Case Study Open Access

Strengthening Quinoa Supply Chains in Pakistan

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Received
June10, 2017

Accepted
December25, 2017

Published Online
December30, 2017

Abstract: Agriculture sector in Pakistan became very fragile due to unprecedented extreme climatic events and changing climatic conditions. Although crop production conditions in Pakistan are diversified ranging from irrigated plains to rain fed lands, however crop yield remained unstable. Farmers are diverting to alternative options to sustain their economic needs. These conditions may lead to severe food security crisis in the country. Pakistan participated in FAO implemented Quinoa Project CIPDANIDA to explore the potential of growing quinoa as food supplement and potential alternative grain crop. Quinoa was introduced in Pakistan in 2008 potentially as a climate resilient grain crop with high nutritive value. Varietal screening and initial trials were conducted in various agro-ecological locations leading to establishment of its production technology. Based on promising nutritional value of the local grown quinoa cultivars, it was recommended for use food, feed, and oil production. Subsequently, there arises a need to explore and establish domestic and export markets and connect quinoa farmers to ensure sustainable production with demand in the market. A through the supply chain approach following the food safety procedures are recommended to the concerned research, development, and regulatory agencies. The relevant institutes are suggested to initiate and support the quinoa production through consumption programme to set up the industry on sustainable grounds.

Keywords: Non-tradition crops, high nutrition crop, supply chain

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Cite this article as: Mazhar, M.S. and B.E. Bajwa. 2017. **Strengthening quinoa supply chains in Pakistan.** Journal of Environmental and Agricultural Sciences. 13: 16-24.

1. Background

Human population is consistently growing and is expected to exceed 10 billion individuals by 2050 (Jan et al., 2017). Global population is rapidly increasing, with current growth rate of 1.183 % (World Bank, 2017), with significant variations with respect to geographical locations and socio-economic background (Keinan and Clarck, 2012; Wittemyer et al., 2008;). Pakistan is listed in the countries with the highest growth rates, precisely 2.0% in 2016 (World Bank, 2017). Trends reflect that the growth rate of population in already populated cities and countries is further increasing as well as new cities are being set-up at potential points of access to everyday human needs (Mahsud-Dornan, 2007).

Food is one of the primary human needs and its demand is growing besides the growing world population (Conijn et al., 2018; Crist et al., 2017; Long et al., 2015; Tilman et al., 2011). At one extreme of the world, there still are populations who do not have enough food to sustain their lives and on the other extreme are the population communities who are responsible for wastage of abundant amounts of food being conscious of food safety and quality (Hammoudi et al., 2009). Alongside addressing the needs of food security of growing masses in the world by the relevant research and development organizations, the awareness of consumers about food associated health risks is increasingly disseminating consciousness about food safety. Both the food security and food safety are very important areas to be addressed by responsible authorities at the same time (Gustavsson et al., 2011).

2. Objectives of the Paper

This paper identifies the current status of production and marketing of Quinoa in whole of the chain context and suggests opportunities to build on the huge potential of establishing sustainable Quinoa value chains in Pakistan.

While increasing the production quantities of food and making sure that all the food produced with heavy investment of cost and efforts reaches to the consumers; food losses and wastage from production to the time of consumption are very serious issues of current food supply chains (Mentzer et al., 2001; Stadtler, 2015). Major food losses happen in developing and underdeveloped countries due to poor crop handling at the farm at the time of harvest and during the postharvest handling of the food commodities in the supply chains from the farm to the point of consumption (Parfitt et al., 2010; Roodhuyzen et al., 2017; Werf and Gilliland, 2017). Continued efforts of research and development sector worldwide are being made to develop harvesting methods and postharvest handling protocols for individual crops so that maximum amounts of food produced reached to the consumers (El-Mashad and Zhang, 2010). Food waste generally happens in developed countries where the consumers' awareness of food quality and safety is high (Gustavsson et al., 2011). Food products not meeting the quality standards and safety guidelines and aspects are disposed and never reach any consumer.

