

## **Barley enhancement in Latin America in the last 20 years: a story of success**

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### **Abstract**

In this presentation are highlighted the barley history and trends in research and production in Latin America in the last 20 or more years. It is described how the different countries had progress in the production systems, research teams and especially in the germplasm that is offered to producers. Although each country differs substantially in the uses given for the crop and the environmental conditions, it is shown that objectives had been achieved and that the public and private sector have been working together to enhance the barley production in the region.

### **Keywords**

Barley enhancement, Latin America, Production

### **Introduction**

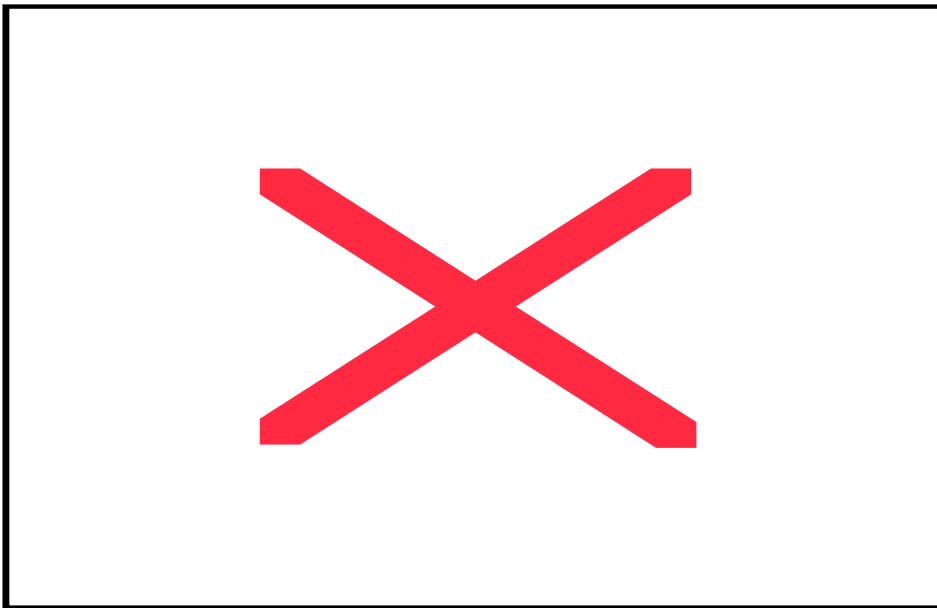
Barley in the Americas was introduced by Columbus as early as in his second trip to the New World. Barley was first planted in 1493 by the Spaniards that stayed at Isabela, Puerto Rico and from there it was introduced to Mexico and USA. It is hard to document the first crop in South America, but is mentioned that it most probably was in the Fort of Sancti Spiritus in 1527, in the actual province of Santa Fe in Argentina, together with wheat (Arias, 1995). From there it spread to the Andean Countries. The first scientific works in barley and wheat in South America were carried out starting in 1912 in Uruguay by Drs. Alberto Boerger and Enrique Klein, selecting pure lines resistant to leaf rust (gene Pa7) from populations being used by farmers.

Barley production in the continent can be divided in two main groups, based on ecological regions and final use. The Andean Region with Bolivia, Ecuador, Colombia and Peru where the main use of barley is for food, feed and forage, and the countries of the Southern Cone of South America with Argentina, Brazil, Chile and Uruguay, plus México, where the almost only

exclusive use of barley is malt for beer production. As we are going to show, the production in the first group is stable, whereas in the second is increasing due to the higher demand because of the rise in beer consumption in the continent and worldwide.

## Production

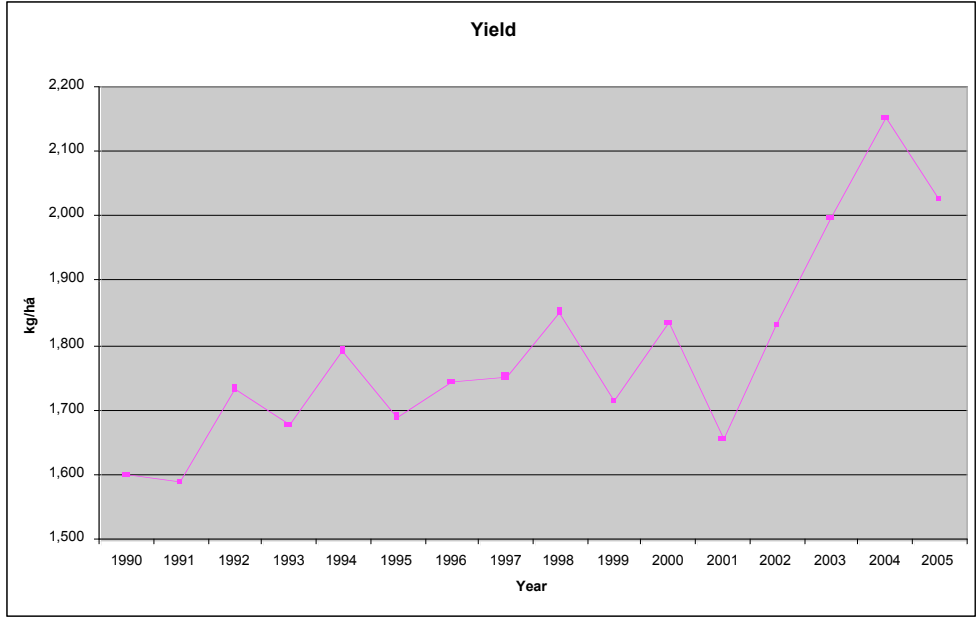
The area of barley harvested in Latin America have had a increasing trend in the last 15 years. The prices paid and competition with other crops have had important effect in the tendency (Figure 1).



