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Survey and conservation of crop landraces in northwest Syria

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Abstract: Syria lies at the heart of the Fertile Crescent – one of the centres of diversity of staple crops such as wheat, barley, chickpea and lentil. The country has historically been rich in agrobiodiversity, including crop landraces valued for their nutritional and culinary qualities, as well as for their resilience. With their cultivation already in decline before the start of the Syrian crisis in 2011, this study was undertaken to assess the current status of crop landraces in northwest Syria, and to initiate an *ex situ* conservation programme. We found a significant decline in the number of landraces in cultivation, indicating a loss of locally adapted genetic diversity. Influencing factors include insufficient seed supply, competition with commercial hybrids, falling market demand and neglect by relevant government authorities. Despite not seeing conservation as their responsibility, the participating farmers were supportive of landrace conservation and willingly contributed seeds for *ex situ* conservation.

Keywords: Plant genetic resources, Genetic erosion, On-farm conservation, Landraces

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Introduction

Crop landraces have been defined as "dynamic populations" of cultivated plant species that have distinct identities and historical origins, and which lack formal crop improvement, and are typically "genetically diverse, locally adapted and associated with traditional farming systems" (Camacho-Villa *et al*, 2005). They are "closely associated with the uses, knowledge, habits, dialects, and celebrations of the people who developed and continue to grow" them (Veteläinen *et al*, 2008), and their continued existence traditionally relies on repeated cycles of seed selection and sowing (Almekinders *et al*, 1994; Maxted *et al*, 1997). These populations characteristically exhibit high levels of adaptation to local environmental conditions, including abiotic and biotic stress tolerances, through a combined process of human and natural selection (Almekinders *et al*, 1994).

Crop landraces are valued not only for their adaptation and resilience to local climatic conditions and resistance to pests and diseases, but also for their nutritional and culinary qualities – such as flavour, colour and texture – and their cultural value (FAO, 2019b). Furthermore, they constitute a valuable pool of genetic diversity for crop improvement – particularly in the development of varieties with abiotic and biotic stress tolerance and for incorporating farmer-preferred traits (FAO, 2019b). However, the socioeconomic change and transformation of production systems that occurred worldwide in the twentieth century, has resulted in the substitution of landraces with modern cultivars and a

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widespread reliance on crop monocultures (Veteläinen *et al*, 2008; Van De Wouw *et al*, 2010; Frison *et al*, 2011; Maxted *et al*, 2011; Dwivedi *et al*, 2016; FAO, 2019b; Petropoulos *et al*, 2019). This homogenization, and associated loss of landrace diversity, has rendered agriculture, food security and livelihoods vulnerable to the impacts of climate change, such as drought, heatwaves, storms, floods and frosts, as well as unexpected pest and disease outbreaks (GenRes Bridge Project Consortium, ECPGR, ERFP and EUFORGEN, 2021).

Under the current climate crisis, diversification in farming is needed, including the use of more genetically diverse crop varieties resilient to the increasingly extreme and uncertain impacts of climate change (FAO, 2008, 2019a; GenRes Bridge Project Consortium, ECPGR, ERFP and EUFORGEN, 2021). The conservation of crop landraces is therefore an essential component of sustainable agricultural development (Dwivedi *et al*, 2016; Ficiciyan *et al*, 2018; FAO, 2019b), and this includes incentives to retain the cultivation of landraces on farm, as well as to ensure complementary *ex situ* conservation in genebanks as a backup for potential losses in farmers' fields, and for access for research and crop improvement (Maxted *et al*, 1997, 2011; Veteläinen *et al*, 2008; FAO, 2011, 2019b).

Syria lies in the Fertile Crescent – a region of considerable topographic and climatic diversity (MSEA, 2009) and in the historical centre of origin of many world food crop staples, such as cereals (e.g. wheat, barley and rye), legumes (e.g. lentil, chickpea and broad bean) and fruits and nuts (e.g. peach, pear, almond and pistachio), as well as animal feed (Vavilov, 1926; Damania, 1994; FAO, 1995; Willcox, 2012; Mazid *et al*, 2014; Jaradat, 2017). Syrian crop landrace diversity has contributed to crop improvement for increased agricultural production (e.g. in barley (Ceccarelli and Grando, 2000)). The same authors concluded that "securing the continuity of the evolutionary processes within landrace populations is of vital importance for future generations."

