

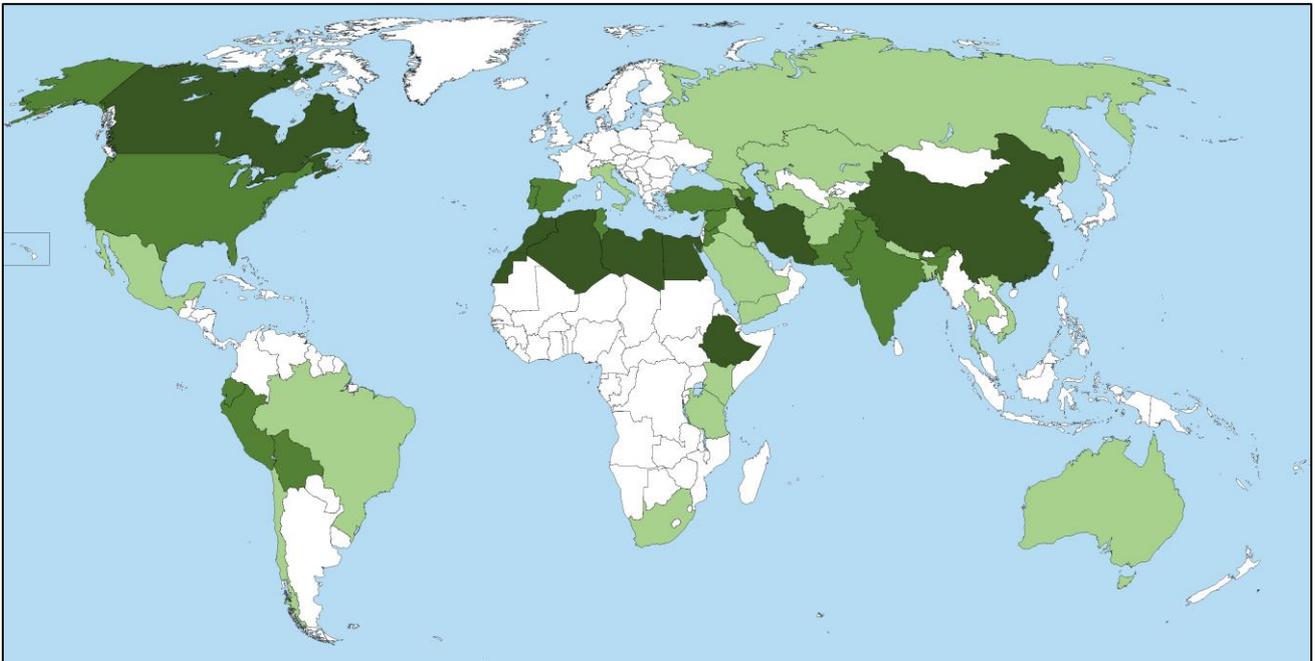


RESEARCH  
PROGRAM ON  
Livestock

*More meat, milk and eggs by and for the poor*

# ICARDA global barley breeding program International nurseries

Miguel Sanchez-Garcia



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## Introduction

Barley is the main crop in the drylands of North Africa covering 3.3 Mha (average of the last 4 years; FAOSTAT 2021) mainly in Morocco, Algeria and Tunisia. For many traditional subsistence farmers, barley is the only and often last option to feed their livestock, especially in the dry years. Climate change is expected to reduce rainfall up to 50% and increase temperatures up to 4°C in the region by the end of the century. Therefore new technologies need to be developed and deployed to increase the productivity per unit area in a scenario of worse climatic conditions. Besides the use of optimum agronomic technologies, hard to implement in a region with low income small-holder farmers, the only successfully tested technology to alleviate climate change effects is to exploit the genetic diversity to improve resilience of locally adapted varieties.

ICARDA has the CGIAR global mandate to breed barley varieties for the developing World. As such, more than 250 spring and winter 2-row, 6-row and naked barley varieties of ICARDA origin have been released in 46 countries, 51 of them in the last 10 years. Besides direct releases, the impact of ICARDA germplasm in both developed and the developing World's breeding programs is notorious and therefore the benefits of the program for farmers worldwide are beyond doubt (Figure 1).

