3.1. The importance of exports

Bolivia is the main world exporter of quinoa. In 1999 official exports of quinoa amounted to US$ 2.7 millions. Up until October of the year 2000, exports had been recorded amounting to approximately US$ 1.5 millions (National Statistics Office 2001). If unofficial exports are added (aimed mainly at Peru), this results in a total volume of exports of approximately 4,600 MT/year, with an approximate value of US$ 5.1 millions. This amount is very low in relation to the main agricultural and agro-industrial exports of Bolivia, but a clear trend towards an increase has been recorded, due to the increasing acceptance of quinoa in the organic products, exotic and highly nutritive products market of the developed countries.

The two countries producing the most quinoa in the world are Bolivia and Peru. Together they produce 88% of world supply. In the year 2000, Bolivia produced 45.6% of world supply and Peru produced 42.2%. In third place is the United States, which produces 6.3% of world supply of quinoa, and in fourth place is Canada, with 2.9% of world supply.

In regard to exports, in general both the varieties produced on the Southern Altiplano and those cultivated on the Central and Northern Altiplanos of Bolivia are of good-quality. However, the marketing system for exports must be in a position to respond to the requirements of the markets of Europe and North America.

5.3.2 Impact on the national economy

Quinoa is a strategic product, especially for the districts of Potosí and Oruro, in relation to the western part of these districts, where the productive economy hinges on quinoa production and llama rearing. By achieving substantial improvements in production technology, and assuming an integral perspective, the production levels could be improved to assist in improving the income for the quinoa-growing families. This income will enable them to meet, in part, some basic needs which today are unsatisfied (education, health, housing, electricity and water), which will also have an effect on regional and district development growth.

It should not be overlooked that a good portion of the production is also for self-supply, which will also enable the existing levels of per capita consumption per annum to be improved, as well as the consumption of a better product than that which is currently consumed by the country dweller families.

In the case of the Central and Northern Altiplano, improved production technology will also assist in converting quinoa into an important economic crop, in line with other crops that are currently considered to be principal crops.

At the level of the region of the Southern Altiplano, the conditions for the processing of quinoa can be improved, by generating technology that could subsequently be spread throughout the Altiplano of the country, which will result in increased volumes of processed quinoa, for family consumption and for meeting local demand. In addition, technology will allow income to be generated for other sectors that are not necessarily connected with quinoa production, such as the metal/mechanical industry (machinery manufacturers), suppliers of products and services, sectors generating sources of employment, albeit temporary.

Improved processing means that is available will lead to amounts of processed product, which are always ready to meet the demand of the merchants and exporters of quinoa, with timely deliveries when the grain is at its optimum price, which will lead to the generation of secure income for quinoa exports and will also have an effect on the national GDP based on exports of this product.

At the present time the critical factors identified and which have a marked influence on the traditional processing efforts and the quality of the final product, are:

- Insufficient quality standards
- Insufficient quality control
- Little investment in equipment
- Low operating capital
- Little investment or incentive to create the lacking technology

These factors have a direct influence on the quality of the product, which also influences the sales prices both in the national market and in the international market, particularly in the latter where the quality requirements are more rigorous.

5.3.3. Characterisation of the demand for quinoa

According to the study carried out by PROINPA (2003) on the "Characterisation of the demand for quinoa in grain and in a form processed by agro-industry destined for the local and export markets", the following results were obtained:

8 companies specialising in the field were characterised: The National Association of Quinoa Producers ANAPQUI-Challapata, Andean Valley - La Paz, Industrias IRUPANA- La Paz, Salinas-Oruro Quinoa Processing Plant, Provincial Association of Quinoa Producers - Uyuni, ANDINA Cereals Processer - La Paz, Association of Agricultural Producers - Quijarro-Uyuni and La Chapaquita Dood Workshop - La Paz. Overall demand amounts to 2,310 MT/year, (800 and 1510 MT for the national and international markets, respectively). Approximately 2,445 farmers supply these industries, mainly on the Southern Altiplano, where unprocessed quinoa grain is sold, between 90 and 180 Bs/quintals, which values exceed the prices paid by the stockpilers or intermediaries (informal merchants) in Challapata, the biggest marketing centre for Royal Quinoa on the Southern Altiplano.