The threat to Syrian crop landraces was already recognized in the 1990s, particularly in relation to wheat, vegetables and fruit trees, as a result of the adoption of genetically uniform modern varieties and the lack of policies to protect landraces from competing commercial varieties (FAO, 1995). Although landraces remain in cultivation in Syria, their use has declined over time due to the push towards new higher-yielding varieties, when fertilizers and agrochemicals are available (FAO, 1995). In addition, the younger generation is moving away from agriculture, either as a profession or for subsistence purposes (Veteläinen *et al*, 2008; Maxted *et al*, 2011; Mazid *et al*, 2014), and while crop landraces are often valued for their unique qualities, some do not produce sufficiently high yields for adequate income generation (Veteläinen *et al*, 2008).

Organizations active in plant genetic resources conservation and crop research in Syria before the onset of the crisis in 2011 included the Arab Centre for the Study of Arid Zones and Dry Lands (ACSAD), founded in Damascus in 1968, the Syrian Ministry of Agriculture and Agrarian Reform (SMAAR) seedbank in Douma, and the International Centre for Agricultural Research in the Dry Areas (ICARDA), established in Tel Hadya in 1975. The majority of ICARDA's international staff fled Syria in 2012, with its genebank operations ceasing in 2015 (Alkiswany, 2012; Gewin, 2015). Following damage to its facilities, the General Organization for Seed Multiplication (GOSM), the national source of seed multiplication and supply for commercial varieties, also ceased its operations in Idleb Governorate, northwest (NW) Syria (CRS, 2015). In 2013, the Syrian Interim Government (SIG) established a parallel seed-multiplication entity in opposition-controlled areas of Idleb and Aleppo Governorates to try to meet local needs in NW Syria through the import and export of commercial/hybrid seeds for cereals, legumes, potatoes, and vegetables, with its seed-multiplication activities limited to commercial wheat varieties.

Since the beginning of the Syrian crisis, agricultural production has fallen considerably due to drought, migration, insecurity, loss of government subsidies and the rising prices of inputs, such as fuels and fertilizers, as well as limited access to markets (Kelley *et al*, 2015; Mohammed *et al*, 2019; Al-Ghazi, 2021). For example, by 2017, only 18 out of 33 commercial wheat varieties were still in use by farmers in NW Syria, 9 for durum and 9 for soft wheat (GOSM, 2017). At the same time, the conservation of Syria's crop landraces has not been a priority for local authorities and humanitarian actors, and initiatives to conserve local genetic resources have been limited by insecurity and loss of expertise. At national level, ACU (2016) reported that Syria's farmers were still producing 32% of their own wheat seeds, while being reliant on traders for 50%, and other sources (including donated and subsidized seed) for the remaining 18%. However, in NW Syria, farmers were reported to source 90–95% of their seed through informal channels (CRS, 2015). Further, the primary focus of ICARDA and SMAAR on cereals and cash crops has resulted in an absence of data on landrace vegetables, legumes (e.g. common bean and cowpea) and forage crop varieties (ICARDA, 2017)

It was within this context that in 2018, the authors initiated a study of the status of crop landraces of vegetables, legumes, cereals, forages and cash crops in NW Syria, with the aim of ensuring the availability of this diversity for future generations, and in the longer term, the multiplication and provision of good quality seeds for small-scale farmers in the region. Specifically, the objectives were to: (a) understand the current use of crop landraces in NW Syria and assess whether there has been any loss of diversity, (b) reveal the factors influencing their continued cultivation as well as the potential causes for declining use and (c) inform the process of collecting landrace seeds to initiate *ex situ* conservation.

Materials and methods

The study was conducted between December 2018 and November 2019 in Idleb Governorate in the districts of Maaret Tamisrin, Saraqeb, Ma'arrat An'Numan and the Idleb subdistrict (Figure 1). This region is located within the second and third agroecological zones, incorporating both mountains and plains. Agroecological zone 2 covers 2,473,000 ha (13.4% of the country) with an annual rainfall of 250 to 350mm and no less than 250mm across two-thirds of the monitored years. Agroecological zone 3 comprises 1,306,000 ha (7.1% of the country) with an annual rainfall of 250 to 350mm and no less than 250mm over half of the monitored years (FAO, 2003).

In December 2018, prior to starting the data collection, preliminary meetings were held with local council and community representatives in each of the four districts to explain the information on the study, its methods, objectives and importance, as well as to help identify suitable study participants from the local areas (i.e. individuals with considerable experience and a good knowledge of agriculture and crop diversity within the study area).

