Increasing marginality in production systems creates the need for innovative solutions

The Central Asia region is facing serious food security challenges with the need to feed larger number of people amongst increasingly limited water resources and highly variable climatic conditions. In all these countries, intensive water use for irrigation are also taking priority over the scarce freshwater resources, leaving agriculture to use low-quality and mineralized water with adverse effects on agricultural productivity as most of the commonly cultivated crops, like cotton, wheat, corn are sensitive to salinity. Adding to the complexity, climate change projections for the region indicate considerable negative impact on farm-level productivity. Identifying stress-tolerant alternative crops is therefore seen as an important strategy to improve agricultural production and sustain the livelihoods of the poor farmers – especially those dependent on marginal quality land and water resources.

Increasing marginality of production systems are emerging as the major constraints to enhance productivity at the farm level, thus ensuing in enormous food and nutrition security challenges for the region. There are two major strategies for the utilization of salt-affected lands: first, the use of reclamative and preventive measures to make the salt-affected soils fit for agriculture; and the second, growing halophytes (huge underutilized plant resources, adapted to grow on high saline environments) and salt-tolerant traditional crops/cultivars. Reclamative or preventive measures are costly and require major infrastructure development and availability of fresh water for leaching salts – a luxury given the increasing heavy demand on fresh water. The latter approach, also referred to as the ‘‘biological approach’’ includes the production of new genotypes through conventional breeding methods (for glycophytes) or selection and adaptation of existing salt tolerant germplasm (both glycophytes and halophytes). Therefore, the introduction, evaluation, and selection of suitable alternative crops tolerant of saline and marginal growing conditions can be an important option for future agriculture in Central Asian and Caucasus region.

Besides salinity, drought and temperature stress, especially early frosts are the most important constraints to crop production in arid and semiarid zones of Central Asia. Drought has major implications for the profitability of agricultural operations due to reduced yields, crop failure and decreased amounts of land available for production. The total annual value of crop losses caused by drought is estimated to be in the range of USD 30–50 billion worldwide. Research shows that heat stress (above 30°C) even for a few days during flowering and seed maturation drastically reduces seed yields. Similarly, chilling temperatures during early reproductive growth cause yield losses, particularly in high altitudes and hilly areas. Subsistence farmers in the whole region may come under significant additional risk as crop cycles and yields are negatively affected by reduced rainfall. In such circumstances, it is important to use available water more effectively and there is a vital need for alternative crops that are water-use efficient as well as drought and heat tolerant.

Nutrition deficits are predicted to intensify in many vulnerable lower-income countries of the region which are facing highly variable weather and deteriorating land and water resources. In this context introduction of crops, with high nutritive value combined with stress-tolerance will indeed be of great value in meeting the twin challenges of abiotic stresses and malnutrition.

Its great ability to adapt to weather variations and its efficient use of water make arid fodder production by using of both salt tolerant crops and halophytes an excellent agriculture alternative in the face of emerging challenges to food production in CA. All these crops is achieved maximum production at salinity levels where wheat production is commercially non-profitable, sorghum, pearl millet, triticale, quinoa, amaranth and others in pure or mixed farming based systems can indeed be an alternative cereal for saline agriculture.

The main challenge, however, to the use of marginal environments for agricultural production is the need to develop sustainable and economically viable production systems. This depends on the

identification of appropriate cultivars and the production and management systems that fit into novel environments.
Studies on value-chain and market development will have to be taken-up in the countries if the results from field trials and economics of cultivation are found encouraging. Therefore, analysis of profitability of biosaline alternative agriculture production and assessment of the potential market demand for products for human consumption and animal feed continues to be a key issue.

Evaluation, domestication and sustainable utilization of native and introduced halophytic and salt-tolerant plant resources it would have a significant goal for salinity control, remediation of arid/saline lands for increasing income and r better livelihood of rural communities. The ICBA project "Towards a sustainable food production on marginal saline lands in Aral and Caspian seas basins" main goal is to enhance food security by increasing food production on marginalized saline lands through the use of salt tolerant multi-purpose crops, trees and/or halophytic crops. The core of the new project is the integrated, interdisciplinary research conducted by a team of specialists in plant eco-physiology, soil science, plant chemistry, animal nutrition, extension crop and other disciplines that will provide novel knowledge on the use and melioration of marginal lands in Uzbekistan, Azerbaijan and Kyrgyzstan.

In summer season of 2014 ICBA in collaboration with scientists from the Institute of Karakul Sheep Breeding and Samarkand State University evaluated vulnerability (exposure, sensitivity and adaptive capacity) of rural desert agropastoral communities to climate change and introduced multi - purpose salt and drought tolerant crops in strip-alley-system as adaptation measures.

