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A New Future for the Ancient Perennial Mediterranean Vegetable ‘Akkoub (Gundelia spp. and Asteraceae)

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Abstract *Gundelia* has been cooked as a wild edible plant from pastures and open areas in many countries bordering the Mediterranean Sea. The foliage of this hardy, prickly, perennial genus resembles the artichoke (*Cynara cardunculus*) and has similar culinary uses. However, the heads are quite distinct and produce edible seeds that may once have been harvested as a source of vegetable oil. Though avoided by grazing sheep and goats, the dried foliage is palatable and nutritious when chopped and mixed in animal rations. Independently, several small producers in Palestine have begun sowing and raising *Gundelia*, known as ‘akkoub, as a crop because of its economic and cultural value, and because of increasingly constrained access to wild stands. An international collaboration could develop improved genetic varieties and agronomic practices to revive its use for oil seeds and to accelerate the domestication of this valuable, hardy plant.

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Introduction to *Gundelia*

Gundelia (Figure 1) is a small genus of prickly, perennial relatives of lettuce with a long ethnobotanical history across the Mediterranean region in Cyprus, Turkey (Anatolia), Armenia, Kurdistan, northern Iraq, Iran, Afghanistan, Syria, Turkmenistan, Kazakhstan, Uzbekistan, Israel, Palestine, Lebanon, Jordan, and Egypt (Hind 2013). *Gundelia tournefortii* L. (Aramaic: ʿakkub; Kurdish: kerenk; Arabic: ʿakkoub, ʿakub, kaʾub, Farsi: kangar, Turkish: kenger, French: Gundelie, English: tumbleweed, tumble thistle) was originally considered the only species in the genus with several varieties. These varieties have now been named as a species (Genç and Firat 2019), although ethnobotanically we will consider them a single crop here.

Gundelia is associated with well-drained soils and sunny landscape habitats such as steppe or open woodland plant communities, along with moderately disturbed sites such as roadsides and fallow fields (Hind 2013). Remarkably, although the plant also grows in rocky and inhospitable or overgrazed areas and looks thistle-like, nearly all parts of the plant are edible and even prized in local cuisine (Cakilcioglu 2020), with a range of documented human uses (Table 1). Until very recently, this genus has been exclusively harvested from the wild. However, it may have once been on the verge of domestication as an oilseed crop because early neolithic archaeological remains in Iraq and Turkey indicate gathering, threshing, and oil extraction (Hind 2013; Pieroni 2005; Rivera et al. 2011; Rosenberg et al. 1995; Savard et al. 2003). Gathering this plant from the wild may have continued for 10,000 years as contemporary villagers rank *Gundelia* among the 8 most important edible wild-harvested plants in Agri Province (Turkey) (Kadioglu et al. 2020). It is an important wild food plant in Palestine (Ali-Shtayeh et al. 2008; Hinnawi 2010; Tesdell 2018). Finally, the literature points to local and regional traditions for methods of processing and specific recipes for pickles, stews, and other dishes (Cakilcioglu 2020) as well as international trade (Lev-Yadun and Abbo 1999).

The deep, varied, and ongoing history of human relationships with and use of *Gundelia* provides evidence that this plant is culturally and economically valued. Such cultural valuation can be an important driver for cycles of domestication that could also feature agronomic and genetic changes, including artificial selection, for new and expanded human uses (Van Tassel et al. 2020). As access to wild stands of *Gundelia* is increasingly constrained, cultivation has been proposed to reduce pressure on wild populations (Padulosi and Giuliani 2004). In some places this is underway. Accelerated domestication of this wild vegetable, while sustaining its culinary significance, could help support diversity in regional food systems for the sake of resilience, sustainability, nutrition, and equity (Streit Krug et al. 2023). A new future for this perennial plant requires timely international collaboration for conservation.

Incipient Cultivation

Concerns within the scientific community about the growing dependency of the global food system upon a shrinking genetic base have been raised for many years (Harlan 1972; Khoury et al. 2014). Diversification of the food base could include genetic diversification of major crops using "crop wild relatives" (McCouch et al. 2013), de novo domestication of wild species–particularly those with life histories (Van Tassel et al. 2010) or adaptations (Rozema and Flowers 2008; Warschefsky et al. 2014) that diverge from our dominant staple crops–and revival of "orphan" crops that have not received modern investment in the form of genetic or agronomic research and development (Streit Krug et al. 2023). However, it is difficult for funding agencies to justify investments in crops that are currently low in yield, expensive to produce, and unknown beyond their center of origin. It may also be difficult to rank plant species, given the huge number of wild and underutilized plant species. Collection of this vegetable in Palestine is highly restricted by Israeli Authorities. This crop, along with za'tar (*Origanum syriacum*), is highly politicized in the context of Israeli restrictions on Palestinian use of traditional plants in the West Bank. Regardless, here we introduce a regionally high value but globally unfamiliar crop as a candidate for further investment.