The study combined 75 one-to-one face-to-face interviews and 25 focus groups (FGs), each of which involved 5 to 10 participants. The research participants included established farmers (67), agricultural engineers (15) and agricultural researchers (18) – the latter including former local researchers from ICARDA and the General Commission for Scientific Agricultural Research (GCSAR). An interview questionnaire (see Supplemental Data) was developed and shared with both interviewees and FG participants, requiring them to answer questions as to which landraces had fallen out of use and why they believed this had happened, as well as to provide related timeframes. In the FGs, each of the questions was discussed collectively, in order to reach consensus on the answer.

The recruitment of participants with good local background knowledge was central to obtaining a full and accurate picture and to achieving the research objectives, as was the willingness of study participants to share that local knowledge. The majority of the farmers involved (89%) had farms of 1,000m^2 plus, so of sufficient size to be cultivating a range of crops, with 22 of those interviewed aged 55 years or over. The age and experience of this group provided the study with good historical knowledge of the crop landraces that had been cultivated in the area, as well as changes in their use. Due to local social norms, all study participants were male. However, some farmers' wives participated in the interviews and shared their knowledge.

The one-to-one interviews were conducted from January to March 2019 using hard copies of the questionnaire to allow interviewees to provide answers in writing. As an introduction to the interviews, the interviewer shared information on the study, its methods, objectives and anticipated duration. Participants were then invited to sign a consent form. If the participant was happy to proceed, the interviewer then proceeded to the interview, reading out each question in sequence. Where requested, the interviewer provided further clarification to avoid any misunderstanding and ensure accurate responses to the questions. Answers were provided by the interviewees in writing on the questionnaire form. In the case of illiteracy amongst some of the farmers, the interviewer wrote interviewee responses on their behalf. In the case of the FGs, the interviewer captured the groups' answers in writing once consensus had been reached. All interview and FG data were transferred to MS Excel and anonymized by the team prior to analysis, to ensure confidentiality. The research team discussed the characteristics of each landrace to make sure that each was correctly identified and recorded in one of the five crop categories (vegetables, legumes, cereals, forages and cash crops).

The study also involved asking participating farmers to share seed samples of particular landraces to form the nucleus of the *ex situ* collection. Seed samples from 74 landraces, both field crops and vegetables, were collected from farmers across the four districts and planted for multiplication purposes in a safe location in Sarmada, NW Syria, near the Syrian-Turkish Bab Alhawa border crossing, using typical local cultural practices. At maturity, seeds were collected, dried and disinfected using thiram fungicide. Each sample was then placed in a labelled paper bag on which the variety, original location, source of the variety, name of the farmer who had donated the sample (with their permission), sample size, collection date and storage date were recorded, prior to being stored in airtight plastic barrels with dry silica gel. At this stage, this modest seed-multiplication activity aims only to increase their quantity as part of this *ex situ* collection. Additional funds will be required to expand seed-multiplication activities in order to support their distribution for use by local farmers.

Results

The 75 interviewees and 25 FG participants took part willingly in the study, providing the information being sought by the study team. They had good knowledge of the crop landraces that had been widely cultivated in their local area over the previous 20 years, and which were still in cultivation in 2019. More than half of the 73 landraces recorded in the study as previously widely cultivated were of vegetable crops (54%) – the remaining comprising legumes (19%), cereals (18%), forages (7%), and cash crops (2%) (Table 1).

In terms of actual numbers (Table 1), the study revealed that amongst the ten wheat landraces that were once widely cultivated, only five were still in use, and of the five species of legumes being grown in the study area, the number of landraces that were still in use had fallen from 23 to 11. The eight vegetable crop species had once included 27 landraces, whereas only 14 were still in widespread cultivation in 2019. Of the four sunflower cash-crop landraces known to the farmers, only one was no longer grown, whereas the majority of forage landraces (six out of nine)