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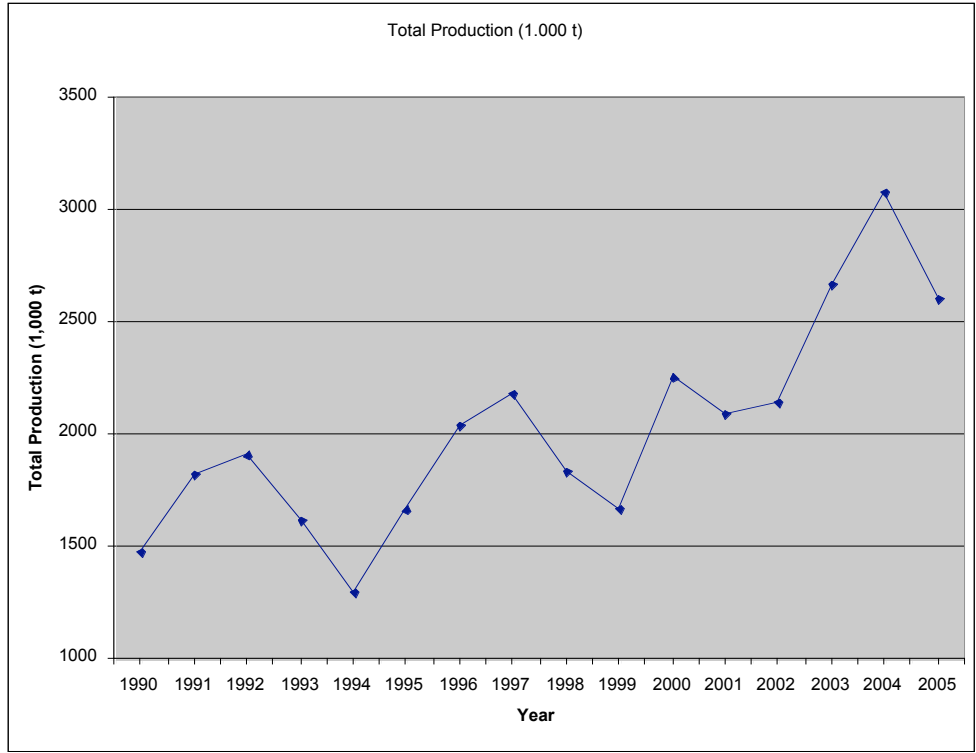
**Figure 1.** Total area of barley harvested (1,000 há) in Latin America from 1990 to 2005.

The average yield for the region has increased substantially in the same period, reflecting that the local research has had some positive effects. Average yield in the region increased from around 1.6 t/ha in the early 90's to more than 2.0 t/ha at 2005. Better agricultural practices and improved varieties helped to increase the average yields.



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**Figure 2.** Average barley yields obtained (kg/há) in Latin America from 1990 to 2005.

The total yield obtained from the same period reflected the result of both tendencies (area plus yield), increasing the total production more than twice for the same period.

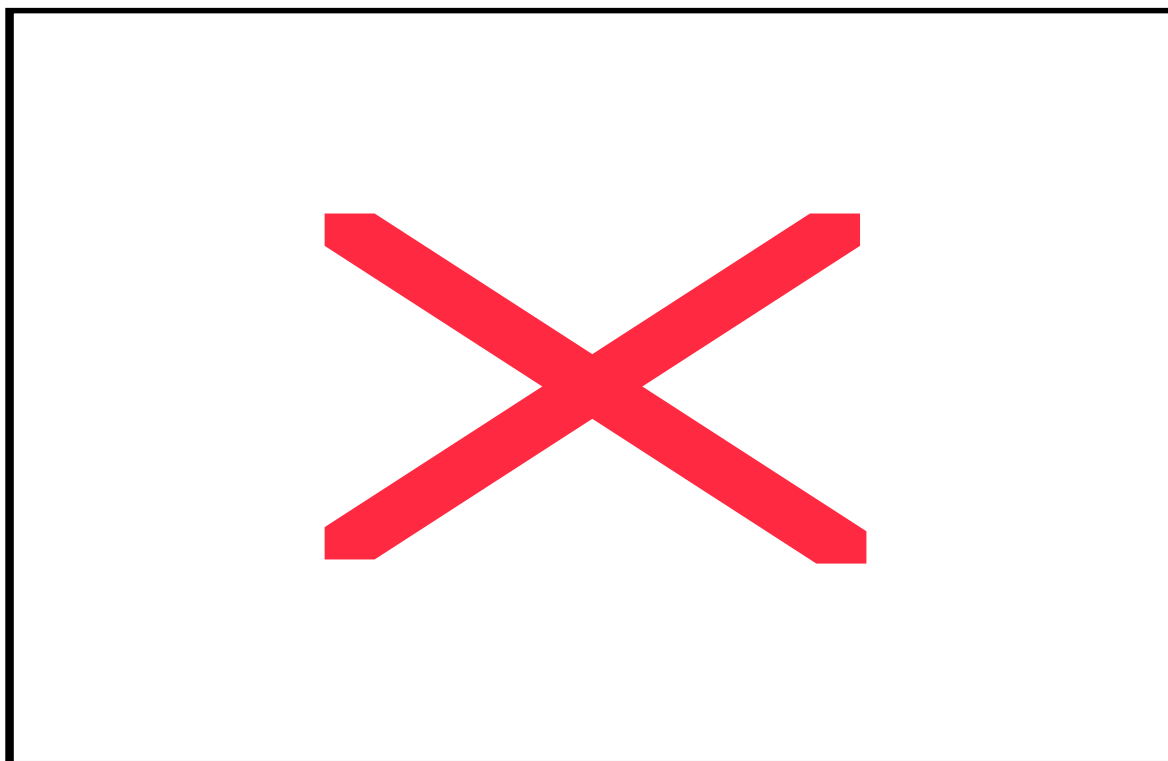


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**Figure 3.** Total barley production in Latin America from 1990 to 2005.