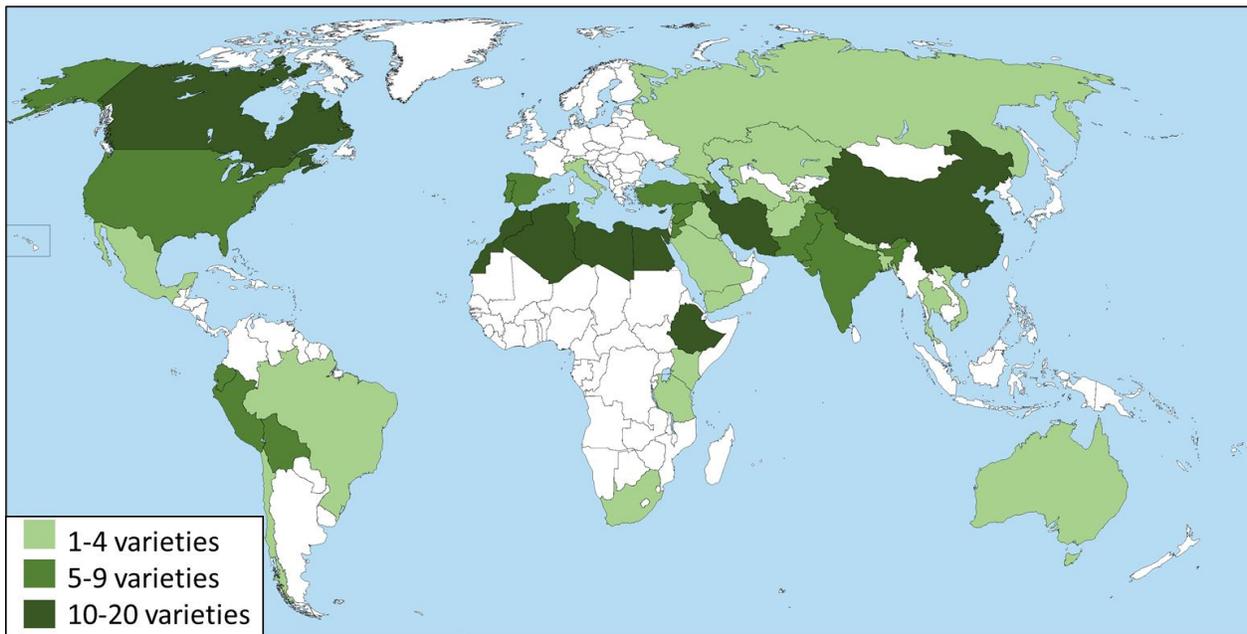


Figure 1 Number of barley varieties of ICARDA origin released per country.

## 2020 Barley international nurseries

ICARDA holds the global mandate within the CGIAR system to breed barley. As such, more than 250 spring and winter 2-row, 6-row, hooded and naked barley varieties of ICARDA origin have been released in 46 countries to date and many more are being used as parents in breeding programs worldwide. This use has been possible thanks to the wide distribution of the ICARDA Barley International Nurseries (IN). These Nurseries have been continuously provided to cooperators for the last 40 years and are the keystone of ICARDA's impact. All the technical and scientific discoveries and advances made by ICARDA scientists of multiple disciplines and collaborators worldwide are ultimately made available to National Agricultural Research Systems (NARS), Universities and private sector of the Developing Countries and beyond through the IN.

