Advantages of the new advanced lines of crop wild relatives in farmer's fields during the season 2019-2020

Published on: February 9, 2021, Submitted by Noureddine El Haddad on: February 1, 2021

The extra harsh climatic conditions of the season 2019-2020 posed a great challenge to our improved lines emanating from crop wild relatives project (DIIVA-PR) especially in Safi region where rainfall was less than 100 mm. The covid-19 epidemy was also a serious challenge to visit DIIVA-PR trials, however, our connection with farmers has persisted throughout the period of the epidemy. Remarkable results were achieved especially regarding high yield potential, drought resistance, and disease resistance by using the improved lines of durum wheat, barley and lentil. These lines hold potential in contributing to improve the living conditions of many farmers, and therefore, make their food system more sustainable.

Crop wild relatives of durum wheat and barley grown in the farmer field at Guigou during the cropping season 2019-2020

DIIVA trials for large-scale environmental conditions

In the season 2019-2020, the new candidate varieties of durum wheat, barley and lentil generated from the crop wild relatives (CWR) were evaluated at 19 farmers' fields at different locations in Morocco, representing very dry areas, irrigated zones, mountain and rain-fed plateaus. The development of robust varieties against the multiple biotic and abiotic stress that hamper agriculture remains the main objective of DIIVA-PR project under the current climate change scenarios. Today, all breeding programs worldwide are more conscious of the necessity to integrate farmers opinions and impressions on the improved lines through "Participatory varietal selection (PVS)", so farmers can select improved varieties with desired characteristics.

This approach has shown a significant benefit in the identification of farmer's requirements and facilitates the selection stages by obtaining farmer's preferences at the early stage of selection. By involving farmers in the various stages of the selection process, the PVS might reinforce the dynamic farmer system and save time and money substantially to release the adorable varieties that can replace the older ones, which become vulnerable to many environmental restrictions. However, the replacement of the older varieties; which have been cultivated several years and passed from one generation to another; can sometimes meet some resistance from some farmers. Great efforts are required to convince these farmers, and a small demonstration in their own field can prove the superiority of the new varieties and change their mindsets for better returns in their crops.

In the last cropping-season 2019-2020, the CWR-derived lines of durum wheat, lentil and barley were evaluated in different agro-ecological zones distributed from Midelt and Guigou Atlas Mountains (West of Morocco) to the severe conditions of Safi regions in western Morocco on the Atlantic Ocean. In most areas, the low precipitation rate persists as a critical challenge for the agriculture sector and lead to dramatic yield losses. For example, Oued Zem region located in the center of Morocco received less than 150 mm, which caused substantial yield losses.

Over several years, the cultivation of barley and sheep remains the principal farming systems in Oued Zem region. The new CWR-derived lines have been introduced for the first time and planted at two farmers' fields. Despite the low precipitation, the new CWR derived lines could withstand severe drought either in comparison with standard checks or the local varieties grown by farmers. "Farmer 1" is one of the biggest farmers in Oued Zem and he worked for several years with many national and international institutes including ICARDA. During the period, he accumulated strong knowledge and experience that lead him to select comfortably the best varieties that can be incorporated into his own field. Unfortunately, "Farmer 1" has lost around 300 ha of barley and about 100 ha of bread wheat due to the harsh drought stress. Despite the loss, he showed a great appreciation for the strength of the new CWR varieties in resisting the extreme conditions.

During selection day, "Farmer 1" alongside his farmer friend started investigating each variety of durum wheat first and they saved the seeds in their hands to give final decision picking the first-class variety. Both farmers selected trustingly the CWR elite named Jabal which was derived from *Ae. Spetoides* as the preferred variety. Once more, Jabal was selected among durum wheat elites as the top due to its high specific qualities. The size of the spikelet, black awns, seeds size, grain colour and the high resistance to drought were the major attractive features for "Farmer 1" and his colleague. Our results revealed the superiority of the elite Jabal against other varieties of durum wheat and it surpassed the yield of the commercial check Karim by 50% in the field of "Farmer 1". Also, the two farmers selected the entry Furat-3 as the best entry among the newly derived lines of barley. The perfect size of seeds was the most attractive trait for both farmers, and they expected to gain more benefits using this variety (Furat-03). Regarding the productivity, entry-1 registered the highest yield with about 1384 Kg/ha followed by Amalou (6 rows local check) with 1328 Kg/ha under the severe drought condition of Oued Zem.