**Research**

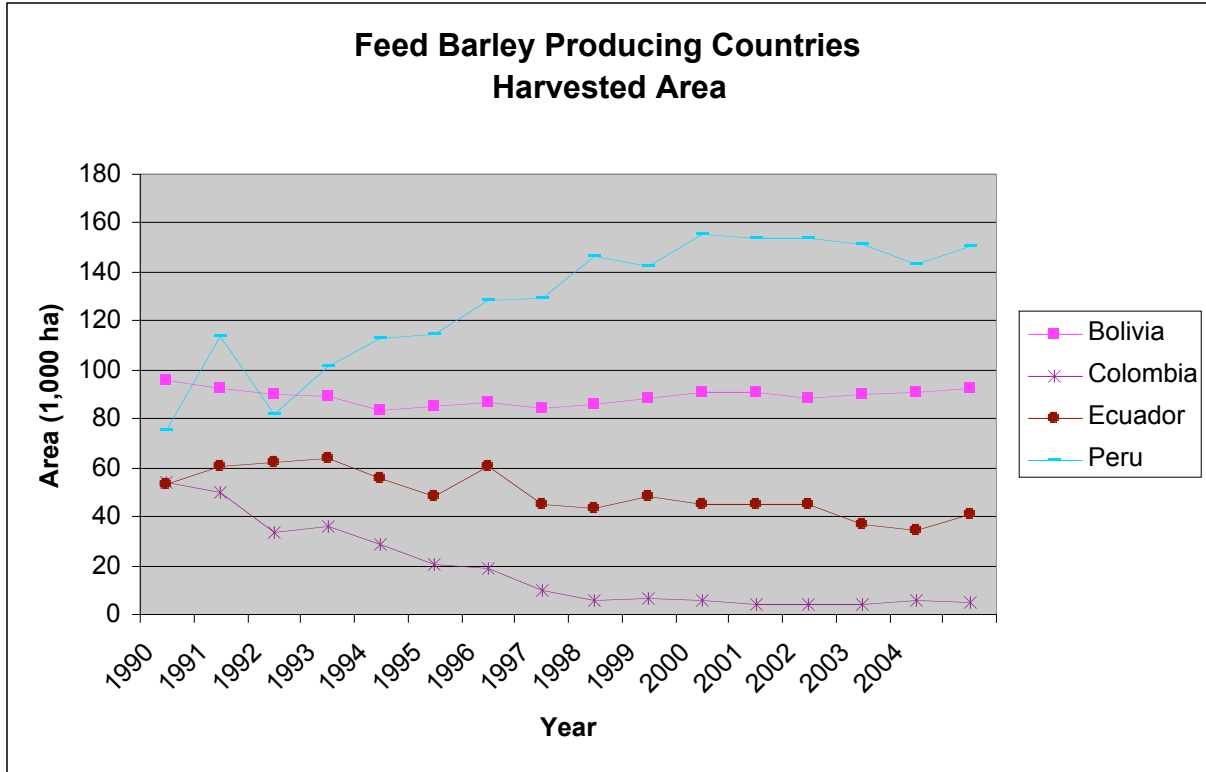
After the establishment of the first barley research program in La Estanzuela, Uruguay, research has been carried out at different times in different countries in the region. The barley breeding has always been appendices of the wheat breeding and has always counted with lower economic and human resources for research and breeding when compared to wheat. Despite this, an important volume of research and selection has been done in the Latin American countries in where barley is cultivated at commercial scale (Arias, 1995). As the main varieties released were for malting, very low local genetic resources have been used in crossings because they were forage and feed barleys. Almost all cultivated barley in Latin America has spring habit, except for Chile where some winter or facultative barleys have been released. Almost all cultivars are covered, except for few exceptions where hulless varieties were released, like in Ecuador, Peru and Brazil.

In the Andean countries an epidemics of stripe rust introduced from Europe in the late 70's affected all varieties planted at the moment, decreasing severely the production in all the highlands. All the native cultivars were highly susceptible, and the local breeding programs had to produce resistant cultivars in a relatively short period of time. At the present all released cultivars must show resistance to this disease in the Andean countries and Mexico.



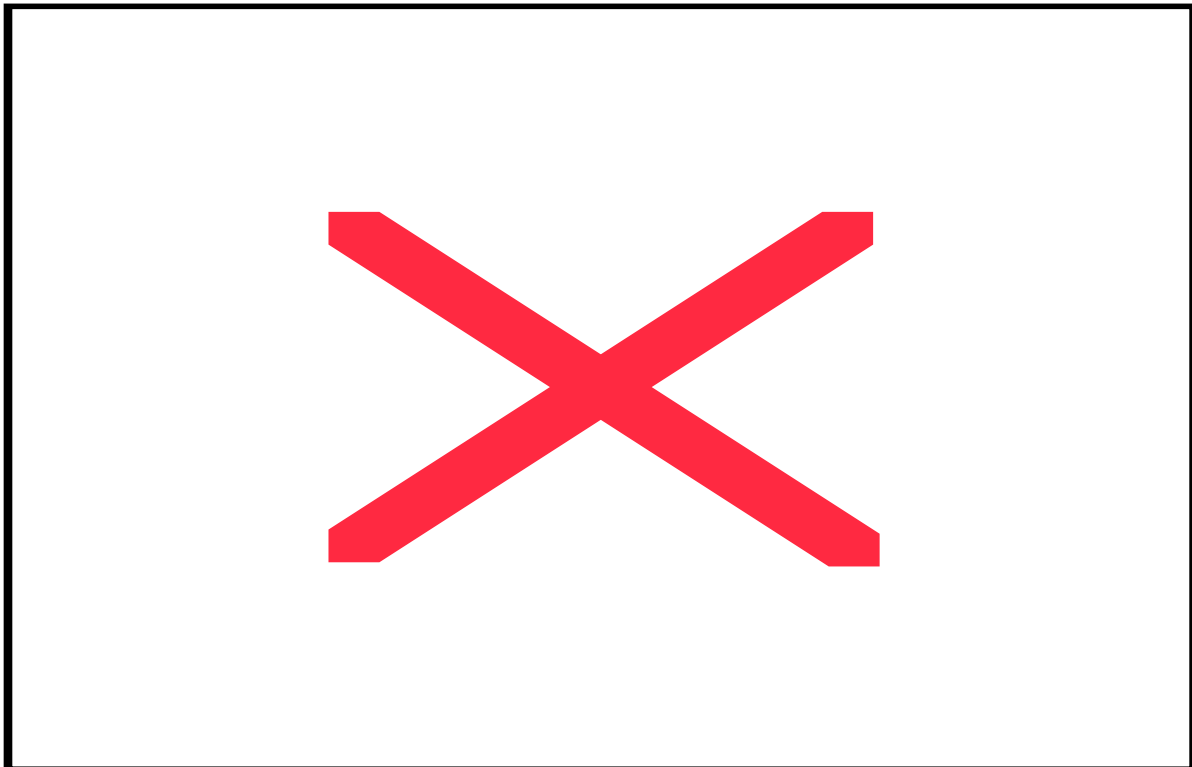
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**Figure 4a.** Total area harvested per malting barley producing countries in the period 1990 – 2005.