Community research conducted through interviews and a survey of Arabic-language literature and social media material in Palestine points to increasing cultivation of *Gundelia* in recent years. There has been a great increase in English language journalistic coverage emerging in recent years (Farzin 2018; Hart 2023; Kamisher 2018; Rubin 2020). However, there is currently no evidence of selection for particular characteristics taking place in cultivation sites.

According to a journalistic report from 2019, a farmer in the Tulkarem district of Palestine established a large *Gundelia* seedling nursery (Al-Akkub 2023). The farmer explained, "I got this idea to collect these seeds from the wild and from the valleys, and step-by-step I had a large amount of seed that I planted next to my house." With a grant from a Palestinian local non-governmental organization, she then built three plastic greenhouses where she produces *Gundelia* seedlings for sale in the West Bank. Production has increased massively. As of 2023 she produces about 500,000 seedlings each year, with production taking place in open air and in greenhouse environments. Greenhouse temperatures must be adjusted to allow for the cold period the plant requires to be productive; greenhouses also utilize irrigation in contrast to wild, rainfed growth.

Two women farmers in the Palestinian West Bank, interviewed in March 2023 by co-authors of this article, said that they began to cultivate *Gundelia* because of Israeli authorities' restrictions on wild harvesting. One farmer purchased *Gundelia* from a non-profit organization years ago and are now in their eighth season of producing for home use by growing and harvesting plants in their home garden. Another farmer has been growing *Gundelia* for two years after collecting seed from wild plants. Co-authors of this article have also observed seeds widely available for sale in shops in the West Bank; *Gundelia* is one of only two wild plants commonly available in local seed shops.

This research group in Ramallah, Palestine has four accessions of *Gundelia* from various parts of the West Bank and will be making a large collection in May 2023. For three years it has been propagating and distributing from these accessions in its nursery. Accessions germinate at a high rate. Moreover, the group has produced the first Arabic-English online platform for wild food plants of Palestine, Barari Flora (https://www.barari.org), where the entry for *Gundelia* is one of the most-viewed pages on the site (Barari Flora 2023). Makaneyyat researchers surveyed Arabic-language social media in 2022 and 2023 and identified seven high-quality videos, dating from 2017,

Figure 1 High Wild *Gundelia tournefortii,* in bloom, in the central hill region of the West Bank, April. Photo: Omar Tesdell. *Gundelia* is a stout, taprooted perennial herb that forms a basal rosette. After about three years (Hind 2013) the plant begins to bolt each spring flowering generally May-June. Abscission of the entire mature stalk allows it to blow around as a tumbleweed, dispersing seed. One source described seeing the tumbleweeds carried hundreds of feet into the air by whirlwinds (Hind 2013). *Gundelia* currently belongs within the sunflower family (Asteraceae) and most authorities currently place the genus within the same tribe as lettuce and chicory (Funk et al. 2009). However, while it shares the latex-producing canals diagnostic of this tribe, its florets and the overall structure of the head are dissimilar to other close lettuce relatives and some authorities prefer to keep *Gundelia* in its own tribe (Hind 2013). Capitula (heads) are the norm in the Asteraceae and represent the compression of multiple flowers (florets) into a single flower-like structure. This tendency to compress structures can continue, with multiple capitula again condensing into a single structure and finally, very rarely a third-order structure appears. *Gundelia* is one of only 4 genera in the family (with over 1600 genera) with tertiary capitula (Harris 1999). Defined as a monospecific genus for many years, *Gundelia* tournefortii (named by Linneus in 1753 for the German and French botanists who collected it on an expedition between 1700 and 1702 [Hind 2013]), varieties have recently been designated as 16 species, 10 of which are endemic to Turkey, and all of which are diploids with 2n =18 chromosomes (Genç and Firat 2019). It's range essentially tracks with that of the Fertile Crescent, with the top countries with occurrence records on GBIF being Israel, Palestine, Iran, Turkey, and Syria (Global Biodiversity Information Facility 2022.