Plenty of research and development has been done and is being conducted worldwide to make sure that more food is produced and secured in whole of the production to consumption supply chain context (Beske et al., 2014; Godfray et al., 2010). Particular food chains, suitable to specific geographical locations and adhering to the livelihood and needs of the local communities, have been focused by for example Food and Agriculture Organization of the United Nations (FAO) and several other related national, regional, international, and multinational research, development and support organizations. Worldwide forums and groups of think tanks are engaged in rescuing the world from the threat of food insecurity (Alexander et al., 2017; Barrett, 2010; Smith et al., 2017). While the challenges of changing climatic conditions and water availability for crops production does persist (Nawaz et al., 2016; Darand et al., 2017). Combined efforts of the research and development agencies have resulted in set-up of advanced production technology for the existing crops, water efficient crop production methods, identification and multiplication of high yield crop varieties, and identification and awareness of new crop species to supplement the existing food sources.

3. Climate Change and Water Scarcity

Changing climatic conditions and their impact on crops productivity is relatively a new area of concern (Reynolds, 2010). Crops being grown at certain geographical locations for decades have suddenly started struggling to achieve their yield potential (Rehmani et al., 2014). This has resulted in development of continuously varying production technology of the existing food commodities so that the farm productivity, farmers' incomes, sustainability of commodity chains, and livelihood of the communities do not suffer from the climatic changes (Gregory, 2010). Nonetheless, developing crop production technology to match the shifts in changes in environmental and soil conditions is beyond the capacity of most research and development organizations.

In particular context of water scarcity, the production, area, and yield of commercial agronomic and horticultural crops are continuously decreasing (Siebert and Döll, 2010). Irrigation water has become the most limiting resource in agriculture. While new sources of irrigation water cannot be explored, more cost and resource effective irrigation methods are being employed. Where possible, crops with larger water availability are being transformed to grow on lesser amount of water. Low water efficient crops are being replaced by high water efficient crops. In severe conditions of water scarcity, new crop species are being identified and intensified to replace the existing traditional crops.

In recent years, more specifically, the production of staple food, i.e., wheat and rice is compromised due to the seasonal and climatic changes and availability of limited amount of water for rice crop (Guerra, 1998). In these circumstances, there arises a need of an alternative low cost high performance nutrient rich food crop that can potentially replace existing staple food crops like wheat and rice (Zwart and Bastiaanssen, 2004). While the identified alternate food source would supplement the available staple food and minimise the threat of food security, there also remains a need to adequately address the international food safety standards in the food chain for its ready acceptance.

4. Quinoa - the Super Food

Quinoa has been identified as an appropriate addition and possibly a substitute of the currently commercially grown grain crops (Ruiz et al., 2014). Quinoa is an annual herbaceous dicot and a pseudo cereal (Schoenlechner, 2017). Due to its unique tolerance mechanism against abiotic stress, it can give better production even on marginal lands with little irrigation, and low economic input needs, therefore it is considered a climate resilient crop (Jacobsen et al.,

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2003; Iqbal, 2015; Ruiz et al., 2014; Ruiz et al., 2016). This has been known for its dietary uses since the beginning of the recorded history (Jacobsen et al., 2003). However, commercial cultivation as food supplement was reported from Southern America in Eighteenth Century. Quinoa grains are rich in vitamins and essential amino acids. Botanical classification of quinoa is "Kingdom, Plantae; Phyllum and Class, unclassified; Order, Caryophyllales; Family, Amaranthaceae; Subfamily, Chenopodioideae; Genus, Chenopodium; and Species, C. quinoa". Some of the members of subfamily Chenopodioideae are spinach, sugar beet, and Swiss chard.

World leading countries in wheat production and export, including the United States and Australia, are gradually promoting and increasing the production of Quinoa to replace the existing and limiting food grains - rice and wheat (Bhargava and Srivastava, 2013). Popularity of Quinoa amongst the farmers is increasing also because its average market price is ten folds that of wheat. Anecdotal data analysis by FAO reflects that world demand of Quinoa has grown 300 % from 2007 to 2012. The growth in demand is largely from the health conscious consumers in high end markets where traditional producers of Quinoa are struggling to meet the rising requirements.

5. Quinoa in Pakistan

Pakistan participated in FAO implemented Quinoa Project CIPDANIDA to explore the potential of growing quinoa as food supplement and potential alternative grain crop. Quinoa was introduced in Pakistan in 2008 for assessment of the potential of this high value crop production in different agro-climacteric regions of the country (Jacobsen et al., 2002). The research trails were conducted by a team of University of Agriculture Faisalabad in several parts of country which were apparently suitable for the cultivation of Quinoa (Hassan, 2011). The selected areas were chosen based on the climatic and edaphic conditions of the trial sites. These included Bahawalpur, Chakwal, Faisalabad, Gujrat, and Rahim Yar Khan (Basra et al., 2014). Quinoa has also been tested for field production in Swat (Khan, 2000).

