ICARDA

Science for resilient livelihoods in dry areas

Diversification of germplasm and genetic enhancement of barley for biotic and abiotic stress and malting quality for different agro-ecologies

Section A: New diverse donors for desired traits identified and utilized in malt, feed and dual-purpose type barley

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Introduction

Barley is a main staple crop and large areas in the world are devoted to the crop. In India, barley is an important crop cultivated since ancient times. The major barley growing states in India are Rajasthan, Uttar Pradesh, Haryana, Punjab, Madhya Pradesh, Uttarakhand, Himachal Pradesh, Bihar, Jammu and Kashmir, West Bengal, Chhatishgarh and Sikkim. However, its area decreased in the country throughout the 20th century, mainly due to competition against wheat. As a result, barley is generally confined to marginal, problematic soils as a rainfed crop. The main usages of barley in the country are feed for livestock (ca. 65%), malt (20-30%) and food (less than 10%). An increased interest in barley is apparent in the country since the 90s. The use of malt barley as a cash crop coupled with the increased number of breweries in the country, the high frequency of drought events that can make barley more suitable as feed than other crops (i.e. sugar cane or oats) in drought prone environments and its nutritional quality as food have increased the interest over barley. However, to fulfil the needs, new germplasm with superior productivity, yield stability, disease resistant and fit for purpose needs to be developed.

ICARDA has a long-lasting collaboration with the ICAR, IIWBR and other Indian research institutions that has resulted in a number of varieties released coming from ICARDA nurseries or having ICARDA germplasm as parental material. The interest of the NARS in ICARDA germplasm relies in its high productivity, diversity and resistance to biotic and abiotic stresses. In order to deliver fit-for-purpose varieties to the NARS that will ultimately reach the farmers, the Global Barley Breeding Program of ICARDA uses a multi-location approach to identify the best varieties combining the desired traits. Thus, combining the information from stress hot-spots in Morocco, Tunisia, Lebanon, India and Turkey among others, ICARDA is capable of selecting elite germplasm combining several traits of interest and with yield stability and specific adaptation. In the present report we show results of the efforts made in 2020 in India to provide the NARS with disease resistant high grain and straw yield genotypes as well as new diversity for Indian barley germplasm.

Identify high yielding barley genotypes

More than 350 new ICARDA elite lines for low and high input environments were tested in yield trials in Amlaha station during the 2019/20 crop season. Among the genotypes targeting high input conditions, 10 showed higher grain yield than the best local check (BH959) and 26 showed higher biomass. Up to 7 of the new genotypes combined both higher grain yield and biomass than the best local check (Figure 1 top).

One hundred and fifty-seven new ICARDA barley genotypes adapted to low input conditions were also tested in Amlaha under no irrigation. Of them, 23 genotypes showed higher grain yield than the best check (Rihane-03) and 36 showed higher biomass. Up to 7 genotypes combined both higher grain yield and biomass than the best local check (Figure 1 bottom).

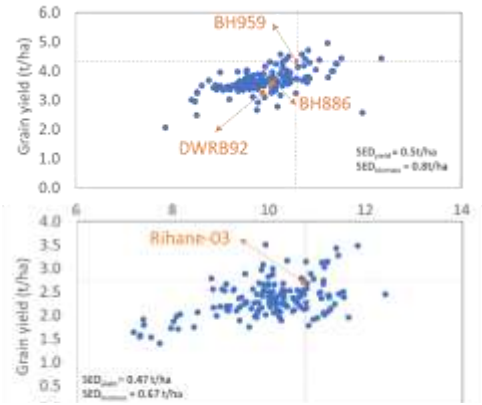

Figure 1 Grain and biomass yield of a set of ICARDA genotypes adapted to high input (top) and low input (bottom) conditions grown at Amlaha (India) station in 2019/20 season. The best checks are highlighted in orange.

New malt barley ICARDA lines tested at Amlaha station

During the 2019/20 season, 28 new ICARDA elite lines selected for malt quality were tested in yield trials in Amlaha station. Five of them showed higher yield than the best malting barley local check tested (BH886) and all lines analyzed had a grain weight of more than 45mg. From the 5 lines out yielding the local check, 2 of them also showed a grain weight larger than 45mg in the low input conditions of Marchouch in 2020 (Figure 2). This is an important result since grain size is one of the requisites for malt barley. High grain size stability, particularly related to insufficient water input, is of interest for farmers that will not have their malt barley premiums penalized in low rainfall years.

