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Potato production and its constraints in Peru

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Abstract. The paper is focused on the potato production in Peru, that is the Latin America's biggest potato producer, with a record harvest in 2007 of almost 3.39 million tones, followed by Brazil, Argentina, Colombia and Mexico. National potato production is enough for internal demand; the annual consumption in is about 80 kg per capita. The cultivated area in Peru is about 270000 ha, which is produced mainly by small farmers, at altitudes of from 2000 m to 4500 m in the Peruvian highlands. Today, in Peru, there are around 3000 cultivated varieties of potato, which include the eight species some of them are exclusive to the Andes. Unfortunately, potato biodiversity in Peru is vulnerable, partly due to the tradition of local knowledge being passed down through the generations by word-of-mouth, young people move to the cities, and also by abiotic and biotic threats. The study underlines the main constraints on potato productivity, but also the solutions the research activity may offer to sustain the efforts in crop improvement.
Key words: potato, production, biodiversity, constraints, solutions.

Introduction. The potato has been the staple diet of the people of the Andes for thousands of years. Archaeological evidence indicates that potato was cultivated in the Peruvian Andes 8,000 years ago, and recent research suggests the potato's centre of origin lies in Peru, neighboring areas of Lake Titicaca (Spooner et al 2005). Today, Peru's farmers cultivate around 3000 varieties of potato, which include the eight species some of them are exclusive to the Andes. Production of native varieties is mainly concentrated in the hands of small farmers, which is located in the Peruvian highlands. These Andean landraces exhibit huge morphological and genetic diversity, and are distributed throughout the Andes, from western Venezuela to southern Chile, including northern Argentina. The wild species are distributed throughout Americas (from South USA to Chile).

Production. Peru is Latin America's biggest potato producer, with a record harvest in 2007 of almost 3.39 million tones, followed by Brazil, Argentina, Colombia and Mexico with 3.38, 1.95, 1.90, and 1.75 million tones respectively (FAO 2007). In Peru, for 2008 the production was increased 3.6 million tons, with average yield 13.4 t/ha (MINAG 2009). In overall, during many years the cultivated area in Peru is about 270,000 ha, which is produced mainly by small farmers, at altitudes of from 2,000 m to 4,500 m in the Peruvian highlands; while a smaller area in coastal valleys is devoted to irrigated commercial production (see Figure 1). The yield is varying between 4-35 t/ha, according to the region where is cultivated.

Highland farmers are using mostly ancient landraces, without seed potato production, low inputs, and poor quality soils, consequently they have low yields. Some smallholder are growing about 110-180 native varieties in small plots, which seems a germplasm collection (http://www.lamolina.edu.pe/hortalizas/catalogopapas/, Figure 2). These traditional potato growers cultivate mainly for their own consumption, however, there are some small production oriented to local market. But potato biodiversity in Peru is vulnerable, partly due to the tradition of local knowledge being passed down through the generations by word-of-mouth, young people move to the cities, and also by abiotic and biotic threats, e.g. late blight and Andean potato weevil. Due this situation, it is necessary to push works more closely with communities and other partners to strengthen these problems, which could promote a sustainable potato crop in the Andean region. For that, it was decided to document potato varieties *in-situ* and their official registration, which could help on-farm conservation and utilization.

For other side, farmers in lowland (coastal area) cultivate new commercial varieties with high yields (30-35 t/ha), that are often grown to satisfy urban consumer preferences. Also there are producers for commercial purpose in some low valleys (under 3,000 masl), when the irrigation is available two crops of potato can be grown.

