RESEARCH PROGRAM ON Livestock

More meat, milk and eggs by and for the poor

Identification of new drought tolerant 6-row barley genotypes for the drylands of North Africa

Miguel Sanchez-Garcia

CGIAR ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE ICARDA Science for resilient livelihoods in dry areas CIAT International Center for Tropical Agriculture Since 1967 / Science to cultivate change giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH SLU

CGIAR is a global partnership that unites organizations engaged in research for a food-secure future. The CGIAR Research Program on Livestock provides research-based solutions to help smallholder farmers, pastoralists and agro-pastoralists transition to sustainable, resilient livelihoods and to productive enterprises that will help feed future generations. It aims to increase the productivity and profitability of livestock agri-food systems in sustainable ways, making meat, milk and eggs more available and affordable across the developing world. The CGIAR Research Program on Livestock brings together five core partners: the International Livestock Research Institute (ILRI) with a mandate on livestock, the International Centre for Tropical Agriculture (CIAT) which works on forages, the International Center for Agricultural Research in the Dry Areas (ICARDA) which works on small ruminants and dryland systems, the Swedish University of Agricultural Sciences (SLU) with expertise particularly in animal health and genetics and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) which connects research into development and innovation and scaling processes.

The CGIAR Research Program on Livestock thanks all donors and organizations who globally supported its work through their contributions to the **CGIAR system.**

Patron: Professor Peter C Doherty AC, FAA, FRS
Animal scientist, Nobel Prize Laureate for Physiology or Medicine–1996

Box 30709, Nairobi 00100 Kenya
Phone +254 20 422 3000
Fax +254 20 422 3001
Email ilri-kenya@cgiar.org

ilri.org
better lives through livestock

ILRI is a CGIAR research centre

Box 5689, Addis Ababa, Ethiopia
Phone +251 11 617 2000
Fax +251 11 667 6923
Email ilri-ethiopia@cgiar.org

ILRI has offices in East Africa • South Asia • Southeast and East Asia • Southern Africa • West Africa

Contents

Introduction

Barley is the main crop in the drylands of North Africa, particularly in Morocco, Algeria and Tunisia. It covers 3.3 Mha (average of the last 4 years; FAOSTAT 2021) and is the last resource of the most vulnerable farmers. For these 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 4ºC 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. To this aim, the ICARDA Global barley breeding program is developing new elite barley genotypes capable to increase the productivity of the farms in the region. The new lines must be genetically diverse and better adapted to the target environment, highly productive in terms of grain and straw and more stable. The aim of the present study is to identify new climate-smart feed barley genotypes for the drylands of North Africa.

Plant material

A set of 72 new elite 6-row feed barley genotypes selected for adaptation to mild to extreme drought conditions and 2 commercial checks (Taffa and Rihane-03) was assembled and tested in field trials in 5 locations in Morocco, Lebanon and India in the 2019/20 cropping season. The set was selected also to provide genetic diversity and wide adaptation. Up to 73 different parents were used in the 72 combinations and 65 of them were unique, that is, only 6 sister lines were present in the set.

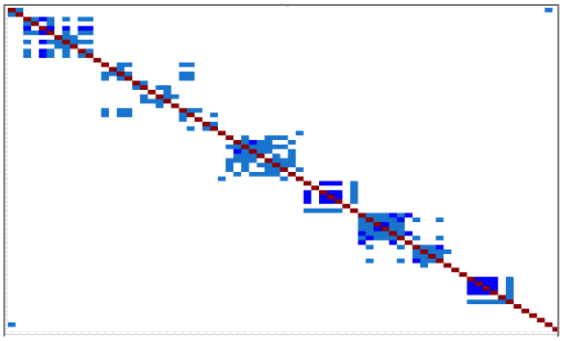

Figure 1 Pedigree matrix of the 72 elite 6-row barley lines selected for dought tolerance and tested in 2019/20. Light blue colours represent half-sister lines; dark blue colours represent full sister lines and red colours represent the same line.

