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Quinoa for Future Food and Nutrition Security in Marginal Environments

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Quínoa Research and Development in the Andean Countries

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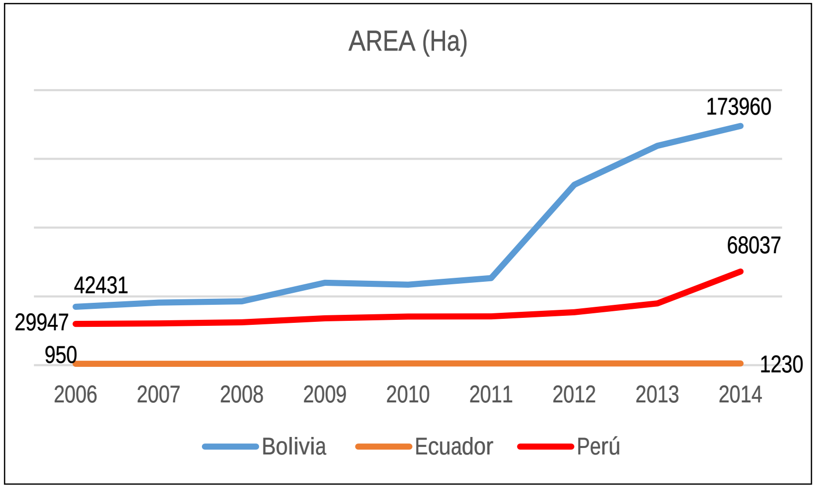
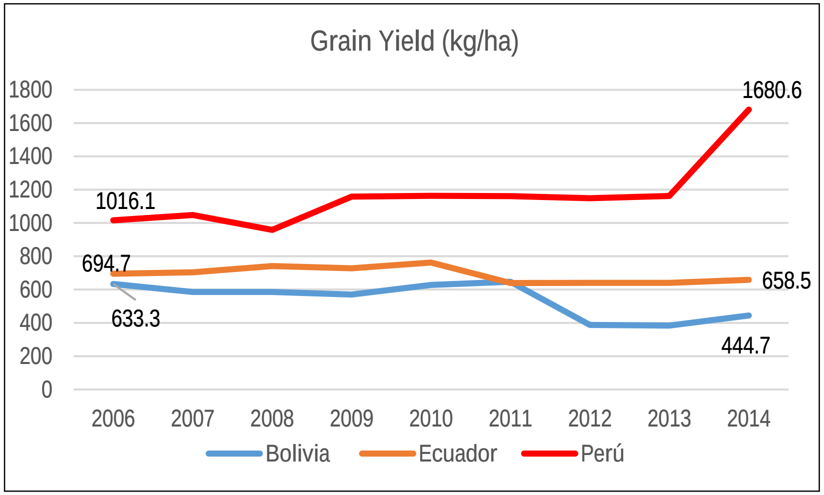
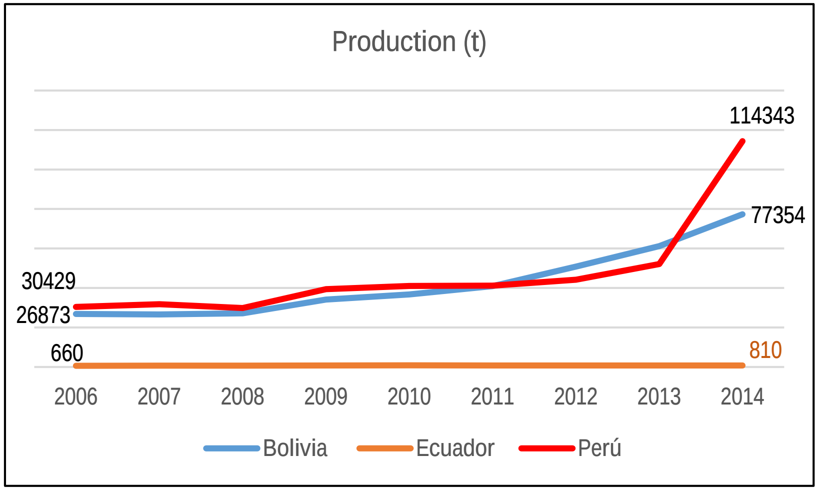
Background/Introduction