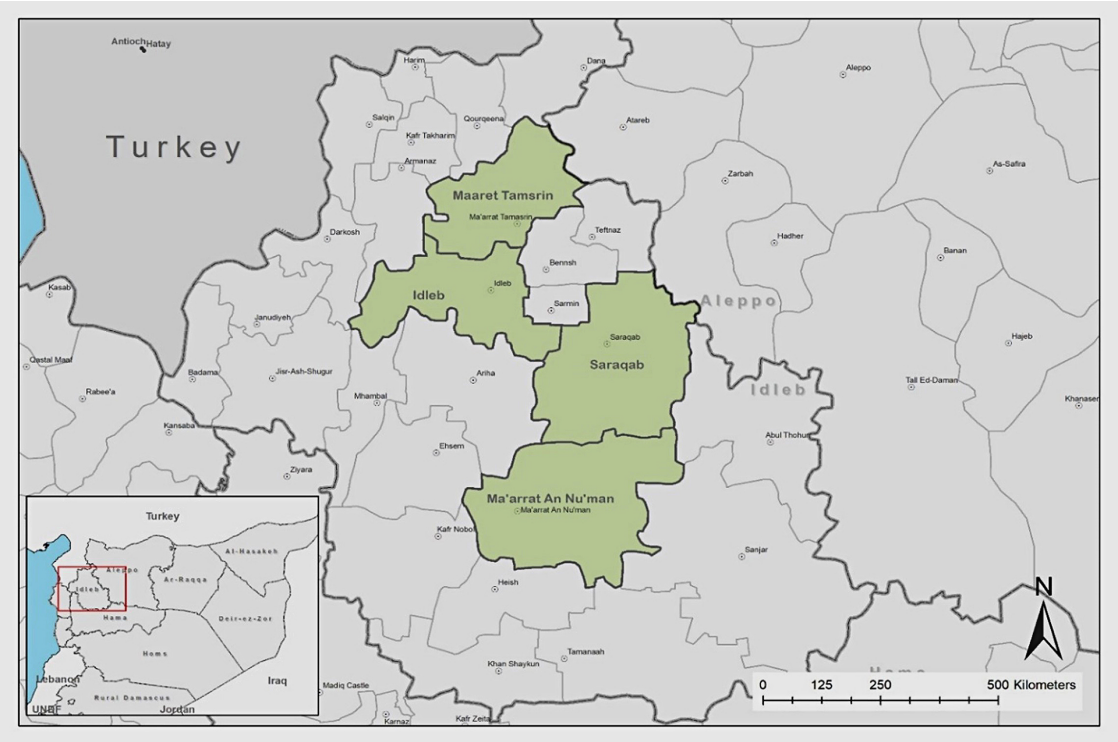

Figure 1. Study area. The inset map shows the research area in green, relative to the whole of Syria. Source: Humanitarian Data Exchange https://data.humdata.org/dataset/syrian-arab-republic-administrative-boundaries-populated-places

Table 1. Status of the cultivation of landraces by crop category across the study area (NW Syria) in 2019. PWC, previously widely cultivated, i.e. common and widely available in the communities in terms of yield and seed during the period 1999–2019; CWC, currently widely cultivated, i.e. previously widely cultivated, and still common and widely available.

Category	Common name	Scientific name	PWC	CWC
Cereals	Wheat	*Triticum aestivum*	10	5
Legumes	Broad bean	*Vicia faba*	4	3
	Chickpea	*Cicer arietinum*	6	2
	Common bean	*Phaseolus vulgaris*	5	3
	Cowpea	*Vigna unguiculata*	3	1
	Lentil	*Lens culinaris*	5	2
Vegetables	Armenian cucumber	*Cucumis melo flexuosus*	5	1
	Eggplant	*Solanum melongena*	5	2
	Pepper	*Capsicum annuum*	4	3
	Tomato	*Solanum lycopersicum*	4	1
	Watermelon	*Citrullus lanatus*	3	2
	Zucchini	*Cucurbita pepo*	1	1
	Okra	*Abelmoschus esculentus*	3	2
	Squash	*Cucurbita pepo*	2	2
Forages	Barley	*Hordeum vulgare*	4	1
	Corn	*Zea mays*	5	2
Cash crops	Sunflower	*Helianthus annuus*	4	3
		Totals	73	36

had been abandoned. Notably, none of the landraces that were previously widely cultivated are now only rarely cultivated or found only in restricted or very local cultivation. Furthermore, no new landraces were recorded and none of the landraces currently widely cultivated were previously only cultivated on a small scale. Figure 2 shows the decline in cultivation of the landraces that were once widely grown by crop category, which all the interviewees agreed had been well adapted to the climatic conditions in their area.