Experimental set-up

The set of new elite 6-row feed barley genotypes assembled tested in field trials in 5 locations in Morocco, Lebanon and India in the 2019/20 cropping season. The locations selected represent some of the main agroecologies for drought prone barley growing environments. Thus, Marchouch (MCH, Morocco) represent a Mediterranean environment with terminal drought and heat stress and an average rainfall during the cropping season of 350mm (300mm in 2019/20 season); Annoceur (ANN; Morocco) represent the highlands of North Africa characterized by shallow soils, cold winters, dry and hot summers and scatter rainfall pattern of 400mm average rainfall during the cropping season (314mm in 2019/20 season + 40 in irrigation); Sidi-el-Aidi (SEA; Morocco) represent a typical low-land North-African dry and hot environment with limited rainfall (120mm in 2019/20 season); Kfardan (KFR; Lebanon) represents the dry and cold highlands of West Asia (553mm in 2019/20 season) and Amlaha (AMH; India) represents the dry rabi season of South Asia were dryland cereals are grown with the remaining underground moisture from the summer rains.

The set was evaluated in field trials consisting in a replicated Alpha-Lattice design with 160 plots 2.5 m-long, 6 rows and 20cm between rows. Heading date and maturity date were collected from all plots as the date when 50% of the spikes were out the shoot (Zadoks 55) and the date when 50% of the peduncles turned yellow (Zadoks 87). Plant height was also measured as the distance in cm from the ground to the tip of the spike without the awns. Before anthesis, NDVI measurements were collected in SEA. Finally, the plots were mechanically harvested at ripening and grain and biomass yield were determined, except at Annoceur were biomass could not be collected. In addition, a disease scoring under natural conditions was carried out in the hot-spot of Sidi-Allal-Tazi (Morocco) and in Marchouch were the set was scored for Net Form of Net Blotch and Spot Form of Net Blotch.

The trials were analyzed individually assuming a resolvable rox*column design to take into consideration the spatial variability of the fields and Best Linear Unbiased Estimates (BLUE) were calculated using *R* software (R Core Team 2020) package *statgenSTA* (van Rossum 2020a). All GxE and stability analysis were performed using the BLUE and the *R* software package *statgenGxE* (van Rossum 2020b). GGE biplot was performed using Genstat v21 (VSN International 2020). The correlations between environments were performed using the R based software META-R (Alvarado et al., n.d.).

Environment characterization

All the traits considered for the analysis showed heritabilities above 0.2 and yield heritabilities ranged from 0.38 to 0.80. The results obtained from the analysis of the environments showed that the average grain yield followed a similar pattern as the rainfall. Thus the distribution of BLUEs of genotype means for GY for each trial summarized as boxplots (Figure 1a) showed KFR as the location being both the highest