Quinoa seed of 150 accessions was imported into Pakistan from Denmark and United States Department of Agriculture. These lines were acclimatized at the aforementioned trial sites for four years and ten most promising accessions were shortlisted for further research and development and for commercial production in the areas of comparative performance. Results of the trails conducted over four years established crop production technology of Quinoa at selected sites. This was recommended that Quinoa can be sown from start of November to mid of December (Sajjad et al., 2014), about the time when wheat is sown in most areas of Pakistan. Best sowing methods was suggested the pore sowing on ridges. Up to 100 kg per hectare dose of nitrogen was recommended for optimal yield (Chattha et al., 2016; Iqbal et al., 2014). It was reported that crops grows well in sandy soil with up to 200 mm rainfall, in winter season the crop could tolerate -8°C temperature for up to four hours, the crop performed well in sodic soils as this is also reported to grow in sea water, and it was also found biotic stress tolerant as resistance to disease and insects was significantly high (Abbas et al., 2012). Yield potential for Pakistan was recorded eight tonnes per hectare.

Assessment of the nutritional value of Quinoa cultivated in Pakistan revealed that the grains were comprised of high quality protein (protein contents up to 20% on mass basis) (Nasir et al., 2015), free from gluten and sodium, contained healthy edible fats, higher contents of Ca, Fe, Mg, and Zn as well as high vitamin content (Ogungbenle et al., 2009).

Despite the efforts made by research organizations to establish the protocols for Quinoa production in Pakistan (Munir et al., 2011), there still remain many gaps to be addressed in 'whole the supply chain context' before the high value Quinoa crop is adopted as in areas suitable for its production in Pakistan.

5.1 Strengthening Quinoa Supply Chains in Pakistan

Supply chain management refers to the process that mainly results from a conscious and collective decision of the members of a chain to co-operate amongst themselves to deliver superior value to the consumer int he target market segments (Jaafar et al., 2011). It is a competitive and collective strategy of participating firms which share a common vision and is based on the capabilities of individual participating firms for innovation and to effectively enhance the abilities of the firms to respond to the consumers' requirements (Stadtler, 2015).

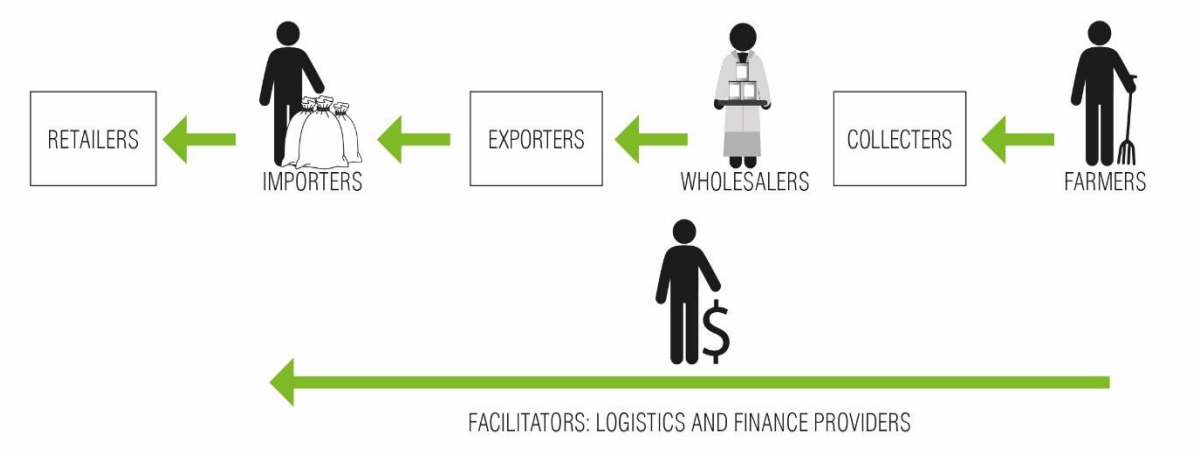

Fig 1: A generic supply chain model: Starting at farmers and ending at retailers while several other stakeholders are involved to link these connections (Collins and Dunne, 2007).