Understanding why particular landraces were still in cultivation or not was an important part of this study. Interviewees and FG participants were asked to select one or more reasons from a list of possible causes

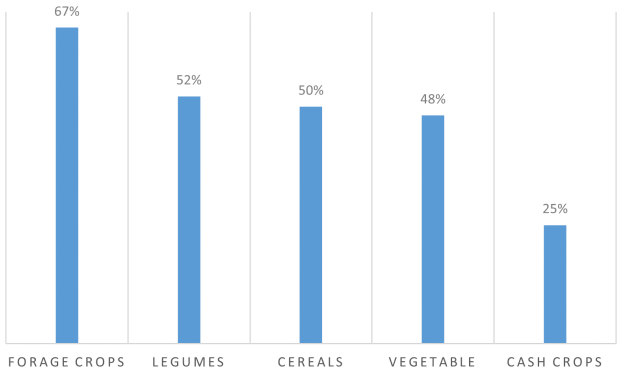

Figure 2. Percentage reduction in the number of landraces cultivated in the study area before and after 2019 by crop category.

developed by the study team for each crop category (Figure 3). Participants gave good taste, pest resistance and drought tolerance as the most important reasons for the continued use of crop landraces. Other factors, such as yield, historical interest and storage properties were deemed to be of less importance.

When offered a second set of reasons as to why they might continue cultivating these landraces, the most significant were local sale (cited by 41% of participants) and seed production (34%). Use for personal consumption (18%) and national sale (7%) were seen as less important.

Figure 4 shows that when 67 participating farmers were asked to consider why they no longer cultivated a particular landrace, the main factors given were lack of seeds (50%), competition from new hybrids (24%) and competition from more productive commercial varieties introduced from other parts of Syria (18%). Factors such as neglect by the competent authorities, disinterest amongst the next generation of farmers, lack of market demand and the absence of government control, were seen as less important.

When the farmers were asked about seed exchange, 90% confirmed the exchange of small quantities with other growers, with the remaining 10% open, in principle, to the practice of regular seed exchange. This was

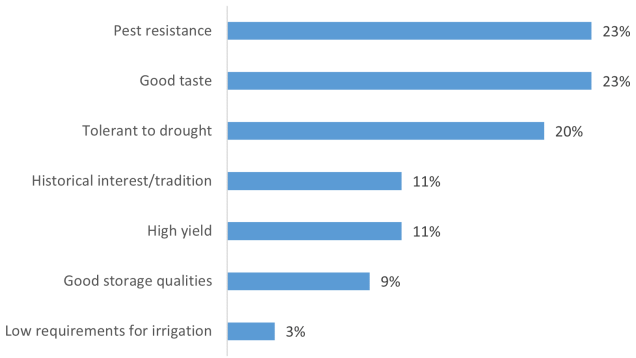

Figure 3. Reasons for the continued cultivation of crop landraces in NW Syria (based on the responses of the 75 interviewees and participants in the 25 FGs).

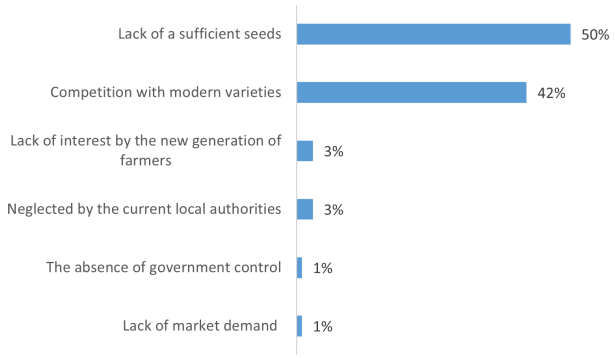

Figure 4. Reasons for farmers no longer cultivating crop landraces (based on the responses of 67 farmers).

reflected in their responses to questions on measures that might be taken to conserve landraces (Figure 5). All expressed an interest in conserving landraces, with the exchange of seeds with other farmers (61%) considered the most important protection measure, although conservation in genebanks was also seen to be important (22%). Although farmers did not consider the general conservation of crop landraces to be their responsibility, nevertheless, all those interviewed expressed a willingness to share their knowledge to support conservation of landraces through the establishment of a farmers' association.

Discussion

Prior to this initiative, the most recent available information on the status of crop landraces in Syria dated back to 2016 and focused on wheat. However, our 2019 study of vegetable, legume, cereal, forage, and cash-crop landraces reveals that about half of the landraces in cultivation in NW Syria 20 years ago are no longer cultivated. Although the range of crop species remains comparable, farmers no longer maintain or use all the landrace varieties that were cultivated in the past, indicating a significant loss of locally adapted crop diversity.

