CHAPTER 1.4

THE DYNAMICS OF THE GLOBAL EXPANSION OF QUINOA GROWING IN VIEW OF ITS HIGH BIODIVERSITY

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Abstract

Quinoa (*Chenopodium quinua* Willd.) was first domesticated in Andean countries over 5 000 years ago. Following the Spanish conquest, quinoa was rejected and scorned as “Indian food”. Its potential was rediscovered during the second half of the twentieth century and, since then, the number of countries growing quinoa has risen from 6 to 13, while 23 other countries are in the process of actively experimenting before launching field production in the near future. Another 20 countries are planning to plant quinoa for the first time in 2014. The organization of research has had a powerful impact, creating links and strategic partnerships between countries as is the case of the worldwide CIP/DANIDA programme in the 1990s or, more recently, with trials conducted by the European project SWUP-MED around the Mediterranean Sea. By networking researchers around the world, countries form partnerships based on affinities. One example is the United Kingdom which has established special contacts with India, Australia, China and Nepal. Today, experimentation centres are to be found in new countries that did not previously import quinoa. Although most publications of scientific findings are based on studies carried out in the Andean countries (Bolivia and Peru in particular), research is spreading around the world with studies conducted in new areas such as virology, dietetics, or quinoa processing for uses other than food. South American countries must now face global competition for the enhancement of quinoa varieties and must reflect upon possible competition between countries to access new markets. This is why some of them have already adopted the plant variety certificate (COV) system to protect their improved varieties, or they are in the process of applying for certificates. This paves the way for the conservation of plant genetic resources through recognition of local farmers’ varieties and their use in future enhancement programmes.

Introduction

The genus *Chenopodium* (Chenopodiaceae) includes some 150 species which are mostly annual herbaceous plants occupying large areas of America, Asia and Europe, although some are also perennial and arborescent. The genus is cosmopolitan, meaning that it can adapt to any environment in the world, but it is concentrated in temperate and subtropical regions. Because of its great ecological plasticity and hardiness, the genus has given rise to a large number of species through a long process of adaptation and diversification in order to survive in environments with major biophysical constraints. As a result, most of its species are major constituents of arid and/or saline environments. Today, cultivated *Chenopodium*

– especially *C. quinoa* – are gaining importance due to the excellent quality of their proteins (good balance of all amino acids) and their high content of a variety of minerals and vitamins (Vegas-Gálvez *et al.*, 2010). Their potential contribution to global food security was recognized in the declaration of the International Year of Quinoa (IYQ, 2013) (Small, 2013). Furthermore, quinoa represents an alternative as a new crop in response to global changes (Jacobsen, 2003; National Academy of Sciences, 1975; Schlick and Bubenheim, 1996). For example, the increased salinization levels on farmlands due to intensified conventional farming since the 1960s leads to a decline in agricultural production, followed by the abandonment of degraded land depending on its location. Quinoa's tolerance to saline soils offers an alternative, not only in terms of recovery of these lands, but also by producing food of high nutritional value. In view of climate deterioration within the framework of global change, quinoa's resistance to drought raises expectations for those regions that are strongly impacted by these factors.

Domesticated by farmers in the Andean countries, scorned during the Spanish invasion and appreciated around the world today, the history of quinoa is both rich and complex. As for all domesticated crops, the history of quinoa and its diversity is directly linked to human activities (Bermejo and León, 1994). The last 60 years have seen major advances in quinoa expansion and experimentation, in its enhancement and adaptation to various environments around the world. This chapter seeks to explain how the quinoa cultivation area has spread from 6 to 56 countries and why today, in 2014, nearly 20 more countries wish to try.

Interest in quinoa (*Chenopodium quinoa* Willd.) goes back a long way and it should be recognized that quinoa is not the sole species of the genus *Chenopodium* – on the contrary, there are very close relationships between the various species of this genus. Current specificities tend to relate to its rapidly increasing spread worldwide since the 1970s as grain for consumers in the northern hemisphere, with the aim of introducing it as a new crop on all continents. The dynamics existing today affect the balance that had been established between producers and consumers from 1990 to 2010. Thus, the global spread of quinoa creates new outlooks for many countries, but at the same time profoundly disrupts the balance, as it is necessary to maintain sustainable production, while enabling Andean countries to cope with the upsurge in international demand (Bazile, 2014; Jacobsen, 2011, 2012; Winkel *et al.*). In addition, new relationships are being forged between countries – not only to trade grain, but also to establish rules and regulations on access to quinoa seeds. The current tensions concerning the flow of genetic resources and quinoa seeds necessitate international dialogue and global governance, so that countries can adjust to the environmental shift already underway and modify the agricultural model.

Although informal research networks in the past drew attention to quinoa growing, resulting in its experimentation in various parts of the world, greater transparency is now required to adapt activities to international legal regulations which acknowledge the Andean people's role in creating and maintaining quinoa biodiversity.

The conclusion of this chapter shows that, in facing the challenges of learning about the quinoa plant, its origin and evolutionary dynamics, its adaptation and enhancement, it is essential for farmers, researchers and policy-makers from around the world to exchange information, in order to be able to move forward, together with all those stakeholders seeking to capitalize on this plant.

Globalization of quinoa: a historical fact

It is important to make an in-depth examination of the ancient origins of the worldwide distribution of the genus *Chenopodium* and the diversity of its species, in order to properly understand the current development of cultivated quinoa. It is a historical fact that the use of *Chenopodium* leaves and seeds for human consumption is not exclusive to the Andean region. A species of Chenopodiaceae (classified as *Chenopodium album*) was cultivated in the Himalayas a long time ago at altitudes of 1 500–3 000 m asl (Hooker, 1885; 1952; Partap, 1982). When Stewart (1869) described the complete flora of the Punjab region in northern India, the presence of three groups of Chenopodium in the area studied was mentioned:

- *Chenopodium álbum* album L. was a common weed in the plains and also appeared at altitudes of 2 600–4 100 m asl in the Ladack region, where the plant was sometimes used as a "pot herb" or in soup.