that demonstrate the cultural use and importance of *Gundelia* in Palestine and Lebanon. Many of the videos focus on the ways that it can be cooked, either fried in olive oil, cooked in a reconstituted dried yogurt sauce, or with eggs (Barari Flora 2023). Other videos focus on the conflict over harvesting between Palestinians seeking food and a livelihood and Israeli authorities who claim it is over-harvested. The price of *Gundelia* makes it an enticing vegetable to forage. The price of half-cleaned (meaning that the main spikes are removed) in the markets in late-March of 2023 is $10.90/kg. (40 Israeli Shekels per kilogram)

Table 1 *Gundelia* traditional uses by category and potential new and expanded research uses.

Category	Documented traditional uses, historical and contemporary	Research into potential new and expanded uses
Food - vegetable	Ethnobotanical surveys of local people in Iran (Yazdanshen et al. 2016), and Turkey (Ertu 2003; Cakilcioglu 2020; Kadioglu et al. 2020; Yurtoğlu 2017) have documented many indigenous uses of *Gundelia* as food. Leaves may be eaten cooked and young leaves eaten raw. The peeled young shoots and inflorescence buds are considered a kind of artichoke in Turkey (Yazdanshen et al. 2016) while early European botanical explorers likened this vegetable to asparagus (Hind 2013). The roots are eaten as pickles, and plant extracts are mixed with milk during yoghurt fermentation (Cakilcioglu 2020) or as medicines (Ertu 2003).	The immature flower buds, part of the artichoke-like vegetable that is stewed in the most well-known and economically important use of *Gundelia* (Pieroni 2005) turns out to be nutritious as well as delicious: 13% protein and 16% lipid. It is also a good source of tocopherol (vitamin E). Searching for local ingredients that could substitute for conventional ice cream stabilizers, *Gundelia* extracts were considered but not found to be functionally equivalent (Cakmakci and Dagdemir 2013).
Food - other	Cakilcioglu (2020) describes a method to produce chewing gum that involves severing the plant's stems at ground-level and collecting the exuded latex from the soil surface the next morning. Finally, the seed-containing fruits (herafter "grains") are roasted for two main uses. First, pan roasting 5-10 minutes in olive oil and salt (Kadioglu et al. 2020) to singe the spines off of the hull (Gillett, J. 1911–1995, annotations on herbarium sheets, reported by (Hind 2013), allows them to be eaten as a snack (Cakilcioglu 2020) "like sunflower seeds" (Yazdanshen et al. 2016). Second, the roasted seeds can be used as a coffee substitute (Cakilcioglu 2020; Hind 2013).	Pollination is by insects, including honeybees (Hind 2013), implying that this plant could be valuable for apiculture, where wild harvesting pressure is weak enough to allow flowering.
Food - oilseed grain	Although this genus has been exclusively harvested from the wild until very recently, it may have once been on the verge of domestication as an oilseed crop, as early neolithic archaeological remains in Iraq and Turkey indicate gathering, threshing, and oil extraction (Hind 2013; Pieroni 2005; Rivera et al. 2011; Rosenberg et al. 1995; Savard et al. 2003)	Several workers have investigated the quantity and quality of oil in wild-harvested *Gundelia* grain and while the specific details vary, presumably due to environmental and genetic differences, the general consensus is that the oil is similar to sunflower and soybean: rich in oleic and, especially, linoleic fatty acids (Abdul and Hamd 2012; Al-Saadi 2017; Khanzadeh et al. 2012). The percent lipid content of the true seed (embryo) ranged from 22 to 32% but when considering the whole grain, the hull (pericarp) composes 70% of the mass. For perspective, oilseed sunflower embryos are 40-60% oil and the hull is only about 20% of the mass of the entire grain (fruit) (Rondanini et al. 2006). Khanzade studied other physical and chemical characteristics of extracted *Gundelia* oil and concluded that it was within the range of other major vegetable oils for all important characters and could serve as an edible oil (Khanzadeh et al. 2012).