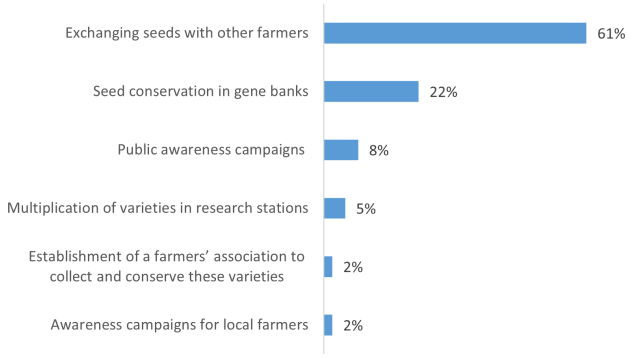

Figure 5. The importance given by the survey participants to different landrace conservation measures (based on the responses of the 75 interviewees and participants in the 25 FGs).

Although the study did not allow us to determine confidently whether this erosion of local genetic resources had increased since the start of the Syrian crisis in 2011, observations and knowledge gained throughout this period by the authors point strongly to an overall decline in biodiversity in NW Syria (both on-farm and in the wild), particularly due to social pressures such as migration and a dependency on collection of local natural resources. Although a number of the farmers who participated in the study did consider that an absence of government control and neglect by competent local authorities was a factor in the decline of their crop landraces, the ongoing crisis is clearly an underlying factor, pointing to the need for urgent interventions to protect these landraces from further genetic erosion. The reasons given for continuing to grow particular landraces were a mix of end-use and practical cultivation considerations. For example, flavour and texture were highlighted as important qualities, along with pest resistance and drought tolerance. The value of crop landraces for pest and disease resistance, as well as for drought tolerance, has been widely reported (Almekinders *et al*, 1994; FAO, 1995; Veteläinen *et al*, 2008; Dwivedi *et al*, 2016; FAO, 2019a)

Interestingly, yield was ranked lower than good taste, pest resistance and drought tolerance as a reason for continuing to cultivate crop landraces in this study, and equally with tradition and historical considerations. This indicates that while yield is often considered the most important aspect of crop production, landraces continue to be cultivated for other qualities that are not available in high-yielding varieties. The importance of local sales as a reason may also speak to the value of taste or tradition of the crop in the local area. One evident barrier to the continued cultivation of landraces is a lack of seeds (noted by 50% of the participating farmers), pointing to a need for landrace seed regeneration, which could be organized through the establishment of a farmers' cooperative. However, some landraces clearly yield sufficient seed quantities, as seed sales were given by 34% of the farmers as a reason for continuing to grow them. Notably, the availability of seeds of competing hybrid varieties, regardless of their suitability for cultivation in the local environment, was given by 24% of the farmers as a strong reason for their cultivation over and above landraces. The quantity of good-quality landrace seeds may also account for the fact that many landraces are abandoned, rather than continuing to grow them only on a very restricted scale.

Ninety percent of the participating farmers noted the occasional exchange of landrace seeds with other growers – an action reliant on local trust-based seed supply networks. This indicates continued interest in the cultivation of landraces and the need for a formal seed-multiplication and quality-control system to maintain their production following the cessation of the activities of the GOSM in NW Syria since the start of the crisis. The effectiveness of the efforts of the SIG to replace that function in NW Syria has been limited and has not involved the seed multiplication of crop landraces.

Seed-exchange activities and local seed sales of landraces are a positive sign, although clearly insufficient to sustain landraces, given the study's finding that half of those in cultivation 20 years ago in the study area are no longer being grown by the farmers involved in the study, or based on the knowledge of other interviewed participants (agricultural researchers and engineers). These two ongoing activities may be the sole reason for the continued existence of the landraces that remain in cultivation, which might otherwise have become extinct. The extent of the remaining diversity could be determined through morphological and molecular genetic analyses.

Although the farmers involved in the study did not see themselves as the custodians of landraces, or believe that working together in farmers' associations would help, in the current crisis, they are nevertheless by default fulfilling this custodial role. The commonly held view was that this was the role of an external body, as had been the case prior to the crisis – a view illustrated by their willingness to support the practical measures initiated by the study team in the form of seed collection for *ex situ* storage and subsequent multiplication. Additional funds will be required to expand current landrace seed-multiplication activities and allow for their distribution amongst local farmers.