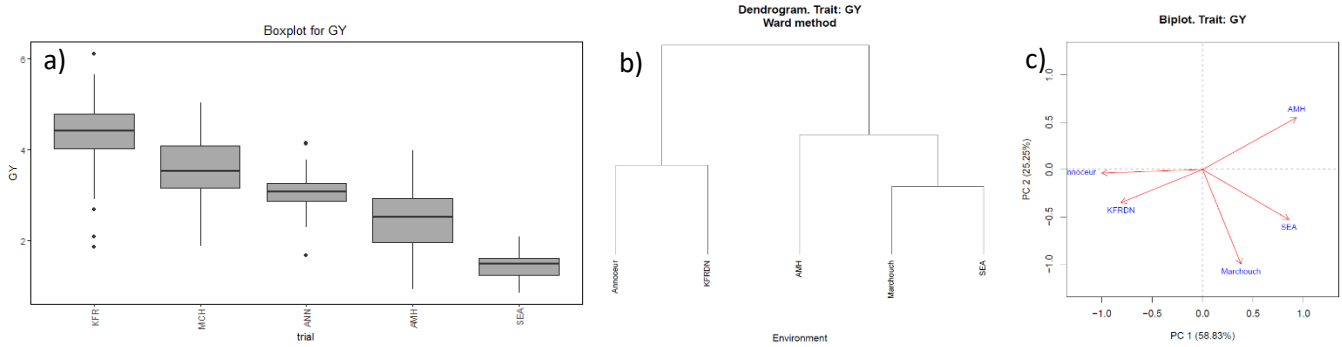

Figure 2 Box plot of the average yield per environment of the set of 72 ICARDA elite barley genotypes and the 2 commercial checks (a); Dendrogram of the similarity of the environments based on the yield performance of the set of genotypes (b); Biplot of the first two axis of the Principal Component analysis showing the values of the environments obtained with the yield performance of the set of varieties in the 5 environemnts. The testing environments in 2019/20 were Amlaha (AMH; India), Kfrdan (KFR; Lebanon); Annoceur (ANN; Morocco), Marchouch (MCH; Morocco) and Sidi-el-Aidi (SEA; Morocco).

yielding and most humid and SEA being the dryiest and lowest yielding. On the other hand, the results of the GGE biplot representing the genotype and GxE effects of the lines and environments showed that the first PC grouped KFR and ANN, the two environmnets located in the highlands, with cold winters and with higher rainfall in 2020 together in the negative side of the axis while the other three locations (MCH, SEA and AMH) were in the positive side of the PC1 axis. The second axis separated AMH, the only environment South from the equator and the one relying only in underground water from the rest.

Genotype performance and stability

The results of the multi-location analysis showed that genotypes superior to the best check could be found in all locations (Table 2). However, except for the two lowest yielding environments (AMH and SEA), the Mega-Cultivar Rihane-03 was among the best 10 genotypes identified in the locations analyzed. Among the 32 different elite barley genotypes among the 10 highest yielding ones at all locations, three (32,40,46) were in among the top10 in 3 locations and another 7 in 2 locations. The high yielding lines also produced more biomass than the checks (Table 2).

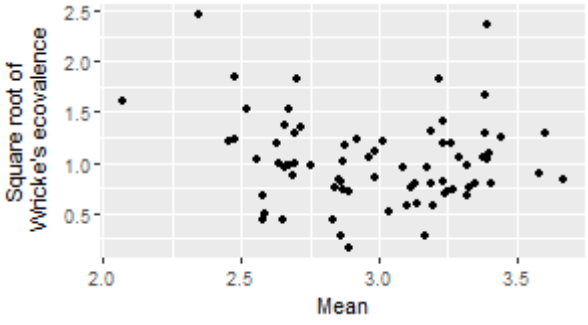

Figure 3 Scatter plot of the relationship between Wricke's ecovalence stability value and the average yield performance of 72 elite 6-row barley genotypes and 2 commercial checks obtained from yield trials carried out in 2019/20 in Amlaha (AMH; India), Kfrdan (KFR; Lebanon); Annoceur (ANN; Morocco), Marchouch (MCH; Morocco) and Sidi-el-Aidi (SEA; Morocco).

Dynamic stability is a desirable trait, especially when breeding for dry environments with inconsistent rainfall patterns. In order to evaluate the yield dynamic stability of the lines, Wricke ecovalence test was calculated for the set of 74 genotypes. No correlation could be found between average yield across environments and their stability. However, among the 32 top yielders, 9 showed higher

stability than the most stable commercial check and higher average yield.

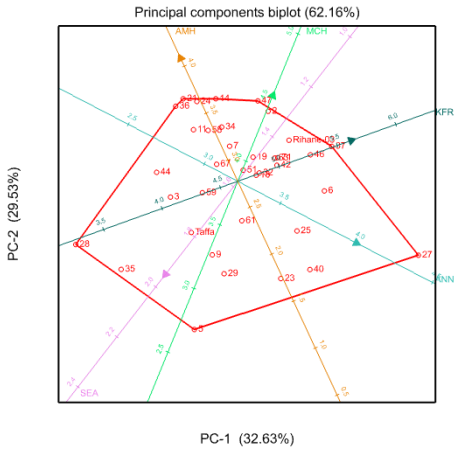

Figure 4 GGE biplot of the BLUE for grain yield of 32 elite 6-row barley genotypes and 2 commercial checks obtained from yield trials carried out in 2019/20 in Amlaha (AMH; India), Kfrdan (KFR; Lebanon); Annoceur (ANN; Morocco), Marchouch (MCH; Morocco) and Sidi-el-Aidi (SEA; Morocco).