- *Chenopodium murale* L. was present on the plains where it was also consumed as a pot herb.

- *Chenopodium sp.* belonged to a complex of two species (*C. album* and *C. quinoa*) grown in the Himalayan regions of Punjab, and more precisely at high altitudes (1 700–2 700 m asl) in the Ravi River basin, as well as higher up in Kashmir and Ladack. The plant was cultivated for its leaves and used as a pot herb, but these Chenopodium species were mainly grown for their grains, which were considered superior to buckwheat (Singh and Thomas, 1978).

Stewart's document is of considerable historical value in understanding the phylogenic relations caused by contact, in a certain period, between species of the genus *Chenopodium*. Moreover, since plant selection is guided by the intended uses, the same line of reasoning is adopted by peoples in both the Andean mountains and the Himalayas. Ethnobotanical studies by Partap and Kapoor (1985a) show that the group of *Chenopodium* grains used in the Himalayas was a minor subsistence food crop for many isolated hill communities in the middle Himalayan range. It has been consumed in various forms since time immemorial and its consumption is part of the people's eating habits in isolated hill communities. The authors describe it as a summer crop cultivated in mixed cropping systems (finger millet, rice, potatoes, maize and beans) (Partap and Kapoor, 1987b).

The analysis carried out by Partap and Kapoor (1985b) of the Himalayan Chenopodiaceae consumed as grains shows that they were considered domesticated forms of *Chenopodium album* L. Given the great morphological diversity, the authors selected four varieties recognized by local farmers to perform an agromorphological analysis (Partap and Upadhya, 1987b). Three of the four cultivars (black, brown and red) had a similar morphology and only their seed polymorphism differed. The findings produced sufficient evidence to be able to classify them as the domesticated *C. album* L. species. The type of polymorphism found in these cultivars is further indication of their close relationship with the non-domesticated form of *C. album* L. The authors presented the fourth cultivar as being very different from the others, expressing doubts about their close taxonomic relationships with C. *album* L. and *C. quinoa* Willd.

Nevertheless, Stewart's publication also bears witness quinoa's early role in globalization, given the international grain trade already existing at the time:

"Within the last year, considerable stir has been made by correspondents of the Agri-Horticultural Society of India, regarding the introduction into the Himalaya of the C. quinua *Willd. of the Andes; and the Society made arrangements to get a supply of seed, which has arrived and been distributed. The original proposition appears to have been made in ignorance the fact that a* C. *is cultivated extensively in the Himalaya, and there seems reason to doubt if very much would be gained from the introduction of the quinoa in these mountains, where cereals are cultivated to quite as high elevations as men can occupy throughout the year."* (Stewart, 1869)

The same *Chenopodium album* L. species prevalent throughout the geographical area delineated as Eurasia (Uotila, 1978) is now regarded as a European cosmopolitan weed (see Chapter 6.11) for cereals, although it was once a secondary crop and part of the human diet according to prehistoric human remains found in Tollund (Denmark) and Cheshire (United Kingdom) (Helbaek 1950, 1954, 1958, 1960; Rowley-Conwy, 1982, 2000; Rowley-Conwy and Stokes, 2002). Although there is evidence that *Chenopodium album* L. was an important crop in Europe –via a domesticated form that was also found in the Himalayas – researchers and enhancers have focused their efforts on Europe to adapt *Chenopodium quinoa* Willd., a tropical species (Galwey, 1989, 1993; Risi and Galwey, 1984, 1989, 1991; Jacobsen, 1997), to temperate climates. In plant breeding programmes, cultivation of this crop from the Andes highlands was considered suited to the relatively low temperatures of regions in northern Europe (e.g. United Kingdom and Denmark). This reasoning was based on the analysis of *C. album* as a wild species from which it would be difficult to obtain a crop. Today, this vision may be revised to make better use of the genetic resources available and the adaptability of *C. album.*

Furthermore, a similar species – *Chenopodium berlandieri* subsp. *Nuttaliae* – is consumed in Mexico. Considered a wild species in the United States of