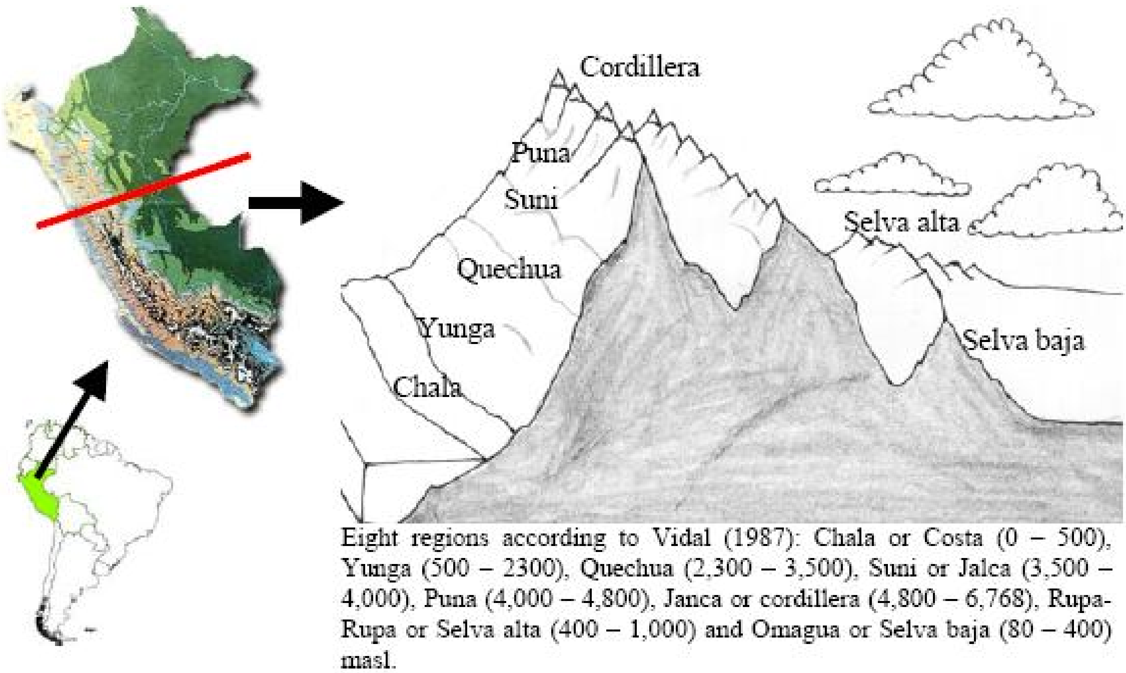

Figure 1. The Peruvian mountainous regions, showing different regions where the potatoes are growing.

Figure 2. Native landraces showing different flesh color.

In spite of low average yield (13 t/ha), the production is enough for internal demand. The annual consumption in Peru is about 80 kg per capita. This, consumption of the potato is low than many European countries e.g. Poland, Russian (Struik & Viersema 1999). Paradoxically, in last decanis, this consumption is dropping, with many Peruvians turning to rice or bread (wheat, about 80% of which is imported to Peru). For this raison, Peru is working to drive the internal consumption of native potatoes, which come in a rich variety of colors, shapes and flavors. In 2008, the Peruvian Government has declared 30 May "National Potato Day", in order to create aware about the importance of potatoes.

Also there is some works in order to promote the market launch of new products by highlighting the unique features of native potatoes (high dry matter content, culinary quality, natural product, morphological variability and colors) can help increase the income margin of the various peasant farmers in the highlands and also all the peoples involved in the production chain. In the years 2007 and 2008, Peru exported some fresh and processed potato products for US$ 1'074,210 and 1'528,650 respectively (MINAG 2009). The promotion of fair trade markets could increase the exportation volume and promote to obtain new products in order to satisfy new demands. Also, there are some facilities to develop processing companies, which could profit the facilities to access into new markets from Peru Trade Promotion Agreement (TPA) with others countries (e.g. with USA, Canada).

In Peruvian highlands, potato is the main crop, sharing this area with others minor tuber crops: Oca (*Oxalis tuberosa*), Olluco (*Ullucus tuberosus*) and mashua (*Tropaeolum tuberosum*). The most important step in growing potatoes in highlands is to carefully plan a crop rotation scheme that allows each 7-8 years between potato crops on the same land. Mashua, Oca, Olluco, wheat, and barley, which are commonly grown in rotations with potatoes. In the traditional crop rotation in the highlands, first are planted potatoes. Then, following year with Mashua, Oca and Olluco, cultivated as a multicropping system. Finally, the following year with wheat or barley and after that the fallow periods is by 4-5 years.

By contrast, in the cost, modern market forces have contributed to the sharp reduction in potato varieties, and the trend is toward shortened fallow periods and monocropping. But also, high input requirements and market price fluctuations have led to significant loss of profitability. The effects of ecological disturbance are acutely evident with late blight, bacterial wilt and virus.

Main Constraints. The most important constraints on potato productivity in Peru are late blight, virus disease, bacterial wilt, the Andean Potato weevils, the potato moth, nematodes and tolerance to drought, heat and frost. In this sense, potatoes with durable resistance or tolerance to insects (moths and weevils), diseases (late blight, viruses) and drought and forst stress could have a positive impact on income generation and food security of poor farmers in the Andes.

Consequently, abiotic stress in one form or another still limits production on most of the world including Andean region, where the climate change will have high impact. For example, yield reductions due to drought stress are already serious. High and low temperatures, acid soils and soils with high levels of metal ions continue to reduce productivity over vast tracts of land and will remain an agricultural challenge for the foreseeable future.

