"PERUVIAN QUINOA RESEARCH AND DEVELOPMENT"

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Pullman, Washington

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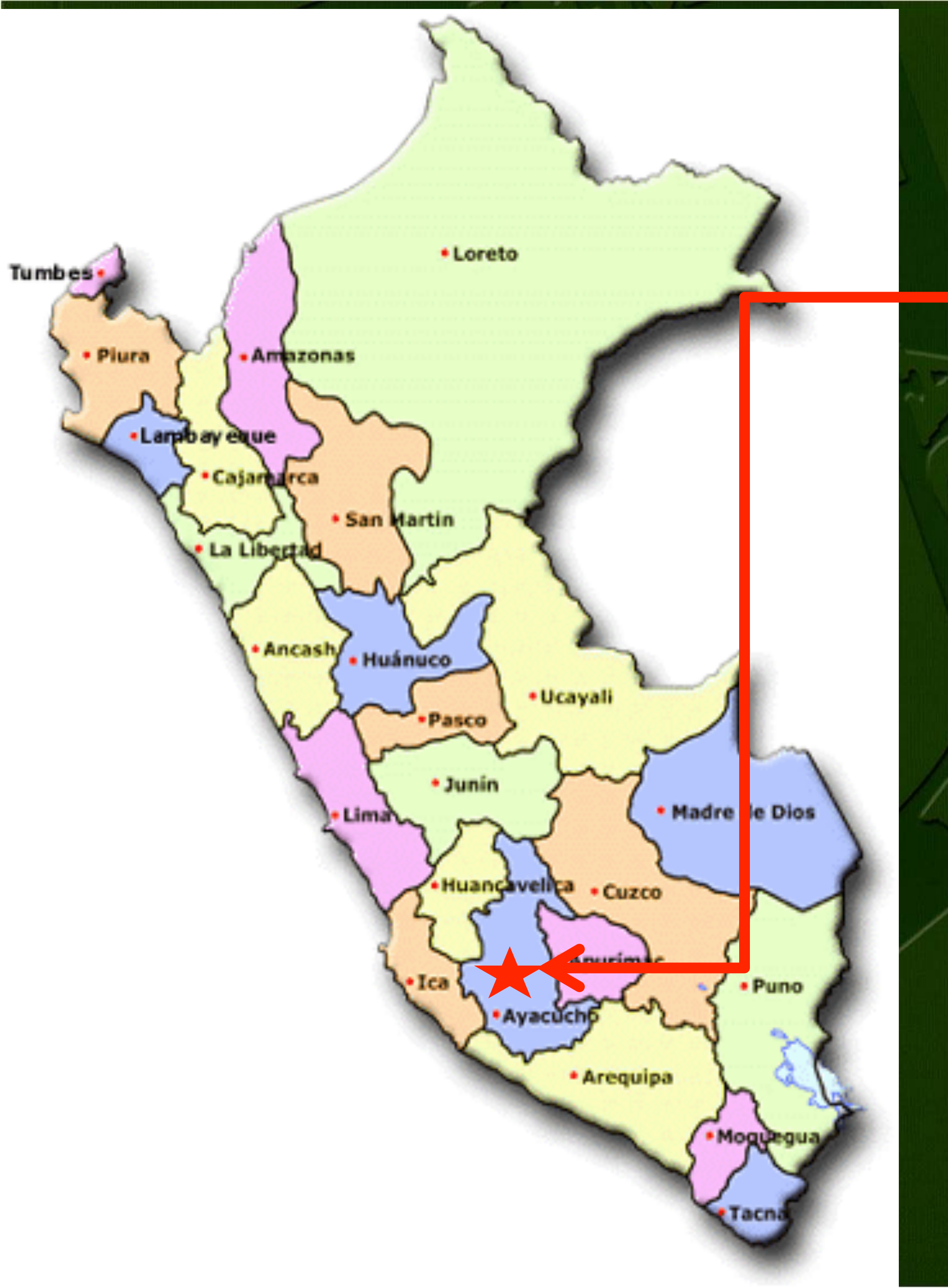
CEREALS AND NATIVE GRAIN RESEARCH PROGRAM

UNIVERSIDAD NACIONAL AGRARIA LA MOLINA

INTRODUCTION

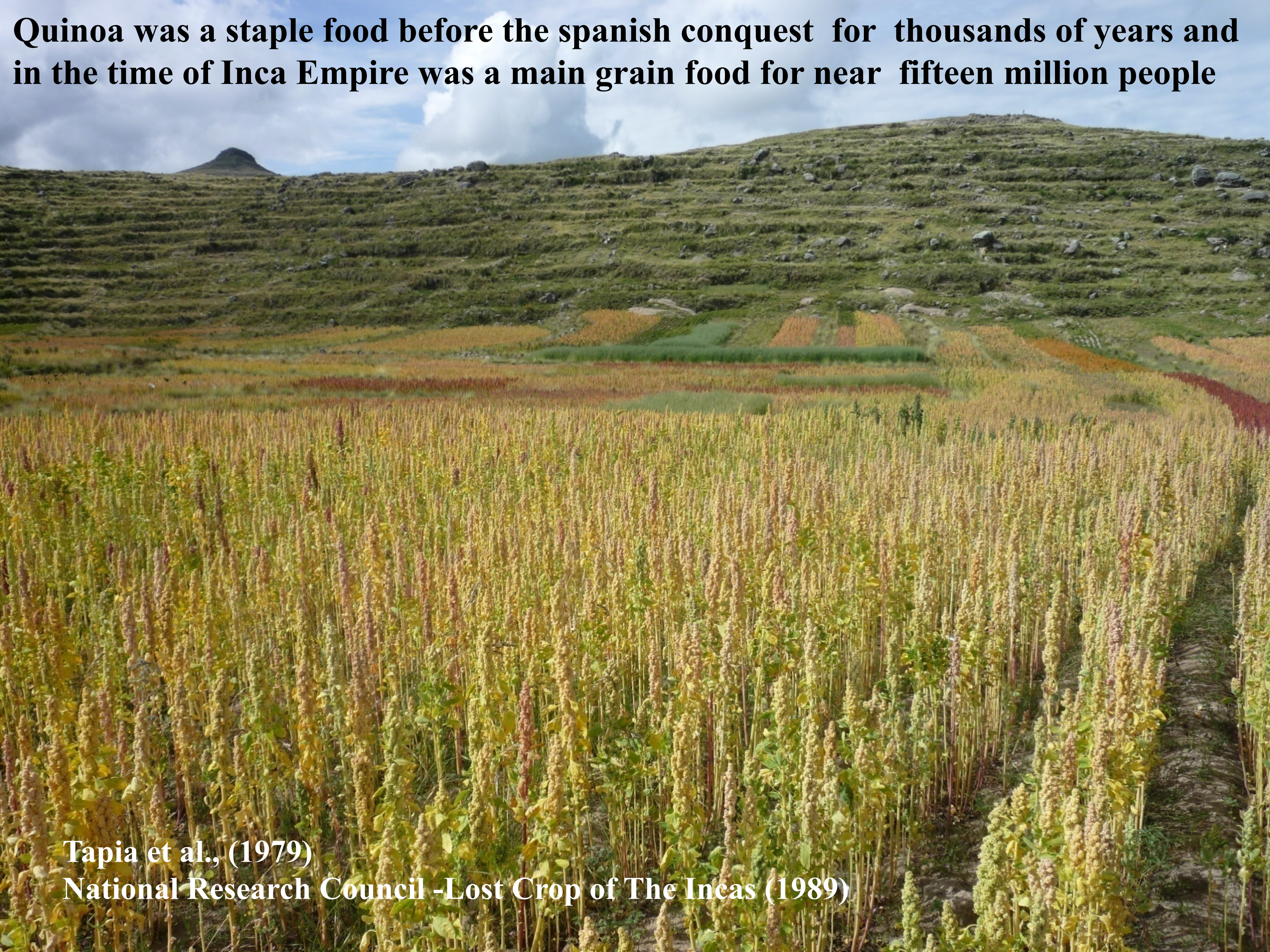
The Andean Region is the center of origin of quinoa with a mayor biodiversity in the bolivian-peruvian altiplano

There are many evidences about its domestication in this Region



The oldest remains of quinoa grains corresponds a discovery of in Ayacucho-Peru (4500 BC)

Jorge Silva Sifuentes (2000). «Origen de las civilizaciones andinas». En Teodoro Hampe Martínez. *Historia del Perú*. Culturas prehispánicas. Barcelona: Lexus. ISBN 9972-625-35-4


Quinoa was a staple food before the spanish conquest for thousands of years and in the time of Inca Empire was a main grain food for near fifteen million people
Tapia et al., (1979)
National Research Council -Lost Crop of The Incas (1989)