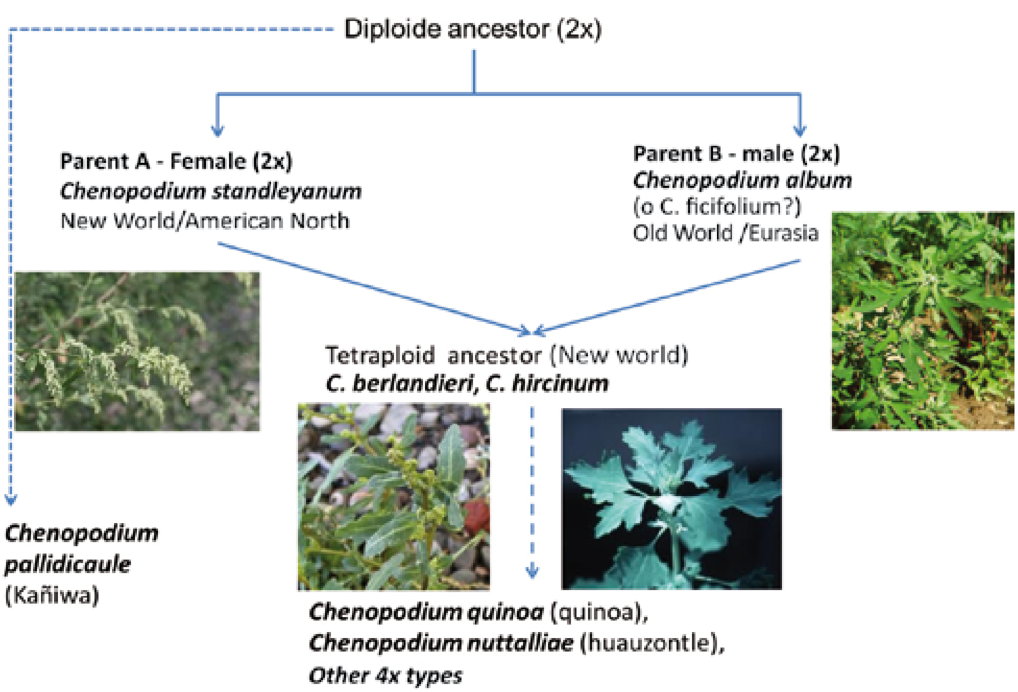

Figure 1. The origin of modern quinoa (*adapted from* Jellen and Maughan, 2013)

America, *C. berlandieri* is being studied for its potential for crossing with *C. quinoa* so as to withstand high temperatures. Without going into more detail about the entire genus, it may be noted that cultivated *Chenopodium* are becoming increasingly important. *Chenopodium quinoa*, which offers a wide adaptability to many harsh environments, as it is resistant to salt and drought tolerant, shares its food niche with two closely related species, cañihua (*Chenopodium pallidicaule*) and huazontle (*Chenopodium nuttaliae*), which are also used in human nutrition (Wilson and Heiser, 1979).

A study of quinoa phylogeny highlights various species of the genus Chenopodium, some of which are of economic importance:

- *Chenopodium quinua* (2n = 36) used as a grain crop;
- *Chenopodium pallidicaule* (2n = 18) and *Chenopodium berlandieri* subsp*. nuttalliae* (2n = 36) used for both grains and vegetables;
- *Chenopodium album* (2n = 18,36,54) used mainly as a leaf vegetable and forage crop;
- Some types from the Himalayas (*C. album* and *C. quinua*)) grown for their grains and leaves.

Chenopodium species are well known for their uses in cooking (see chapter 3.4), but there are also medical applications (see chapters 3.5 and 3.6).

There are four stages in the complex process of creating quinoa from its various wild ancestors (Heiser and Nelson, 1974; Nelson, 1968; Wilson, 1990), explaining not only its domestication, highlighting the key milestones in its history, and giving insight into the genetic aspects of its evolutionary dynamics (Pearsall, 1992). The first stage in the life of quinoa was when the two diploid ancestors hybridized to create the first form of wild quinoa. This is how a female relative, *Chenopodium standleyanum* from temperate America, was crossed with a male relative, *Chenopodium album* from Eurasia (another theory proposes *C. ficifolium*) through a natural hybridization process engendering its tetraploid ancestor in the New World (Figure 1). *C. berlandieri* and *C. hircinum* are tetraploid forms derived from the tetraploid ancestor enabling domestication of the ancestor of modern-day quinoa and generating the second stage of its evolution (Jellen and Maughan, 2013).

A first "bottleneck" in the genetic diversity of quinoa may have occurred when the two diploid ancestors hybridized to form wild quinoa. A second bottleneck may have occurred when quinoa was domesticated from tetraploid wild ancestors (Fuentes, Maughan and Jellen, 2009). This could explain quinoa's constant ability to be crossed with other tetraploid species (Wilson and Manhart, 1993) and to exist in multiple forms. The importance of this second bottleneck is directly contingent upon the first bottleneck. This implies the presence of a relatively small degree of genetic diversity suitable for sharing with compatible wild relatives across the board (Fuentes *et al.*, 2009).

Seed exchanges and circulation of quinoa in Latin America have generated five ecotypes associated with subcentres of diversity (Fuentes *et al.*, 2012). Nevertheless, this third stage of species diversification after local domestication around Lake Titicaca came to an end following the Spanish conquest for several reasons: loss of interest in the product which was viewed as "food for Indians"; the Catholic Church's rejection of its use as a drink in cultural ceremonies (Mudai); changes in dietary habits due to schooling; and new agricultural modernization policies adopted to impose the Spanish Crown's authority (Bazile and Negrete, 2009; Bazile and Thomet, 2013; Thomet and Bazile, 2013). The soaring demand for quinoa in the 1990s brought the fourth stage of its evolutionary dynamics and its current dissemination around the world (Bazile, Fuentes and Mujica, 2013).

Importance of quinoa biodiversity for its worldwide distribution

The ancient process of quinoa domestication was developed by leveraging the species' diverse genetic resources. They adapted to different geographical areas with specific environmental contexts, determining the overall survivability of quinoa, and creating multiple forms within the same species throughout the ages. Due to the special adaptations of quinoa in different zones in the Andes, five ecotypes are recognized: Inter-Andean valleys (Colombia, Ecuador and Peru); Altiplano (northern highlands in Peru and Bolivia); Yunga (Bolivia); Salare (salt flats or southern highlands in Bolivia, Chile and Argentina); and Coastal (coastal or sea level areas in central and southern Chile, extending to at least the Island of Chiloe) (Fuentes *et al*., 2012; Risi and Galwey, 1984).