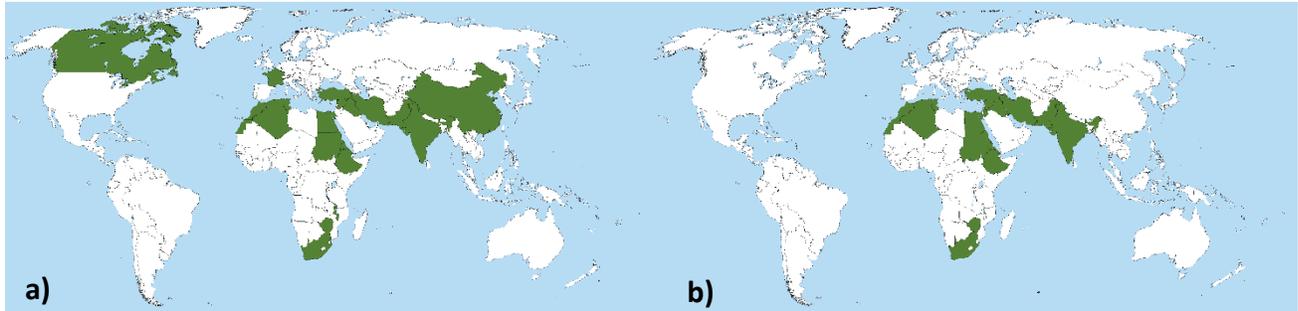


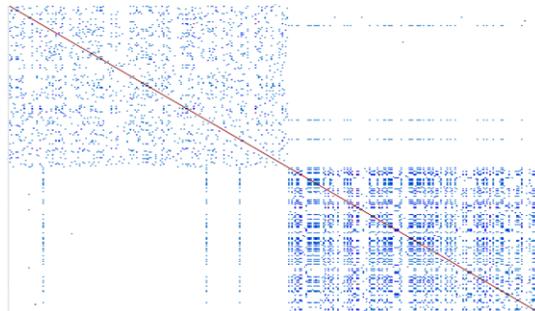
Figure 2 World distribution of the high-input (a) and low-input (b) barley international nurseries.

In 2020, 4 Global Barley International nurseries were assembled and distributed to 23 countries the World, 2 for low and 2 for high input environments (Figure 2).

1. Global Spring Barley Yield Trial (GSBYT) and Observation Nursery (GSBON) for Low Input Environments: These trials/nurseries are targeted to the low inputs production conditions globally for rainfed, drought and other marginal areas. The Yield Trial would constitute 25 lines including one local/national check and constituted by the genotypes with proven performance and adaptation from typical to severe drylands of the World, coupled with diseases resistance and targeting different products and uses (especially food, feed, and fodder). The Observation Nursery would have approximately 120 diverse barley advanced lines combining several traits of interest to deliver enough variability to national breeders to make selections and use in their own program

2. The International Barley Yield Trial (IBYT-HI) and Observation Nursery (IBON- HI) for High Input Environments: The ICARDA nurseries for High Input (HI) environments provide materials targeted for areas where barley is grown under more favorable conditions and with the use of near-optimum level of inputs. The Yield Trial contains 25 lines including one local/national check and is constituted by elite barley genotypes with proven grain yield performance and adaptation across high input testing sites around the World (India, Lebanon, Morocco among others) coupled with diseases resistance and targeting different products and uses (especially food, feed, malting, forage and fodder). The Observation Nursery would have approximately 120 diverse barley advanced lines combining several traits of interest to deliver enough variability to national breeders to make selections and use in their own program.

In total, 335 new elite barley genotypes were assembled and distributed in 159 sets shipped to 34 collaborators in 23 countries upon demand. The set showed high genetic diversity, specially between the low and high input sets (Figure 3). The set carried 189 unique combinations of 168 parents. Tables 1 and 2 show the lines present in the IBYT-HI and GSBYT.



## 2021 Barley international nurseries

The Global Barley Breeding program is continuously trying to improve the genotypes provided to its collaborators. Thus, following the recommendations of the CGIAR Excellence in Breeding (EiB) Platform, the program has adopted a strategy based on the systematic use of product profiles (Box 1) and on rapid development of new genotypes that maintain the successful traits of existing key varieties (benchmarks) and further incorporate traits including tolerance to new stresses. These are often climate change related and include resistance to new pests and diseases, and tolerance to more frequent droughts, heat waves, and increasing soil degradation and salinity.