The said companies acknowledge operators purchasing quinoa for export, such as: QUINOA CORPORATION PREMIAL, UNITED NATURAL FOOD, MARKAL, RAPUNCEL and GEPA, which convey the product to the markets of the United States, France, Germany, Italy, Japan and Holland. The price of processed organic Royal Quinoa varies between 900 and 1,100 US$/MT, while for conventional quinoa the prices are reduced by up to 25% on average. In relation to the South American market, the main export countries are: Chile, Ecuador, Colombia and Peru. An estimate of the overall demand of the countries concerned varies between 1,500 and 2,000 MT/year, distributed as follows: USA 550, France 250, Germany 200, Holland 150, Peru 150 and other countries 200 MT. However, it is important to state that contraband amounting to 2,500 MT/year reaches Peru.

CHAPTER VI

PLAN FOR MANAGING INTELLECTUAL PROPERTY

6.1 Impact on Human Rights (Intellectual Property)

The impact on human rights or intellectual property in this study is basically centred on subjects such as access to genetic resources and the distribution of profits, although the subject of patents was also of considerable interest, due to the intervention of a North American University in the decade of the 1990s, as we will see below.

Access to genetic resources and the distribution of profits, were subjects that were widely treated on an international level, leading to the Biological Diversity Convention (1992(, Decision 391 of the Andean Community of Nations (1996), Agreement on Aspects of Intellectual Property Rights with Commerce (ADPIC) of the OMC, negotiated in the Uruguay Round (1986-94), Agreement 169 of the OIT, which acknowledges the rights of indigenous and tribal peoples (1989), the International Treaty on Phytogenetic Resources for Agriculture and Food of the United Nations Organisation for Agriculture and Food (2001).

6.2 Intellectual property and distribution of profits

In Bolivia the regulations relating to the protection of traditional knowledge and the distribution of profits are contained in the following legal texts: Law 1,257 approving and ratifying Agreement 169 of the OIT concerning Indigenous and Tribal Peoples in Independent Countries (1991); Law of the Environment (1992); Law 1,580 ratifying the Agreement on Biological Diversity (1994); Forestry Law (1996), Regulation on Decision 391 Common System of Access to Genetic Resources and Regulation on Bio-Safety laid down by means of Supreme Decree 24676 (1997), The Law of the Environment, in its art. 334, in general establishes that: "The special laws pronounced for each natural resource must establish the rules regulating the different methods, conditions and priorities for acquiring the right of use of renewable natural resource in the public domain, depending on the specific characteristics, regional potential and social, economic and cultural aspects", including traditional knowledge linked or associated with these resources.

The Regulation of Decision 391 was prepared in 1996, the aspect that was considered in more detail for regulation purposes having been that relating to the distribution of profits. Among the additional conditions established for the contract of access to genetic resources, there is included the fair and equitable participation of the Bolivian State in any economic, technological or other kind of benefit generated by such access, and equally when countryside or indigenous communities are involved, such as suppliers of the associated intangible component, the participation of such communities in the benefits through their representative organisations must be agreed. (Art. 15.2.).

In addition in Chapter VI of the State Participation in the Benefits Derived from Access to Genetic Resources, provision is already made for the use of the benefits obtained, which is that of introducing measures that are conducive to the conservation, sustainable use and development of the genetic resources within the national territory (Art. 40). Specific information is provided on the consistency of the said benefits, the following having been noted: the transfer of technologies and knowledge used in research and/or experimentation; the development of technical and scientific capacities of national institutions; payment of royalties for commercial use, by-products or the intangible associated component; the franchises of merchants or processors granted to the country, and others that may be agreed within the scope of the Andean common regime (Art. 41).

In addition, the Law of Agrarian Development acknowledges the existence and value of what the rule calls ancestral production systems, and provision is to be made in subsequent rules for contractual mechanisms for the acknowledgement of benefits. The said regulation reproduces the mandate of Art. 8j of the Agreement on Biological Diversity, when it establishes that "the innovations and practices of the indigenous and local communities involving traditional lifestyles pertinent to the conservation and sustainable use of the biological diversity will be respected, preserved and maintained, and their widest application will be promoted with the approval and participation of those possessing such knowledge, innovations and practices, and it will provide that the benefits deriving from their use are equitably shared." A Fund is also formed for this Programme of Training and Transfer of Agrarian Technology.