Quinoa has soared remarkably since the 1980s due to increasing regional and international demand. It remains a staple product in Andean countries and is increasingly appreciated in North America and Europe for its dietary properties, organic farming and fair trade principles. To meet demand, production has more than doubled in Bolivia, the second largest producer after Peru, while Chile has taken initiatives to develop and capitalize on this marginal crop. Quinoa has also attracted the interest of researchers in Europe and North America for its nutritional characteristics and resistance to adverse factors, and there have been several attempts since the 1980s to introduce quinoa at high latitudes (Lopez-Garcia, 2007; NRC, 1989). The problem is understanding what can be grown in temperate environments? Early attempts systematically failed using materials from Peru and Bolivia (latitudes near Ecuador) which did not reach maturity during the summer at high latitudes. The requirements for temperate agriculture are present in the Coastal quinoa ecotype accessions from southern and central Chile.

Global recognition since 1973

The United States of America has shown interest in quinoa grain since 1948. A pioneering crop experiment using seeds from Chile was carried out in southern Colorado in the early 1970s (Johnson and Croissant, 1985). Although two Andean countries, Bolivia and Peru, currently account for most of global quinoa production, cultivation really has been spreading across all continents since the 1980s (Figures 1 and 2). The United States of America conducted quinoa experiments on a large scale for the first time in southern Colorado and then gradually extended trials to other states (Cranshow *et al.*, 1990; Kephart, Murray and Auld, 1990; Oelke *et al.*, 1990; Tobin, 1995). In Canada, quinoa is grown in the Saskatchewan and Ontario lowlands (traditionally occupied by grasslands or wheat cultivation), and it is estimated that the whole of North America accounts for nearly 10% of world quinoa production. In the United States of America, quinoa tests are currently been carried out on the Northwest Pacific coast using materials from Chile; results are very promising. However, although these developments appear significant at first sight, they are negligible when compared to the total volume actually sold in the United States of America and which is still imported from South America.

Quinoa was first introduced in Europe (see Chapter 6.11) in 1978 using Chilean germplasm (University of Concepción, Chile), which had been collected, selected and tested by Colin Leakey in Cambridge (United Kingdom) and in the Loire Valley (France). This Chilean germplasm – together with the Andean germplasm collected in 1982 by Galwey and Risi – laid the foundations for the breeding programme carried out at the University of Cambridge and directed by Nick Galwey (Fleming and Galwey, 1995; Galwey, 1989, 1993) (Figure 3). From Cambridge, quinoa then spread to Denmark, the Netherlands and other European countries (Risi and Galway, 1991). In the United Kingdom, quinoa is used as a cover crop and is planted separately or mixed with rapeseed. In Denmark, quinoa is widely recognized and used by people allergic to gluten and this could become a specific market segment.