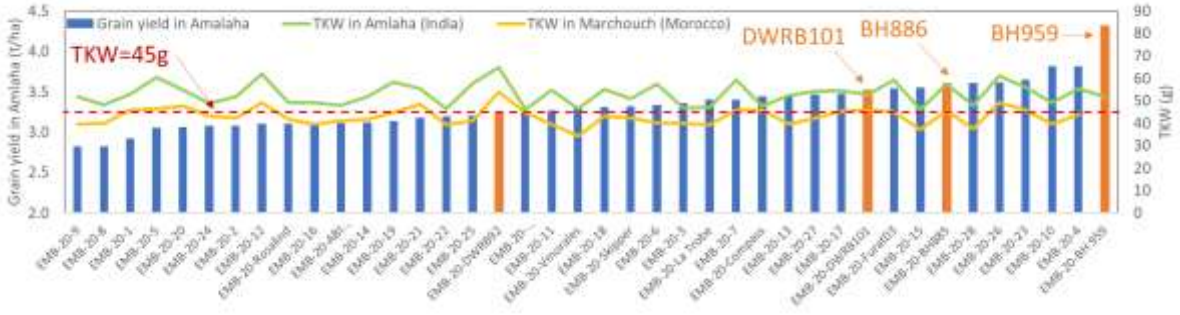

Figure 2 ICARDA malt barley performance in Amlaha (India) in the 2019/20 season. The green and orange lines represent the grain size at Amlaha (green) and Marchouch (orange). The local checks are highlighted in orange.

New naked barley ICARDA lines tested at Amlaha station

Food barley is an important food security crop in India, particularly in the Northern hills and plains. For it, 51 new ICARDA elite naked barley lines were tested in yield trials in Amlaha station in 2019/20. The best lines showed a yield penalty of only 14.8% as compared to the 6-row hulled Rihane-03 variety under drought conditions in Amlaha. Two of the top 5 naked barley lines also showed high grain size, a trait particularly appreciated by farmers and consumers and with direct impact in flour yield (Figure 4). Some of t he highest yielding lines tested also showed high biomass, making them suitable for a dual-purpose food and fodder strategy (Figure 3).

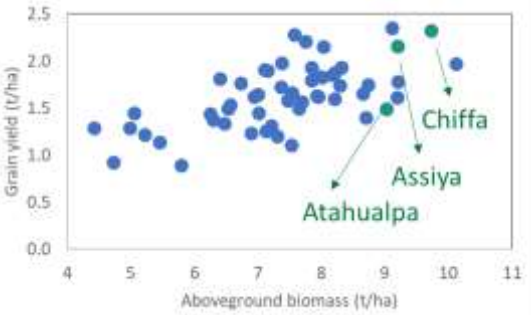

Figure 3 Grain yield and biomass performance of 51 ICARDA elite naked barley genotypes tested at Amlaha in 2019/20. Checks are highlighted in green dots.

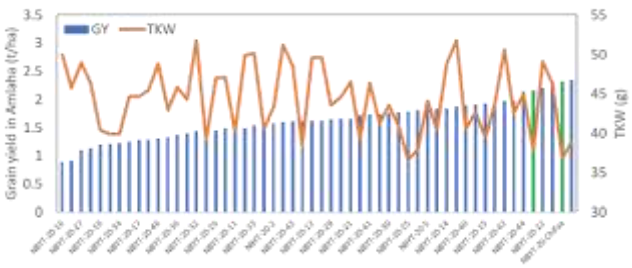

Figure 4 Grain yield performance of 51 ICARDA elite naked barley genotypes tested at Amlaha in 2019/20. The grain size is also depicted with an orange line. Checks are highlighted in green bars.

The **best lines** for high and low input feed purposes as well as malt and naked barley genotypes were selected together with National Breeders and have been **transferred to the National Program** for further multi-location testing (Supp. Table 1).