However, some of the high yielding lines evaluated showed low stability due to high specific adaptation to a particular agroecosystem. For instance genotype 27 showed low dynamic stability but a high specific adaptation to the highland environments of Annoceur and Kfardan. A similar case was found for genotype 5 that showed specific adaptation to extreme drought environments both regarding yield and biomass production (Table 1; Figure 4). In this case, these genotypes can be directed to environments with similar characteristics were their particular adaptation can increase genetic gain.

Finally a set of 13 genotypes was selected based on yield performance and biomass production particularly for the North African barley growing areas. The genotypes selected combined high dynamic yield stabily – ensuring superior yield performance under different drought conditions – and specific adaptation to particular agroecosystems sucha as the highlands or the extreme drought environments.

Conclusions

The present study allowed selecting 13 genetically diverse new elite barley genotypes with superior yield and biomass productivity as compared to the commercial checks under mild to extreme drought conditions. The genotypes selected combine yield stability with specific adaptation to particular agroecosystems sucha as the North African highlands or the extreme drought environments. These selected lines have been assembled in a yield trial and shared with NARS of Morocco, Algeria and Tunisia in 2020 to identify the next generation of North African barley drought tolerant varieties.

Acknowledgements

Sincere acknowledgements are expressed to CRP Livestock for supporting this research on barley at ICARDA. Sincere acknowledgements are expressed to ICAR for supporting the research carried out in India. The author would like to thank the contribution of ICARDA Integrated Pest Management team under the lidership of Dr S. Kemal for their contribution to this work. Finally, the barley team at ICARDA (especially Dr. A Visioni, Mr. Sunil Kumar, Mr. Rachid Bouamar, Mr Raafat Azzo, Mr Abdullah Anflous, Mr Redouane Taiq and Mr. Boukri Mohamad) is acknowledged.

References

Alvarado, G., López, M., Vargas, M., Pacheco, Á., Rodríguez, F., Burgueño, J., & Crossa, J. (n.d.). META-R (Multi Environment Trail Analysis with R for Windows) Version 6.04. (I. M. and W. I. Center, Ed.). CIMMYT Research Data & Software Repository Network. https://doi.org/hdl:11529/10201

van Rossum B-J (2020a). statgenSTA: Single Trial Analysis (STA) of Field Trials. R package version 1.0.6. https://CRAN.R-project.org/package=statgenSTA

van Rossum B-J (2020b). statgenGxE: Genotype by Environment (GxE) Analysis. R package version 1.0.1. https://CRAN.R-project.org/package=statgenGxE

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

VSN International 2020). Genstat *for Windows* 21st Edition. VSN International, Hemel Hempstead, UK. Web page: Genstat.co.uk)

Table 1 Top ten higher yielding genotypes at each location. The BLUE of grain yield (GY), aboveground biomass and straw yield obtained from yield trials carried out in Amlaha (India), Annoceur (Morocco), Kfardan (Lebanon), Marchouch (Morocco), Sidi-El-Aidi (Morocco).