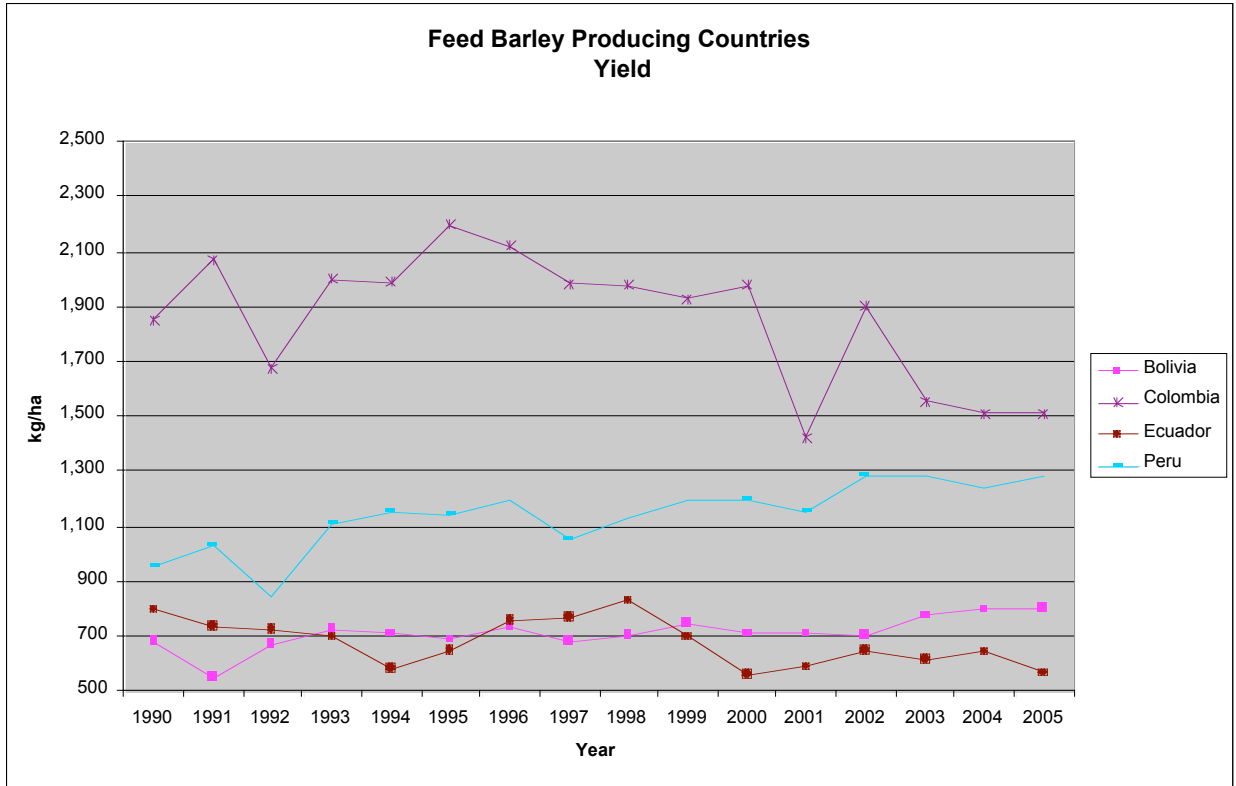
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**Figure 4b.** Total area harvested per feed barley producing countries in the period 1990 – 2005.



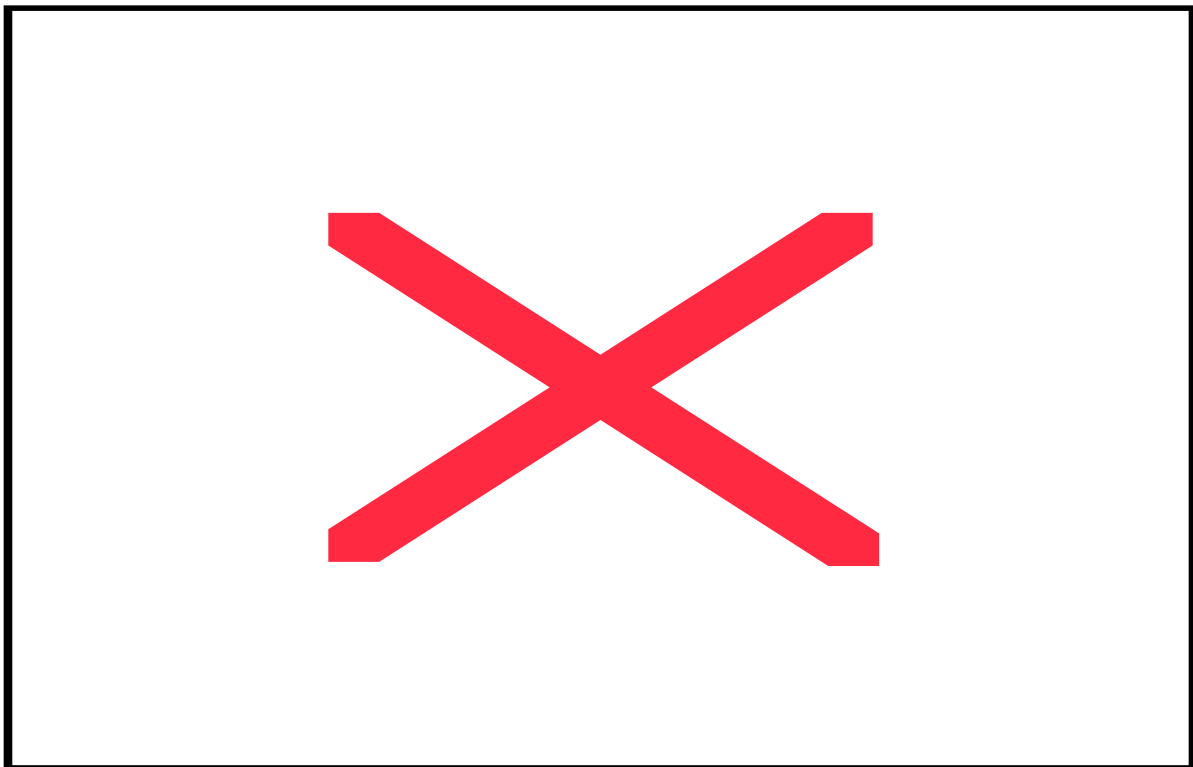
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**Figure 5a.** Yield obtained at malting barley producing countries from 1990 to 2005