In the agriculture and livestock sector, the treaties of greatest relevance at the international level were the CDB and Decision 391. The CDB, on referring to access to genetic resources (Art. 15) establishes that "each contracting party will adopt legislative, administrative and political measures... to share in a fair and equitable way the results of the activities of research and development and the benefits deriving from the commercial use and any other type of use of the genetic resources with the contracting party contributing those resources". And in relation to the distribution of benefits, both in their respective ambit, establish the equitable sharing of the benefits deriving from the use of the knowledge, innovations and traditional practices, or by-products of access to the genetic resource (Arts. 8.j. and 2.a., respectively).

Decision 391, is currently regulated in Bolivia by means of Supreme Decree 24676 of July 1997. This regulation regulates access to genetic resources; therefore, every request for genetic resources for any kind of work must conform to an access procedure before the Competent National Authority, which in this case is the Deputy Ministry for Natural Resources, the Environment and Forestry Development of the Ministry of Sustainable Development.

To date no request for access to genetic resources of quinoa has been made, as has occurred with crops of potatoes, peanuts and medicinal plants. This leads one to assume that the regulation has to some extent put the brake on indiscriminate use in the management of this crop by national and foreign researchers.

Before this regulation quinoa was already outside Bolivia being researched and used by various institutions in several countries throughout the world, among which we can mention the United States of America; England, Holland, Italy, Greece, Sweden and Denmark in Europe, Vietnam in Asia, as well as Australia, Namibia and Kenya in Africa, as well as neighbouring Bolivia's countries such as Argentina, Brazil, Chile, Colombia, Ecuador and Peru. The latter benefited from varieties of quinoa released by the Bolivian Institute of Agricultural Technology (IBTA).

Of all these Bolivian collections abroad, no benefit has been obtained for the country and even less so for the producers, who are the true owners of this valuable resource.

The use of the genetic resources of quinoa by national institutions (public and private), translates into technology transfer, through which some quinoa-producing communities on the Central and Southern Altiplano benefited, mainly in the form of conventional and organic production technologies. Undertakings for export and transformation were essentially carried out by private initiatives of the producers themselves or of other companies.

At the present time no tangible benefit exists for the quinoa-producing communities and possessors of this excellent genetic material, due mainly to the fact that there is no clarity in the application of the rules relating to the distribution of benefits, both at the national and at the world level.

6.3 Patenting of Bolivian quinoa

In 1994, the agronomists Duane Johnson and Sarah Ward of the Colorado State University received patent No. 5,304,718, they being granted the exclusive monopolicistic control over masculine sterile plants of the traditional Bolivian quinoa variety "Apelawa" and its use for creating other hybrid varieties of quinoa. Apelawa is a quinoa variety of the Altiplano (plains located at a great height) in the region of Late Titicaca, Bolivia. Duane Johnson readily admits that he and Sarah Ward did nothing to create the male sterile varieties of quinoa: "These form part of the population of native plants", explains Johnson, "We merely took them".

The patent of Johnson and Ward sustains that they were the first to identify and use reliable cytoplasmatic male sterility systems in quinoa for the production of hybrids. In order to produce the cytoplasmatic sterile males, they visually selected the sterile male plants which were naturally present in the Apelawa variety and subsequently crossed these with fertile quinoa plants to obtain the sterile male hybrid.

The patent application not only at that time limited to a single hybrid variety, also claimed any quinoa hybrid derived from the cytoplasm of the sterile male Apelawa. According to the patent, it includes traditional Andean varieties, but is not limited to these, such as: Apelawa, 407, Cahuil, Tango, Janco, Kanchi, Baer, Calcha, Chullpe, Killuvirginiana, Lihio, Marangani, Isluga, Sajama, Chuppi, Kanccolla, Blanca de Juli, Rosada de Junín, Blanca de Junín, Illimani, Oxfam, Tupiza, Ccoyto- 1, Chewecca, Real, Pasankalla, Litu, Pichaman, Faro, Amarillo de Marangani, Dulce de Quitopamba, Lipez, Lirio, Rojo de Cusco and Tanso Kanta. According to the requirements of the patent, the seeds of the traditional Bolivian variety Apelawa are currently in the store of the American Type Collection (accession No. 75154) en Rockville, Maryland.