	Environment																	
	Amlaha (India)				Annoceur (Morocco)				Kfardan (Lebanon)				Marchouch (Morocco)				Sidi-El-Aidi (Morocco)			
Yield rank	Geno	Biomass (t/ha)	Straw (t/ha)	GY (t/ha)	Geno	Biomass (t/ha)	Straw (t/ha)	GY (t/ha)	Entry	Biomass (t/ha)	Straw (t/ha)	GY (t/ha)	Geno	Biomass (t/ha)	Straw (t/ha)	GY (t/ha)	Geno	Biomass (t/ha)	Straw (t/ha)	GY (t/ha)
1	**24**	10.6	6.6	4.0	**27**	NA	NA	4.13	**27**	9.73	3.64	6.09	**47**	7.77	2.74	5.04	44	4.70	2.61	2.10
2	14	8.1	4.1	3.9	**40**	NA	NA	4.12	71	11.04	5.41	5.64	19	8.51	3.55	4.96	5	7.19	5.14	2.05
3	21	9.7	5.8	3.9	23	NA	NA	3.77	**32**	10.34	4.81	5.52	Rihane-03	7.56	2.68	4.88	**40**	7.20	5.26	1.94
4	36	10.2	6.5	3.6	**46**	NA	NA	3.73	37	10.22	4.77	5.44	51	10.26	5.56	4.70	**9**	6.03	4.09	1.93
5	7	9.6	6.2	3.5	25	NA	NA	3.71	**47**	9.11	3.71	5.40	11	8.87	4.22	4.65	29	4.58	2.68	1.90
6	34	8.5	5.1	3.4	**42**	NA	NA	3.65	**46**	10.16	4.84	5.32	**24**	9.57	4.95	4.62	35	4.89	3.04	1.85
7	**46**	9.4	6.0	3.4	Rihane-03	NA	NA	3.61	**6**	11.47	6.37	5.10	**40**	6.73	2.26	4.47	**32**	5.60	3.76	1.84
8	58	8.9	5.5	3.4	63	NA	NA	3.57	**2**	10.44	5.36	5.08	18	5.75	1.30	4.46	28	3.01	1.19	1.82
9	**32**	9.4	6.0	3.4	**9**	NA	NA	3.52	Rihane-03	10.83	5.75	5.08	61	5.87	1.42	4.45	3	7.97	6.20	1.77
10	**2**	7.9	4.5	3.4	**6**	NA	NA	3.50	67	11.88	6.80	5.08	**42**	8.76	4.33	4.43	59	5.28	3.52	1.76
Trial average		7.70	5.22	2.48				3.08		10.05	5.73	4.33		7.38	3.80	3.58		5.06	3.60	1.46
Best check	Rihane-03	8.29	5.09	3.19	Rihane-03	NA	NA	3.61	Rihane-03	10.83	5.75	5.08	Rihane-03	7.56	2.68	4.88	Taffa	4.69	3.05	1.64

Table 2: List of the 32 top yielding genotypes across locations and the 2 check varieties ordered by their grain yield dynamic stability according to Wricke ecovalence test. The BLUE for grain yield obtained in the 5 testing locations is also included.