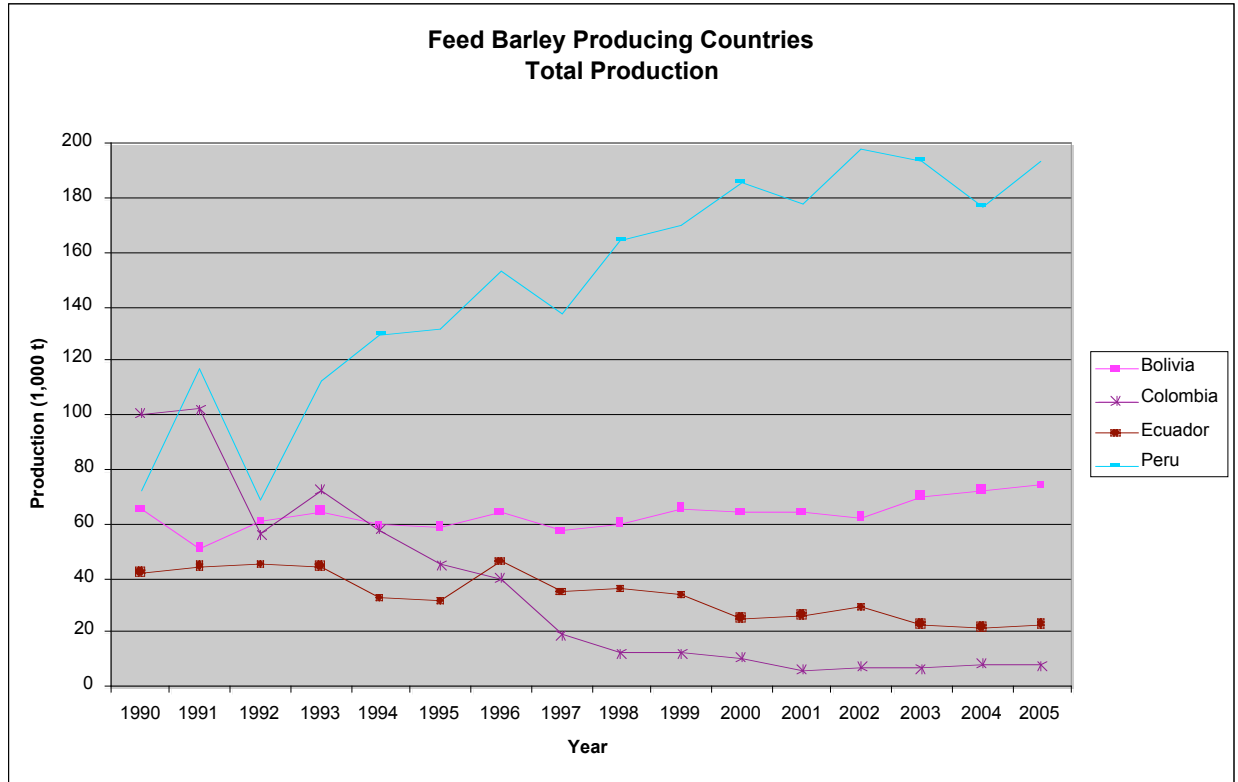
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**Figure 5b.** Yield obtained feed barley producing countries from 1990 to 2005



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**Figure 6a.** Total production obtained at malting barley producing countries from 1990 to 2005



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**Figure 6b.** Total production obtained at feed barley producing countries from 1990 to 2005

## Latin American Countries

### Argentina

In the early years, feed and forage barley had more importance than malting types in Argentina, which was the main barley producer of the continent for several decades. Between 1955 and 1960 an average of 874,000 has of barley was cultivated, with a maximum of more than 1 million hectares in 1956. The area decreased lately to a minimum of 75,000 has in 1985. The Quilmes Brewing Company was the first to start a scientific research and malting breeding program in 1917, hiring Dr. Enrique Klein (Arias, 1995). This breeder released the first cultivars to be used by the industry: Maltería Heda and Maltería 150. The National Institute of Agricultural Technology (INTA) worked in association with Quilmes to incorporate leaf rust resistance and scald to Maltería Heda. Later Quilmes supported the cultivars released by Mr. Gino Tomé – Ana, Bonita, Laura – and more recently, since 1974 the company supported by their own program under the leadership of Mr. Hugo Savio, releasing the cultivars Quilmes Pampa, Q. Alfa, Q. Sur, Q. Palomar, Q. Payné, Q. Ayelén, etc. After 1988 a new company, Maltería Pampa initiated activities, associated at that time to the Brazilian Brewing Company Brahma. This company is now owned by InBev (created by merger of Interbrew and AmBev). Besides the private sector, the INTA always participated in barley research, especially through their stations at INTA Bordenave and the Institute of Genetics Ewald Favret at Castelar. More recently the University of Buenos Aires also participated in basic barley research (Passarella et. al, 2003). The industry at the present are also using as cultivars Scarlett developed by Breun and B1215 from BARI. Cargill is also playing important role in the country with a large malthouse that demands large amounts of barley.

