17th Australian Barley Technical Symposium,

13-16 September, 2015,
Sydney, Australia.

Barley improvement programs at ICARDA to meet the global challenges. 17th Australian Barley Technical Symposium. ***Full papers collated. pp: 107-110***

Barley improvement programs at ICARDA to meet the global challenges

R.P.S. Verma*, S. Gyawali and A. Amri,
International Center for Agricultural Research in Dry Areas (ICARDA)
*Corresponding author (r.verma@cgiar.org)

Abstract

The International Center for Agricultural Research in Dry Areas (ICARDA) is one of the 15 CGIAR centers and has a global mandate for barley improvement, specifically for more than 19 million ha of barley grown in dry areas across the globe. ICARDA's barley improvement program has been reorganized into high input (HI), low input (LI) and winter (W) barley programs to address the requirements of different agro-climatic conditions/regions. The HI barley program targets germplasm improvement for optimal conditions for feed, food and malt purposes, while LI barley program targets germplasm improvement for stressed environments to address the feed, forage and food uses. Both, HI and LI barley programs deal with both hulled and naked spring barley improvement activities. The winter barley program is basically focused to improve germplasm for colder regions in West and Central Asia where cold and frost are the major stresses along with drought. Each year, nearly 10,000 advanced lines are evaluated for various agronomic, biotic and abiotic stress tolerances, and quality parameters in each of the breeding programs. ICARDA's gene bank holds more than 33,000 barley accessions of which 2,042 accessions are wild relatives of barley. Recently our gene bank has successfully used the Focused Identification of Germplasm Strategy (FIGS) to mine efficiently this collection for by selecting manageable subsets with higher frequencies for finding the sought traits. ICARDA's barley improvement programs are now streamlined with CGIAR Research Program on Dryland Cereals. In 2013-2014 and 2014-2015 cropping seasons, 317 and 339 sets of international trials & nurseries, respectively, were distributed to more than 60 collaborators in 35 countries. During 1977-2014, more than 250 barley varieties have been released across globe by different countries, with direct introduction of germplasm from ICARDA's barley breeding programs, out of which 18% releases were by developed countries including Australia and Canada. These releases do not include the use of ICARDA bred advanced lines through hybridization with respective national germplasm. In recent year, ICARDA's feed and food barley improvement programs aim at improving nutritional qualities of barley, specifically Zn, Fe, and β-Glucan contents. Simultaneously the malt barley improvement has been initiated through private-public partnership in Mexico with the target to improve/ identify better malting quality germplasm for developing countries in Africa and Asia. The demand for industrial uses of barley is on sharp rise and local industry is looking for assured supply of quality raw materials through contract farming with a possibility of additional income to farmers through premium price for better quality in east Africa and south Asia.

Keywords: Barley, FIGS, Germplasm, *Hordeum*, ICARDA

Introduction

The International Center for Agricultural Research in Dry Areas (ICARDA) is one of the 15 CGIAR centers and has a global mandate for barley improvement, specifically for more than 19 million ha of barley grown in dry areas across the globe. Realizing the fourth major grain crop after rice, wheat, and maize, ICARDA has been engaged in contributing research and development of barley at global scale since its establishment. Barley is grown in more than 48 countries with 16.1 m ha in dry areas under ICARDA's immediate mandate regions (Fig. 1). There are more than 228 million farming families who are directly engaged in barley production in

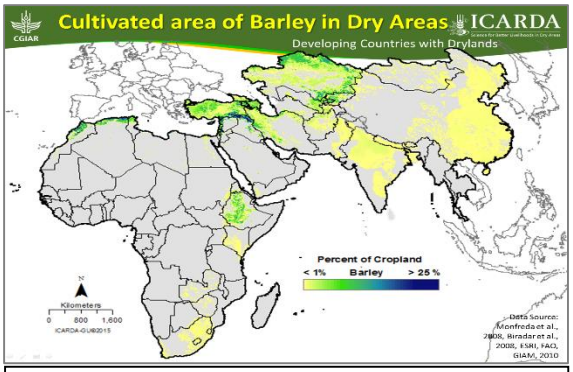

Fig. 1. Distribution of barley growing developing countries in CRP DC (FAOSTAT 2013).

developing countries with potentially 55 million further beneficiaries arising from off-farm activities in barley value-chain (FAOSTAT 2013).

CRP Dryland Cereals (Barley Component)

ICARDA's barley improvement programs are now streamlined with CGIAR Research Program on Dryland Cereals (CRP DC). In CRP DC, barley program is having six focal countries (Table 1) in the five regions to address the needs of many target countries. However, barley being the global mandate crop, ICARDA has been serving non-focal countries as well through direct germplasm sharing. Table 1 presents the current constraints and/or opportunities of barley improvement in focal countries.