Under the patent law of the United States, Johnson and Wood were entitled to prohibit any one, without permission and the payment of royalties, from producing, using or selling quinoa hybrids deriving from the cytoplasm of Apelawa. Technically, the inventors had the legal right to prohibit the entry of imports of quinoa to the United States, if they had been produced using their patented technology. Furthermore, they had the right to prohibit other researchers from using the germplasm of Apelawa to create quinoa hybrids - even for non-commercial purposes. Duane Johnson stated that he is already distributing his invention free of charge to scientific researchers. Why did he therefore patent Apelawa and the technique for developing quinoa hybrids? "Frankly", responds Johnson, "It was because the University wishes as to patent this type of technology - patenting is only one of the procedures". The patent was available through licences and could be acquired by a company interested in selling the technology to produce quinoa hybrids. The patent expires in 2011.

This fact caused a protest among Bolivian farmers and NGO’s, who approached the United Nations to condemn the quinoa patent as being a threat to food security and a violation of Human Rights. The National Association of Quinoa Producers of Bolivia (ANAPQUI) asked the two professors at the Colorado State University to suspend their controversial patent in respect of one of the most important crops - quinoa. "Our intellectual integrity has been violated by this patent" said Luis Oscar Mamani, President of ANAPQUI, in that year. "Quinoa has been developed by the Andean farmers for millennia; it was not "invented" by the researchers in North America," said Mamani. "We demand that this patent be suspended and that all countries of the world refuse to recognise its validity.

This patent no longer exists, thanks to international campaigns mobilised by international producers and organisations against the patent. 20 April 1998 was the deadline for renewing the patent and the owners decided not to do so.

BIBLIOGRAPHY

ANAPQUI. **2001**. "Nutritional Food of the Andes for the World". National Association of Quinoa Producers. La Paz, Bolivia.

AOPEB, 2000. AOPEB Rules for ecological production in Bolivia La Paz, Bolivia.

Bonifacio, A. 1995. Genetic Improvement of Quinoa and Its Prospects

CEDLA, KIT. 2001. Virtual and real scenarios of the livestock and rural sector of the Bolivian Altiplano La Paz, Bolivia

Crespo, F. Bellot, S. 2003. Organic Quinoa Market (Outlook). La Paz, Bolivia

Crespo, F. Brenes, E. Madrigal, K. 2001. Quinoa Workshop Results, Bolivia. Latin American Centre for Competitiveness and Sustainable Development Document in Progress.

Mcknight Foundation, MACIA, SINARGEAA, PROINPA Foundation. 2003. Royal Quinoa Catalogue La Paz, Bolivia.

Foundation for Agricultural Technological Development on the Altiplano (FDTA-Altiplano). 2002. Projected Demands of the Quinoa Production Chain in Bolivia. Consultora CEP. La Paz, Bolivia

PROINPA Foundation. 1999. Alternatives for Aetiological and Biological Control of Pests in Quinoa Cultivation. Cochabamba, Bolivia

PROINPA Foundation. Plan for Managing the Protection of Intellectual Property.

Gandarillas, H. 1968. Quinoa Strains Bolivia, Ministry of Agriculture, Agricultural Research Division. Experimental Bulletin No 4. 53p.

IBTA, 1995. Reports on Seminar/Workshop on technology available for the cultivation of quinoa and technology transfer. La Paz, Bolivia.

IICA/PNUD. June 1991. Study of the Royal Quinoa Market in Bolivia. La Paz, Bolivia.

Annual Report - IBTA.1981-1982. La Paz, Bolivia

Annual Report - IBTA.1983-1984. La Paz, Bolivia

Annual Report - IBTA.1984-1985. La Paz, Bolivia

Annual Report - IBTA.1985-1986. La Paz, Bolivia

Annual Report - IBTA.1986-1987. La Paz, Bolivia

Annual Report - IBTA.1987-1988. La Paz, Bolivia

Annual Report - IBTA.1988-1989. La Paz, Bolivia

Annual Report - IBTA.1991-1992. La Paz, Bolivia

Annual Report - IBTA.1992-1993. La Paz, Bolivia

Annual Report - IBTA.1993-1994. La Paz, Bolivia

Annual Report - IBTA.1994-1995. La Paz, Bolivia

Annual Report - IBTA.1995-1996. La Paz, Bolivia

Annual Report - IBTA.1996-1997. La Paz, Bolivia

Annual Report - IBTA.1997-1998. La Paz, Bolivia

Annual Report - PROINPA Foundation. 1998-1999. La Paz, Bolivia

Annual Report - PROINPA Foundation. 1999-2000. La Paz, Bolivia

Annual Technical Report 2001-2002 (Año 1). IPGRI, PROINPA Foundation, IFAD. La Paz, Bolivia