The product profiles designed in collaboration with the NARS are then grouped in 4 Product Lines:

- **Feed Barley for Arid and Semi-Arid regions:** consisting in mostly 6-row barley advanced genotypes with high grain and straw productivity and stability from mild to severe drought conditions. The lines are selected in trials from the hot and dry semi-desertic regions of North Africa to the cold and dry West Asian highlands and the short, hot and dry rabi season in Central India.
- **Food and Fodder Barley:** consists in advanced drought tolerant and mostly hull-less genotypes combining high grain size and yield with enhanced nutritional quality ( $\beta$ -glucan, Iron and Zinc content) and straw production. These lines are particularly adapted to mountainous areas.
- **Feed and Forage Barley for Favorable Environments:** combining high grain and biomass production, diseases and lodging resistance with traits such as early vigor and regeneration capacity to be used for grazing.
- **Malt and Fodder Barley:** consisting in mostly 6-row barley advanced genotypes combining high grain size and stability, malting quality in agreement with international industrial standards with disease and lodging resistance and high straw production.

Following the product profile strategy, new breeding schemes have been designed to deliver new genotypes that meet the requirements of a product profile in the shortest possible time to maximize impact in farmers' fields. To deliver on this strategy, the breeding program is strengthening the traditional extensive use of the barley landrace and wild relative collections hosted at ICARDA genebank to find new sources of traits of interest in collaboration with pre-breeders, physiologists, pathologists, entomologists, agronomists and food technologists among other disciplines. Additionally, the use of genotypic data both

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**Box 1: A Product Profile** describes a variety with the necessary characteristics to replace an older variety that dominate a particular market. They are a means of focusing breeding activities on the development of products that will replace established varieties on the market towards maximizing impact in the shortest possible timeframe.

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for parent selection and genomic predictions; the use of biotic (aphids, leaf rust, yellow rust, net blotch, powdery mildew and scald among others) and abiotic (drought, heat, salinity and cold) stress hot-spot testing locations in 4 countries from Morocco to India and a precise end-use product classification (ICARDA has a fully functional quality laboratory with micro-malting unit, equipment for malting quality traits determination (friability, malt extract, FAN, Diastatic power,  $\beta$ -glucan and others), ICP for micro-element content determination, direct and indirect (NIR-based) feed quality determination of grain and straw, etc.) (Malt [micro-malting process], Food [hull-less,  $\beta$ -glucans, Fe and Zn content] and Feed and Forage quality determination).

The program will distribute for the 2021/22 season 3 IN sets consisting in two yield trials and one observation nursery of genetically diverse advanced genotypes targeting the 4 Product Lines:

- The **2022 International Barley Yield Trial for Arid and Semi-Arid regions (22-IBYT-ASA)**: This trial contains 24 genetically diverse barley genotypes (including two international checks and one local/national one) targeting two product lines: Feed Barley for Arid and Semi-Arid environments and Food and Fodder Barley. It is suggested to grow the IBYT-ASA in 2 replications with 6 rows and 2.5 meters long plot in the layout provided under low input conditions.
- The **2022 International Barley Yield Trial for Feed Forage and Malt (22-IBYT-FFM) in Favorable Environments**: This trial contains 24 genetically diverse barley genotypes (including two international checks and one local/national one) targeting two product lines: Feed and Forage Barley for Favorable Environments and Malt and Fodder Barley. It is suggested to grow the IBYT-FFM in 2 replications with 6 rows and 2.5 meters long plot in the layout provided under optimum input conditions.
- The **2022 International Barley Observation Nursery (22-IBON)**: This trial consists in approximately 120 advanced barley genotypes representing the genetic diversity of the Breeding Program. The nursery includes barley lines targeting the four main Product Lines and can be conducted as 2 rows of 2.5 meters plot in augmented design as per the layout provided.