Abiotic stress such as drought, temperature, salinity and soil toxicities of such elements as Na, Al and Fe, and from soil deficiencies of elements like P and Zn reduce crop productivity. The abiotic stress is location-specific, exhibiting internal variation in occurence, intensity and duration. These could occur at any stage of plant growth and development wich represent the dynamic nature of crop plants and their yield. The breeding to drought tolerance requires the identification of traits for phenology and those contributing to yield so that these can be pyramided using conventional means. In places where climatic extremes are of regular occurrence and predictable, agricultural activity is usually very limited and dependent populations are small, but in many other places where these stresses occur in an unpredictable manner the agricultural activity may be intense and the dependent populations large. It is in these latter regions that abiotic stresses are major contributors to food insecurity and poverty for hundreds of millions of the rural poor. Farmers in these environments adopt a risk-aversion strategy of low inputs, resulting in low outputs, poor human nutrition and reduced educational and employment opportunities, especially for girls. The rural poor are particularly badly affected because of lack of access to alternative sources of employment or food (Gale 2003). Solutions to the problem will be as diverse as the lands affected. However new, locally adapted and improved varieties will always be a central component in any package of engineering, agricultural management, sociological and political solutions.

Overcome the Constraints. Plant breeding for abiotic stress tolerance is a viable option. Most crop species show considerable genetic variation in tolerance to the major climatic and chemical stresses. Now, with the advent of genome-wide tools such as microarrays, gene chips, proteomics and metabolomics, most approaches are integrated into a single approach, with the hope of identifying the key events and intervention points. At the International Potato Center (CIP) and others research centers are examining the genes for drought tolerance traits in several native Andean potato landraces (Andre et al 2009). Also, the CIP in Lima, Peru maintains the world's largest collection of tubers in the interest of conserving the genetic diversity of potato as well as investigating traits such as resistance to various insects and diseases, as well as to cold, heat and drought. The results of this research will be used for screening and breeding efforts in crop improvement.

Apparently, it was identified about 2000 genes that were differentially regulated under drought conditions. Many of these genes contribute to the increased drought tolerance of the two clones under investigation. Up-regulated genes included transcription factors and cell signaling-related genes such as kinases and phosphatases, which regulate numerous functions, including metabolic changes and cell defense functions. Solute concentrations were increased, lowering osmotic potential, to induce uptake of water from drying soils. Increased expression of lipid transfer genes and fatty-acid and wax synthase genes suggested the reinforcement of cell membranes and cuticles (Schafleitner & Hyps 2008). Also, the fact that the potato genome was sequenced means that the behavior of most of the relevant genes under drought, heat or frost stress can be studied using functional techniques approach, in order to identify novel genes related to different abiotic stress. However, the interpretation of this vast outpouring of data will require access to special genetic resources and special knowledge of traits and environments.

If poor farmers had access to cultivars with enhanced tolerance of abiotic stresses, they would reduce their economic risks, improve the livelihood and nutrition of their families, put their marginal land to work, and protect the environment by providing an alternative to slash-and-burn activities Links with scientists in advanced laboratories, including the Arabidopsis community, will be essential to achieve rapid progress. Research centers can work together with farmers on environmental characterization, germplasm evaluation protocols, genomics analysis, molecular breeding strategies, crop management strategies and research on participatory plant breeding. Also, potatoes with durable resistance to insects (moths and weevils) and diseases (late blight, viruses) could have a positive impact in genetic diversity conservation of native potato in the Andes.

Seed Supply System. In Peru, there are informal and formal seed systems. After more than 25 years ago, that was established laws for seed certification, about 95% potato growers demand seed from informal system. The informal system includes two main forms of seed supply: use own seed from the previous harvest, exchange seed from families and neighbor peasants, this is practiced for the millennia in the Andes.

In contrast, formal potato seed system are supported by government research stations, including some universities and non-governmental organizations (NGOs), where it was developed new varieties, cleaned locally adapted cultivars from virus diseases and provide pre-basic seed. There is seed potato growers officially registered, and the process of certification is done by private association (CODESE), which is under supervision by ministry of agriculture. This process is established according to the potato law certification, including the following categories: Genetic (not certified), basic, registered, certified and inspected seed; also there is a common category which is not certified. Seed is growing in highlands (above 3,000 masl), where the virus incidence is very low.

Conclusions. In conclusion, in Peru traditional potato production, without seed certification is predominating and small processing activities. However, in the last years, it is rising potato production stimulated by United Nations International potato year in 2008, and the establishment of National Potato Day; which could improve life standards of Andean peasant and sustainable potato crop management and genetic resource conservation in the Andes. But, it is necessary to continue with plant breeding applying new techniques in order to obtain new varieties more tolerant to different constraints and to establish potato seed production for native varieties, which could help a sustainable management of the potato diversity in the Andean region.

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