Argentina has enormous potential for cereal production. Soils with high fertility sustained by an adequate rotations, soil conservation practices and a relatively dry climate that do not favor disease development allows high production with low inputs and excellent sanitary conditions. The rain fed conditions sometimes creates drought stress, but the still makes the agriculture profitable due to the low inputs used. The area planted and total production more than duplicated in the last 15 years (Figures 4a and 6a) and the yield also substantially increased in the same period (Figure 5a). Four programs are currently breeding barley: INTA Bordenave, Quilmes Malting & Brewing Company, Pampa Malting and most recently Busch Agricultural Resources Inc. – BARI (Anheuser-Busch). Emphasis has been made in obtaining cultivars with high yield and quality that can compete with wheat in the most productive areas. Selection has also been made for drought and heat tolerance during the grain filling period. Diseases are usually not important due to relatively dry environmental conditions.

## Brazil

Forage and feed barley exists in Brazil since the Portuguese colonization time (1583). The Antarctica Paulista Brewing Company started a production program in the early 30's and in 1950 hired the services of Weibull Research Company from Sweden to carry out breeding activities. This company discontinued the activities in 1970, distributing its germplasm among the largest Brewing Companies (Antarctica & Brahma), which started their own programs (Arias, 1985). In 1975 Brazil became the third world importer of malted barley, so the government launched a plan to increase the barley and malt production in the country, targeting the self sufficiency. In 1977 a barley research program was initiated at the Brazilian Agricultural Research Corporation – EMBRAPA in Passo Fundo, creating a breeding, genetics, pathology as well as a testing network.

Barley production in Brazil has higher costs than other countries in the region. Erosion has to be controlled and conservation agriculture plays an important role in the production system, especially in the high slope fields of the Southern states. Acidity has to be corrected to avoid aluminum toxicity and fertilizers have to be applied for phosphorus and potassium. Nitrogen application has to be split to avoid losses due to the abundant rainfall and fungicides are applied for disease. More recently, *Fusarium* head blight became also important.

Despite the several challenges, research has been able to supply cultivars with adequate agronomic performance as well as the high quality parameters requested by the industry. That was reflected by enhancement of the physical quality (plumpness, color, husks, shape) and chemical quality traits (malt: extract, protein, beta-glucan, DP, etc.). Better resistance to biotic and abiotic stresses is present in the newest cultivars. Varieties were supplied by programs from Antarctica & Brahma, which were combined after both companies merged into Ambev and became part of InBev – as well as by EMBRAPA. Barley research is coordinated through EMBRAPA Trigo at Passo Fundo and supplementary research is carried out and/or supported by Agraria Entre Rios Cooperative Malting Company in the State of Paraná, EMBRAPA Cerrados in the central region, Malteria do Vale in the State of São Paulo and Agricultural Universities (eg. in the Federal University of Rio Grande de Sul at Porto Alegre). Breeding objectives are high and stable malting quality and yield, early maturity, tolerance to Aluminum toxicity, decreased grain sterility, tolerance to pre-harvest sprouting and high temperatures during grain filling, and resistance to lodging and prevalent diseases: net and spot blotch, powdery mildew, leaf rust, *Fusarium* head blight and also rice blast. Germplasm used are locally developed cultivars and lines as sources of adaptation and introduced two row malting materials mainly from Europe, Canada, USA, and Australia. Modified bulk is the method mainly used, but according to the needs and objectives, pedigree, SSD, double haploids can be used. At the

beginning the introduction of Al toxicity tolerance by the cultivars FM 404 and Antarctica 01 allowed the expansion of the crop and earliness was essential for double cropping. Quality parameters were enhanced with the release of the varieties MN 599, MN 656. BR2 released by EMBRAPA in 1989 was the most widely grown cultivar planted in the country from 1994 to 2002. MN 698 released by Brahma in 1997 and BRS195 from EMBRAPA (release in 2000) were the most widely used cultivars until the present. Other cultivars planted are EMBRAPA 127 and EMBRAPA 128. (both released in 1997).

The total area grown has oscillated but increased in the last years, as well as the yields obtained and the total country production, which almost duplicated (Figures 4a, 5a, and 6a). Despite that the local production supplies only 30-60% of the raw material required by the industry, giving a lot of room for production increase to reach the 1.2 million tons per year needed by the brewing industry.

### Bolivia

Barley is cultivated in the Andean Countries from 1,800 to more than 4,000 m asl. At higher altitudes barley does not produce grain, being utilized for forage. Around 85% is used for food, feed and forage and the remaining is used for malt. Barley grown in the highlands has good conditions for production, although the small size of the production areas make it difficult to obtain higher yields. Limited research is carried out in this country at the present after the restructure of the national agricultural research system in 2000.

### Colombia

Barley is cultivated in Colombia around 2,300 and 2,600 m asl where the best yields and quality are obtained. Growers wait until the first rains to plant and they try to fit the harvest to the lower rainfall season. The area has been consistently decreasing since the industry has been giving priority to imported barley and malt. Growers associations are also encouraging the planting of legume and pulses.

### Chile

Barley is produced in Chile since the conquest time. The National Society of Agriculture started the first research at the beginning of the XX century and later by the Department of Genetics and Breeding of the Direction of Agriculture and the College of Agriculture of the University of Chile. National Agricultural Research Institute – INIA started a program in 1976 and two years later a research agreement with the Compañía Cervecerías Unidas (CCU) was initiated. This program released cultivar in a constant manner, enhancing the industrial quality. Before that breeding was based mostly in the introduction of European cultivars: Breusn Wisa and Firlsbeck Union were used in 1978. Carina replaced the first in 1980. After that the National program released several cultivars that covered the production needs: Libra INIA, Leo INIA, and Acuario INIA which was planted in 100% of the area in 1999. More recently the local companies, CCU started recommending introduced varieties especially from Europe – Barke, Scarlett, Alexis, etc. The excellent growing conditions at the southern region allow the highest yields obtained at commercial fields in the region (Arias, 1995). Positive conditions are mostly explained by favorable weather conditions, long days and mild temperatures during grain filling.

The total area increased significantly in the last few years (Figure 4a), reaching close to 30,000 ha this year. With the highest yields in the continent, the total production also increased in an important manner lately (Figures 5a and 6a).