## Acknowledgements

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Table 1 2020 International Barley Yield Trial for High Input environments (IBYT-HI)

Pedigree	Selection History
BLLU//LEGACY/CHAMICO	CBSS07Y00360S-36T-05T-05CJ -05CH-3CJ-0CH
CIRU/BGCLM 157.MBV	CBSS07Y00319S-21T-05T-05CJ -05CH-2CJ-0CH
CIRU/TOCTE	CBSS07Y00321S-10T-05CJ-05T-05CJ -010CH-CH1-0CH
P.STO/3/LBIRAN/UNA80//LIGNEE640/4/BLLU/5/PETUNIA 1/6/TOCTE	CBSS07Y00476S-24T-05CJ-05CH-04CJ-0CH
MSEL/FNC1/6/MERIT,B/4/AZAF/3/ARUPO/K8755//MORA/5/MSEL	HIICB10-0539-0AP-0TR-0MR-0MR CBSS07Y00326S-24T-05CJ-05T-05CJ -010CH-CH1-0CH
CIRU/3/LEGACY//PENCO/CHEVRON-BAR	
V MORALES	V MORALES CHECK 1
RECLA 60/BICHY2000//LIMON/BICHY2000/3/BCD12DH	CBSS06Y00340S-25Y-0M-05T-05CJ-05T-1CJ-0CH
GLORIA-BAR/COPAL/3/LBIRAN/UNA80//LIGNEE640	CBSS07Y00003S-26T-05CJ-05T-05CJ -010CH-CH4-0CH
BLLU/6/P.STO/3/LBIRAN/UNA80//LIGNEE640/4/BLLU/5/PETUNIA 1	CBSS07Y00350S-12T-05T-05CJ -05CH-3CJ-0CH
NC	NC CHECK 3
CIRUELO/6/P.STO/3/LBIRAN/UNA80//LIGNEE640/4/BLLU/5/PETUNIA 1	HIICB10-0486-0AP-0TR-0MR-0MR CBSS07Y00013S-19T-05CJ-05T-05CJ -010CH-CH4-0CH
GLORIA-BAR/COPAL/3/CHAMICO/TOCTE//CONGONA	CBSS07Y00382S-39T-05T-05CJ -05CH-4CJ-0CH
CANELA//LIMON/BICHY2000	CBSS05M00686D-G-5M-0M-05T-05CJ-05T-9CJ-0CH
FRESA/PETUNIA 1/7/P.STO/3/LBIRAN/UNA80//LIGNEE640/4/BLLU/5/PETUNIA 1/6/LEGACY//PENCO/CHEVRON-BAR	
RIHANE-03	RIHANE-03 CHECK 2
BLLU//6B89.2027/CHAMICO	CBSS07Y00361S-15T-05T-05CJ -05CH-1CJ-0CH
ACUARIO T95/BCD12DH//Canela	HIICB10-0603-0AP-0TR-0MR-0MR CBSS06Y00152S-1Y-0M-05T-05CJ-05T-9CJ-0CH
MSEL//LIMON/BICHY2000	CBSS07Y00357S-10T-05T-05CJ -05CH-5CJ-0CH
BLLU/3/BREA/DL70//3*CABUYA	CBSS07Y00014S-4T-05CJ-05T-05CJ -010CH-CH1-0CH
GLORIA-BAR/COPAL/6/P.STO/3/LBIRAN/UNA80//LIGNEE640/4/BLLU/5/PETUNIA 1	CBSS07Y00061S-3T-05CJ-05T-05CJ -010CH-CH2-0CH
LBIRAN/UNA80//LIGNEE640/6/P.STO/3/LBIRAN/UNA80//LIGNEE640/4/BLLU/5/PETUNIA 1	CITV10B060S- 0100T-0100CJ-4CH-04CJ-0CH
M104/PFC 88210//DOÑA JOSEFA	CBSS07Y00012S-1T-05CJ-05T-05CJ -010CH-CH5-0CH
GLORIA-BAR/COPAL//ZIGZIG	
Reem/PETUNIA 1	HIICB10-0185-0AP-0TR-0MR-0MR

Table 2: 2020 Global Spring Barley Yield Trial (GSBYT)

