Interreg Sudoe
Fleurs Locales
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Medio ambiente
eficiencia de recursos

Native seeds for biodiversity

Flowers to recover what is ours

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1. Use of native seeds in Mediterranean ecosystems: the state-of-the-art

1.1. Executive summary

The objective of "Fleurs locales" project working group 1 (GT1) is to explore the state-of-the-art on biodiversity restoration by native species in different SUDOE biogeographic areas to identify gaps and promote knowledge. For this, we designed three activities. Firstly, carry out a literature review on native species amenable to agroecosystems under the Mediterranean conditions. Then, identify the stocks of seeds available in the market, and finally, select the most promising species according to the restoration specificities.

Here we reviewed the state-of-the-art on the utilization of seeds of local origin (native seeds) as an efficient measure to mitigate plant biodiversity threatening's caused by climate change and human activities.
We also address the supply limitations of seeds for both ecological restoration and agrosystems management and the relevant guidelines pointed out in the literature to overcome these limitations in Europe.
In addition, we pointed out the Mediterranean as a global biodiversity "hotspot", and the importance of the use of native seeds for restoration and maintenance of ecosystem services in the landscape simplification caused by the intensive agriculture in the context of climate change. This document also approaches the services benefits of using native seeds in the agroecosystems target of "Fleurs locales" project; the constrains observed in Europe regarding the collecting and production of native seeds and the availability of native seeds in the three countries of the Sudoe region.

1.2. Preamble

Plant biodiversity is threatened by climate change and human activities (urbanization, fires, soil erosion, intensive agriculture, over-exploitation of natural resources, biological invasions, etc.) and entails negative effects such as: alteration of the dynamics and area of population distribution, changes in the structure of ecosystems, extinction of species, fragmentation of habitats. These effects have been accentuated by climate change. The "Fleurs locales" Interreg SUDOE project aims at promoting alternatives to prevent the massive erosion curve of biodiversity, considering the challenges of climate change. Our main goal is supported by the awareness of the civil society on the urgency of these measures. In addition to environmental challenges, the restoration of biodiversity and its adaptation to climate change is essential for boosting of economic activities. The new awareness of the risks of climate change requires, among other tasks, the development of agrosystems restoration initiatives based on adapted and resilient vegetation cover.

A native (or autochthonous, or indigenous) plant species can be defined as a species existing within its natural distribution and dispersion range. In recent years, the importance of using native seeds of local provenance has become widespread 'best practice' when considering restoration projects, but this does not always translate into 'the ideal' on the ground. Limitations may come from the lack of knowledge, but also because the amount of local seeds is not sufficient to supply the end-users. The best that can be hoped are seeds from the same region or country rather than from the district or valley closest to the restoration site (Ladouceur et al. 2017).

Several restoration projects (e.g. Ecovars, Alp'Grains, SOS Praderas, etc.) using native species have been implemented for maintaining or increasing the biodiversity of different ecosystems, however, studies focusing on the use of native species, from collection to its end use, are still incipient in the literature.

Biodiversity conservation, mitigation and adaptation to climate change are in the agenda of the United Nations, EU and other institutional initiatives. The connection between ecosystem services and society (Target 14), and the restoration of 15% of degraded ecosystems around the world (Target 15), has been emphasized in the UN Convention on Biological Diversity (CBD) Strategic Plan for Biodiversity 2011 – 2020 (CBD 2015; CBD 2016). The current "ready-made" policy frameworks in Europe regarding the native seed supply of herbaceous species is generally unsatisfactory for both producers and users (Abbandonato et al. 2017). The authors reported that, initially, such policies were designed for fodder species and relate to distinctness, uniformity, and stability, traits that do not reflect the genetic heterogeneity of native species required for ecological restoration. Until recently, more suitable certification standards were designed to multiply fodder seeds for preservation of the natural environment. However, due to the discrepancy of the seed market in Europe, this policy is rarely practical and fails to encompass all herbaceous native species often resulting in unregulated seed sales. The native seed market in Europe regarding native species was characterized as unregulated, and poor seed quality is a common occurrence (Marin et al. 2017). However, vast quantities of native seed are required for large-scale restoration and demands cannot be met by relying solely on wild resources (Merritt & Dixon 2014). Seed supply costs can impose financial constraints on restoration practices, because seed yield and quality (including dormancy) fluctuate with intervariability and intravariability in pollen flow, natural disturbances and climate variability (Merritt & Dixon 2014; Broadhurst et al. 2016; Abbandonato et al. 2017).

A recent study (Ladouceur et al. 2017) evaluated the native seed supply and the restoration species pool available in Europe where the authors propose: "(1) substantial expansion of research and development on native seed quality, viability, and production; (2) open-source knowledge transfer between sectors; and (3) creation of supportive policy intended to stimulate demand for biodiverse seed".