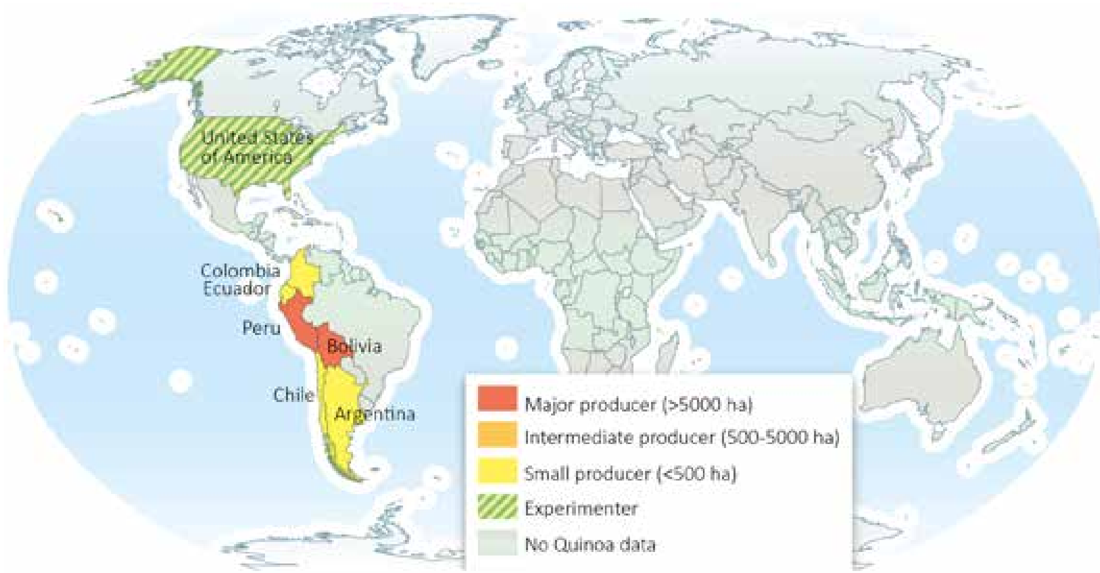

Figure 2. Quinoa worldwide development in 1973

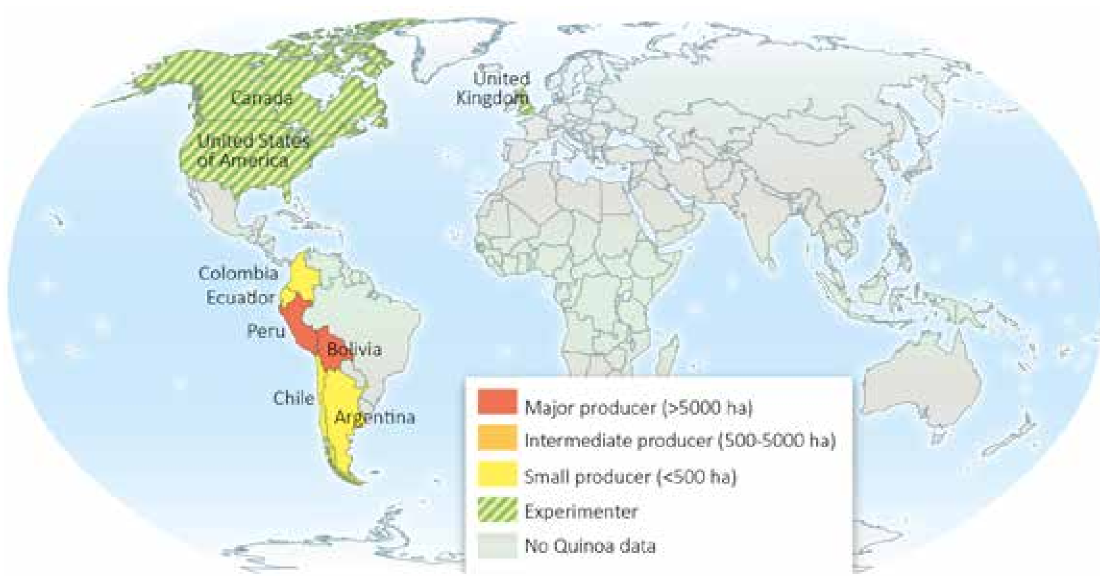

Figure 3. Quinoa worldwide development in 1983

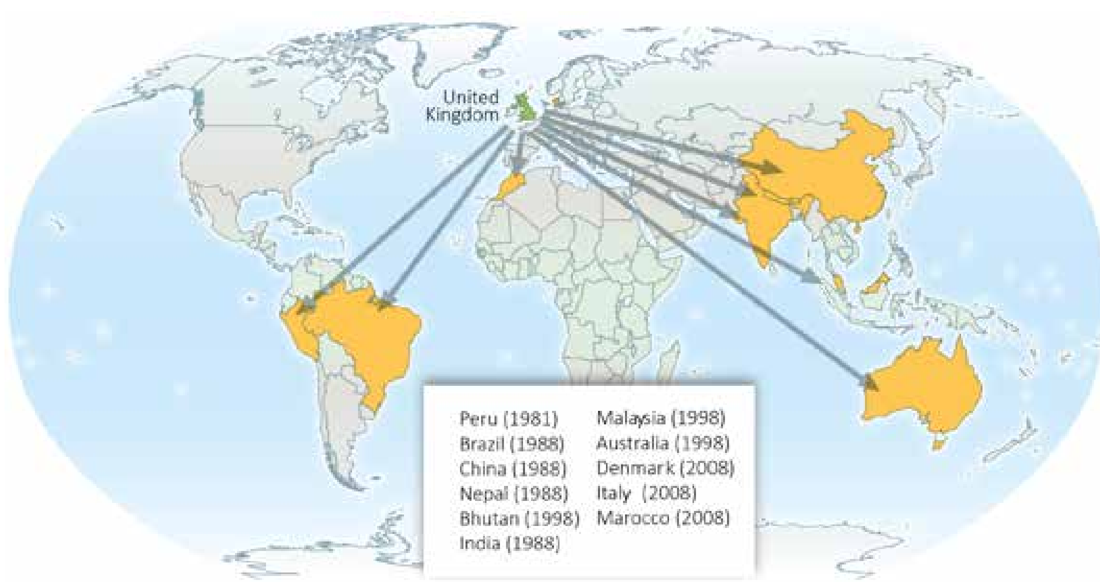

Figure 4. Collaboration with Cambridge, United Kingdom, to begin testing quinoa (since 1981)

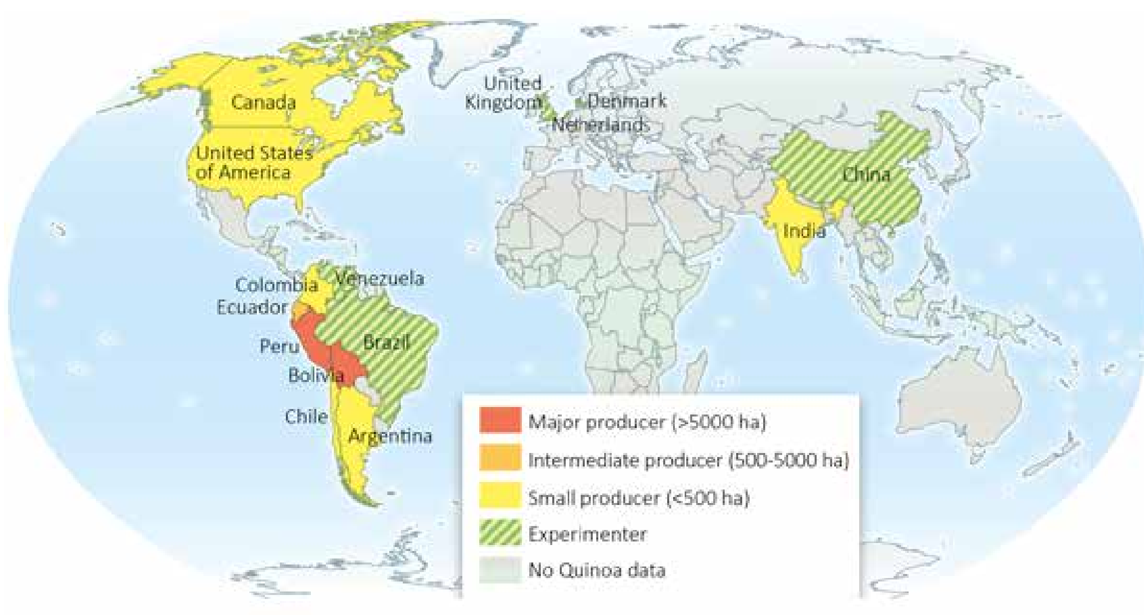

Figure 5. Quinoa worldwide development in 1993

Tests around the world in the 1990s and 2000s

From its point of entry in Europe, Cambridge (United Kingdom), quinoa then spread to Denmark, the Netherlands and many other countries (Gesinski, 2008; Jacobsen, 1997, 2003). During this period, experiments also began in Brazil and Asia (India and China) (Bhargava *et al.*, 2006) (Figure 4).