5.2 Better Co-Ordinated and Efficient Supply Chains

Globalization has increased the opportunities of market access and also resulted in competitive markets, both for domestic consumption and export. Consolidation of the supply chain firms which have remained competitive over a period of performance. Consistent consumer demand for safe food has significant influence on supply chain. Governments usually demand to develop sustainable systems for production and processing of food commodities. There are broadly two types of participants in a supply chain including primary participants and facilitators. Primary participants are generally farmers, wholesalers and retailers, whereas logistic suppliers and financiers are listed in facilitators.

From supply chain management perspective product integrity, relationships amongst the participating firms, information and financial flow are of vital importance (Aqlan and Lam, 2015; Martínez-Jurado and Moyano-Fuentes. 2014; Shibin et al., 2016; Vickery et al., 2003).

The management of information flows is crucial to the existence of responsive and co-ordinated supply chains since information flows underpin product and financial flow management. Information flows are of two types - strategic and operational (Ho et al., 2015; Mancilla and Sepúlveda, 2017). Strategic information relates to such things as trends in consumer needs and competitor analysis. Moreover, it is vital for competitive strategy formulation and execution. Operational information includes customer and consumer feedback, supply and demand forecasts, and performance evaluation. Operational information is used to co-ordinate activities, reduce duplication and monitor performance. In both cases information flows have to be managed to ensure that the information transferred along the chain is relevant, accurate and timely (Aung and Chang, 2014).

The nature of inter-firm relationships that exist within supply chains can vary across a broad range from those where little interaction exists outside of the transaction itself, through relationships that promote cooperation and coordination to relationships that are collaborative that involve a high degree of interdependency. While all relationships are based on trust and commitment, the degree to which they are present in any relationship determines the nature of the relationship. The nature of the relationship will influence the type and quality of the information exchange and therefore it needs to be managed if chain performance is to be improved.

The maintenance of product integrity in perishable product chains is highly dependent on the systems and processes associated with its physical handling, storage and transport. In particular postharvest practices and the establishment of an effective cool chain are crucial management factors that are necessary to deliver the right product in the right place at the right time. The capacity of each member of a supply chain to deliver in full on time to quality specifications is a prerequisite of an effective and responsive chain.

If the relationships between supply chain partners are to be maintained and developed (Damien, 2005). Subsequently it becomes essential that the consumer

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value created by the chain is shared in a way that reflects an individual firm's contribution to the total value created and the risks they undertake in creating that value. An essential component of an effective value distribution process is a transparent information system along with the absence of any opportunistic behaviour by members of the chain. All of the supply chain management components are interdependent and for establishing an effective 'whole of the supply chain' system none of these can be managed in isolation (Collins and Dunne, 2007).

Furthermore, in recent years there has been an increased focus on food safety particularly in the developed world (Hammoudi et al., 2009).Food safety standards of several brands have been developed and these are being enforced through legislation. There are private sector independent bodies which are responsible to make sure that the food safety requirements / protocols are being implemented at independent stages of the supply chain as well as in 'whole of the supply chain' context.

The requirements of the standards vary with the country of origin and the country of export. Some of the relevant examples include Codex Alimentarious, Global GAP, HACCP, ISO, BRC, and some of the local standards. Codex Alimentarious is product specific quality standard developed by the FAO and World Health Organization; Global GAP refers to globally accepted good agricultural practices established, monitored, implemented and governed by private sector; HACCP stands for hazard analysis critical control points and ISO is the International Standards Organization which are implemented at processing and packhouse facilities; BRC is a specific list of practices developed by British retailers consortium and adopted at several stages of a supply chain; and the local standards at production and postharvest and processing stages have been developed and registered by several countries of the world. Key features of these standards include practices adopted for crop production in the supply chains, MRLs in the ready to consume product, traceability of the produce in case a food related issue my arise at destination and the supply chain stakeholders need to find the origin of the issue to take corrective measures. Most food safety standards are continuously being reviewed for further improvements to address the ever increasing demands of consumers and considering the growing capacity of its users.