## Ecuador

In Ecuador the growing season depends on the rainfall distribution. The INIAP is the main institution dedicated to barley research and has been successful in the release of several local varieties. Like in Peru, the use of barley as staple food is very important, and in the local supermarkets barley products can be found in different forms: flour, flakes, pearled, etc. The crop is cultivated in small properties, usually not larger than 1 ha. It is estimated that more than 120,000 families grow barley for self consumption. Due to environmental and varietal limitations for malting barley production, almost all barley and malt used by the local brewing industry is imported. In the highlands the production systems have barley in the rotation, especially above 3,200 m asl. The rotation usually includes potato, barley and legumes. The low income conditions of the farmers and the high risk of the crop makes barley be grown with basically no fertilizers or agrochemical inputs. For that reason resistance to biotical and abiotical stresses is the main breeding objective of the local breeding program carried by the INIAP. The offer of varieties have been diversified. At early 70's most of the planted cultivars were local landraces multiplied by native farmers. After the stripe rust epidemics, several enhanced cultivars were released: Dorada, Duchicela, Terán 78, Shyry 89, Calicuchima 92, Atahualpa 92, Rita Pelada, Shyry 2000, Cañicapa and Quilotoa. This diversity in options to producers includes covered, hulless, 2-row and 6-row varieties.

The total area planted has been oscillating in the last years, as well as the yields and the total production in the country. This has mostly responded to changes in economical conditions.

## México

Barley was introduced into Mexico in the sixteenth century by Spanish farmers and has since been grown since in the High Valleys of the Central Highlands. The first sowings were of Spanish varieties – “Crudo” or “Criollo” – brought over by the colonists. However, these early varieties performed poorly due to the difference in production conditions between Spain and Mexico.

Barley grain production was boosted by the establishment of the first brewery in 1865. Despite this demand, it was not until nearly a century later in 1954 that a research program was established by the Ministry of Agriculture, the Rockefeller Foundation and the Mexican Malting Barley Association in response to problems of low industrial quality and very low yields. After this first agreement was signed, materials were selected from a worldwide collection of some 4,000 accessions with the hopes of finding varieties better adapted to the demands of Mexican production. Unfortunately, these strains did not measure up to the quality or yield demands of the industry by virtue of the fact that they were North American varieties an ill-adapted to Mexican conditions. In an attempt to surmount these hurdles, the Office of Special Studies began the first program for Genetic Improvement of Malting Barley in 1957 at El Horno with the involvement of Dr. Ignacio Narváez, Dr. Manuel Navarro-Franco and Ing. José Rodríguez-Vallejo, among others.

Malting barley is an important crop in global and local markets, most notably for its role as a raw ingredient in brewing industries. As such, malting-quality barley is the main source of income for thousands of families in relevant production areas. Barley is also used as a food source for people, though to a lesser extent than its uses in brewing and as forage for livestock.

Furthermore, barley can be grown successfully in areas of low and irregular rainfall, can escape early frost damage and provide production security to growers due to its short growing period. In Mexico, the main areas of barley production are the High Valleys of the Central Highlands in the

States of Hidalgo, Tlaxcala, Puebla and state of Mexico. Barley is also cultivated in the states of Coahuila, Nuevo León, Guanajuato, San Luis Potosí, Jalisco, Durango and Zacatecas. In the Bajío Region (parts of Querétaro, Michoacán, Guanajuato and Jalisco) barley is grown under irrigated systems.

Some 313,000 ha are annually planted to barley in Mexico with production totaling roughly 750,000 tons and a national average yield of 2397 kg ha<sup>-1</sup>. If the technology developed by INIFAP were applied in all the planted areas, it is conceivable to expect that yield be increased by 166% in the High Valleys of the Central Highlands in the States of Hidalgo, Tlaxcala, Puebla and State of Mexico and by 266% in the Bajío and similar areas. With these yields, barley farming should be a profitable venture in all producing areas of Mexican production.

The first improved variety of barley in Mexico was developed in the 1950s through selection of Canadian segregant F3 lines and assayed in the Valle de Toluca Experimental Station in 1955. Toluca I was the first improved variety released for commercial plantings in 1959 and was well accepted by producers due to its good agronomic characteristics and excellent industrial quality; however this variety was not grown for long due to grain shaking and early ear fall which reduced yield by 50%.

In the 1960s five new varieties were developed, Promesa, Porvenir, Chevalier del Bajío, Apizaco and Apam. Promesa was planted mainly in the High Valleys of the Central Highlands while Porvenir was widely accepted in the Bajío until late 1976. Chevalier del Bajío was the result of masal selection carried out by Ing. Felipe Suberbie from Extractos y Maltas in commercial planting of two-row barley. This variety was widely accepted in the Bajío where the best yields were obtained. Apizaco was the result of the first crosses carried out by INIA (now INIFAP) researchers, and was released for commercial plantings in 1966 and sown until 1971 when it was discarded due to grain filling problems which adversely affected yield.

In the 1970s the Genetic Improvement Programme for Barley developed seven new varieties: Zoapila, Celaya, Puebla, Cerro Prieto, Centinela, Tlaxcala and Ensenada. Only three of them stood out and Puebla was released for commercial plantings in 1974 in both rainfed and irrigated systems. Cerro Prieto was the result of crosses carried out at the University of North Dakota by Dr. Manuel Navarro as part of his research program and was released for commercial plantings in 1975 and sown in the main growing areas.

Centinela, owing to its precocity and good adaptation to poor soils in the High Valleys of the Central Highlands is considered as one of the best barley varieties ever in Mexico. It was released for commercial plantings in 1975 and recommended for rainfed systems. These three varieties have been of great importance for both rainfed and irrigated systems and for the brewing industry, because they allowed for self-sufficiency for Mexico in barley production in the 1980s.