Identify molecular markers for better quality and disease resistance

Disease resistance is the main strategy to prevent productivity and end-use quality loses due to pathogen, especially in a traditionally low input crop as barley. Among the main diseases that hinder productivity in India **spot blotch** (*Cochliobolus sativus)* is a major constraint to barley production in warmer regions.

Due to its importance for barley productivity in India and thanks to the India-ICARDA collaboration, the 350 ICARDA elite barley genotypes were tested in Faizabad and Varanasi, two hot spots for spot blotch, through the All India Coordinated Research Project on Wheat and Barley (AICRP).

Despite the high disease pressure, especially at Varanasi, more than 20 lines showed combined moderately resistance to spot blotch at both locations. The data as well as the lines have been shared in the India National Barley Breeding Programs to be used as resistance donors (Figure 5).

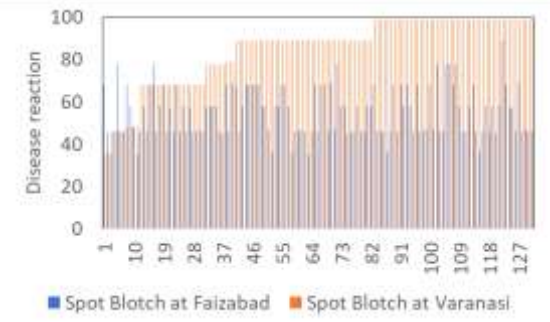

Figure 5 Disease reaction of ICARDA elite barley genotypes to spot blotch in Faizabad (blue) and Varanasi (orange) in 2020.

In addition to the test of new varieties, a collaborative research between ICARDA and Institute of Agricultural Sciences of Banaras Hindu University (Varanasi, India) and the Narendra Dev University of Agriculture and Technology (Faizabad, India) among other collaborators was undertaken to identify the basis of spot blotch resistance in ICARDA germplasm. Using an ICARDA association mapping panel, 23 QTL at the seedling stage with Moroccan isolates and 15 QTL at the adult plant stage resistance in Indian hot spot locations (Faizabad and Varanasi) were detected. Of them, common QTL providing resistance to spot blotch at seedling and adult plant stages were identified and can now be used for marker assisted selection strategies (Visioni et al., 2020)

In addition to spot blotch, the 350 ICARDA elite barley genotypes were also tested for yellow rust (*Puccinia striiformis hordei*) response at Rajasthan Agricultural Research Institute (Durgapura, India). The results

showed good level of resistance in the ICARDA lines targeting high input environments. These environments are generally the most prone to disease severity. Particularly interesting was the level of resistance in the malt barley genotypes, for which disease resistance is a must in order to prevent quality loses that would decrease the selling price of the grain for the farmers (Figure 6).

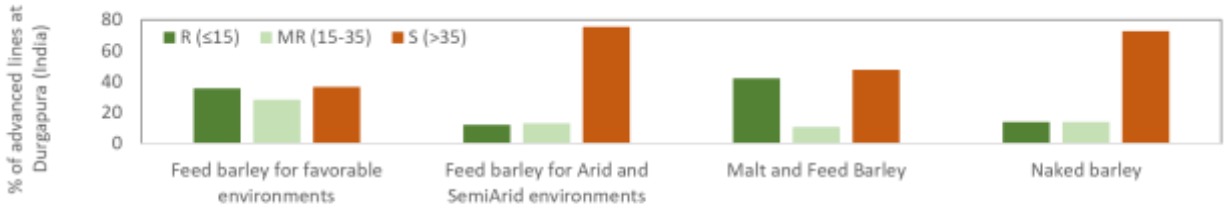

Figure 6 Disease response of the 350 ICARDA elite barley genotypes tested in Durgapura (India) in 2020.

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Reference

Visioni, A., Rehman, S., Viash, S. S., Singh, S. P., Vishwakarma, R., Gyawali, S., Al Abdalat, A. Verma, R. P. S. (2020). Genome Wide Association Mapping of Spot Blotch Resistance at Seedling and Adult Plant Stages in Barley. Frontiers in Plant Science. https://doi.org/10.3389/fpls.2020.00642