The miracle of crop wild relatives continues to tell the whole story in multiple tested environments. Their high adaptation and performance were engraved on the memory of many farmers, like what was happened in Guigou. In this mountain region where agriculture is the main source of livelihood for many families, several farmers started to discover the efficiency of CWR against multiple biotic and abiotic stresses which influence agricultural activity, principally drought stress. In Guigou region, farmers often grow staple crops like barley, wheat and onion to feed and support their families. "Farmer 2" is one farmer who has been growing the CWR lines of barley, durum wheat and lentil for the second season. In the last season, "Farmer 2" selected wisely the elite Zagharin-2 (originated from *T. araraticum*) of durum wheat and the entry-19 (two rows variety of barley) (Fig. 1). He was very attentive to store their wonderful seeds for the next planting season and planted them on a large scale. Many farmers have visited his field and provided significant feedback on the high adaptation of CWR lines to the conditions of Guigou, which is very cool to chilly in winter and extremely hot in summer. The size of spikelet and grain's size/color, the good plant height and the high resistance to drought were the most striking characters by Guigou's farmers. Moreover, many local varieties that have been transmitted from generation to generation remains unfamiliar for many farmers in this region. The reasons for this might be that most farmers got their seeds from the local market, without focusing on the name of varieties. Yet, the name of the advanced breeding lines was engraved on farmers minds, it's one great advantage of ICARDA breeding programs that are using uncomplicated appellations, with significant advantages.

Fig 1. Harvest period of the new CWR-derived lines of durum wheat and barley by in the farmer field at Guigou in summer 2020.

It was wonderful to see how some farmers can recognize the candidate varieties of three crops and their specific behaviors with a great consciousness. Their wide experience in the field across many years guides them to be astute farmers in the selection of the most suitable varieties. "Farmer 3"is another farmer who accumulated skills and knowledge along with his farming life. In Tedla region, "Farmer 3" spent more than 30 years in the field and grown several varieties of durum wheat and barley which are relatively unbalanced to the fluctuations of climate change. Yet, he is very satisfied with the performance of the new CWR varieties which provided him high yield and showed great stability, comparing to what he was cultivating for several years. The grain size; biomass and very good disease resistance were the most chief traits for "Farmer 3" selection. In the following year, all the tested lines were planted again by "Farmer 3" alongside his preferred CWR variety IDON39-70 of durum wheat (Fig 2) and barley (Entry-2) which were planted on a large scale (around 0.5 ha for each).

Fig 2. 2020. IDON39-70 derived from *T. araraticum* grown in farmer field at Tedla region during the season 2019-2020.

In Midelt, the advanced lines of crop wild relative of the three crops had faced a violent challenge (thunderstorm) at the maturity

phase. The heavy rain with a high wind occurred in Fes- Meknes and Midelt regions caused intense detrimental effects on crop yield of many species, and therefore, agricultural production. Assessing the CWR of durum wheat, barley and lentil in such extreme conditions of weather disaster is more relevant, explaining the magnitude of climate change. Today, the latter being of great concern worldwide. In the field of Mr. “Farmer 4” who has grown DIIVA material for the second year in Midelt, entry-2 (two rows barley) and Jabal derived from *Ae. Spetoides* were exceedingly great in resisting the severe thunderstorm and making the story of our CWR line more spectacular. However, the commercial checks Amalou and Karim were highly vulnerable to this extreme weather, which caused an important reduction in their yields.

Re-introduction of lentil cultivation in the altered environments caused by climate change

Many farmers have abandoned the cultivation of lentil due to numerous limitations caused mainly by the high vulnerability of their local varieties against the multiple biotic and abiotic stresses. Generally, heat and water stress are the two major abiotic constraints leading to a serious decrease in yield for most cultivated areas dedicated to lentil crop. In Morocco, lentil is often grown in rainfed regions and its productivity is frequently restricted by irregular rainfall. The renaissance of lentil cultivation in the areas severely affected by climate change is the primary target of DIIVA-PR project, which aims also to improve the income and food security of smallholders. For that, ICARDA lentil breeding program has made great efforts towards developing promising varieties that are better adapted to the extreme conditions. Crop wild relatives have recognized as a great reservoir of genetic material to incorporate desired traits. To limit the impact of climate change, the effort has been made chiefly to develop extra short-duration varieties of lentil for a cereal-based system for West Asia and North Africa (WANA) and sub-Saharan countries, drought and heat tolerant varieties.

The extreme water stress of the season 2019-2020 was a real challenge for the new CWR of lentil as well as the local check Bakria. In the field of Mr. Farmer 5, the yield of two advanced lines surpassed the yield of Bakria by 5-15%. On the selection day, Mr. Farmer 5 was looking carefully into each variety of lentil separately and select the best line that can be grown in his field. Many criteria were considered in his selection principally: early flowering, early maturity, seeds size and colour, biomass and high productivity.