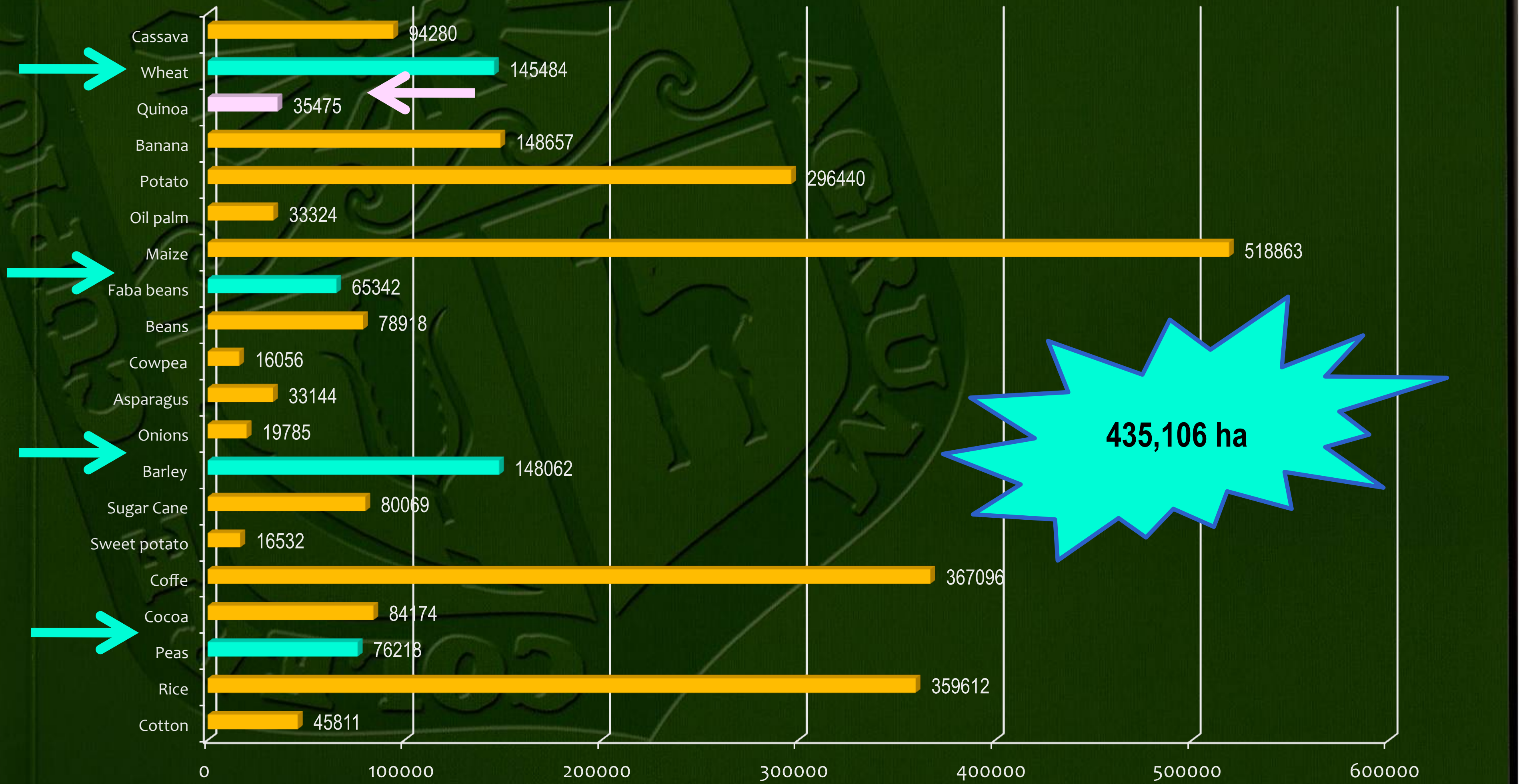
Genetic and cultural erosion of Crops has been intense since the discovery of Peru, by many factors, among them the introduction to the peruvian highlands of crops such as:

barley, wheat, broad beans, peas and oats

Introduced crops started to increase during many centuries significantly because:

- They were a main food for Spanish people
- High adaptation to marginal conditions
- Easy crop technologies and low costs.
- Easy storage and processing for consumption

Main Crops (Ha)
Peru - 2011



MINAG, Series Historicas, 2011

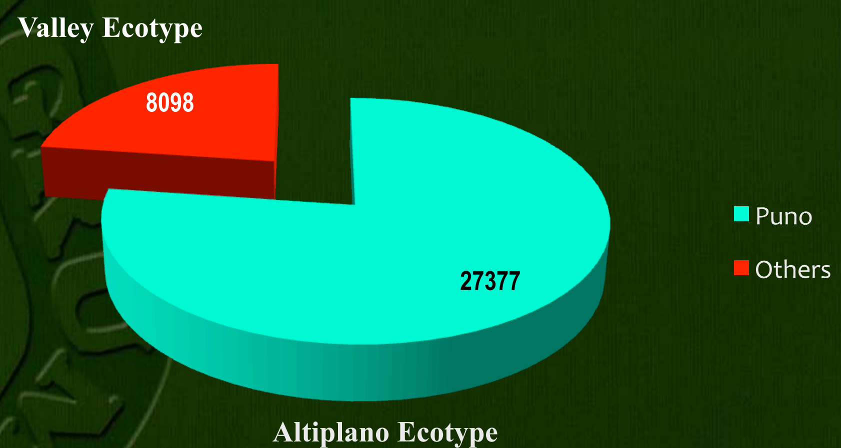
Historical Series of the Quinoa Surface (ha) Cultivated in Peru 1951 -2011

MINAG, Series Historicas, 2011

National Average Yield (kg/ha) of Quinoa 1951 -2011

MINAG, Series Historicas, 2011

Distribution of Quinoa Area (ha) - Peru 2011



MINAG, Series Historicas, 2011


Quinoa important Inca Staple food remain largely restricted to the Peruvian Altiplano-Puno and was unappreciated elsewhere
Since 1960 started the recognition of quinoa and this crop become important new contributor to the modern world’s food supply

The renewed interest in quinoa is based in the recognition of two important characteristics:

- 1.- Its high nutritional value
- 2.- Its remarkable adaptation to stressful conditions of soil and climate.

Quinoa Uses

Grains:

- ☼Pearled Grains
- ☼Flour
- ☼Flakes
- ☼Popped grains

Quinoa Uses

- Leaves
  - Horticultural use
  - Dried and grounded
- Biommass
  - Fodder
  - Toccra (Stem-Ash)

QUINOA FARM PRICE (KG) CAMPAIGN
1994 - 2009

	$			
Year	1994	2006	2010	2011
National	0.27	0.17	0.49	0.55
Huancavelica	0.47	0.70	1.1	1.24
Arequipa	0.31	0.72	1.32	1.77
Ayacucho	0.41	0.55	1.29	1.28
Junín	0.35	0.61	1.36	1.50
Cuzco	0.32	0.55	0.94	1.09
Puno	0.23	0.42	1.32	1.43

MINAG, Series Historicas, 2011

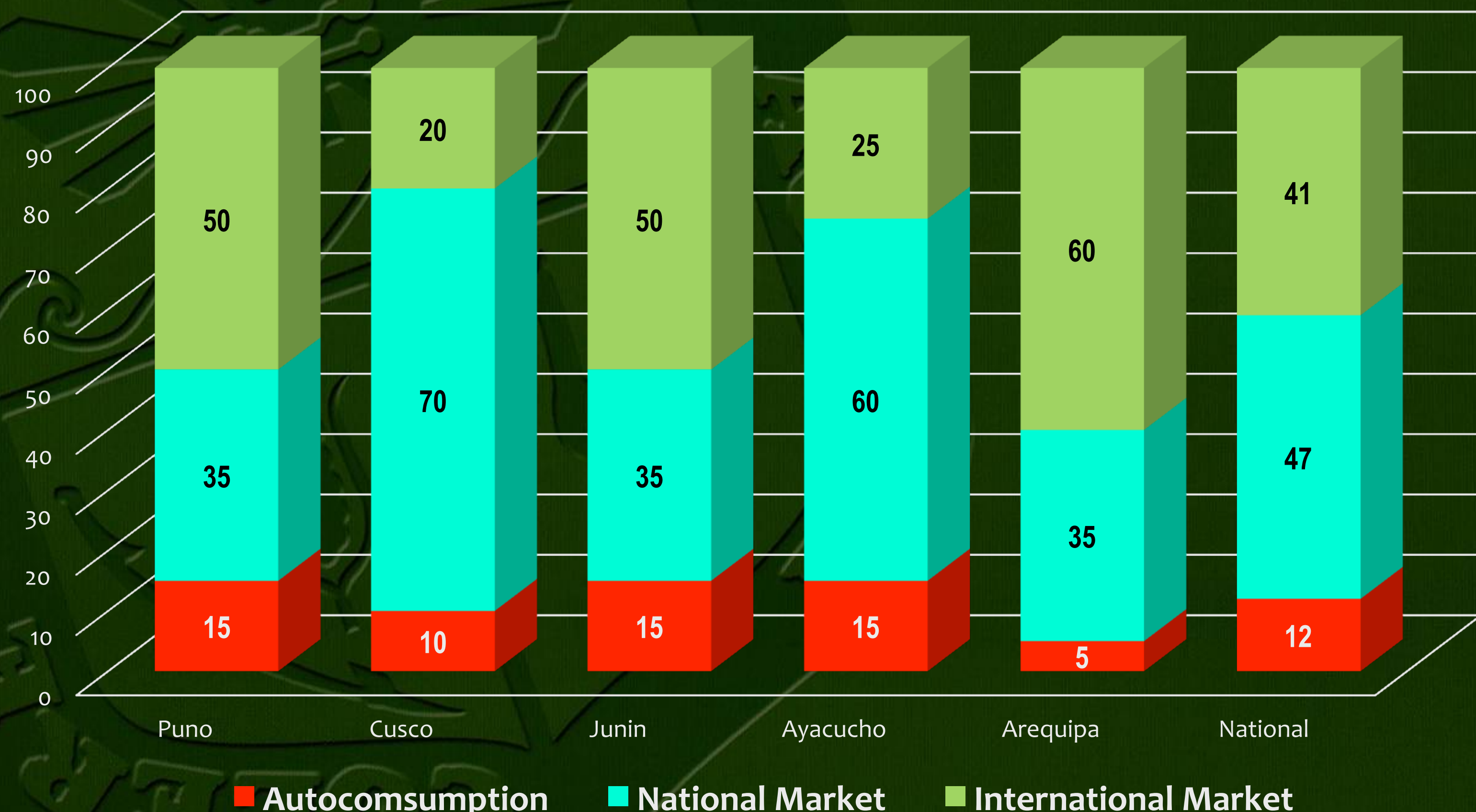
DESTINATION , VALUE (FOB)AND AMOUNT (kg) OF QUINOA PERUVIAN EXPORTS 2007- 2011

Year	2007	2008	2009	2010	2011
Destination	**USA. 60.84%**	**USA 62.58%, and Japon 8.63%**	**EE.UU. 45.54% and Germany 10.09%**	**USA 64.23% and Germany 7.96%**	**USA 63.43% and Canada 7.94%**
Value FOB (US $)	1’787,784	5’079,427	7’304,703	13’190,249	16’800,386
Amount (kg)	**1’348,150**	**2’096,263**	**2’711,780**	**4’782,863**	**5’327,731**
Unit Value (US$)	1.33	2.42	2.69	2.76	3.15