Geno	Pedigree	Wricke stability	Grain yield (t/ha)				
			AMH	**ANN**	**KFR**	**MCH**	**SEA**
3	Alanda-01/4/SICB-105935/3/Hma-02//11012-2/CM67/5/Aths/Lignee686/3/Nacha2//Lignee640/Hma-01	0.26	2.72	2.80	4.18	3.73	1.77
9	Zanbaka/H.spont.41-2/4/Arar/H.spont.19-15//Hml/3/H.spont.41-1/Tadmor/5/Zanbakian/7/Lignee527//Bahtim/DL71/3/Api/CM67//Mzq/5/Alanda-01/4/WI2291/3/Api/CM67//L2966-69/6/Lignee527/Chn-01//Arar/Rhn-03	0.35	2.56	3.52	4.16	3.51	1.93
59	Aths/Lignee686/4/Avt/Attiki//Aths/3/Giza121/Pue/6/Lignee527/Chn-01//Alanda/5/Arizona5908/Aths//Avt/Attiki/3/S.T.Barley/4/Aths/Lignee686	0.48	2.86	3.24	4.06	4.27	1.76
18	As57/DL530//Alanda-01/4/Lignee527/Chn-01//Alanda/3/As57/Kc	0.50	2.48	3.29	4.52	4.46	1.51
63	Una80/IPA7	0.53	2.80	3.57	4.35	4.34	1.31
42	Zanbaka/H.spont.41-2/4/Arar/H.spont.19-15//Hml/3/H.spont.41-1/Tadmor/5/Zanbakian/6/WI2291/3/CI03309/Attiki//Hja33/4/Gustoe/5/Arar/H.spont.19-15//Hml/3/H.spont.41-1/Tadmor	0.57	2.80	3.65	4.36	4.43	1.38
51	Lignee527/NK1272//JLB70-063/3/IPA99/5/Arig8/Imperial//M7/3/Rt013/4/Alanda-01	0.62	2.78	3.31	4.56	4.70	1.68
25	Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda/6/Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda	0.62	2.16	3.71	4.88	3.62	1.57
34	Alanda/Hamra//Alanda-01/3/Alanda/Hamra//Alanda-01	0.64	3.44	3.07	4.63	4.13	1.48
Taffa		0.66	2.14	3.13	3.59	3.80	1.64
58	Lignee527//Bahtim/DL71/3/Api/CM67//Mzq/5/Alanda-01/4/WI2291/3/Api/CM67//L2966-69/6/Lignee527/Chn-01//Arar/Rhn-03/7/Rihane-03/3/As46/Aths*2//Aths/Lignee686/4/Alanda-01	0.67	3.41	2.95	4.52	3.84	1.44
Rihane		0.71	3.19	3.61	5.08	4.88	1.59
32	Arig8/Imperial//M7/3/Rt013/4/Alanda-01/5/Lignee527/NK1272//JLB70-063/3/IPA99	0.79	3.41	3.43	5.52	3.72	1.84
67	Alanda/5/Aths/4/Pro/TolI//Cer*2/TolI/3/5106/6/Baca'S'/3/AC253//CI08887/CI05761/7/Alanda/5/Aths/4/Pro/TolI//Cer*2/TolI/3/5106/6/CalMr/CI16155	0.92	2.89	2.75	5.08	3.21	1.52
61	Lignee527/Chn-01//Alanda/5/Arizona5908/Aths//Avt/Attiki/3/S.T.Barley/4/Aths/Lignee686/6/Aths/Lignee686/4/Avt/Attiki//Aths/3/Giza121/Pue	0.92	2.17	3.45	4.11	4.45	1.70
2	Alanda/5/Aths/4/Pro/TolI//Cer*2/TolI/3/5106/6/Baca'S'/3/AC253//CI08887/CI05761/7/Alanda-01/3/Alanda//Lignee527/Arar	0.94	3.40	3.19	5.08	3.73	1.20
35	Alanda/5/Aths/4/Pro/TolI//Cer*2/TolI/3/5106/6/AwBlack/Aths//Arar/3/9Cr279-07/Roho/7/Robur-Bar/142-B//Astrix/Sutter332-3/8/Arig8/Imperial//M7/3/Rt013/4/Alanda-01	1.05	1.92	2.63	3.30	3.09	1.85
71	Alanda//Lignee527/Arar/6/Multan/M23/4/HopRo/3/Md/AT//CM/5/24569/7/U.Sask.1766/Api//Cel/3/Weeah/4/Arar/5/Aths	1.07	2.82	3.13	5.64	3.83	1.55