The results of this research point to the urgent need for complementary *in situ* (on-farm) and *ex situ* conservation to protect landraces that may otherwise be lost (Maxted *et al*, 1997; Camacho-Villa *et al*, 2005). Continuation of this work to create a local seedbank, and to support the regeneration and distribution of landrace seeds to farmers, could revitalize the cultivation and spread of these landraces in this war-torn region. The provision of seed samples to existing genebanks would provide additional protection against deleterious natural and human-induced events. The conservation of locally adapted crop landraces is an essential component of sustainable agricultural development for future food, nutrition and livelihood security for future generations in Syria and worldwide.

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Supplemental Data

Interview questionnaire

Author contributions

Munzer Al Darvish coordinated the research and contributed to the research design and manuscript; Anas Al Kaddour, Akram Bourgol and Yasser Ramazan contributed to the research design and manuscript, and

undertook the data analyses, Yousef Hallak contributed to the research design and carried out the field data collection; Shelagh Kell provided academic guidance and support throughout the research process and contributed to the manuscript.

Conflict of interest statement

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

References

ACU (2016). Syrian wheat reality. Report. 21. Assistance Coordination Unit. Şehitkamil/Gaziantep, Turkey

Al-Ghazi, S. (2021). The wheat and bread crisis in Syria and its impact on the population. url: https: //orsam.org.tr/dhbanaliz/the-wheat-and-bread-crisis-in-syria-and-its-impact-on-the-population.pdf.

Alkiswany, H. (2012). Syrian conflict forces research institute to relocate. url: www.scidev.net/global/news/syrian-conflict-forces-research-institute-to-relocate/.

Almekinders, C. J. M., Louwaars, N. P., and De Bruijn, G. H. (1994). Local seed systems and their importance for an improved seed supply in developing countries. *Euphytica* 78, 207–216. doi: https://doi.org/10.1007/BF00027519

Camacho-Villa, T. C., Maxted, N., Scholten, M., and Ford-Lloyd, B. (2005). Defining and identifying crop landraces. *Plant Genetic Resources* 3(3), 373–384. doi: https://doi.org/10.1079/PGR200591

Ceccarelli, S. and Grando, S. (2000). Barley landraces from the Fertile Crescent: a lesson for plant breeders. In *Genes in the Field: On-Farm Conservation of Crop Diversity,* ed. Brush, S. B. (IPGRI/IDRC/Lewis Publishers), 51-76.

CRS (2015). Seed System Security Assessment: NW Syria. url: https://seedsystem.org/wp-content/uploads/2016/05/SSSA-NW-Syria-Sept-2015-Report-for-distribution.pdf.

Damania, A. B. (1994). In situ conservation of biodiversity of wild progenitors of cereal crops in the Near East. *Biodiversity Letters* 2, 56–60. url: https: //www.jstor.org/stable/2999669.

Dwivedi, S. L., Ceccarelli, S., Blair, M. W., Upadhyaya, H. D., Are, A. K., and Ortiz, R. (2016). Landrace germplasm for improving yield and abiotic stress adaptation. *Trends in Plant Science* 21, 31–42. url: https://www.sciencedirect.com/science/article/abs/pii/S1360138515002605.

FAO (1995). Syria: Country Report to the FAO International Technical Conference on Plant Genetic Resources. url: https://www.fao.org/fileadmin/templates/agphome/documents/PGR/SoW1/east/SYRIANAR.PDF.

FAO (2003). Agro-ecological zones and farming systems. *In Fertilizer Use by Crop in the Syrian Arab Republic* . url: http://www.fao.org/3/Y4732E/y4732e06.htm

FAO (2008). Climate Change and Biodiversity for Food and Agriculture. url: https: //www.fao.org/uploads/media/FAO 2008a _ climate_change and biodiversity 02.pdf.

FAO (2011). Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture. url: https://www.fao.org/agriculture/crops/thematic-sitemap/theme/seeds-pgr/gpa/en/.

FAO (2019a). The State of the World's Biodiversity for Food and Agriculture. url: http://www.fao.org/3/CA3129EN/CA3129EN.pdf.

FAO (2019b). Voluntary Guidelines for the Conservation and Sustainable Use of Farmers' Varieties/Landraces. url: https://www.fao.org/family-farming/detail/en/c/1251445/.