Table 1. Focal and target countries with production constraints under CRP DC on barley.

Region	Focal Country	Targeted countries	Production constraints of the region
North Africa	Morocco	Algeria, Tunisia, Libya, Egypt, Mauretania	Heat and drought stress, lodging, diseases and insect pests
East Africa	Ethiopia	Eritrea, Kenya, Tanzania, South Africa, Yemen	Lower productivity of malt and food barley (63.3 k tons deficit in 2015), drought, disease resistance
South Asia	India	China, Pakistan, Afghanistan, Nepal, Bangladesh, Bhutan	Productivity of malt barley (demand increasingly 10-15 % annually), lack of high yielding varieties for marginal areas, food (high β-Glucan), biotic stresses (stripe rust, foliar blights)
West Asia	Iran	Syria, Iraq, Jordan, Lebanon, Armenia,	Cold and drought stress, biotic stresses (leaf rust, powdery mildew, and scald)
West Asia,	Turkey	Syria, Iraq, Jordan, Lebanon, Armenia, Georgia, Azerbaijan,	Heat and drought stress, biotic stresses (net blotch, scald, insect pests)
Central Asia	Kazakhstan	Uzbekistan, Azerbaijan Tajikistan, Kyrgyzstan, Turkmenistan	Drought, heat, cold and salinity stresses, lower productivity of malt and feed varieties, diseases and insect pests
Latin America barley requirements are being addressed under contract research in Mexico			

Barley is the keystone crop in non-tropical and tropical dry area across the globe. Livelihood of poor farmers and their livelihood strategy which is based on livestocks (especially small ruminants) they own, are dependent on barley (both as food and feed, and forage crops) (Fig. 2). In dry areas, a conservative estimate indicates that one ha of barley production can normally supports 5 small ruminants (sheep and goat) for feed and fodder for one year. Therefore, potentially barley has been key feed and forage crops supporting more than 80 million small ruminants in dry area. It is evident that small ruminants are the livelihood assets for small farmers especially in dry areas and barley has pivotal role in livelihood of poor farmers.

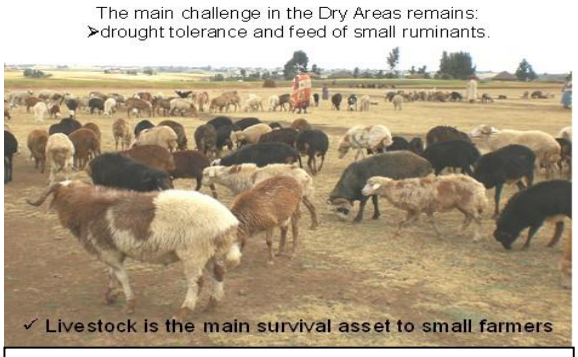

Fig. 2. Barley in dry areas plays pivotal role to survival strategy of poor farmer through "small ruminants".

Barley is the climate resilient crop for present and future. Barley is successfully grown and cultivated in drylands of arid, semi-arid, and temperate regions of the world in general and Africa and Asia in particular. Barley is the most important feed and food crop for climate change considering its resilience and buffering capacity as well as to adapt quickly to the gradients of moisture stresses, and short growing season. Being one of the most early vigor and faster vegetative growing crop among small grains, it is adapted to the raising temperature and frequent droughts stresses. The range of cultivation of barley is from the sea level to as high as 10-12 thousand feet high in the cold deserts (where no other crop is growing), providing the human food, and feed and forage for livestock. The added advantage of survival in cold stress with faster biomass

production makes winter type barley a possible option in cold regions of west and central Asia. The worldwide increasing salinity problem also makes barley as a crop from marginal and problematic soils.

Fig. 3. Value added products of barley with potentially several new products in pipelined for future.

In the dryland area, major cropping systems is cereal-food legume (and/or feed) based system and barley dominates as major cereal in the cropping systems prevailing in the arid and semi-arid zones. In the CRP programs, CRP Dryland Cereals (DC) and CRP Legumes are working closely to benefit from synergies between two CRP programs and importance of legume-cereal based cropping systems across dry areas. Therefore Consortium Office has decided to merge DC, Legume and Dryland System together in future CRP programs. The short and fast growing season of barley perfectly fits farmer cropping systems with various legumes. Under the one year with two seasons rotations in winter season barley is an ideal crop for rotation with legumes /cereals of summer season. Barley is one of the most potential dryland crops for harnessing benefits from value addition of natural properties of barley grain such as food crop (value added food products), forage (hydroponic green forage throughout the year with limited water use), malting (alcoholic and non-alcoholic beverages), and nutraceutical food (barley powder and barley flakes with rich in β-glucan to lower cholesterol, higher antioxidant activities).