7	Arig8/Imperial//M7/3/Rt013/4/Alanda-01/5/Lignee527/NK1272//JLB70-063/3/IPA99	1.09	3.45	3.07	5.07	3.34	1.52
44	Lignee527/Chn-01//Alanda/3/As57/Kc/6/Lignee527/Chn-01//Alanda/5/Arizona5908/Aths//Avt/Attiki/3/S.T.Barley/4/Aths/Lignee686	1.11	3.28	2.56	4.98	3.95	2.10
19	QB813-2/5/Aths/Lignee686/4/Rhn-03/3/Bc/Rhn//Ky63-1294/7/Rhn-03/3/Mr25-84/Att//Mari/Aths*3-02/6/Lignee527//Bahtim/DL71/3/Api/CM67//Mzq/5/Alanda-01/4/WI2291/3/Api/CM67//L2966-69	1.19	2.60	3.21	4.63	4.96	1.59
6	Carbo/Hamra/4/Rhn-08/3/DeirAlla106//DL71/Strain205/6/Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda	1.24	2.04	3.50	5.10	3.22	1.08
11	Lignee527/NK1272//JLB70-063/3/IPA99/5/Arig8/Imperial//M7/3/Rt013/4/Alanda-01	1.40	3.20	2.93	4.02	4.65	1.50
36	Lignee527//Bahtim/DL71/3/Api/CM67//Mzq/5/Alanda-01/4/WI2291/3/Api/CM67//L2966-69/6/Lignee527/Chn-01//Arar/Rhn-03/7/Rum/4/Rhn-03/3/Mr25-84/Att//Mari/Aths*3-02	1.42	3.65	2.66	4.38	4.01	1.46
29	AwBlack/Aths//Arar/3/9Cr279-07/Roho/6/Alanda-01/5/CI01021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70/7/ArabiAbiad/Arar//H.spont.41-5/Tadmor/3/Sara	1.45	2.48	3.48	4.64	2.58	1.90
23	Lignee527/NK1272//JLB70-063/3/Rhn-03/6/Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda	1.49	1.87	3.77	4.56	2.81	1.59
40	Aths/Lignee686/4/Avt/Attiki//Aths/3/Giza121/Pue/6/Lignee527/Chn-01//Alanda/5/Arizona5908/Aths//Avt/Attiki/3/S.T.Barley/4/Aths/Lignee686	1.58	1.92	4.12	4.77	4.47	1.94
24	SLB21-81/SLB22-74//Soffet no.9	1.67	3.98	2.96	4.76	4.62	1.71
14	Tadmor//Roho/Mazurka/3/Tadmor/5/Arig8/Imperial//M7/3/Rt013/4/Martin	1.68	3.91	2.92	4.97	3.73	1.42
37	Bda/4/SICB-105935/3/Hma-02//11012-2/CM67/5/Lignee527/NK1272/4/Avt/Attiki//Aths/3/Giza121/Pue	1.72	2.05	3.23	5.44	4.14	1.08
21	Rum/4/Rhn-03/3/Mr25-84/Att//Mari/Aths*3-02/6/Arig8/Imperial//M7/3/Rt013/5/Aths/Lignee686/3/DeirAlla106//Sv.Asa/Attiki/4/Cen/Bglo'S'	1.97	3.86	2.92	4.01	4.04	1.32
28	Hma-02//11012-2/CM67/3/Alanda/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda/6/Osiris	2.34	2.77	2.50	3.04	2.48	1.82
47	Avt/Attiki//M-Att-73-337-1/3/Aths/Lignee686/4/Kabaa/5/Alanda-01/3/Alanda//Lignee527/Arar	2.77	2.53	2.56	5.40	5.04	1.38
5	H.spont.41-3/SLB34-40/7/Lignee527//Bahtim/DL71/3/Api/CM67//Mzq/5/Alanda-01/4/WI2291/3/Api/CM67//L2966-69/6/Lignee527/Chn-01//Arar/Rhn-03	3.30	1.84	3.21	4.55	1.89	2.05
46	Hma-02//11012-2/CM67/3/Alanda/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda/6/Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda	3.31	3.43	3.73	5.32	2.51	1.12
27	Rihane-03/3/As46/Aths*2//Aths/Lignee686/6/Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda	5.60	1.11	4.13	6.09	4.13	1.50