FAOSTAT, 2016

The increase in area, yield and production is mainly due to the domestic and international demand for quinoa and the high prices per kilo of quinoa received by farmers. In Peru, the increase in quinoa productivity was mainly due to the introduction of this crop to the Yunga and Coast region and the application of improved agronomic practices and more favorable environment significantly influenced in productivity

KEY LIMITING FACTORS

- Increase of weeds, diseases and pests problems and lack of appropriate technology; of control, especially for organic production in big areas
- Varieties susceptible to diseases
- Varieties with inadequate adaption to modern technology and agro-ecological zones with high temperature during anthesis and grain filling period (Peruvian coast)
- Inadequate harvesting and post harvesting process for big production
- Limited knowledge of the germplasm quality for the different uses and new quinoa products

RESEARCH ACTIVITIES AND DEVELOPMENTS

- Genetic Improvement
- Evaluation of Nutritional Values and Traits to Develop New Products
- Agronomic Production Improvement

Results

GENETIC IMPROVEMENT

Germplasm collection and use before 2013

Espindola and Bonifacio 1996; Ochoa et al., 1999; Bonifacio et al, 2006; Gomez and Eguiluz, 2011; Rojas et al, 2015; Bonifactio et al, 2015

	N° Accessions	Type of Evaluation	Main varieties developed
BOLIVIA	6721	Agro-morphological (all), response to biotic stress (downy mildew, insects pests) and abiotic stress (salt, drought, frost) and nutritional and industry traits (3178 accessions).	Sajama, Samaranti, Huaranga, Kamiri, Chucapaca, Sayaña, Ratuqui, Robura, Jiskitu, Amilda, Santa María, Intinarira, Surumi, Jilata, Jumataqui, Patacamaya, Jacha Grano, Kosias, Kurmi, Horizontes, Aynoq'a and Blanquita
ECUADOR	673	Agro-morphological (all), response to biotic stress (downy mildew, identification of three resistance genes) and some quality traits	INIAP-Cochasquí and INIAP-Imbaya in 1986, INIAP-Ingapirca and INIAP-Tunkahuan in 1992 [9, 10], and the variety INIAP-Pata de Venado in 2005
PERU	6302	Agro-morphological (all), response to biotic stress (downy mildew) and abiotic stress (salt, drought, frost) and nutritional and industry traits (900 accessions)	INIA 431- Altiplano, INIA 427- Amarilla Sacaca, INIA 420- Negra Ccollana, INIA 415 Pasankalla, Illpa INIA, Salcedo INIA, Qillahuaman INIA, Ayacuchana INIA, Amarilla Marangani, Blanca de July, Blanca de Junin, Cheweca, Huacariz, Hualhuas, Huancayo, Kancolla, Mantaro, Rosada de Junin, Rosada Taraco, Rosada de






In the present, a group of advanced lines developed using mutation induction and hybridization has been selected for further evaluations or consideration for release in the near future.

During the years of testing, mutant lines showed a range of yield from 3000 to 4000 kg/ha in coastland condition, in spring to summer cycle of seeding, showing some tolerance to temperature above 25°C during flowering stage

QUALITY RESEARCH

Rojas and Pinto, 2015; Gandarillas et al., 2015; Ramirez, 2014; Pereda, 2016,

Physical grains characteristics:

Grain size (diameter and thickness)
1000 grain weight
Grain color
Grain shape

Nutritional Characteristics 953 Germplasm Accessions from Peru (Gomez and Eguiluz, 2011)