In context of Quinoa supply chains in Pakistan; there is a need to consider both the principles of supply chain management as well as the international requirements of food safety so that the stakeholders involved in Quinoa production in Pakistan are fully advantaged for their investments in this new sector and the produce is fully compliant of international food safety requirements and ready for marketing in any potential market.

Recently, a private sector enterprise from Pakistan is reported (Anonymous, 2016) to have developed a working relationship with International Center for Biosaline Agriculture (ICBA) for promotion of Quinoa in Pakistan. Engagement of private sector in production, procurement, processing, and marketing of the crop in Pakistan is very promising. Nonetheless, local research and development strengths also need to be realised to make sure the best production technology meeting the varying climatic and edaphic conditions of Pakistan are employed. Furthermore there is a continuous need to explore the potential of 'other' areas suitable for production of this high value crop in Pakistan so that the marginalized farming community can be trained to grow this high value crop following the international food safety standards all the way through the supply chain and can improve their livelihood.

Major challenges of Quinoa supply chains in Pakistan include limited sources of planting material, lack of availability of species and geographical location specific agronomic practices, lack of consumers' awareness about the nutritional and health benefits of this high value grain crop (Milovanović et al., 2014), unstructured marketing channels for producers to sell their ready produce, and continuous trials for exploration of new areas suitable for production of most eminent varieties of Quinoa across the marginalized lands and in areas of adverse climatic conditions in Pakistan.

6. Way forward - Role of Public and Private Sector

Keeping in view the potential of Quinoa production in Pakistan and the aforementioned limitations in context of Pakistan (Ahmad and Malik, 2013); the following suggestions are made for further research, development, and capacity building

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interventions by the relevant government and private sector organizations.

There is need for continued research for identification high yielding agroecological regions, varietal development and establishment of production technology for optimal performance of Quinoa in Pakistan.

Policy reforms for diversification and acclimatization of Quinoa in new geographical areas of optimal conditions for its production. Balochistan is currently suffering from immense water shortage and hence can be a potential candidate for further research trials to establish its production and agronomic technology.

Develop a mechanism of sustainable availability of seeds of desired Quinoa varieties for plantation in recommended regions.

Research to develop maturity indices, harvest and threshing techniques, and postharvest handling protocols for the Quinoa varieties of optimal performance in Pakistan.

Conduct market / consumer research on demand of Quinoa grains and value addition of its products for enhancing role of Quinoa in food chains. Knowledge and skill gap management of farming communities along Quinoa value chain. Develop food safety protocols for 'whole of the supply chain'(production to consumption) of Quinoa.

Education of farmers for production of good quality Quinoa crop including production technology, harvest maturity determination, harvesting and threshing, and postharvest handling. Education of traders for better postharvest handling, storage, and marketing of Quinoa is required. Education of value added service providers and entrepreneurs to launch consumers' attractive Quinoa products. Education of consumers for consumption of highly nutritious Quinoa raw and value added products.

7. Opportunities for International and National Research and Development Organizations

There are various international and national research and development organizations engaged in suggesting science based solutions for agriculture and climate change related problems in Pakistan. As reported by ICBA (Anonymous, 2016):

"…despite all benefits that Quinoa offers and its growing global recognition, the constraints to its scaling up are considerable. The institutions and farmers have limited knowledge and skills in its cultivation, harvesting, processing and overall management. In addition, rural populations are not familiar with the nutritional benefits of the crop and its incorporation to local dishes for local consumption."

International organizations having the right capacity for scaling-up Quinoa production in Pakistan and connecting its producers with domestic and international markets in the scope of food security and nutrition sensitive agriculture an achieve this by incorporating Quinoa production and its supply chain management with the national development plans as per requirements and potential of Pakistan. The relevant international research and development organizations can be engaged by relating the opportunity of Quinoa production in Pakistan with Standard Development Goals and pitching the possibility at adequate forums.

8. Conclusion

Conclusively, Quinoa has all the features of an excellent food crop. This has the potential of production on marginalized lands of Pakistan with minimal input resources. Relevant organizations from the public and private sector in Pakistan need to develop a supply chain strategy for this crop to meet the future needs of food for growing population of the country, region, and the world.

Acknowledgements: The authors acknowledge the support extended by CABI colleagues and the staff of the commercial supply chains who extended their inputs for development of this manuscript.

Conflict of Interest: This is declared that authors have no competing interests.

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