MINAG, 2011

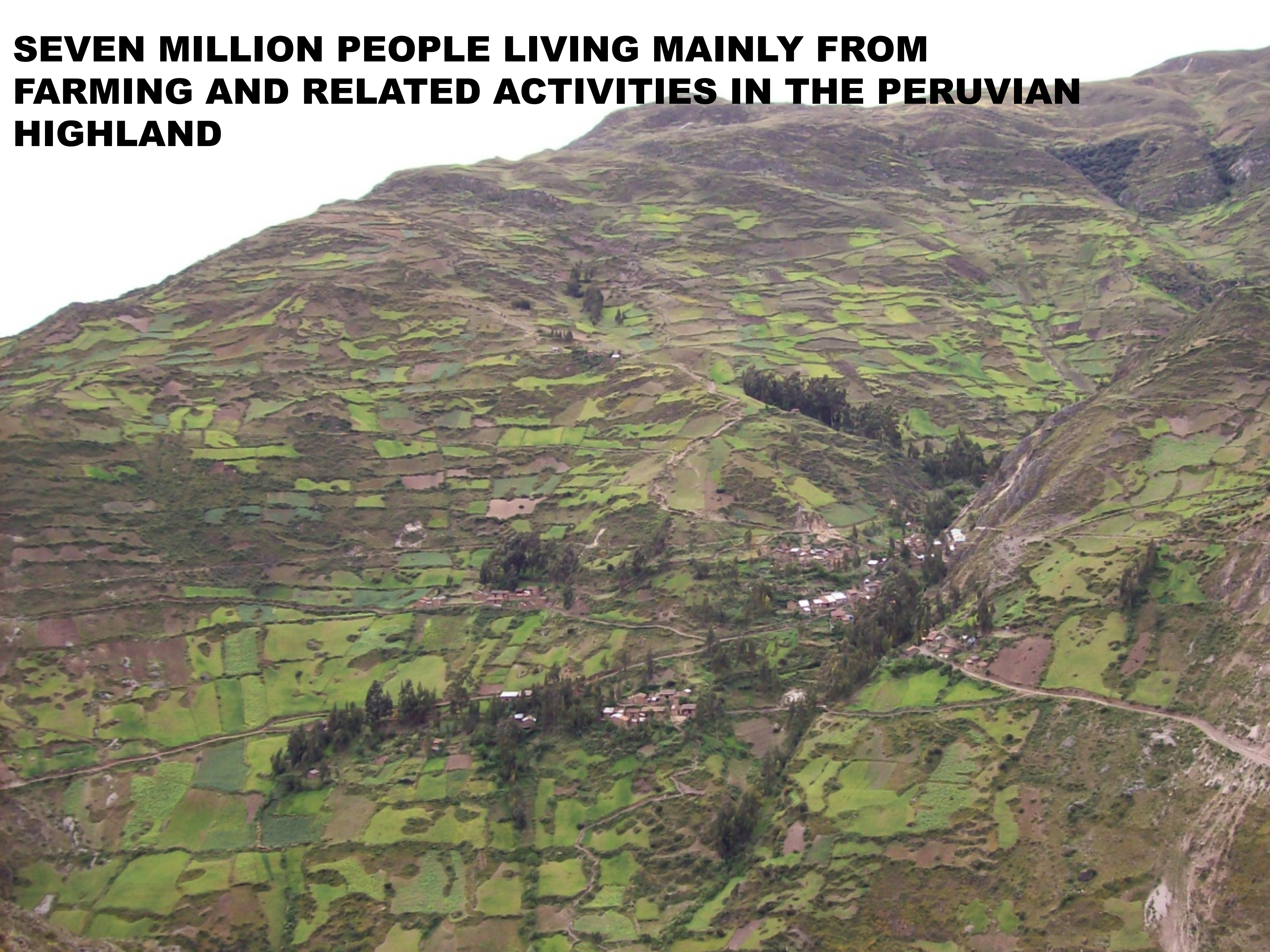
DESTINATION OF QUINOA PERUVIAN PRODUCTION (%) – YEAR 2011

MINAG - INIA, 2011



Quinoa is a highly nutritious crop and should be a staple food for the Peruvian population. However, the current price is so high that only a small population with economic capacity can use it as main food.

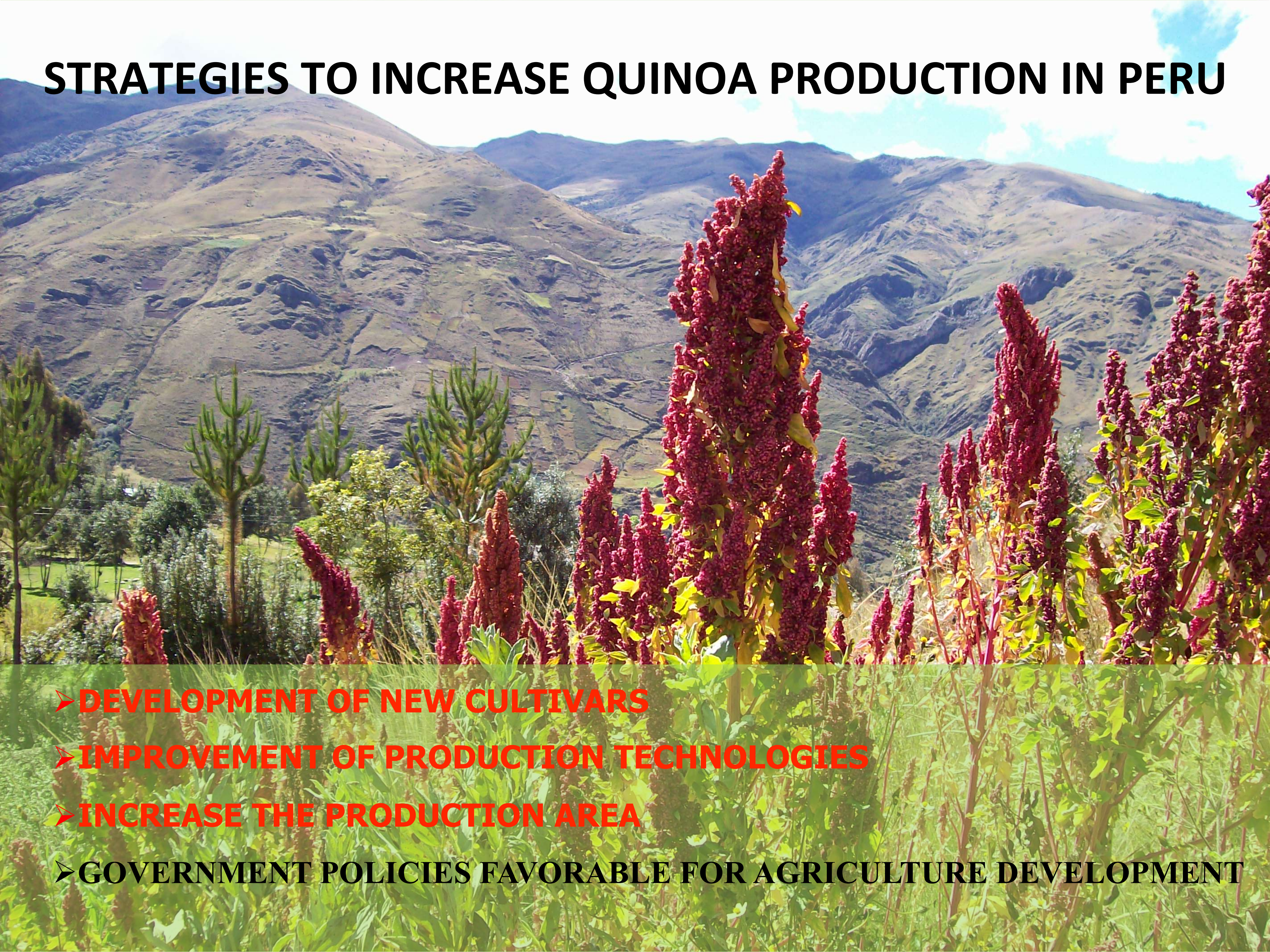
SEVEN MILLION PEOPLE LIVING MAINLY FROM FARMING AND RELATED ACTIVITIES IN THE PERUVIAN HIGHLAND



THE YIELD AND QUALITY OF THE CROPS ARE VERY LOW AND SOMETIMES THE FIELDS YIELD ONLY ENOUGH FOR FAMILY CONSUMPTION WHICH CREATES PROBLEMS LIKE MALNUTRITION AND POVERTY

Area	Year	Malnutrition rate among children under 5 years old
Rural	2007	45.7
Rural	2009	40.3
Urban	2007	15.6
Urban	2009	14.2

STRATEGIES TO INCREASE QUINOA PRODUCTION IN PERU



- DEVELOPMENT OF NEW CULTIVARS
- IMPROVEMENT OF PRODUCTION TECHNOLOGIES
- INCREASE THE PRODUCTION AREA
- GOVERNMENT POLICIES FAVORABLE FOR AGRICULTURE DEVELOPMENT

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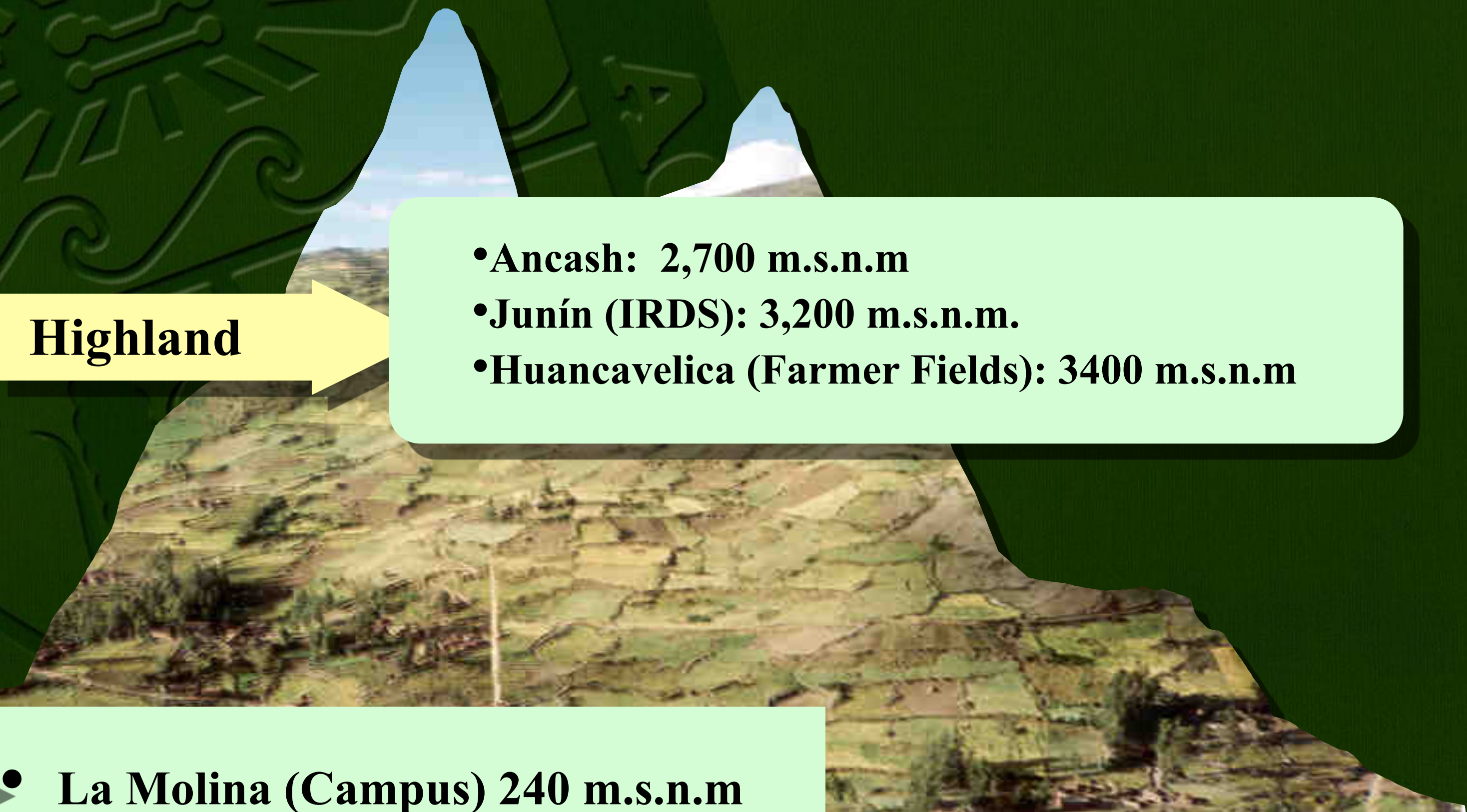
Quinoa Genetic and Agronomic Improvement