Pedigree	Selection History
Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda/6/Lignee527/Aths//Lignee527/NK1272	ICB09-0533-0AP-0AP-0MC-10MC
NC	NC CHECK 3
ALISO/CI3909-2//FALCON-BAR/3/HIGO/4/Petunia1	ICB10-0692-0AP-020TR-3AUB
Roho//Alger/Ceres362-1-1/3/Kantara/4/Tipper/5/MADRE SELVA	ICB09-1962-0AP-0AP-0MC-9MC
Moroc9-75//WI2291//WI2269/3/Nawair 1	ICB09-0869-0AP-0AP-0MC-7MC
ALISO/CI3909-2//FALCON-BAR/3/HIGO/4/Alanda-01//Gerbel/Harma/3/Gloria'S'/Celo'S'//Teran78	ICB10-0691-0AP-020TR-8AUB
ALISO/CI3909-2//FALCON-BAR/3/HIGO/4/Petunia1	ICB10-0692-0AP-020TR-8AUB
Atahualpa/IraqiBlack/7//WI3159/6/ANCA/2469//TOJI/3//SHYRI/4//ATACO/5//ALELI	ICB10-0671-0AP-020TR-5AUB
Roho/4/Zanbaka/3//ER/Apm//Lignee131/5//Mzq/Gva//PI002917/3//WI2291//WI2269/4//WI3213	ICB09-0786-0AP-0AP-0MC-2MC
Gloria'S'/Copal'S'//As46/Aths/3/Rhn-03/4//Lignee527/Aths//Lignee527/NK1272	ICB09-0497-0AP-0AP-0MC-8MC
Moroc9-75//WI2291//WI2269/3//Clipper//WI2291*2//WI2269	ICB09-0861-0AP-0AP-0MC-2MC
Viringa'S'//WI2291//WI2269/3//H.spont.38-3//Akrash-01/5//WI3257/4//ALISO/CI3909-2//HB602/3//MOLA//SHYRI//ARUPO*2//JET	ICB10-0576-0AP-020TR-8AUB
Kulih/Gobernadora	ICB09-1226-0AP-0AP-0MC-1MC
Carise/Shyri//Aleli/3//Mpyt169.1Y//Laurel//Olmo/4//Canela/5//MADRE SELVA	ICB09-1944-0AP-0AP-0MC-10MC
Melusine/Aleli/3//Matico/Jet//Shyri/4//Canela/5//MADRE SELVA	ICB09-1942-0AP-0AP-0MC-1MC
ChiCm/An57//Albert/3//Alger/Ceres.362-1-1/4//Arta/5//Clipper//WI2291*2//WI2269	ICB09-0982-0AP-0AP-0MC-1MC
Carbo/Hamra/4//Rhn-08/3//DeirAlla106//DL71//Strain205/5//QB813-2/5//Aths/Lignee686/4//Rhn-03/3//Bc/Rhn//Ky63-1294	ICB09-0528-0AP-0AP-0MC-9MC
RIHANE-03	RIHANE-03 CHECK 1
Hma-02//11012-2//CM67/3//Alanda/5//Rhn-03//Lignee527/NK1272/4//Lignee527/Chn-01/3//Alanda/6//Lignee527/Aths//Lignee527/NK1272	ICB09-0602-0AP-0AP-0MC-10MC
Aths/Lignee686/3//DeirAlla106//Sv.As/Attiki/4//24569/5//ICB_116132	ICB09-0487-0AP-0AP-0MC-10MC
Clipper//WI2291*2//WI2269/3//Clipper//WI2291*2//WI2269	ICB09-0828-0AP-0AP-0MC-4MC
ChiCm/An57//Albert/3//Alger/Ceres.362-1-1/4//Arta/5//Mzq/Gva//PI002917/3//WI2291//WI2269/4//WI3213	ICB09-0957-0AP-0AP-0MC-2MC
ICARO/MORA//CANELA	ICB09-1975-0AP-0AP-0MC-4MC
FURAT-3	FURAT-3 CHECK 2
ChiCm/An57//Albert/3//Alger/Ceres362-1-1/4//Arta/5//Nawair 1	ICB09-0903-0AP-0AP-0MC-2MC