Executive Report 2001-2002. PROINPA Foundation, Cochabamba, Bolivia

Final Report 2001-2002. PROINPA Foundation, Cochabamba, Bolivia

Annual Report - PROINPA Foundation. 2002-2003. Reports. La Paz, Bolivia

Melgarejo, K., A. Turumaya, E. Perez, J. Rojas, A. Bonifacio and J. Maugham. 2004. Characterisation of the genetic diversity of the Bolivian collection of quinoa, using molecular markers of the micro satellite type. In: XI International Congress on Andean Crops Cochabamba, Bolivia. 4p.

Regulations for Gene Banks 1994. United Nations Organisation for Agriculture and Food, Rome. International Institute of Phytogenetic Resources, Rome.

First Report Overview, 2001. PROINPA Foundation, Cochabamba, Bolivia

First Vice President of the Honourable National Senate, 1995. "Quinoa - Reality and Prospects", i) First National Symposium Report, La Paz, Bolivia.

Andean Project on Competitiveness, CAF, CID, CLACDS-INCAE. 2001. Characterisation and Analysis of the Competitiveness of Quinoa in Bolivia La Paz, Bolivia.

Ramos N. 2000. "Ecological Agriculture of Quinoa as an Alternative to the Impacts of Desertification on the Southern Altiplano", UMSA.

Ritva Repo - Carrasco.**1992**. "Andean Crops and Infant Feeding". Lima, Perú.

Risi J. 1994. Final Report of the Assessment of the Quinoa Programme Within the Framework of the IBTA/BM Project. 1 September 1992 – 31 August 1994. La Paz, Bolivia.

Rojas, W., M. Pinto and G. Aroni. 2004. State of Genetic Variability of Royal Quinoa on the Southern Altiplano of Bolivia. In: XI International Congress on Andean Crops Cochabamba, Bolivia. 4p.

Rojas, W. 2003. Multivariate Analysis of Genetic Diversity of Bolivian Quinoa Germplasm. Published in Food Reviews International , Volume 19:9-23.

Rojas, W., M. Pinto and J.L. Soto. 2003. Study on the Genetic Variability of Quinoa in the Area Surrounding Lake Titicaca. Annual Report 2002/2003. McKnight Project. PROINPA Foundation. 5 p.

Rojas, W., M. Pinto and A. Camargo. 2003. Decentralised Collection of Germplasm of Cañahua and Quinoa. In: Annual Technical Report 2002/2003 (Year 2). Project "Increasing the contribution made by the forgotten and underutilised species towards food security and the income of the population with scarce resources". IPGRI-IFAD, PROINPA Foundation. La Paz, Bolivia. pp 9-18.

Rojas, W. and A. Camargo. 2003. Establishment of a method of reducing the moisture content of quinoa grain Annual Report 2002/2003. Mcknight Project. PROINPA Foundation. 4 p.

Rojas, W. and M. Pinto. 2003. Descriptors of cañahua and quinoa standardised in the Andean region. In: Annual Technical Report 2002/2003 (Year 2). Project "Increasing the contribution made by the forgotten and underutilised species towards food security and the income of the rural population with scarce resources". IPGRI-IFAD, PROINPA Foundation. La Paz, Bolivia. pp 59-94.

Rojas, W. 2002a. Collection of cañahua and quinoa germplasm. In: Annual Technical Report 2001/2002 (Año 1). Project "Increasing the contribution made by the forgotten and underutilised species towards food security and the income of the population with scarce resources". IPGRI-IFAD, PROINPA Foundation. La Paz, Bolivia. pp 13-21.

Rojas, W. 2002b. Core collection of quinoa germplasm In: Annual Technical Report 2001/2002 (Year 1). Project "Increasing the contribution made by the forgotten and underutilised species towards food security and the income of the population with scarce resources". IPGRI-IFAD, PROINPA Foundation. La Paz, Bolivia. pp 34-41.

Rojas, W. 2002c. Geographical distribution of the cultivated quinoa germplasm collection In: Annual Report 2001/2002. Project "Principal activities for the management, conservation and sustainable use of germplasm banks in Bolivia: National High Andean Grain Bank Component". SIBTA - PROINPA Foundation. La Paz, Bolivia. pp 7-11.