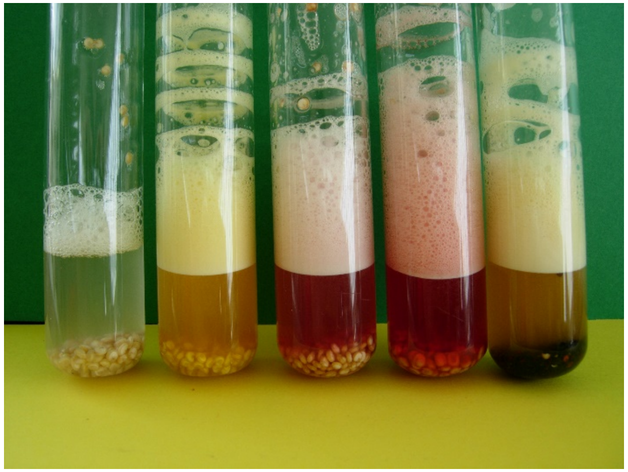
Location	Nº Accessions	Grain size (diameter mm)
Apurimac	145	1.2-1.7
Ayacucho	3	1.4
Cajamarca	12	1.4 -1.7
Ancash	127	1.2 -2.2
Cusco	133	1.4 -1.7
Junín	3	1.4
Puno 1	138	1.4-1.7
Puno2 Amargas	220	1.4 -2.2
Puno 2 Dulces	172	1.4 -1.7






Chemical Characteristics:

Grain saponin content
Protein content
Fat
Fiber
Ash,
Carbohydrates (amylose and amylopectin content)
Caloric energy



Nutritional and Agro-food Characteristics and Statistical Parameters for 555 Germplasm Accessions from Bolivia (Rojas and Pinto, 2015)

Componente	Min	Max	Mean	SD
Protein (%)	10,21	18,39	14,33	1,69
Fat (%)	2,05	10,88	6,46	1,05
Fiber (%)	3,46	9,68	7,01	1,19
Ash (%)	2,12	5,21	3,63	0,50
Carbohydrates (%)	52,31	72,98	58,96	3,40
Energy, Kcal/100 g	312,92	401,30	353,36	13,11
Starch granule (µ)*	1	28	4,47	3,25
Inverted sugar (%)*	10	35	16,89	3,69
Water filling (%)*	16	66	28,92	7,34

Nutritional Characteristics 953 Germplasm Accessions from Peru (Gomez and Eguiluz, 2011)

Location	Nº Accessions	Protein (%)	Saponine 0=sweet 1= bitter
Apurimac	145	10.3 -16.7	0 -1
Ayacucho	3	13.1-13.9	1
Cajamarca	12	13.2-14.9	0 -1
Ancash	127	10.3-16.5	0 -1
Cusco	133	13.3 -18.6	0 -1
Junín	3	14.1-14.3	0 -1
Puno 1	138	7-24.4	0 -1
Puno2 Amargas	220	7.9 -23.7	1
Puno 2 Dulces	172	7.1 - 23.2	0

Additionally 120 accessions were evaluated by the content of fat and ash in grain and flour it was founded a range of 4.79 to 9.46% of fat and 2.51 to 4.62% of ash (Pereda 2016)

Effect of washing and cooking process in the content of total phenols and betalain pigments (Ramirez, 2014)

Five quinoa genotypes; POQ-50 with black grains, Rosada Huancayo with cream color grains, POQ-105 with fuchsia color grains, POQ-55 with yellow grain color and Pasankalla with red color.

Results

Grains before washing

Predominance of betaxanthins (yellow pigments) over betacyanins (red pigments) in all genotypes and genotype POQ-105 had higher content of total phenols and betalains. POQ-50 (black grains) has not betalains and anthocyanin

Grains after washing processes

Reduced betalains values for the five genotypes, especially in POQ-105

Grains after cooking process:

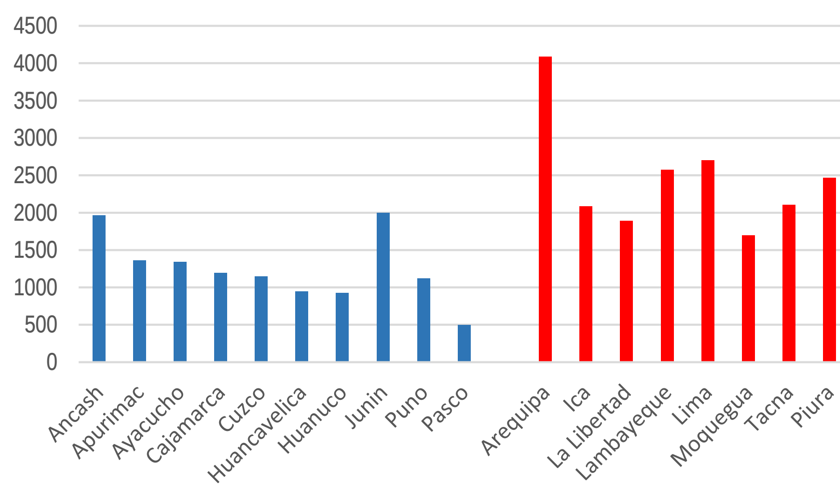
In the five genotypes, the total phenolic content increases in different proportions. Rosada de Huancayo had a increase of betacyanins (50%) and betaxanthins (38%). The total phenol content in the cooked grains was directly related to the content of the red shade of the natural color of the grains.

AGRONOMIC RESEARCH

Research to study the adaptability of quinoa to the conditions of the central coast, dates back to the 1990s and other later research showed better adaptation of quinoa Altiplano ecotype than Inter-Valley ecotype, this last group in general is severe affected by heat. The range of yield of the genotypes evaluated in different experiment is from 0 to 6330 kg/ha

At commercial level the mean yield for traditional locations in the highland range of 500 – 1998 kg/ha and for coast and yunga locations ranged from 1700 to 4093 kg/ha (Peru, MINAGRI 2014)

Highland: Low to medium technology, in adverse environmental condition (3500 – 4000 m asl) being abiotic stress (drought and frost) the principal cause of crop loss



Coast –Yungas: Medium to high technology with favorable environment, irrigation systems; being biotic stress (disease and mildew) the principal cause of crop loss.

Nitrogen use efficiency of mutant lines of quinoa

Sixty-three mutant lines showed significant differences for the efficiency of the use of available and implemented nitrogen on the ground. For *nitrogen use efficiency* (NUE) mutant lines had values within a range of 34.23 to 53.06%. To *agronomic nitrogen use efficiency* (ANE), the range of 10.17 to 35.64 kg grains / kg N applied was observed. For *internal efficiency of nitrogen utilization* (INE) mutant lines with values ranging from 51.02 to 59.01 kg grains / kg N absorbed were identified (Sanchez, 2015).

Response to regimes of drip irrigation and water use efficiency in drought stress

The following volumes of irrigation was used T0 (2638 m^3 / ha net layer, without plastic), T1 (2638 m^3 / ha net layer, plus plastic), T2 (2039 m^3 / ha net layer, plus plastic) and T3 (1319 m^3 / ha net layer, plus plastic) at Central Coast Area. With treatments T0, T1, T2 and T3 the grain yield were 3163 kg / ha, 3333 kg / has, 3039 kg / ha and 2234 kg / ha, respectively. The irrigation regimes had no significant effect on grain quality; however, caused reduction in plant height, stem diameter, panicle length, number of grains per panicle, days to maturity and grain yield. The mutant line La Molina 89-77, showed, high water use efficiency in water stress conditions, reaching a maximum value of 1.68 kg / m^3, higher than the T1 (100% net layer, plastic) and T0 (100% bet layer, without plastic) with values of 1,21 kg/m^3 and 1,15 kg/m^3, respectively (Leon, 2014).