It was also found that irrigation with low quality water (artesian and drainage) act as an alternate water resource and thus, plays an important role in saving freshwater resources as well as promoting agriculture in the marginal arid lands. Using of such integrated approach promotes both economic diversification and sustainable options towards improving food security, resilience and sustainable function of ecosystems.

An adaptation experiment for evaluating yield performance of three genotypes of quinoa (*Chenopodium quinoa* Willd.) a facultative halophyte from Chenopodiaceae in the model farms shown very encouraging results in reclamation of degraded salt affected marginal lands of the Kyzylkum desert (Navoi region, Uzbekistan). Seeds of quinoa from ICBA HQ germplasm were sown as main crops in the middle of March 2013 at air temperature ranging +14.5…+17.7^{o}C; soil temperature ranging +2+5^{o}C; air humidity ranging 41–56%; and monthly rainfall of 7.1 mm. Under saline environments (soil salinity of about 5,0-7,8 dS/m , ground water salinity of ~ EC_{iw} 10-15 dS/m) at the stage of seed bedding these crops successfully flowered and produced viable seeds.

Seed germination, plant establishment and growth in the filed trial were found to be good in all the three investigated genotypes of quinoa. First flowering was observed on May 2, 2013. The plants were harvested on July 10, 2013. The vegetation cycle of tested varieties was of 98 -120 days with a maximal height of plant of about 175-190cm. Grain yield per plant varied from in 22.66 to 45.66 g per plant; panicle weights varied from 42.98 to 92.88 g per plant; 1000 seed weights varied between 1,79-1.95 g; and stem weight per plant changed between 32.06 to 52.27 g. Data on biomass and seed yield obtained from these trials indeed supported the findings that quinoa holds promise as a grain and fodder crop for salt-affected arid areas.

Evaluated varieties were more water-use efficient, highly tolerant to salt by do not require preparatory fine leaching work before planting compared with traditional crops. Deficit irrigation showed considerable potential to increase water-use efficiency and yield, there were implications for salinity build up in the soil because of less water availability for leaching of salts added via irrigation.

The results suggest good adaptation and a high degree of flexibility of quinoa for tolerance or resistance to drought and salt stress under desert environments in Uzbekistan. The light saline sandy soils of the Kyzylkum desert are much more optimal for cultivation of this multi-purpose agro-industrial crop that could become a possible and economically interesting alternative flexible options for reclamation of un-utilized marginal salt affected drylands, reducing the summer fallow practices by increasing the land use ratio that will improve biodiversity and generate for improved livelihoods and nutrition of poor farmers and agropastoralists. Nowadays there is a significant increasing interest among farmers for the industrial cultivation of quinoa on the marginal non-productive fields in order to create a strong base of arid food and forage production.

So far, quinoa is not cultivated in the Central Asian region and there not much information is available on the environmental and its genetic diversity. As with any other new crop, one of the key factors for successful introduction and establishment of quinoa under the novel climates will be the identification of appropriate planting material. It is therefore important to study the adaptation and yield potential of several genotypes to select the most promising genotypes suitable for the local agro-climatic conditions. Information on these aspects as well as economic assessment of the profitability of cultivating quinoa is essential.

Quinoa productivity over the world due to its high nutritional value, high protein, and gluten free composition is now considered by nutritional experts to have the ability to play a critical role in overcoming issues of hunger, malnutrition and poverty. It can grow successfully in poor soils, including pure sand and in environments with annual rainfall as little as 120-300 mm. Seeds contains high quality protein, rich in the essential amino acids lysine, methionine and threonine that are scarce in cereals and legumes. In the view of its exceptional nutritional quality and ability to grow under marginal environments quinoa is one of the most nutritious food crops to be largely introduced in the region. Besides its use for human consumption, quinoa seed has other uses as livestock and poultry feed, whole plant is used as green fodder and harvest residues are fed to animals. ICBA will continue research with the focus on evaluating the productivity on a range of soils using different qualities of irrigation water and identifying high yielding salt and heat tolerant quinoa lines/varieties suitable for marginal areas in Aral and Caspian Sea Basins. Introduction and scaling up of quinoa for diversification of agricultural production systems in non-traditional environments requires further investigation of entire technology package, value chain and marketing products of this valuable ,but little , known crops in Central Asia and Caucasus.

Drs Kristina Toderich, Shoaib Ismail & Kameswara Rao Nanduri (ICBA)