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Category	Documented traditional uses, historical and contemporary	Research into potential new and expanded uses
Fodder	Although the prickly foliage clearly deters sheep browsing leading to "invasion" of *Gundelia* in areas with long histories of intensive sheep grazing (Khojasted and Chahouki 2013), goats browse *Gundelia*, even after the foliage is brown, targeting the seed-bearing heads first. Herders have been known to gather *Gundelia* as hay for ruminants, including camels. (Karabulut et al. 2006) in times of fodder scarcity. It has also been used as a winter fodder in Turkey when dried (Rivera et al. 2011).	Although sheep avoid *Gundelia* on pasture, leading to overgrazing of grasses (Khojasted and Chahouki 2013), dried, ground *Gundelia* can be substituted for alfalfa hay in sheep rations with no statistically significant reduction in performance (Dehghani-Samani et al. 2019). Evidence of its use as a winter forage has been documented (Rivera et al. 2011) in laboratory and in-vivo digestion analysis. *Gundelia* hay outperformed wheat straw nutritionally in every category and was not significantly different than alfalfa, except in having slightly less protein but slightly higher metabolizable energy (Karabulut et al. 2006).
Medicinal	Many references to medicinal uses of *Gundelia* can be found in the ethnobotanical literature (Samani et al. 2013) but are beyond the scope of this paper.	Numerous phytochemical analyses have been made of *Gundelia* extracts and this literature, e.g. (de la Luz Cádiz-Gurrea et al. 2020; Farhang et al. 2016) which we will not review here, could lead to new pharmaceutical uses of *Gundelia*. More relevant to this discussion are studies indicating that *Gundelia* oil, grain or vegetation is safe or even beneficial. We are unaware of any human subjects' studies, but rat and in-vitro cell studies suggest that *Gundelia* has antioxidant properties that could be hepatoprotective (Al-Kadhi 2020; Çoruh et al. 2007). Atherosclerotic rats given *Gundelia* oil began to show improvement in total blood lipids and in high vs. low density lipoprotein ratio (HDL:LDL) although the improvement was not as dramatic as with the antilipidemic drug clofibrate. This is good news because *Gundelia* fatty acids are 8-13% palmitic acid, a saturated fatty acid sometimes associated with cardiovascular disease but, confusingly, also found at similar levels in foods considered healthy such as olive oil and at very high levels in human breast milk (reviewed in Carta et al. 2017).

and $21.79/kg. for fully cleaned *Gundelia* (80 Israeli Shekels per kilogram) in Ramallah vegetable shops. The latter costs about the same per kilogram as fresh lamb, the most expensive meat.

Future Domestication Challenges

Intentional harvesting of *Gundelia* may over time lead to altered natural selection pressure with allele frequency shifts resulting, eventually, in populations that make it easier for humans to take over the role of seed dispersal (Van Tassel et al. 2010). In Palestine, neighboring plants may bolt and mature at quite different times, leading to speculation that heavy seasonal harvesting pressure has led to divergent selection for early or late bolting to escape harvest (Lev-Yadun and Abbo 1999). Co-evolution in domestication (mostly cultural on the human side, mostly genetic on the plant side) is a natural and common evolutionary process (Van Tassel et al. 2020). However, it is likely to be very slow, particularly in the case of perennial crops that need only occasional replanting (Van Tassel et al. 2010).

Consequently, artificial selection of *Gundelia*—in which humans decide which plants to preserve and intermate based on traits important to them rather than evolutionary fitness or chance—can result in more rapid genetic change (Darwin 1859). Artificial selection of *Gundelia* has been proposed several times in the late twentieth and early twenty-first centuries. The International Plant Genetic Resources Institute supported a study in Lebanon to look at its domestication and cultivation to release pressure on wild populations while generating income

opportunities for local communities (Padulosi and Guiliani 2004). Lev-Yadun and Abbo (1999) initiated a selection and breeding program to identify spineless *Gundelia* for vegetable production. However, we have been unable to find evidence that these programs were pursued long enough to develop improved *Gundelia* varieties.

Challenges to accelerating domestication to support new and expanded uses of *Gundelia* are primarily agronomic and genetic. Although a grassroots movement to bring *Gundelia* into cultivation has begun, knowledge gained about agronomic practices is not readily available and formal studies are needed to guide farmer innovation. Although the popularity of *Gundelia* as an ingredient in many cuisines suggests that the genus needs no genetic change to be accepted by consumers, bringing this wild plant into cultivation may be facilitated by genetic changes that make it easier to agronomically manage and harvest.