In 1993, the European Union launched a project with field trials in England (United Kingdom), Denmark, the Netherlands and Italy, as well as laboratory tests in Scotland (United Kingdom) and France (Figure 5). However, the project that began in 1996 as a joint venture between the Danish International Development Agency (DANIDA) and the International Potato Center (CIP) in Peru (Mujica *et al.*, 1998, 2001) was certainly the most important in the

Figure 6. Collaboration with CIP-DANIDA (FAO-Univ. Puno): American and European Test of Quinoa (1996-98)

Figure 7. Quinoa worldwide development in 2003

1990s and underlies the global expansion of quinoa. Through this first network of international cooperation to promote quinoa, field trials were set up in other countries such as Sweden, Poland, Czech Republic, Austria, Germany, Italy and Greece (Iliadis *et al.*, 1997). All these countries have expressed interest in quinoa experimentation and most of them participated in the American and European Test of Quinoa (Figure 6), organized by the Food and Agriculture Organization of the United Nations (FAO) and coordinated by the National University of the Altiplano (Puno, Peru), and the CIP-DANIDA project. The aim of this project was to learn the art of quinoa and perform multiple experiments at international level. This initiative strengthened the research network and increased the number of research centres working on quinoa in both developing and developed countries.

Denmark and the Netherlands have both since expressed their interest in breeding quinoa for various environments (Jacobsen *et al.*, 1994). They created the first European variety, 'Carmen', and research is now seeking to reduce the level of saponin on the basis of the sweet variety, 'Atlas'. The University of Copenhagen is also developing new quinoa tests as quinoa breeding becomes increasingly important (Figure 7). Other scientific collaborative efforts were fostered recently during the SWUP-MED project (2008–2012) "Sustainable water use securing food production in dry areas of the Mediterranean region". This project is the last major step in the spread of quinoa and brings together numerous partners from countries in the European Union (Italy, Portugal, United Kingdom, the Netherlands and Denmark) and in the Mediterranean (Turkey, Morocco, Egypt, the Syrian Arab Republic) (Benlhabib, 2006; Pulvento *et al.*, 2012) (Figure 8).

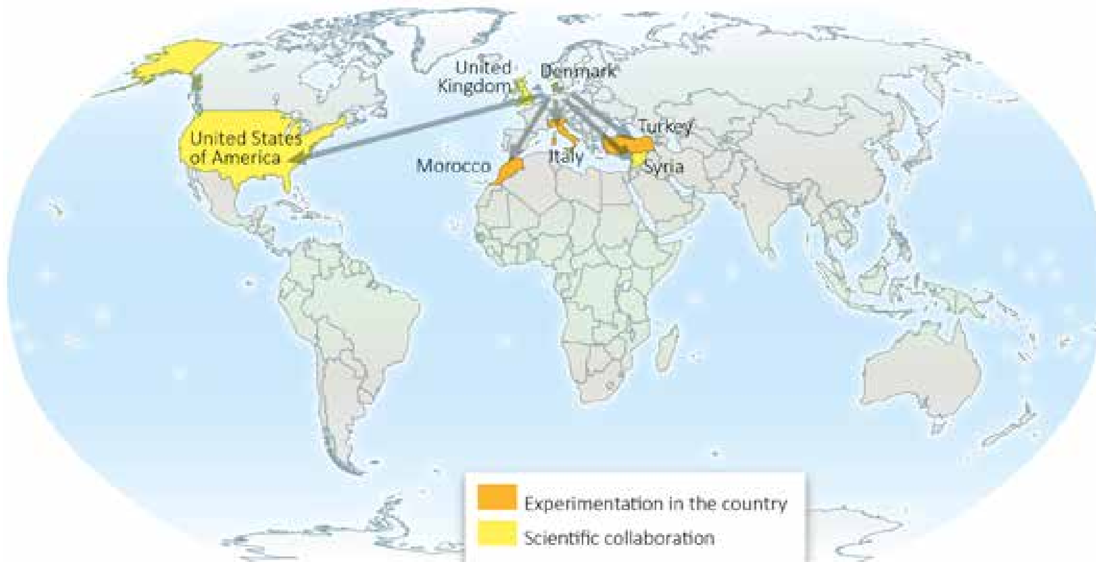

Figure 8. Collaboration with the University of Copenhagen to initiate quinoa testing in the SWUP-MED Project (UE: 2008–2012)