Experimental Locations



Highland

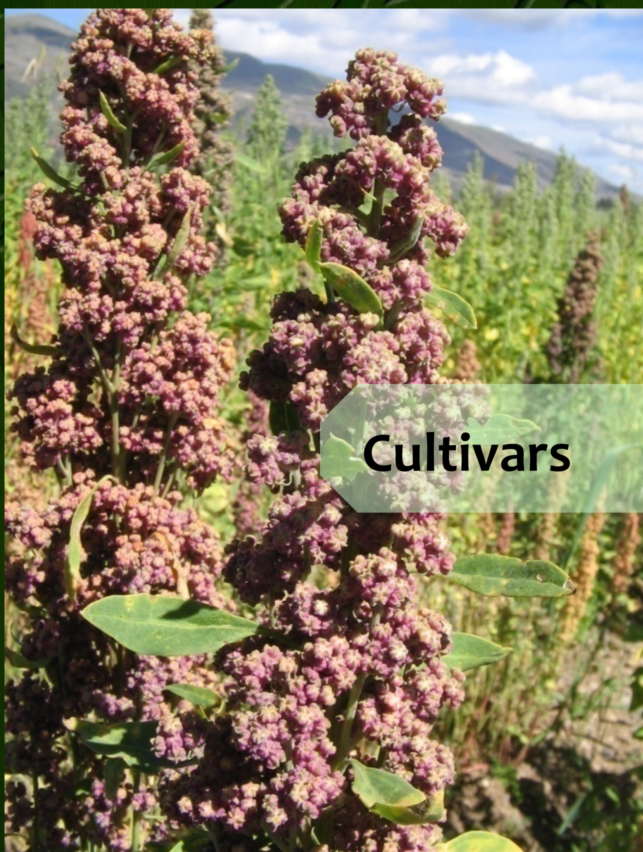
- **Ancash: 2,700 m.s.n.m**
- **Junín (IRDS): 3,200 m.s.n.m.**
- **Huancavelica (Farmer Fields): 3400 m.s.n.m**

Coast

- **La Molina (Campus) 240 m.s.n.m**

GOALS OF BREEDING AND METHODS

Improvement of yield and quality



Cultivars

- Adaptation
- Resistence / Tolerance to biotic and abiotic stresses
- High Yield /Ha
- Quality
  - Food
  - Industry

Methodology

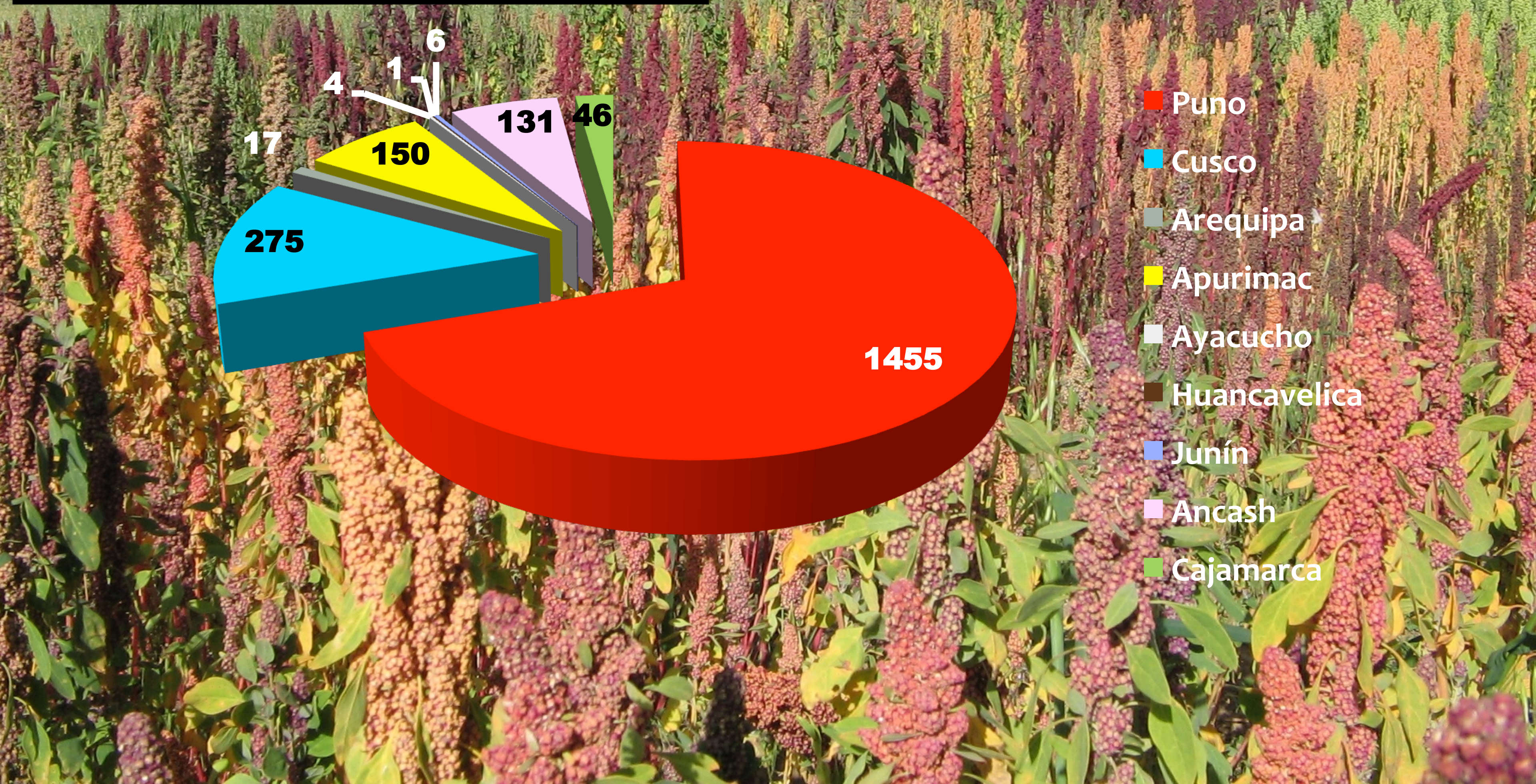
Germplasm Collection and Evaluation

- ➢MasalSelection
- ➢Individual Selection
- ➢Induction Mutation

Germplasm Bank
Universidad Nacional
Agraria La Molina:

2085 accessions collected

Gomez and Eguiluz, 2011



Morphological Characterization

(IBPGR Descriptors – 15 Characteristics).

Gomez and Eguiluz, 2011




Agronomic Characterization (life cycle, plant height, lodging, preliminary yield potential).

Gomez and Eguiluz, 2011




Response to Biotic and Abiotic Stresses

Gomez and Eguiluz, 2011

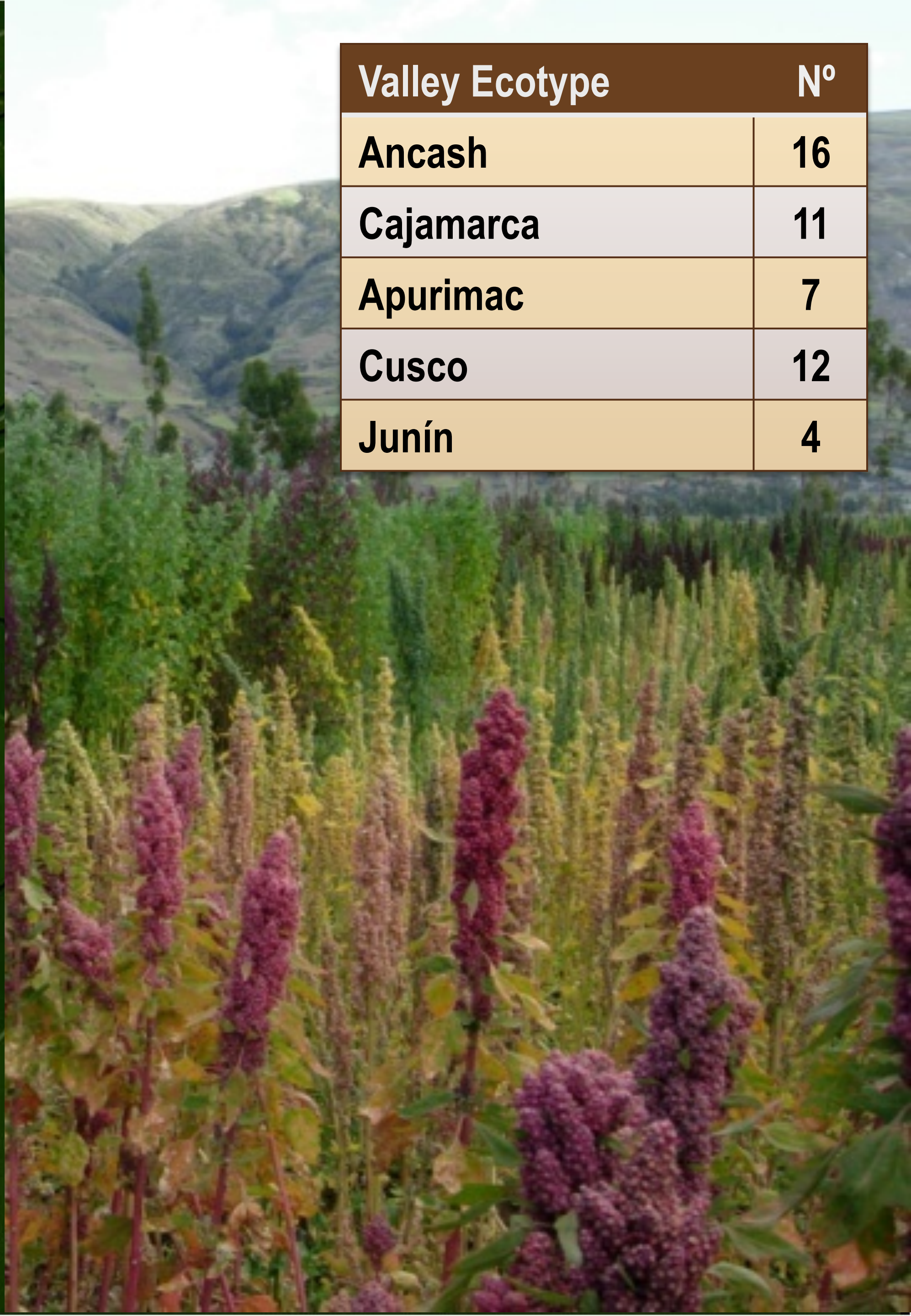



Quality Chracteristics Evaluation

Gomez and Eguiluz, 2011


Genetic Material:
85 accesions

Altiplano Ecotype (Puno)	Nº
El Collao - Ilave	4
Puno:	
Puno	4
Atuncolla	10
Capachica	4
Chucuito	3
Yunguyo	8
Lampa	1
Moho	1