Other kinds of genetic changes may be required to allow this crop to survive and thrive in a new agricultural environment. Cultivated gardens and fields are generally located on relatively fertile soils in the best sites for plant productivity, while irrigation and fertilization create new environmental conditions. The cultivation environment will inevitably include many more *Gundelia* plants and humans serving in a new role.

Challenges to be considered to accelerate domestication in new environments include:

- Abiotic stresses: *Gundelia* appears to be broadly adapted with tolerance of many stresses including heat, drought, rocky soil, and possibly salinity (Qasem 2015), but relaxing one or more of these stresses may greatly increase plant productivity. It will be important to count against the increased productivity, the economic and ecological costs of supplying inputs such as nitrogenous fertilizers or irrigation water.
- Harvest stress: The impact of removing a large part of the plant's aboveground biomass including young leaves on plant survival and regrowth has not been studied. To grow this as a perennial crop, it will be important to identify the frequency of stalk or leaf removal beyond which plants become weakened and vulnerable to pathogens or decline in the number of stalks produced each year. Harvesting mature seed heads is likely to be less costly to plant underground reserves because it takes place later in the season after additional time for photosynthesis.
- Economic stress: As a wild plant unaccustomed to irrigation, the effects of drip irrigation in intensive production is unknown. Irrigation regimes and their costs must be understood and the yield and profit potential in comparison to rainfed production must be weighed in future research.
- Biotic stress: Widely spaced wild-grown plants may experience relatively few pests and pathogens. However, under cultivation, increased plant populations and population density may allow insect herbivores or fungi to flourish and become agricultural pests and pathogens. These pest and pathogens must be identified, their lifecycles studied, and effective management strategies designed (Lev-Yadun and Abbo 1999).

Finally, as discussed below, efforts to accelerate domestication that address these challenges require as a prerequisite available genetic diversity in selection populations.

Future Domestication Opportunities

The contemporary cultural significance of *Gundelia* could serve as an important driver to advance the agronomic and genetic domestication of this Mediterranean plant for new and expanded uses (Van Tassel et al. 2020; Table 1). We envision new crop domestication toward a dual-purpose vegetable and oilseed grain crop that helps grow food system diversity and sovereignty at local and regional scales, by providing nutrition, cultural and economic value through multipurpose use, and an ecologically well-adapted perennial life habit that is more resilient in the face of climate change (Streit Krug et al. 2023).

The most obvious genetic change that would make *Gundelia* easier to cultivate and harvest would be reduction in spines. Fortunately, phenotypic variation for this trait has been observed, suggesting that genetic variation may also be present within or between *Gundelia* populations (Lev-Yadun and Abbo 1999). Another selection target could be the phenology of bolting. Cultivars with different bolting times could be developed to extend the vegetable harvest period. Although acceptable laboratory methods of breaking seed dormancy have been

developed, in the long-term, selection for non-dormant will make it easier for farmers to save their own seed and to make stand establishment more predictable.

For production of seed to propagate new varieties and for the long-term goal of using *Gundelia* as a perennial oilseed similar to sunflower or safflower, the tumbleweed habit may need to be altered, allowing stalks to stand in the field until harvest without the risk of blowing away and scattering seeds on the ground. The dependence of *Gundelia* seed dispersal on inversion of the stalks during rolling could mean that disrupting the main stalk abscission will be enough to reduce seed shattering to acceptable levels.

To facilitate both manual and mechanical seed head harvesting, erect stalks will be preferred and under favorable conditions it is possible that *Gundelia* plants may grow much taller than they do in highly competitive plant communities on marginal soils. Breeding for reduced height may be necessary along with breeding for increased distance between the seed head and the leaves.

One strategy for increasing yield of *Gundelia* under cultivation will be to grow these plants at high density. However, it remains to be seen if *Gundelia* will tolerate intraspecific competition. Grain yield can be increased by selection for plants with more numerous stalks, larger synflorescences with more florets, increased proportion of florets that develop viable seed, increased grain size, and a relative increase in the seed (embryo) to hull (pericarp) ratio of the harvested grain. Oil yield will be improved by any of these components of grain yield and increased percent oil content of the embryo.

Finally, *Gundelia* domesticators should be prepared to select for host plant resistance to insect pests and pathogens as these appear. It may be impossible beforehand to predict which pests and pathogens will take advantage of cultivated *Gundelia* populations, but it is quite possible that there are already regions or micro-environments where endemic *Gundelia* populations have already been co-evolving with these organisms. These populations could be harboring important resistance genes that confer defensive traits. Therefore, extensive collection of wild germplasm from throughout *Gundelia*'s range is critical.