Another group of varieties made up by Rumorosa, Guanajuato, Cucapah 87 and Esperanza were developed in the 1980s. Guanajuato was the first two row variety developed in Mexico, and was principally directed toward malt production for brewing. Its release for commercial purposes began in 1984, chiefly in the Bajío and Chihuahua. Esperanza is the first and only semi-dwarf variety obtained in Mexico, showing an 8.0 t ha<sup>-1</sup> yield potential in irrigated systems and a tolerance to yellow linear rust (*Puccinia striiformis* f. sp. *hordei*), a disease that in 1988 greatly affected commercial barley plantings in Mexico. Production in irrigated systems was still possible with the development and release of this variety as a result of its resistance to yellow rust and its high yield in irrigated systems. Rumorosa and Cucapah 87 were released as forage varieties for Northwest Mexico.

Esmeralda was obtained through a simple cross performed at the beginning of the 1980s and was commercially accepted in 1992. It was the first variety developed for rainfed systems in the High Valleys of the Central Highlands, showing tolerance to linear yellow rust (*Puccinia striiformis* f. sp. *hordei*), and surpassed Puebla and Centinela in yield trials with and without linear yellow rust. Alternate selection in irrigated systems in fall/winter and in rainfed systems in spring/summer contributed to Esmeralda's wide adaptability.

The release of Esmeralda and Esperanza allowed production in both rainfed and irrigated systems and subsequently benefited producers and the brewing industry. Supplementary imports were also reduced, and advantage for local farmers as they were able to meet the demands of the local brewing industry.

Adabella was the result of a single cross carried out in 1989 and was commercially accepted in 2004. This variety is adapted to rainfed systems in the High Valleys of the Central Highlands, is tolerant to yellow linear rust (*Puccinia striiformis* f. sp. *hordei*) and leaf rust (*Puccinia hordei*), surpasses Esmeralda and Puebla in yield and could replace Esmeralda in some rainfed production environments susceptible to leaf rust attacks.

## Perú

In the decade of the 50's the malting industry conducted a program for variety introduction in the Mantaro Valley and Cusco. There are basically two main growing regions, the central highlands at more than 3,400 m asl under rainfall during the rainy season and the coast under irrigation. The main use is for food, feed and forage and only 16% is used for malt.

The research and breeding has been mostly conducted by the Cereal Program at the University of La Molina, at Lima, which started in 1968. This strong program was able to interact with private and public companies as well as international programs, being able to provide the results demanded by the producers. The production system of barley is similar to the other Andean countries and the cultivar demand has been covered by the program, enhancing the production and yields in last years. The cultivars Zapata 588, UNA 80, UNA 8270, Yanamucllo, La Molina 94, La Molina 95 and La Molina 96 have been an example of this wide offer which includes covered, hulless cultivars with resistance to the most prevalent diseases and the quality and stable yields demanded by the consumers.

## Uruguay

The first record of barley crops in the country was by Oyarvide in 1784 in the Department of Maldonado (Berro, 1901) although it most probably at that time barley had already been grown by the Portuguese after settling in at Colonia do Sacramento in 1680. In 1855 the brewing companies of Montevideo and San José promoted the crops by distributing seed to local growers. The first experiments were conducted by Professor Damman from the College of Agriculture from University of the Republic of Uruguay. In 1912 Dr. Alberto Boerger started a selection program from local populations (heterogeneous landraces). Breeding was discontinued and during many years Argentinean varieties were grown until 1968, when the Fabricas Nacionales de Cerveza – FNC ("National Brewing Companies", now MOSA) started a breeding program making the first crosses from where the varieties FNC 1, FNC 2, FNC 4, FNC 6 and FNC 6.1 were released, derived from crossed between cultivars from INTA (Magnif 102 & Magnif 104) resistant to diseases and German varieties. Lately new breeding and research programs were initiated by the National Agricultural Research Institute – INIA and the College of Agriculture of the University of the Republic in 1988. Among the private companies, Cervecería

y Maltería Paysandú – Norteña (CYMPAY) and and OMUSA also started their own breeding programs, based on worldwide introductions and some crossing program.

After 1990 the Barley Board initiated activities, coordinating all the barley resources given by the industry and all barley research in the country. At the time the four private companies, Cervecería y Maltería Paysandú – Norteña, Fábricas Nacionales de Cerveza S.A., Maltería Uruguay and Salus S.A. were growing all the barley area in the country. More recently the consolidation of the industry reduced the number of companies to AmBev (part of InBev) and Maltería Oriental. After a couple of years of initiation of the Barley Board, the Technological Laboratory of Uruguay – LATU started to carry out micromalting analyses to support the research programs. The main objective of the programs was to obtain cultivars with stable malting quality and yield, as well as resistance to the most prevalent diseases. Germplasm used in the programs are locally developed materials, cultivars from Australia for agronomic types, Europe for quality and North Dakota for the Northern warmer region. Early maturing cultivars with some photoperiodic response are best adapted to Uruguayan conditions, in where the optimal growing season extends from June - July to November - December. Cultivars locally developed on introduced from Argentina, Brazil, Australia, Europe and North Dakota have been used by industries' production programs. The main cause for cultivar change has been the increase of quality requirements and susceptibility to diseases.

The barley area, yield and production (Figures 4a, 5a and 6a) as well as exports increased from 20,000 t in 1963 to 100,000 in 1991, supported by the malting and brewing industry. In the last 15 years the area had oscillations due to commercial conditions and sometimes due to climatic situations most commonly excess rainfall, reducing grain quality and favoring necrotrophic diseases. Disease are the most limiting yield factor, followed by high temperatures during grain filling and drought during the growing cycle, mostly in late planted crops (Germán, 2004).

## References

Arias, G. 1985. Ertrag, Ertragsaufbau und qualität brasilianischer braugerstensorten. Dissertation, Freisig – Weihenstephan. D Gräbner, Altendorf beim Bamberg.

Berro 1901

Arias, G. Mejoramiento Genético y producción de cebada cervecera en América del Sur. 1995. Regional Office of the FAO for Latin America and Caribbean. 160p.

Germán, Silvia. 2004. Breeding Malting Barley under stress conditions in South America. Proceedings of the 9<sup>th</sup> International Barley Genetics Symposium, Brno, Czech Republic, 20 – 26 June 2004. pp. 390-398.

Passarella, V.S., R. Savin, G. Abeledo, G. Slafer. 2003. Malting Quality as affected by barley breeding (1944-1998) in Argentina. Euphytica 134:161-167.