Ficiciyan, A., Loos, J., Sievers-Glotzbach, S., and Tscharntke, T. (2018). More than yield: ecosystem services of traditional versus modern crop varieties revisited. *Sustainability* 10(8), 2834–2834. doi: https: //doi.org/10.3390/su10082834

Frison, C., López, F., and Esquinas-Alcázar, J. T. (2011). Plant Genetic Resources and Food Security: Stakeholder Perspectives on the International Treaty on Plant Genetic Resources for Food and Agriculture (New York, NY) . doi: https://www.fao.org/3/bb143e/bb143e.pdf

GenRes Bridge Project Consortium, ECPGR, ERFP and EUFORGEN (2021). Genetic Resources Strategy for Europe. url: http://www.genresbridge.eu/fileadmin/templates/Genres/Uploads/Documents/GRS4E.pdf.

Gewin, V. (2015). But who's preserving them? As climate change makes crop diversity even more important, gene banks struggle to stay afloat. url: https://ensia.com/features/crop-gene-banks-are-preserving-the-future-of-agriculture-but-whos-preserving-them.

GOSM (2017). The project of restoring local Syrian wheat varieties and preventing their loss and deterioration and working to multiply them. url: https://gosm-sy.org/the-project-of-restoring-local-syrian-wheat-varieties-and-preventing-their-loss-and-deterioration-and-working-to-multiply-them/.

ICARDA (2017). Strategic Plan 2017–2026. url: https://www.icarda.org/publications/11367/icarda-strategic-plan-2017-2026.

Jaradat, A. A. (2017). Agriculture in the Fertile Crescent: continuity and change under climate change. *CAB Reviews* 12(34), 1–33. doi: https://doi.org/10.1079/PAVSNNR201712034

Kelley, C. P., Mohtadi, S., Cane, M. A., Seager, R., and Kushnir, Y. (2015). Climate change in the

Fertile Crescent and implications of the recent Syrian drought. *Proceedings of the National Academy of Sciences* 112(11), 3241–3246. doi: https://doi.org/10.1073/pnas.1421533112

Maxted, N., Ford-Lloyd, B., and Hawkes, J. G. (1997). Complementary conservation strategies. In *Plant Genetic Conservation: The In Situ Approach.,* ed. Maxted, N., Ford-Lloyd, B., and Hawkes, J. G. (Chapman and Hall), 15-39.

Maxted, N., Kell, S., and Brehm, J. M. (2011). Options to Promote Food Security: On-Farm Management and In Situ Conservation of Plant Genetic Resources for Food and Agriculture. Background Study Paper No. 51. url: https://www.fao.org/3/am489e/am489e.pdf.

Mazid, A., Shideed, K., and Amri, A. (2014). Assessment of on-farm conservation of dryland agrobiodiversity and its impact on rural livelihoods in the Fertile Crescent. *Renewable Agriculture and Food Systems* 29(4), 366–377. doi: http://dx.doi.org/10.1017/S1742170513000240

Mohammed, S. A., Alkerdi, A., Nagy, J., and Harsányi, E. (2019). Syrian crisis repercussions on the agricultural sector: Case study of wheat, cotton and olives. *Regional Science Policy and Practice* 12(3), 519–537. doi: https://doi.org/10.1111/rsp3.12222

MSEA (2009). The fourth national report on biodiversity in the Syrian Arab Republic. url: https://www.cbd.int/doc/world/sy/sy-nr-04-en.pdf.

Petropoulos, S. A., Barros, L., and Ferreira, I. C. F. R. (2019). Editorial: Rediscovering local landraces: Shaping horticulture for the future. *Frontiers in Plant Science* 12. doi: https://doi.org/10.3389/fpls.2019.00126

Van De Wouw, M., Kik, C., Van Hintum, T., Van Treuren, R., and Visser, B. (2010). Genetic erosion in crops: Concept, research results and challenges. *Plant Genetic Resources* 8(1), 1–15. doi: https://doi.org/10.1017/S1479262109990062

Vavilov, N. I. (1926). Studies in the Origin of Cultivated Plants (Leningrad: Institute of Applied Botany and Plant Breeding).

Veteläinen, M., Negri, V., and Maxted, N. (2008). European landraces: on-farm conservation, management and use. *Bioversity Technical Bulletin No. 15* . url: https://hdl.handle.net/10568/106154.

Willcox, G. (2012). The beginnings of cereal cultivation and domestication in Southwest Asia. In *A Companion to the Archaeology of the Ancient Near East,* ed. Potts, D. (Blackwell, Chicester), 163-180.