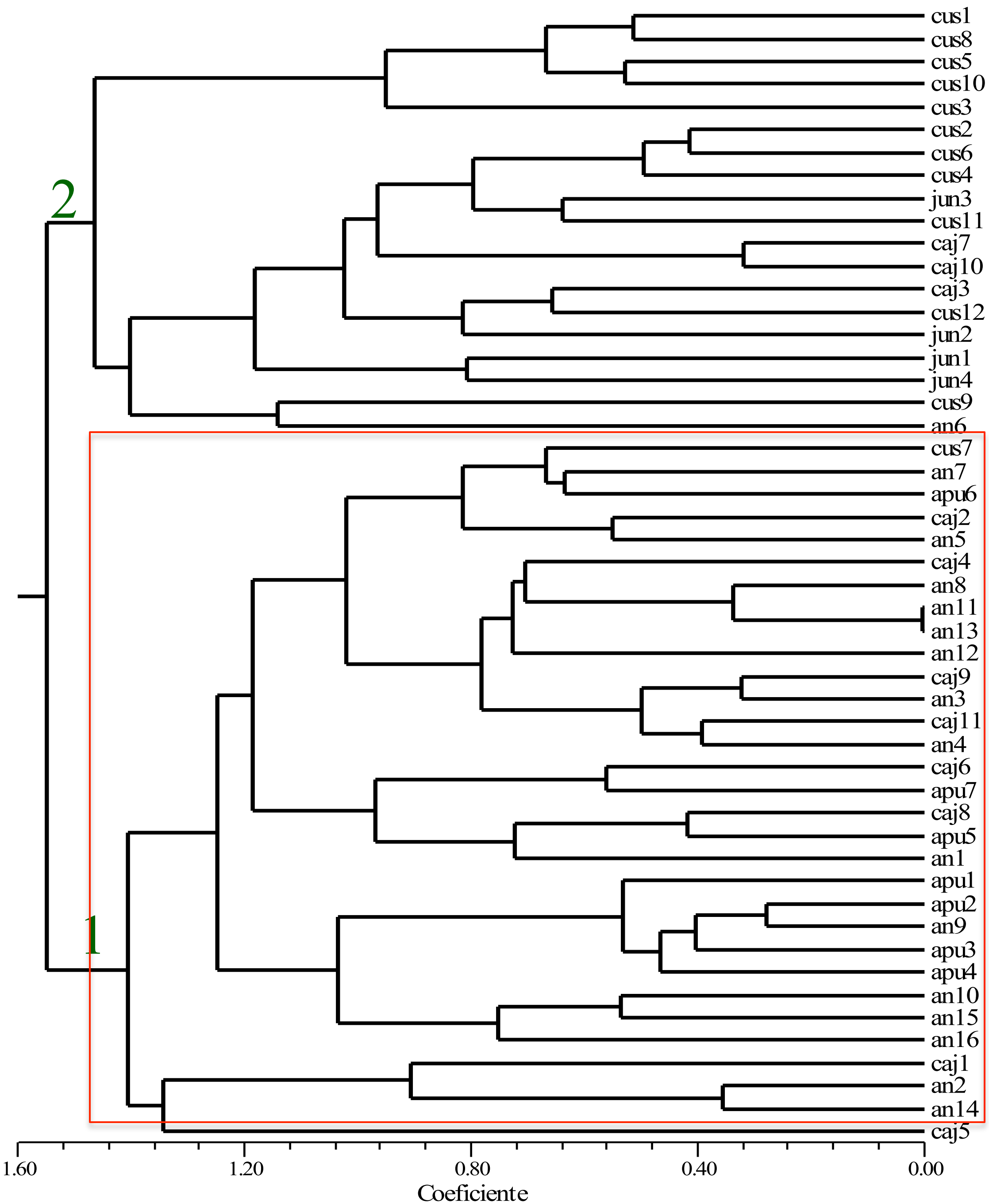
Valley Ecotype	Nº
Ancash	16
Cajamarca	11
Apurimac	7
Cusco	12
Junín	4

Eguiluz *et al.*, 2010

Group N° 1	Characters	Range of Variation
Cajamarca (2)	Protein	11.7 a 17%
Ancash (10)	Saponine	0 a 1.55
Apurimac 7	Flowering	75 a 110 days
Cusco (1)	Plant height	125 a 230 cm
	Maturity	170 a 210 days
	Mildew	30 a 90%
	Grain Yield	256 a 3531 Kg/Ha

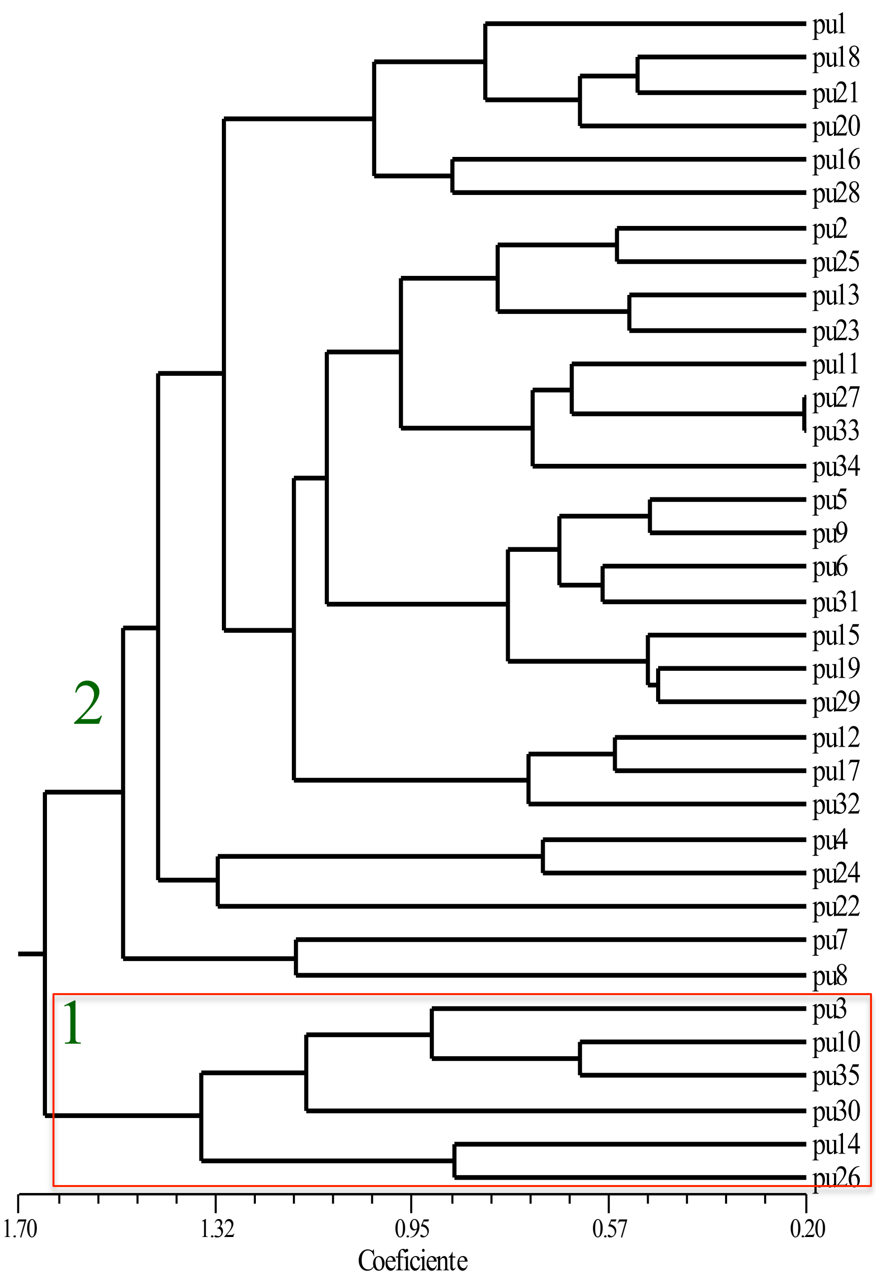
Group N° 2	Characters	Range of Variation
Cajamarca (3)	Protein	11.8 a 17.4 %
Ancash (1)	Saponine	0 a 1.57 %
Junin (4)	Flowering	56 a 106 days
Cusco (11)	Plant height	95 a 185 cm
	Maturity	140 a 190 days
	Mildew	20 a 80%
	Grain Yield	419 a 2991 Kg/Ha

Eguiluz et al., 2010



Group N° 1	Characters	Range of Variation
Chucuito (1)	Protein	14.1 a 16.3 %
Atuncolla (1)	Saponine	0 a 1.4%
Puno (1)	Flowering	58 a 78 days
Yunguyo (1)	Plant height	105 a 155 cm
Capachica (1)	Maturity	145 a 160 days
Ilave (1)	Mildew	50 a 80 %
	Grain Yield	1940 a 2975 Kg/Ha

Group N° 2	Characters	Range of Variation
Capachica(3)	Protein	10.6 a 17.1%
Yunguyo (7)	Saponine	0 a 1.4 %
Ylave (3)	Flowering	56 a 85 days
Puno (3)	Plant height	90 a 145 cm
Chucuito (2)	Maturity	130 a 160 days
Atuncolla (8)	Mildew	50 a 90%
Lampa (1)	Grain Yield	165 a 1375 Kg/Ha
Moho(1)		