Discussion of *Gundelia* Conservation

Collection and conservation of diverse germplasm is foundational to support domestication of *Gundelia* as a future crop with new and expanded uses. The ecological and political pressures on *Gundelia* across its native Mediterranean range also means that international collaboration is required to enable collection and conservation processes and the accessibility of diverse germplasm to domesticators.

The combined pressures of climate change and harvesting under conditions of political and ecological stress may make conservation of *Gundelia* genetic resources increasingly difficult. Seeds from wild population and (rarely) cultivated populations must be collected and maintained by international gene banks and made available for farmers and agronomists around the region. *Gundelia* is native to 16 countries encompassing a huge range of habitats and requiring numerous wild collections to adequately represent the potential genetic variation. As the line between varieties of *G. tournefortii* and distinct species is ever changing, and as all taxa studied thus far have the same chromosome number, it would be wise to consider all species and varieties to be part of the primary gene pool until demonstrated otherwise. Conservation of wild types is crucial for building a botanical base for future crop development.

While some researchers are concerned about increasing *Gundelia* in parts of Iran (Khojasted and Chahouki 2013), the genus is characterized as endangered in Cyprus (Hind 2013), threatened by unsustainable harvesting in Lebanon (Padulosi and Giuliani 2004) and concern about declining populations has led to harvesting restrictions in Israel and Palestine (Hind 2013; Lev-Yadun and Abbo 1999). Given the plant's spiny defenses, heavy grazing pressure leads to declines in grass vigor and population density which reduces competition with *Gundelia* leading to corresponding population increase. In contrast, where human population density is high and human harvesting pressure is greater than grazing pressure, *Gundelia* is preferentially weakened through repeated harvesting and prevented from producing seeds by the removal of immature seed heads.

Exacerbating harvesting pressure around Palestinian villages and cities is military zoning that makes large areas off limits for Palestinians. Legitimate conservation efforts are confounded and

undermined by political pressure on Israeli governments to expand settlements and Palestinian resistance to loss of land access and sovereignty (Kamisher 2018; Rubin 2020).

Currently, the Svalbard global seed vault contains a single accession of *Gundelia*, and only four accessions are available through the Seed Bank (Kew Royal Botanic Gardens 2021; Svalbard Global Seed Vault 2021). The International Plant Genetic Resources Institute (IPGRI) reported having collected 82 accessions of *Gundelia* from Syria (Padulosi and Giuliani 2004). However, this organization has merged with other organizations, and it is not clear if these accessions have been maintained or are available. Genesys lists 44 accessions in various national and international repositories, but it is not clear how many of these are viable or available for distribution (The Crop Trust 2021). In terms of occurrence records, the Global Biodiversity Information Facility (GBIF) database shows only 2,303 records at the time of writing with the top five countries being Israel, Palestine, Iran, Turkey, and Syria, though data is limited to information available from ministries (Global Biodiversity Information Facility 2022).

To maintain rare allele combinations from local populations it will be necessary to propagate these outcrossing wild accessions in isolation plots or by controlled pollination. This requires basic infrastructure and access to research areas which are not available in much of the native range of the *Gundelia*. Conservation and propagation efforts have been underway in Palestine since at least 2015 by individual farmers, local organizations, and research groups including this group and the National Agricultural Research Center of the Ministry of Agriculture (Tesdell et al. 2020). Preliminary evidence from Makaneyyat shows very high seed germination of accessions from the collection, which is important as strong seed dormancy must be addressed for successful propagation of *Gundelia* by seed for conservation or cultivation. But such efforts face questions and limitations of scale. There is significant difficulty in moving germplasm in and out of the Palestinian West Bank, and due to lack of clarity of status under international conventions, diverse collections in Palestine may be excluded from collections in agricultural research centers outside of Palestine (e.g., International Center for Agricultural Research in the Dry Areas, United States Department of Agriculture Germplasm Resources Information Network) that could form the basis for domestication programs.

Gundelia has a rich cultural tradition of historical and contemporary use and valuation by humans. For this perennial plant to play a role in future food cultures, strategic and creative collaborations across borders will be important to sustain local and regional community plant knowledge, conserve accessible germplasm collections, and explore opportunities for new and accelerated crop domestication.

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