Table 3 ICARDA elite 6-row feed barley lines selected for a North Africa

Number	Geno	Pedigree	Selection History	Traits
1	**5**	H.spont.41-3/SLB34-40/7/Lignee527//Bahtim/DL71/3/Api/CM67//Mzq/5/Alanda-01/4/WI2291/3/Api/CM67//L2966-69/6/Lignee527/Chn-01//Arar/Rhn-03	SICB12-0363-0TR-0TR-025KF-015AREC-3AREC-0KF	Top yielder in extreme drought, top biomass in extreme drought
2	**9**	Zanbaka/H.spont.41-2/4/Arar/H.spont.19-15//Hml/3/H.spont.41-1/Tadmor/5/Zanbakian/7/Lignee527//Bahtim/DL71/3/Api/CM67//Mzq/5/Alanda-01/4/WI2291/3/Api/CM67//L2966-69/6/Lignee527/Chn-01//Arar/Rhn-03	SICB12-0382-0TR-0TR-05KF-015AREC-5AREC-0KF	High stability, Top yielder in extreme drought, top biomass in extreme drought and favorable conditions, Early, MR to LR
3	**19**	QB813-2/5/Aths/Lignee686/4/Rhn-03/3/Bc/Rhn//Ky63-1294/7/Rhn-03/3/Mr25-84/Att//Mari/Aths*3-02/6/Lignee527//Bahtim/DL71/3/Api/CM67//Mzq/5/Alanda-01/4/WI2291/3/Api/CM67//L2966-69	SICB12-0176-0TR-0TR-025KF-015AREC-2AREC-0KF	Top yielder in 2 locations, top biomass under favorable conditions, large grain size.
4	**23**	Lignee527/NK1272//JLB70-063/3/Rhn-03/6/Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda	ICB11-0208-0AP-030AREC-015TR-015AREC-3AREC-0KF	Top yielder in highlands, MR to LR and R to NFNB
5	**24**	SLB21-81/SLB22-74//Soffet no.9	SICB12-0595-0TR-0TR-025KF-015AREC-5AREC-0KF	Top yielder in 2 locations, top biomass in 2 locations,MR to LR, MR to YR
6	**27**	Rihane-03/3/As46/Aths*2//Aths/Lignee686/6/Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda	ICB11-0196-0AP-030AREC-015TR-015AREC-4AREC-0KF	Top yielder in highlands, R to YR
7	**32**	Arig8/Imperial//M7/3/Rt013/4/Alanda-01/5/Lignee527/NK1272//JLB70-063/3/IPA99	SICB12-0613-0TR-0TR-025KF-015AREC-1AREC-0KF	High stability, Top yielder in highlands, High biomass, Large grain size
8	**40**	Aths/Lignee686/4/Avt/Attiki//Aths/3/Giza121/Pue/6/Lignee527/Chn-01//Alanda/5/Arizona5908/Aths//Avt/Attiki/3/S.T.Barley/4/Aths/Lignee686	SICB12-0429-0TR-0TR-025KF-015AREC-5AREC-0KF	Top yielder in 2 locations including extreme drought, top biomass in extreme drought
9	**44**	Lignee527/Chn-01//Alanda/3/As57/Kc/6/Lignee527/Chn-01//Alanda/5/Arizona5908/Aths//Avt/Attiki/3/S.T.Barley/4/Aths/Lignee686	SICB12-0451-0TR-0TR-025KF-015AREC-4AREC-0KF	Top yielder in extreme drought, top biomass in severe drought, MR to YR
10	**46**	Hma-02//11012-2/CM67/3/Alanda/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda/6/Rhn-03/Eldorado/5/Rhn-03//Lignee527/NK1272/4/Lignee527/Chn-01/3/Alanda	ICB11-0183-0AP-030AREC-015TR-015AREC-3AREC-0KF	Top yielder in highlands, and top biomass under severe drought, MR to LR
11	**47**	Avt/Attiki//M-Att-73-337-1/3/Aths/Lignee686/4/Kabaa/5/Alanda-01/3/Alanda//Lignee527/Arar	SICB12-0475-0TR-0TR-025KF-015AREC-3AREC-0KF	Top yielder in 2 locations including highlands, MR to LR
12	**51**	Lignee527/NK1272//JLB70-063/3/IPA99/5/Arig8/Imperial//M7/3/Rt013/4/Alanda-01	SICB12-0621-0TR-0TR-025KF-015AREC-1AREC-0KF	High stability, Top yielder and top biomass, Large grain size
13	**61**	Lignee527/Chn-01//Alanda/5/Arizona5908/Aths//Avt/Attiki/3/S.T.Barley/4/Aths/Lignee686/6/Aths/Lignee686/4/Avt/Attiki//Aths/3/Giza121/Pue	SICB12-0423-0TR-0TR-025KF-015AREC-1AREC-0KF	High stability, High average yield, top biomass under severe drought, MR to NFNB