Eguiluz et al., 2009

Mean Values of flowering (days), plant heigh (cm), maturity (days) of 50 valley ecotypes and 35 altiplano ecotypes

Variable	Flowering (days)		Plant Height (cm)		Maturity (days)	
	Altiplano	Valley	Altiplano	Valley	Altiplano	Valley
Mean	64,23	87,96	110,74	172,22	147,91	181,10
SD	7,47	14,18	19,05	31,45	9,11	18,44
VC %	11,63	16,12	17,20	18,26	6,16	10,18
Min	56,00	56,00	85,00	95,00	130,00	140,00
Max	85,00	110,00	155,00	230,00	160,00	210,00

Eguiluz et al., 2010

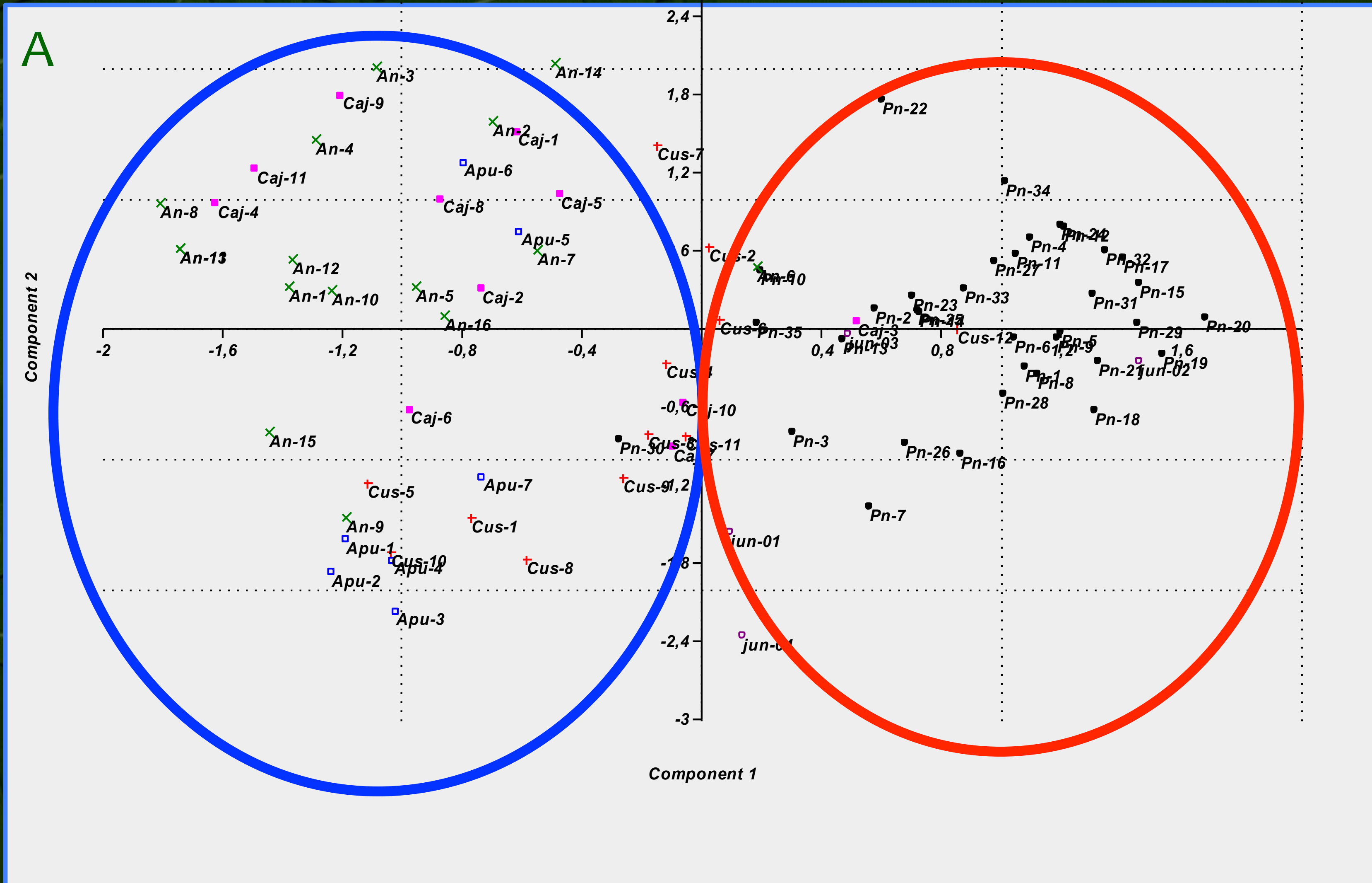
Mean Values of mildew severity (%) and grain yield (kg/ha) of 50 valley ecotypes and 35 altiplano ecotypes

Variable	Mildew (%)		Rendimiento (Kg/Ha)	
	Altiplano	Valley	Altiplano	Valley
Mean	78,29	63,00	1103,46	1580,86
SD	11,24	18,21	615,09	878,68
VC %	14,36	28.9	55,74	55,58
Min	50,00	20,00	165,00	109,00
Max	90,00	90,00	2975,00	3531,00

Eguiluz et al., 2010

Mean Values of grain protein content (%) and grain saponine content (%) of 50 valley ecotypes and 35 altiplano ecotypes

Variable	Protein (%)		Saponine (%)	
	Altiplano	Valle	Altiplano	Valle
Mean	14,83	13,86	0,54	0,84
SV	1,49	1,43	0,51	0,55
VC %	10,05	10,32	94,44	65.48
Min	10,60	11,70	0,00	0,00
Max	17,10	17,40	1,42	1,57



Proyection of Valley and Altiplano ecotypes considering the first principal components

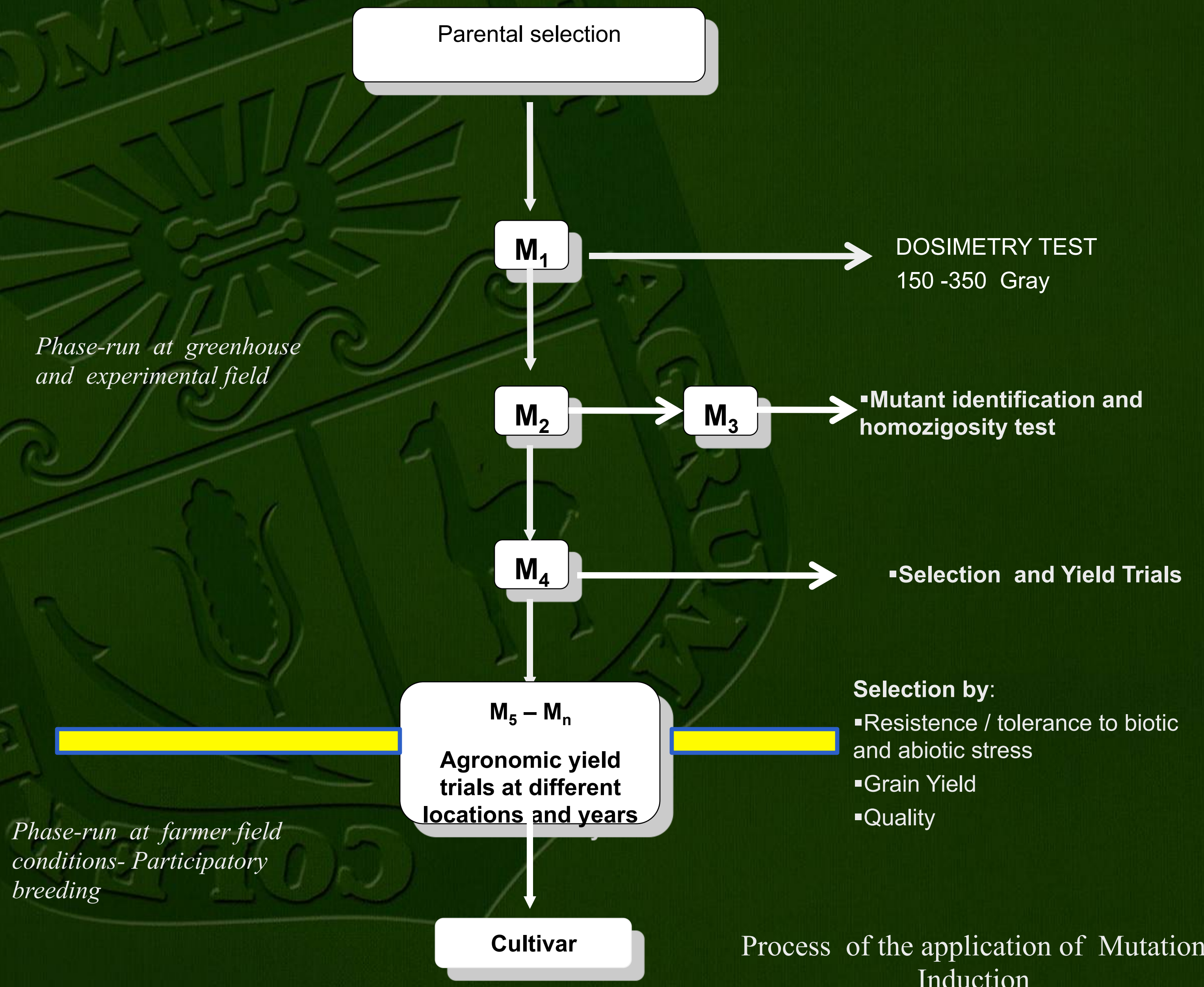
Eguiluz et al., 2010

POSITIVE QUALITIES OF TRADITIONAL CULTIVARS

- ❑Adaptation to adverse environments
- ❑High Nutritive value
- ❑Resistance /Tolerance to disease
- ❑Agronomic Charcateristics - Uses

TRADITIONAL VARIETIES NEGATIVE CHARACTERS

- Tall Plants
- Long life cycle
- Branching Plant Habit
- Susceptible to shattering
- Susceptible to mildew and other diseases