Barley Improvement Program in ICARDA

In ICARDA, there are four major component of barley research, 1) low input program for stressed environment (Food and feed barley), 2) high input program for optimal environments (Food, feed and malt barley), 3) winter barley program (food and feed under cold and drought stressed environments), 4) barley genetic resources for trait discovery and integration (pre-breeding using wild barley, landraces and elite lines). In each programs, nearly 10,000 elite lines are evaluated each year to meet the demand of diverse genetic materials targeted to specific ecological regions and niche specific preferences of farmers. In last two years (2013-2014 and 2014-2015 cropping seasons) only, ICARDA contributed a total of 656 trials and nurseries to more than 60 collaborators each in 35 countries (majority developing countries) through International Nursery Program. During 1977-2014, more than 250 barley varieties have been released across globe by different countries, with direct introduction of germplasm from ICARDA's barley breeding programs, out of which 18% releases were by developed countries including Australia and Canada. These releases do not include varieties developed through hybridization with ICARDA germplasm. The success of continuous improvement of ICARDA germplasm lies in the fact that ICARDA barley program has used barley landraces and wild germplasm for trait discovery and trait integration for several years. ICARDA's gene bank holds more than 33,000 barley accessions of which 2042 accessions are wild relatives of barley. Recently our gene bank has successfully used Focused Identification of Germplasm Strategy (FIGS) to mine potentially important germplasm for various traits. Currently ICARDA is collaborating with several institutes and organization globally mining barley genetic resources using FIGS approaches including BARLEY-CAIGE program with Australian partners. So far, seven FIGS sub-sets have been developed in barley specifically targeted for abiotic (drought) and biotic stresses (powdery mildew, net blotch, yellow rust, BYDV, and barley gall midge). FIGS approach uses algorithms linking environmental conditions with sought traits to select subsets with fewer accessions having higher probability of finding the sought traits. This approach has already allowed to identify adequate sources of resistance to PM, BYDV, Net blotch and drought.

The genetic diversity of ICARDA's barley programs are high and comparable to several international collections (Fig. 4). In the past several 2-rowed by 6-rowed crosses have been made therefore, often, an overlap between two-rowed and six-rowed germplasm is reported within ICARDA's barley genetic resources.

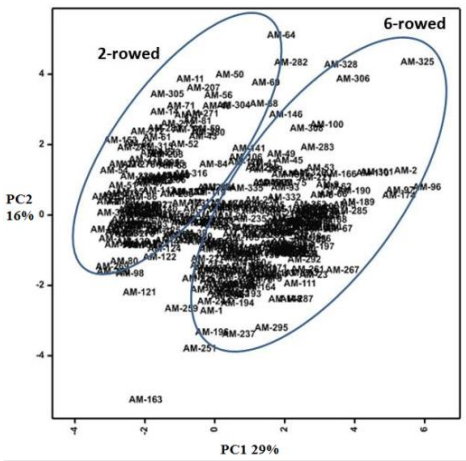

Fig. 4. Genetic diversity of AM-15 panel of ICARDA's based on agronomic traits. (Data unpublished, 2015)

The latest inclusion in ICARDA barley program is the malting quality improvement aspects, currently being addressed through Private-Public Partnership (PPP), in Mexico with M/s Impulsora Agricola de SA (IASA) a joint subsidiary of AB InBev and Heineken groups. The program has identified advanced genotypes with excellent grain and malt traits in two and six row types, which have great potential in East Africa and South Asia regions where the demand on malting barley is on continuous rise in recent past. Ethiopia and India national programs are making good use of such genotypes in evaluation and release in the country for meeting the requirement of malting and brewing industry. Another aspect of malt based industry, energy drinks for infants and children, is also targeted with developing cultivars for non-brewers malt.

Summary

The barley program of ICARDA has been recently reorganized and streamlined with CRP DC. The spring barley (low and high inputs) programs have been relocated in Morocco, while winter program is based in Turkey. Lebanon is serving as hub of International Nursery program and new evaluation sites in Ethiopia and India platforms will further add to the efficiency of the program. Despite the recent reorganization of ICARDA program in different location, barley program has successfully delivered useful genetic resources to it collaborators across globe. Recently, malt and food barley (nutrient dense [Zn and Fe] and high β-Glucan) component have received greater attention at ICARDA to meet increasing demand of diverse raw materials required by barley industry in developing countries.

Reference

FAOStat (2013) Food and Agriculture Organization of the United Nations, Statistics Division. Rome, Italy. http://faostat3.fao.org/browse/Q/QC/E [last accessed June 20 2015].