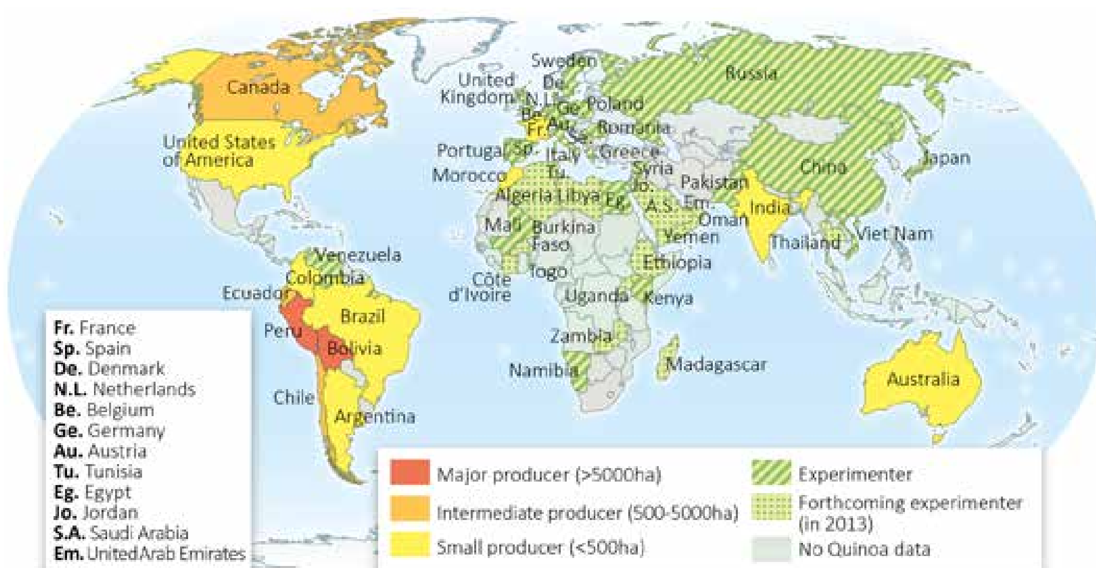

Figure 9. Quinoa worldwide development in 2013

Outlook since the International Year of Quinoa IYQ 2013

The early stages of expansion revealed interest among importing countries and consumers in adapting quinoa to their environments, for example, in the United States of America, Canada, France, the United Kingdom and the Netherlands. Another stage in the global spread of quinoa has begun in recent years as part of a response to global climate change and the salinization of agricultural land. Expansion has spread to the Asian continent in India (Barghava *et al.*, 2006), Pakistan (Munir, 2011) and China, followed by Australia and countries around the Mediterranean Sea and in North Africa.

We are now entering another phase of quinoa development and a turning point prompted by the fact that new producing countries are no longer consuming countries and/or traditional importers (Figure 9). The current wave of quinoa development is linked to the great adaptability of quinoa given its high genetic diversity, its resistance to drought and salt tolerance, its high nutritional value ensuring food security for local populations, and its ability to generate new sources of income for farmers.

The expansion of quinoa cultivation continues, with more than 20 countries on the lookout for seeds with which to experiment this year.

With each stage in the worldwide spread of quinoa, the number of research centres studying the crop and carrying out experiments has increased. International cooperation has generated many different projects, and research stations have been set up around the world, yet remain largely unknown because they were operational only during project implementation.

An analysis of scientific publications over the past 30 years highlights five subjects of particular importance to researchers (Bazile, 2013a):

- Nutrition and dietetics (gluten or saponins)
- Agronomy
- Botany and plant physiology
- Food biotechnology
- Biochemistry

There are very few publications dealing with policies, especially in consideration of the fact that the challenges to biodiversity conservation are increasingly entrusted to international laws governing access to and use and exchange of genetic resources and/or seeds.

The worldwide spread of quinoa is built on strong relationships between institutions that share their genetic material both formally, via legal provisions (Material Transfer Agreements – MTAs), or informally, via research networks. The largest collection of quinoa is still in the hands of the Andean countries (see Chapter 1.5). However, many countries have created their own collections: the red triangles on the map in Figure 10 show 19 non-Andean countries.

A significant number of countries have also developed new certified varieties and have set up a plant variety certificate system (COV in the UPOV system under the 1978 or 1991 Act). Most collections were established prior to the Convention on Biological Diversity in Rio de Janeiro (1992) which provides for the sovereign rights of states over their genetic resources. This means that these countries can develop new varieties with this germplasm without having to refer to the accession's country of origin (see Chapter 1.6). Certain quinoa-breeding countries have applied for plant variety certificates (Israel, Denmark, the United Kingdom, the Netherlands, Canada, Peru and Chile), but a new plant variety certificate is also being assessed at the request of Israel (Figure 11).

The Nagoya Protocol (adopted in Japan in 2010) is an international agreement that aims to share the benefits of using genetic resources in a fair and equitable manner, and to support the conservation of biological diversity and the sustainable use of its components. This begs the question as to how this is relevant to Andean countries in the case of quinoa.

Agriculture has always been based on access to and exchange of seeds, never on the exclusive principles seen today with property rights extended to cover living organisms. It is impossible to classify agrobiodiversity within a grid (private – public, individual – collective) on the basis of the number of interactions in connection with the circulation of seeds. Maintaining agricultural biodiversity requires active and continuous management. *In situ* conservation

