BARLEY (*Hordeum vulgare*) AND KIWICHA (*Amaranthus caudatus*) IMPROVEMENT BY MUTATION INDUCTION FOR SUSTAINABLE PRODUCTION IN PERUVIAN HIGHLAND

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Agricultural production takes place between 3,000 to 4,000 m a.s.l.

Climate is characterized by frequent periods of drought, floods, torrential rains, frosts, hailstorms and others that make agricultural production insecure.

Plots generally smaller than 1 ha. Most small plots are located on slopes in shallow and stony soils.

Crops grow during rainfall season without irrigation systems.

Family subsistence depends of few crops among them: potatoes, barley, wheat, tarwi, pea, faba bean, quinoa, amaranth, roots and andean tubers.

83.4% of the rural population survive in extreme poverty situation, almost 23% of the total national population.

Malnutrition Problem
Traditional cropping technology (manly hand labor) and production for self-consumption
Yield and quality of the crops were very low and sometimes fields yield only enough for family consumption which creates problems like malnutrition and poverty.

STRATEGIES TO IMPROVE CEREALS AND NATIVE GRAINS PRODUCTION

- Crop Genetic improvement
- Agronomic technology improvement
- Transference of results to the farmers
PLANT GENETIC IMPROVEMENT METHODOLOGY

- Collection and introduction of germplasm
- Hybridization
- Mutation Induction

Biotechnology Tools
- Doubled haploid production
- Molecular markers
<table>
<thead>
<tr>
<th>Variety</th>
<th>UNALM 95</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop Species</strong></td>
<td>Barley (Hordeum vulgare L)</td>
</tr>
<tr>
<td><strong>Mutagen</strong></td>
<td>Gamma Ray (250 Gray)</td>
</tr>
<tr>
<td><strong>Mutant trait (s)</strong></td>
<td><strong>Naked grain</strong>, protein content, 1000 grain weight, resistance to stripe rust</td>
</tr>
<tr>
<td><strong>Value:</strong></td>
<td>In peruvian highland between 3800-4000 m asl, barley grain is roasted and is part of the lunch of children and family. Barley contribute with 20% of the caloric intake, it is the second source after potatoe that contribute with 21% in the highland near to the agriculture frontier.</td>
</tr>
<tr>
<td>Variety</td>
<td>Centenario</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Crop Species</td>
<td>Barley (Hordeum vulgare L)</td>
</tr>
<tr>
<td>Mutagen</td>
<td>Gamma Ray (300 Gray)</td>
</tr>
<tr>
<td>Mutant trait(s)</td>
<td>Yield, protein content, 1000 grain weight</td>
</tr>
<tr>
<td>Yield increase</td>
<td>37% over the parent cultivar</td>
</tr>
</tbody>
</table>

Other Values

Centenario mutant cultivar shows four principal differences with the parental cultivar Buenavista, **better yield, earlier life cycle date, better protein content and better test weight.**

The combination of these characters with a good plant height and resistance to yellow rust made the cultivar Centenario very valuable for the highland farmers. It is the main barley variety.
<table>
<thead>
<tr>
<th>Variety (name)</th>
<th>Centenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop species</td>
<td>Amaranth (<em>Amaranthus caudatus</em>)</td>
</tr>
<tr>
<td>Mutagen</td>
<td>Gamma Ray (400 Gray)</td>
</tr>
<tr>
<td>Mutant trait(s)</td>
<td>Yield Potential, color of plant, Tolerance to salt</td>
</tr>
<tr>
<td>Yield increase</td>
<td>29%</td>
</tr>
<tr>
<td>Value</td>
<td>One of the more important cultivars (Growing in more than the 47% of the area), adapted to the highland near to 3200 m asl. It has high economic value increasing the farmer rentability and reducing malnutrition problem</td>
</tr>
</tbody>
</table>
Mean yield (kg/ha) of Barley Mutant Cultivars compared with old cultivars in farmer field at the highland of Peru

Increased profitability of farmers by planting mutant varieties of barley
1500 communities of Junin and Huancavelica improve barley seeds for consumption and sale.
DISTRIBUTION OF SEEDS TO FARMERS

Demostrative Plots at Farmer Communities Land

Ancestral custom in the family farming system in the Andes: Loan of seeds at sowing time (1 bag) and return of seeds at harvest time (2 bags)
Centenario
By the use of improved barley cultivars with diverse methodology plus crop technology
Farmers have a significative increment in barley productivity

Yield increase is 1100 kg / ha. At US$ 0.40 / kg that means US$ 440 / ha additional income per year. Centenario is adding US$ 6,600,000 to the national economy yearly. Considering all nine barley varieties, the contribution to the national economy of Peru is close to US$ 18,000,000.
NEW DEVELOPMENTS

QUINOA (*Chenopodium quinoa*) advanced mutant lines were developed with better tolerance to high temperatures, salt and resistance to the disease downy mildew, both limiting factors for quinoa introduction to the Peruvian coast.

BARLEY (*Hordeum vulgare*) advanced mutant lines with better minerals contents for food use. Mutant Line improved quality for feed use improving milk production in the highland.
Thank You