Process of the application of Mutation Induction





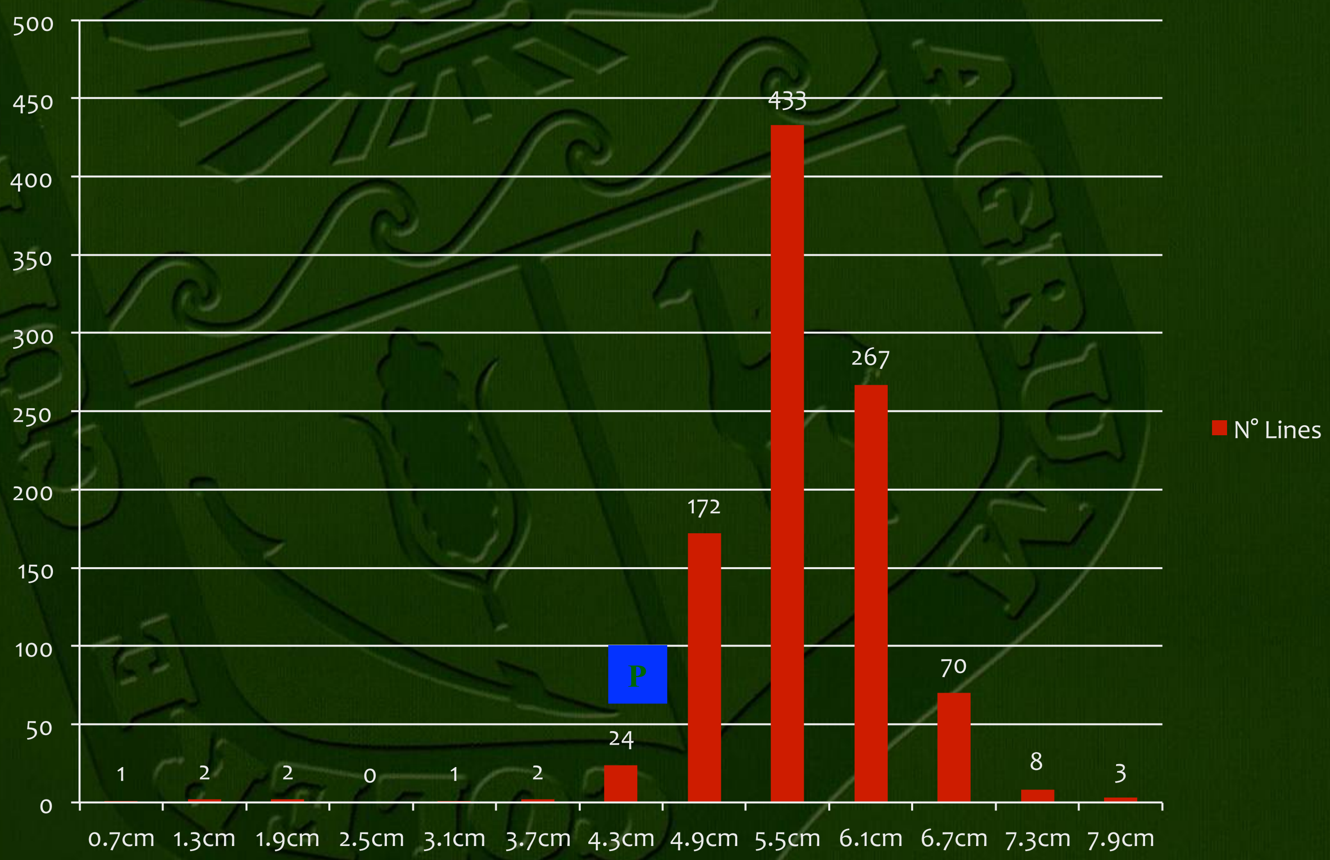




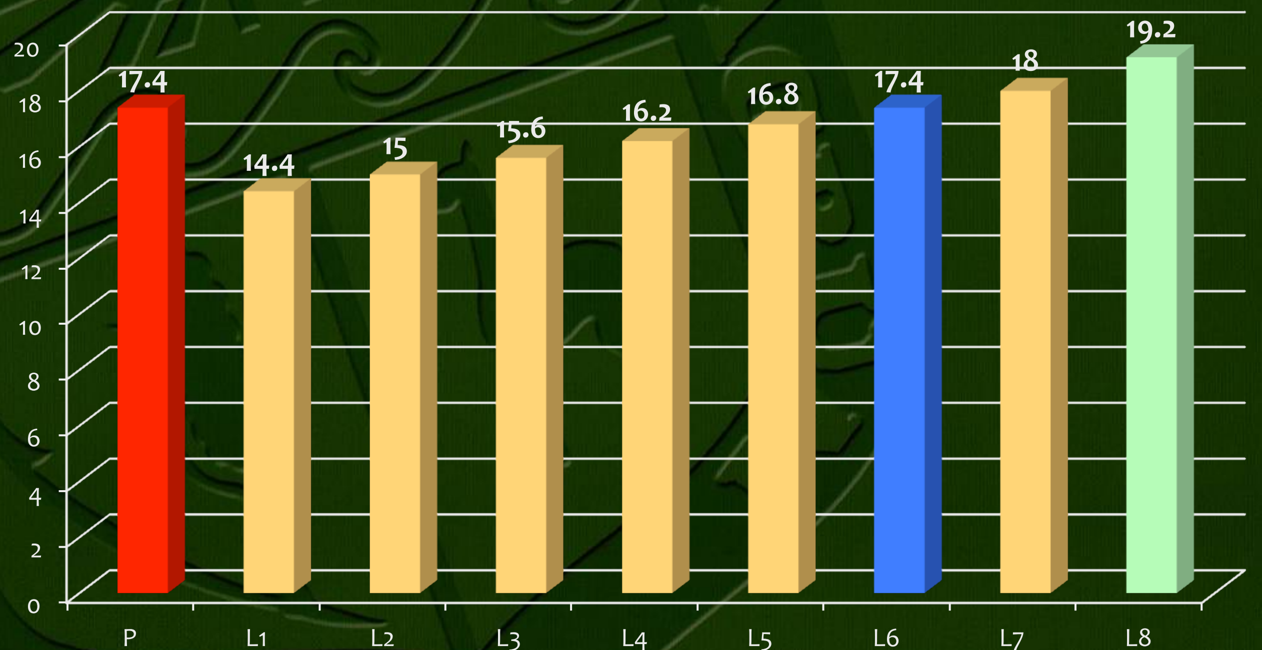
Original Pasankalla
Grain color

Mutante Pasankalla
Grain color

Saponine Content (foam height -cm) of Mutant Lines of UNALM 89 in Generation M_4



Protein Content (%) of Mutant Lines of UNALM 89 in Generation M_4





GRAIN YIELD (KG/HA) OF MUTANT LINES OF UNALM 89 AND PASANKALLA

2012-B – 2013 A.

Mutant Lines	Grain Yield(kg/ha)	Plot
MQLM89-14	4225.0	7
MQLM89-131	4205.2	46
MQLM89-112	4104.5	37
MQLM89-113	4027.4	38
MQLM89-150	4017.7	56
MQLM89-41	3954.4	14
MQLM89-152	3919.5	57
MQLM89-82	3913.3	27
MQLM89-109	3737.3	34
MQLM89-149	3705.0	55

Mutant Lines	Grain Yield(kg/ha)	Plot
MQPas-57	3466.1	13
MQPas-164	3411.5	33
MQPas-50	3381.5	12
MQPas-34	3380.2	7
MQPas-143	3375.0	31
MQPas-22	3346.4	4
MQPas-148	3315.1	32
MQPas-136	3308.6	29
MQPas-142	3259.1	30
MQPas-99	3248.7	19

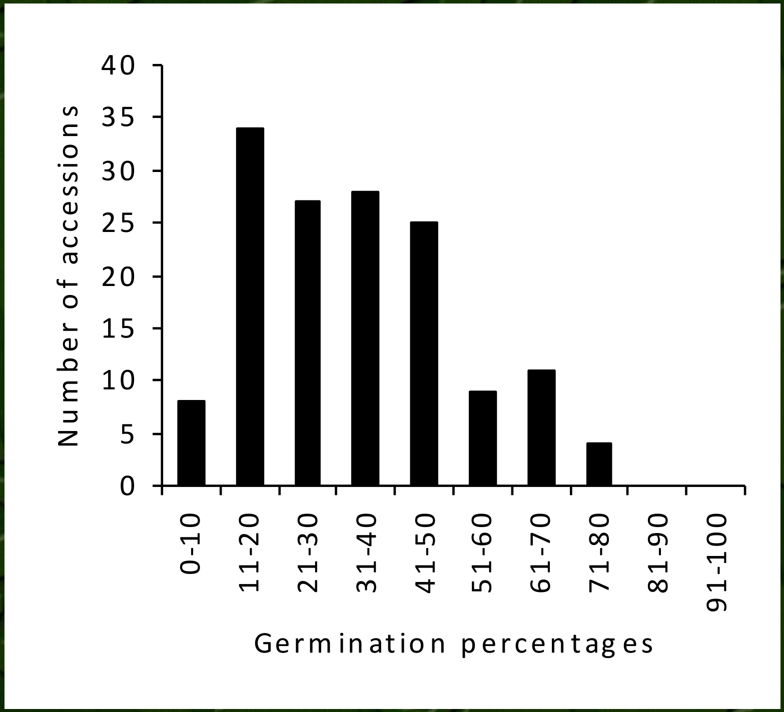
Development of cultivars for the Coast Region

Area of degraded soils by natural regions, 2002

Type of degradation	Total ha	Coast ha	Highland ha	Amazon Rain Forestry ha
Soils affected by erotion	127 945 790	14 871 310	35 810 730	77 263 750
Soils affected by desertification	13 637 000	13 637 000		
Soils affected by salinity	306 701	306 701		
Soils affected by waterlogging	4 635 810	9 199		4 626 611
Soils affected by acidification	77 615 080			77 615 080

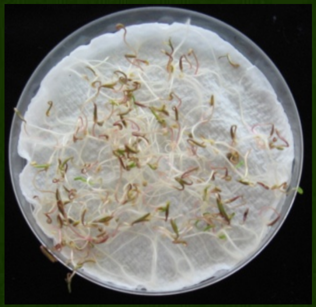
INEI 2007. Fuente : Ministry of Agriculture– National Institute of Natural Resources

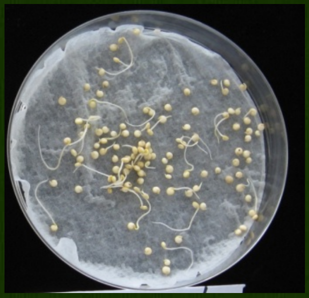
Levels of E.C. (mS/cm).
0 (T1), 15 (T2), 25 (T3), 30 (T4) y 40 (T5)



Accesión	T1	T2	T3	T4	T5
1.0A	100	100	98	21	3
11 B	98	98	87	84	3
11.0 A	96	93	75	18	10
12 B	99	96	44	18	3
12.0 A	97	95	96	34	3
12.0 C	98	87	41	4	3
13 A	99	98	94	16	3
14 A	97	97	79	65	3
15 A	97	89	86	48	3
15 C	99	96	79	63	3
15 D	99	97	93	84	3
17 A	93	96	75	47	3
18 A	96	94	51	3	2
19 A	99	99	99	45	2
19 B	99	96	52	45	1