Rojas, W., M. Cayoja and G. Espindola. 2001. Catalogue of the Quinoa Collection Conserved at the National High Andean Grain Bank La Paz, Bolivia. 128 p.

Rojas, W. and R. Quispe. 2001. Electronic documentation on quinoa germplasm In: Final Report 2000/2001. Project "Conservation and management of the genetic variability of the quinoa germplasm collection". PPD/PNUD, PROINPA Foundation. La Paz, Bolivia. pp 17-19.

Rojas, W. and C. Maydana. 2001. Preliminary studies on the fluctuation of the initial moisture of quinoa germplasm, for long-term conservation. In: Final Report 2000/2001. Project “Conservation and management of the genetic variability of the quinoa germplasm collection”. PPD/PNUD, Fundación PROINPA. La Paz, Bolivia. pp 14-16.

Rojas, W. 2001. Monitoring the variability of quinoa germplasm seeds. In: Final Report 2000/2001. Project “Conservation and management of the genetic variability of the quinoa germplasm collection”. PPD/PNUD, Fundación PROINPA. La Paz, Bolivia. pp 3-7.

Rojas, W. and A. Bonifacio. 2001. Multiplication of late-ripening quinoa accessions under greenhouse conditions. In: Annual Report 2000/2001. Project “Principal activities for the management, conservation and sustainable use of germplasm banks in Bolivia: National High Andean Grain Bank Component”. SIBTA - PROINPA Foundation. La Paz, Bolivia. pp 8-11.

Rojas, W., A. Bonifacio, G. Aroni and J.C. Aroni. 1999. Collection of new quinoa accessions and other Chenopodaea. Annual Report 1998/99. PROINPA Foundation. 5 p.

Saravia R. and G. Aroni. 2001. Current situation of the quinoa crop in Bolivia In: Binational Workshop Perú – Bolivia. Punto, Perú. 9p.

Bolivian System of Productivity and Competitiveness (SBPC) 2003. Plan for Strengthening the Production Chain of Quinoa on the Southern Altiplano within the Framework of the First Bolivian Agreement on Competitiveness. Ministry of Economic Development.

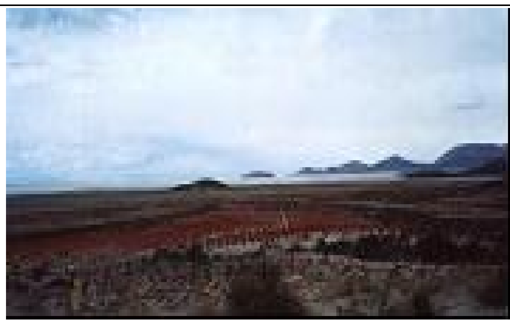
Castiñeria, A. Y Lozano J. Quinoa
http://www.prodiversitas.bioetica.org/quinoa.htm#_Toc23740777

ANNEXES: PHOTO GALLERY

GENETIC VARIABILITY

	
Colour of ears of grain	Variety of grain colours

CULTIVATION TECHNOLOGY

	
Commercial plot of Royal Quinoa variety	Quinoa plot, salt bank border (Salinas GM)
	
Quinoa plot on the Central Altiplano	Formation of arches (‘taucas’) for drying
	
Traditional threshing of quinoa – running over crop with the wheels of a truck or tractor on the Southern Altiplano	

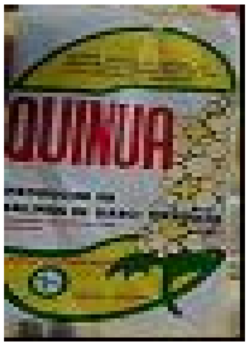
TECHNOLOGIES INTRODUCED

	
Quinoa sowing machine called SATIRI - I	Mechanised harvest with stripper
	
Mechanised thresher (Vencedora type thresher)	Prototype grain venter with motor
	
Quinoa harvest using sickles	Use of HERANDINA thresher, Central Altiplano

TRADITIONAL FORMS OF QUINOA CONSUMPTION

		
Quinoa soup	Quinoa P’esque with milk	Mukuna with mate

MARKETING

		
Quinoa market in Challapata Oruro	Quinoa grain	Quinoa Flakes