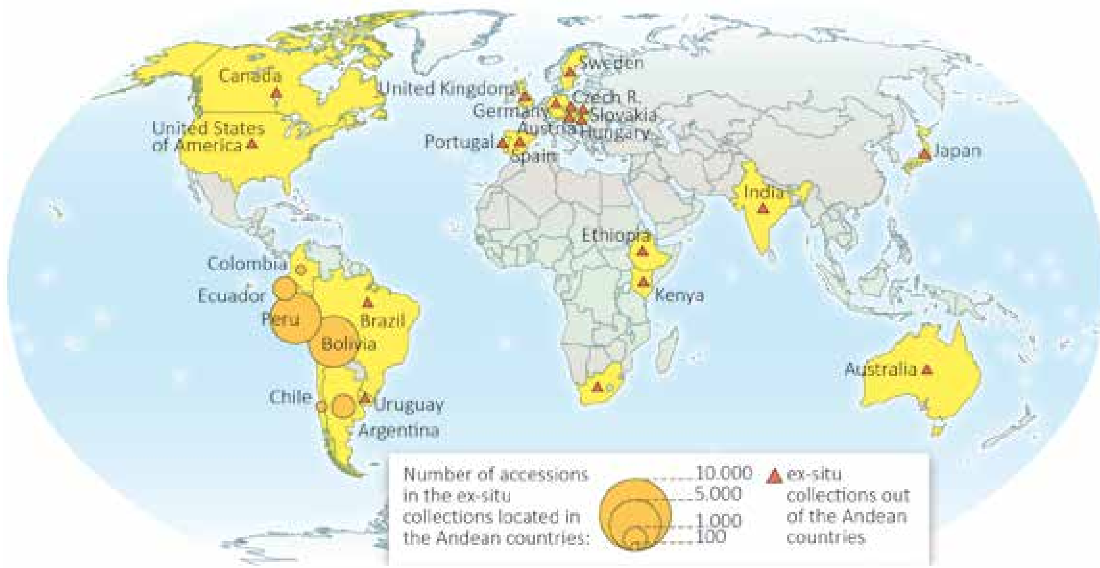

Figure 10. Worldwide Distribution of Quinoa Genetic Resources (*ex situ*) in 2013

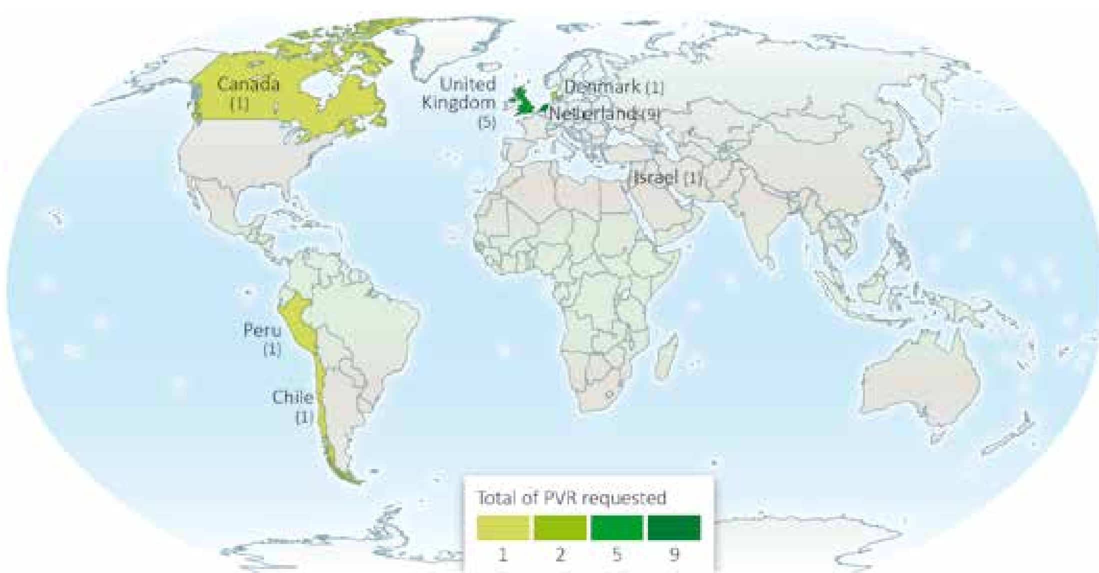

Figure 11. Number of quinoa varieties protected by plant variety certificates according to country of breeding in 2013

in farmers' fields encourages the co-evolution of peasant varieties of quinoa in response to the factors in that environment, generating a continuous momentum of quinoa biodiversity, with the species adapting to changes as they occur.

Conclusion

The wide genetic diversity of quinoa has made it possible to adapt cultivation to different types of soils, particularly saline soils and environments with extremely variable conditions in terms of humidity, altitude and temperature. This hardiness and adaptability is a major advantage in the context of climate change and salinization of agricultural land worldwide (Ruiz *et al.*, 2013). The spread of quinoa around the world is built on strong relationships between institutions sharing their genetic material.

However, the potential role of quinoa biodiversity in the world is based on farmer or peasant varieties that have been maintained via agro-ecological practices developed mainly through family farming (Altieri, 1992). The promotion of quinoa through enhanced varieties, standardized to comply with norms on seeds or to "simplify" farming practices linked to intensified conventional agriculture, will not generate the same resilience in response to the global change faced today. It is, therefore, necessary to maintain quinoa biodiversity – an assertion recognized and valued by organic farming (Bazile, 2014). The dynamics of the global expansion of quinoa cultivation may constitute a threat to farmers if generated with a narrow genetic base.

Thus, irrespective of the possibilities offered by the quinoa chain for the development of territories around the world, several questions arise with regard to the extension of cultivation outside the Andean countries, as promoted by the International Year of Quinoa (Bazile, 2013b). This minor crop may become widespread, but how can fair and equitable compensation (to use the terms of the Nagoya Protocol) be guaranteed for the selection process performed over generations by farmers in the Andean countries? Furthermore, how can this be achieved without prompting a decline in agrobiodiversity in the new producing countries?

We are now at the end of 2013 (International Year of Quinoa). Since the Rio Summit meeting in 1992, several international treaties have been signed on the management of plant genetic resources (CBD, Nagoya, UPOV, ITPGRFA, CAN, TLC etc.). There are many questions about and challenges for the future of quinoa. They need to be discussed in depth, involving all stakeholders and countries in the debate for the benefit of quinoa cultivation and of the farmers who earn their livelihood with quinoa.

Acknowledgments

The authors wish to acknowledge the projects that enabled funding of the research presented: IMAS (ANR07 BDIV 016-01) and IRSES (PIRSES- GA-2008-230862).

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