Seed germination of 146 quinoa accessions in Petri dishes. Irrigation water contained sodium chloride (25 dS/m E.C.). Fifteen accessions showed more than 60% of seed germination. (Gomez *et al.*, 2010)





Accession Number	PASSPORT DATA -UNALM	Departamento	Provincia	Distrito
19	PEQPC-0019	Puno	Puno	Acora
27	PEQPC-0027	Puno	Puno	Acora
44	PEQPC-0044	Puno	Puno	Acora
50	PEQPC-0050	Puno	Puno	Acora
100	PEQPC-0051	Puno	Puno	Acora
103	PEQPC-0053	Puno	Puno	Acora
105	PEQPC-0055	Puno	Puno	Acora
106	PEQPC-0077	Puno	Puno	Acora
127	PEQPC-0086	Puno	Puno	Acora
136	PEQPC-0095	Puno	Puno	Acora
145	PEQPC-0096	Puno	Puno	Acora
146	PEQPC-0101	Puno	Puno	Acora
151	PEQPC-0102	Puno	Puno	Acora
152	PEQPC-0104	Puno	Chucuito	Huacullani
154	PEQPC-0104	Puno	Chucuito	Huacullani

Accessions 100, 136, 127 and 105 were
the best-suited genotypes for saline soils. (Gomez *et al.*, 2010)


Development of Crop Technologies



Seeding Methods

Transplant / Drip Irrigation

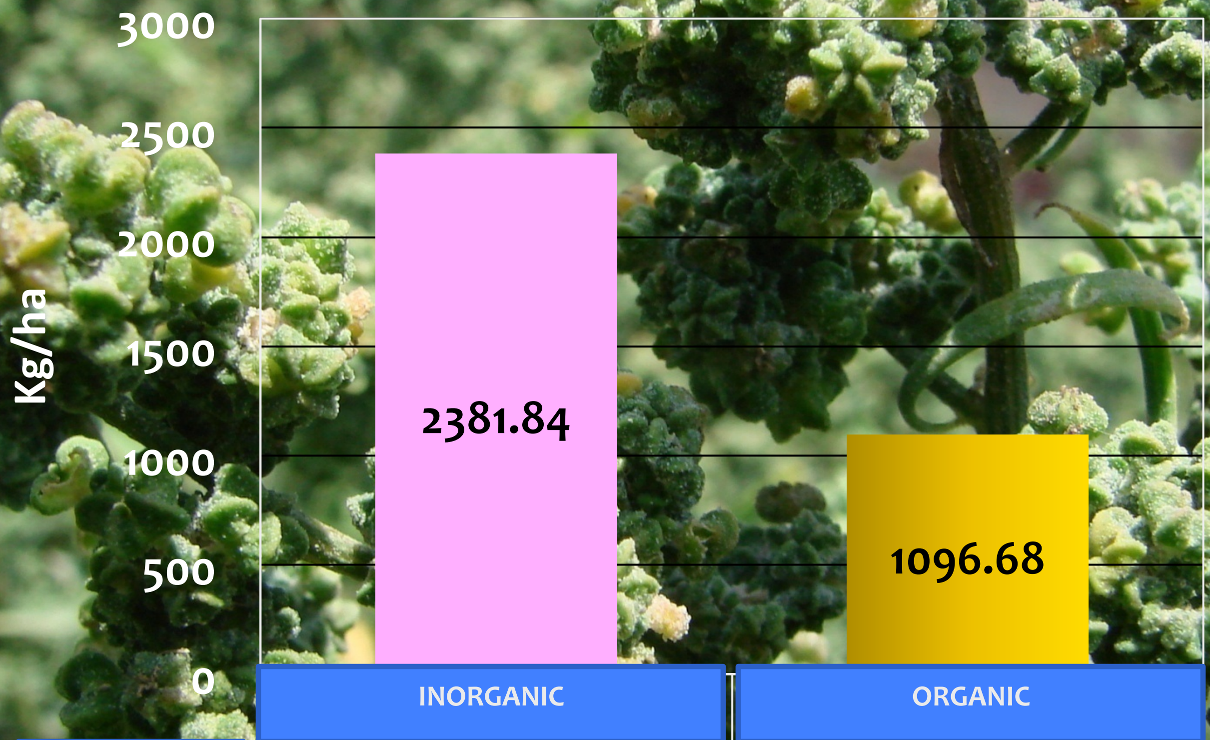
Plant Density

One row by furrow

Two row by furrow

Gordon and Gomez , 2012

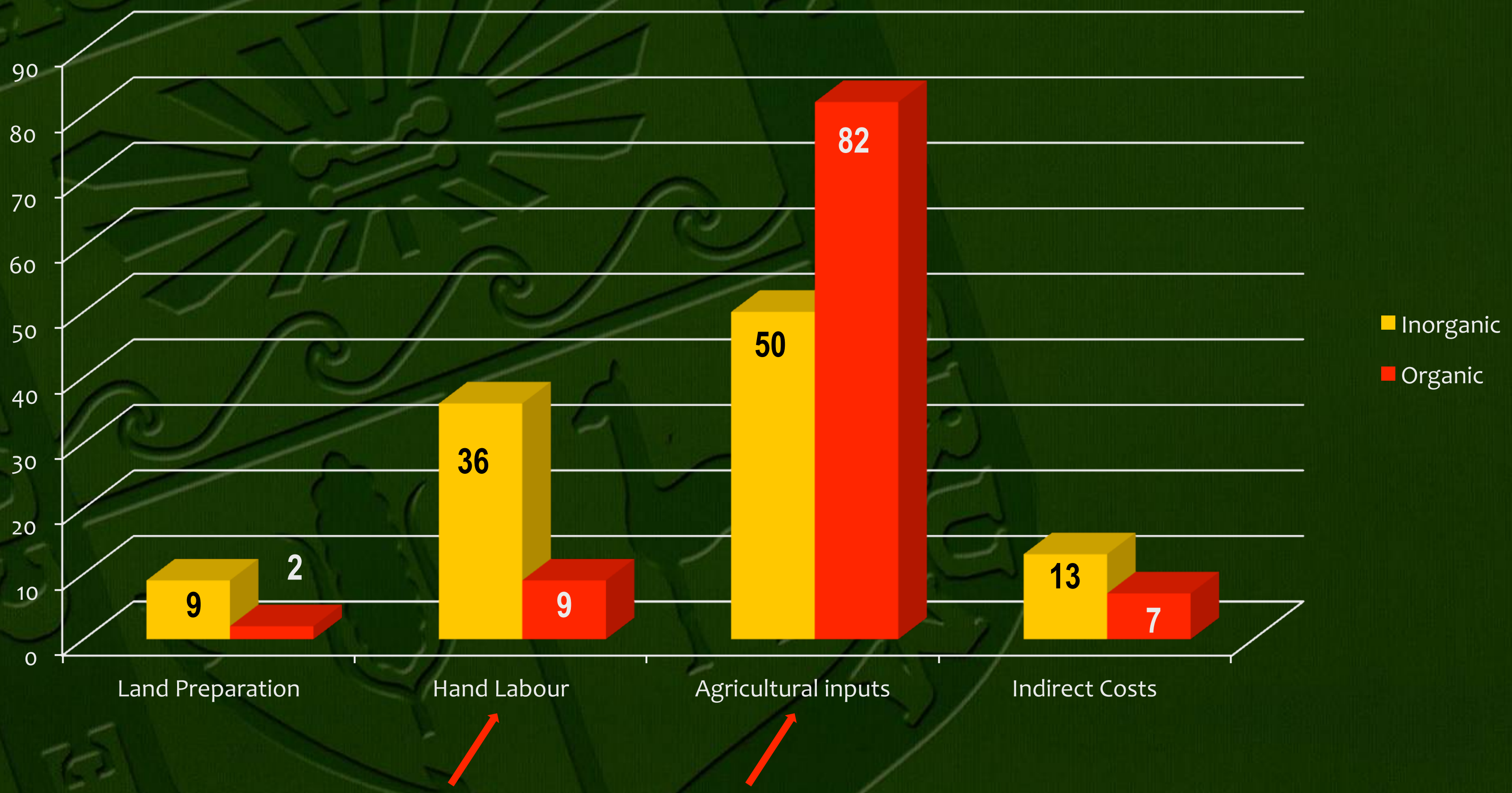
Organic and Inorganic Crop Systems



Systems	2381.84	1096.68

Gordon and Gomez , 2012

Profitability Analysis	$
Production Cost of Organic System	2608
Production Cost of Inorganic System	2285
Quinoa Grain Yield (kg/ha) in Organic Systems	1097
Quinoa Grain Yield (kg/ha) in Inorganic Systems	2382
Organic Quinoa Price (kg)	3.85
Inorganic Quinoa Price (kg)	1.92
Gross Income- Organic System	4223.5
Net Income- Organic System	1615.5
Gross Income- Inorganic System	4573.4
Net Income- Inorganic System	2288.4
Profitability in Organic System (%)	61
Profitability in Inorganic System (%)	100



Proportion (%) of Direct and Indirect Costs for a Organic and Conventional Systems of Quinoa Cropping

Quinoa GrainYield (kg / ha) in different cropping systems in farmer fields Junin-2011-2012

	Organic Systems		Conventonal Systems Inorganic Fertilizer	Traditional System (Check)
	Island Manure	Farm Manure		
Rosada Huancayo	1247.0	1314.0	1137.7	827.3
Huacho 1	1488.0	1217.0	1714.7	737.3
Blanca Hualhuas	1624.3	1620.0	1310.3	925.7

Improvement of harvesting systems

Huancavelica

Workshops at different locations of the highland

Junín IRD-Sierra

FUTURE RESEARCH IN QUINOA
Development of New Cutivars Adapted to The Climatic Change

Improvement of Resistance to Biotic Stresses

Improvement of Resistance to Abiotic Stresses

Salt, High and Low Temperature and drought tolerance

Introduction of modern biotechnology technologies to the Conventional Breeding :

Molecular Markers and Marker-Assisted Breeding in Quinoa

Improvement of New Crop Technologies

New developments in the Use of Quinoa- Quality Studies

Acknowledgement

HOMINEM ET AGRUM COLERE CUPIO

INCAGRO

CONCYTEC

vliruos SHARING MINDS, CHANGING LIVES

IAEA

BRIGHAM YOUNG UNIVERSITY FOUNDED BYU 1875 PROVO, UTAH

alicorp


Thank
you
BEHIND ONE CROP FIELD
THERE IS A FAMILY
TRYING TO IMPROVE ITS
LIFE