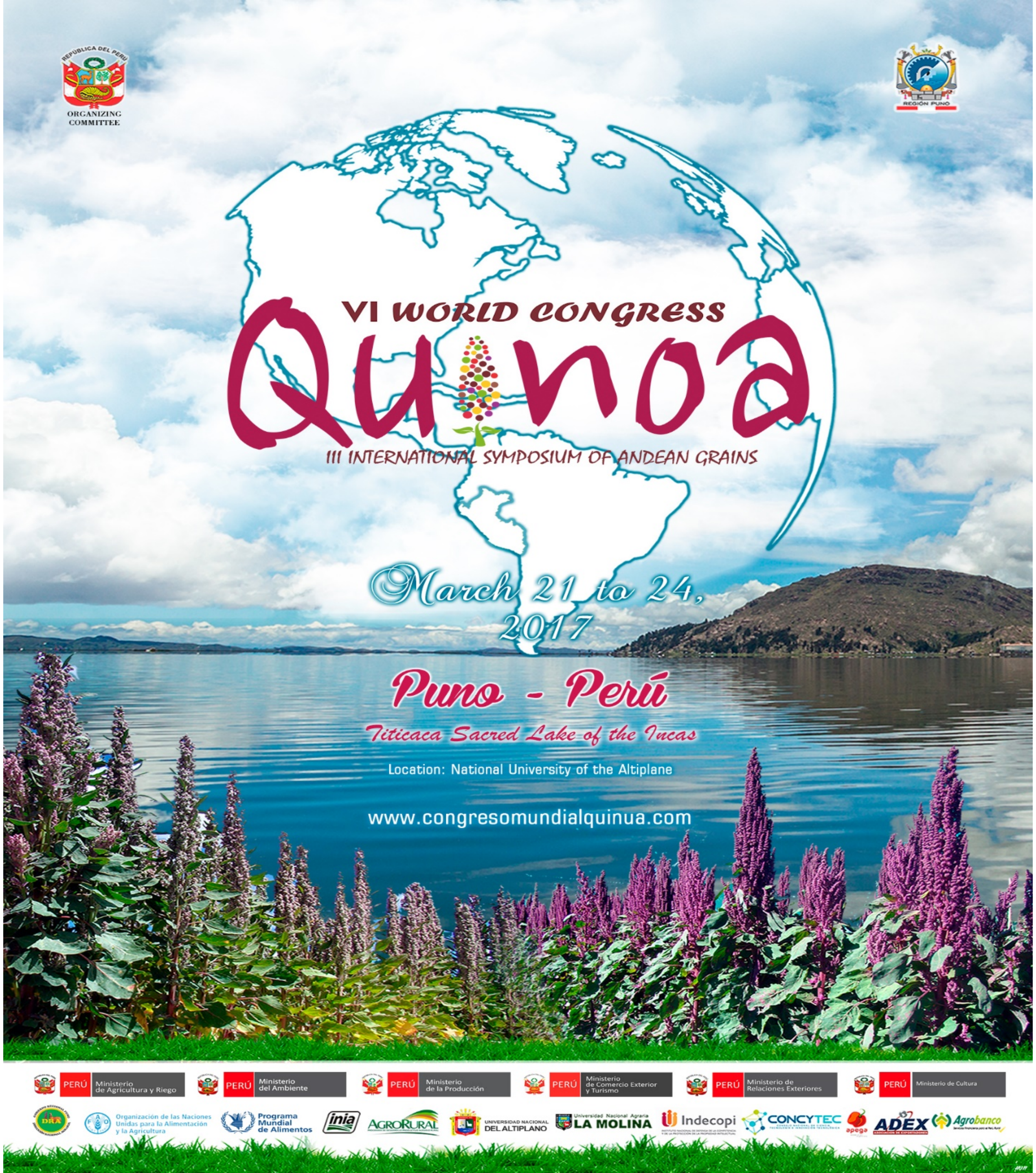
FUTURE RESEARCH AREAS AND PRIORITIES

- The evaluation of the collections of germplasm will continues, giving greater emphasis to the identification of sources of resistance to diseases and insects and to abiotic factors such us tolerance to frost, drought and heat.

- To determine nutritional quality traits of all the collections and new experiments to study the response to industrial processes of elaboration of flakes, popped grains, energy bars, noodles, beverages and others are being performed.

- Development of new varieties of quinoa, suitable for different types of agricultural management, localities, with resistance / tolerance to biotic and abiotic factors and high quality.

- To develop or improve agricultural technologies for organic, ecological and conventional farming for traditional and new areas.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