Fig 3. 2020. Evaluation of the new CWR-derived lines of lentil in farmer field at Marchouch during the season 2019-2020

In Safi region where drought conditions were more difficult, the new CWR lines of lentil performed better under severe drought conditions. In Mr. Farmer 6 field located in Jemâa-Shaim, a significant productivity improvement was observed via the use of advanced lentil lines, and their yield exceeded the yield of Bakria by 40 to 200 %. The severe drought resulted from the poor precipitation (< 150 mm) affected strongly the commercial check Bakria which remains very susceptible to drought. Around 70 km in the south of Jemâa-Shaim, the CWR lines including the new advanced lines of lentil were assessed at Mr. Farmer 7’s field in a region called Echammaia. Yet again, the line 7978/ILWL118/5-4 was the topmost adapted in the plateaus of Echammaia, and registered the highest yield among the tested lines exceeding the yield of Bakria by 20%. Mr. Farmer 7 selected the line 7978/ILWL118/5-4 as the most suitable variety due to its short duration (early flowering and maturity), seed size and colour, plant height, resistance to drought and high productivity.

Superiority of the advanced lines of lentil confirmed as well at Midelt, a region between the Middle Atlas and High Atlas mountain ranges. Mr. “Farmer 3” gained about 20 to 50% higher yield using the CWR-lines. Unfortunately, many farmers in Midelt region abandoned the cultivation of lentil for several reasons, which would be mainly due to the cold weather and the lack of precipitation. Today, the use of these improved and high yielding lines hold potential to bring back area under lentils which can increase the incomes of farmers and help to make their farm systems more resilient and productive.

Such adoption of the improved varieties of durum wheat, barley and lentil originated from crop wild relative has contributed successfully to limit the impact of climate change, and therefore, increase the productivity 2 to 3 times more than the best commercial checks. Hence, PVS was an effective way to identify high yielding and the most appropriate varieties for farmers, and allow them to enhance expressively their incomes and the increased profits are a means for each farmer to improve the life of their families.

Tasty recipes of CWR varieties

No! This is not yet the end for DIIVA-PR project which goes more than selecting the suitable varieties for farmers, but also to taste these varieties in their own Kitchens. After the harvest, each farmer was requested to make the traditional diets using the new advanced varieties of durum wheat, barley and lentil. For the CWR of durum wheat, all the varieties have been tested by farmers’ wives who provided a great appreciation about the quality of bread made from these varieties. They made as well other deities such as couscous, Harsha and Malwi. The same positive response was received from farmer’s wives in making barley semolina, known locally as balboula or dchicha, and can be used also for the production of couscous or barley flour for baking.

The advanced lines of lentil have been also examined by farmers’ wives, and their observations were noted in our survey. For many decades, lentil remains among the indispensable ingredients of the Moroccan cuisine culture, and it is used widely in the preparation of numerous famous traditional meals such as Harira soup, which is consumed during Ramadan when breaking a fast. Moreover, lentil is consumed minimum once per week in the form of salads or lentil stew, as it is easily cooked in a short period of time and substitute anything that might be missing. Red lentils with large size are the most preferred and consumed by Moroccan populations. Our survey with farmers provided favourable responses to the color/shape of seeds, the cooking time and the taste

of the advanced lentil lines.

Linking farmers with Beni-Mellal cooperative

The DIIVA-PR project reached an advanced stage linking the farmers of Telda regions with the cooperative of Beni-Mellal named “Tradi Bio”. After the harvest of DIIVA trials, two farmers who are growing advanced lines emanating from the crop wild relatives have transferred the seeds of durum wheat, barley and lentil to the cooperative, which will test these new varieties for the preparation of their products. This association sounds like an excellent initiative between farmers and cooperatives and effectively supports both for achieving their goals. Unquestionably, farmers can improve their overall profitability and that will add substantial value to the CWR varieties of the three crops. The cooperative can provide at the same time good suppliers that giving the greatest value-in-use and offer top quality products to buyers.

Acknowledgement

1. Norwegian Development Cooperation (NORAD)
2. Crop Trust

Projects

- DIIVA-PR: Dissemination of Interspecific ICARDA Varieties and Elites through Participatory Research

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Keywords

- barley
- crop wild relatives
- yield
- lentil
- durum wheat
- participatory varietal selection approach

Countries

- Morocco

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