European native seed industry consists primarily of small to medium enterprises (De Vitis et al. 2017); responding native seed users purchase annually an average of 3.600 kg of seeds with an average expenditure of 17. 600 €.

These figures indicate a clear insufficient supply of native seed species for both ecosystems and agroecosystems restoration.

The project has identified a community of stakeholders in SUDOE that are potential users of native seeds. However, the necessary seed volumes cannot be obtained by harvesting in nature alone and the current seed market does not offer an adequate response, due to the lack of production of native plant material with local geographic origins. The experiments carried out in previous programs (e.g., Ecovars…) have shown that the multiplication of seeds collected in the natural environment is possible.

With this project, we expect to promote the use of native seeds in the agrosystems by addressing the main current limitations. Landscape managers, scientists, seed producers, communities and users will identify the main technical and economic gaps.

1.3. Biodiversity and Restoration of Agrosystems

Agriculture intrinsically depends on climatic conditions and, consequently, it is one of the most vulnerable sectors to the risks of global climate change. The Mediterranean basin is recognised as a global biodiversity "hotspot", comprising some of the world's most unique biogeographical areas with high species diversity and endemism (Myers et al. 2000). The Mediterranean basin is one of the regions where climate change effects are going to be most negative for agriculture. For example, this region has been reported to be at high drought risk (Carrão et al., 2016), and it has been estimated that global warming above 1.5°C will drive Mediterranean ecosystems beyond Holocene variability (Aguilera et al. 2020). Mediterranean agroecosystems are equally threatened by human-driven impacts like soil erosion after decades of tilling and herbicide use (Laguna and Giráldez, 1990).

Ecosystem services related to biodiversity, including cultural services, are essential for agricultural production. In agricultural landscapes, pesticides and mechanization threaten biodiversity, lead to landscape simplification and may reduce ecosystem services. On the other hand, consumers are more and more aware of environmental issues in food production (Hervé et al. 2017). These changes have substantial impacts on biodiversity protected by EU Directives. Recently, agri-environmental schemes and wildlife habitat improvement measures have been taken to prevent biodiversity loss, although only a small proportion of their total budget is targeted directly at biodiversity conservation. Measures for wildlife are generally limited to restricted areas for a short-term period and in most cases have not been evaluated or properly applied (Sokos et al. 2013). The severe threats posed to Mediterranean agroecosystems by climate change and human impacts require adaptation as a key factor that will determine the future severity of the impacts on agriculture and food production in the Mediterranean (Iglesias et al., 2010; Aguilera et al. 2020). As a response, conservation agriculture promotes a set of management practices such as "no tillage", "reduced tillage" and "ground cover" on woody crops to protect soil from erosion and to improve environmental quality (González-Sánchez et al., 2015; Jiménez-Alfaro et al. 2018).

1.4. Permanent crops agrosystems

Ground covers are particularly recommended to prevent soil erosion in Mediterranean permanent crops. This is achieved by covering the soil surface with inert matter, spontaneous vegetation, or sowing seeds (González-Sánchez et al., 2015), where it produces multiple physicochemical, ecological and economic benefits (Pantera et al., 2018). The use of vegetation cover has been identified as one of the most effective strategies to adapt to climate change, mainly through reducing vulnerability to erosion, increasing management options during drought periods, and retention of N mineralized due to warming (Aguilera et al. 2020). When sowing a ground cover, the chosen species should be adapted to the environmental conditions of the Mediterranean region, such as dry and hot summers and scarcity of water. Most important desirable traits for ground cover species in permanent crops are: self-sowing capacity, low height, fast growth, weeds control capacity, superficial root development, not competitor for water resources, capacity to capture and cycle nutrients (both macro and micro elements), high production of biomass, protection of soil from erosion and runoff, capacity of structuring the soil in order to increase porosity, water retention and biological activity, increase soil bearing capacity, increase beneficial and/or pollinators, easy to mow/cut down/run over, compatibility with sowing machine and persistence as dead matter on the ground. Especially important is that the ground covers develop during the winter season, providing effective soil protection and high biomass production, while not competing for water with the woody crop during summer (Alcántara et al. 2011; Jiménez-Alfaro et al. 2018).

Despite further investigation is still needed to better understand the effects of different types of vegetation cover when employed as tools in wildlife conservation (Rollan et al., 2018), different authors have noted an increase in wild animal species associated to the presence of ground covers, including species of conservation interest (Carpio et al., 2017; Castro-Caro et al., 2015; Giralt et al., 2018, Barbaro et al., 2021, Hendershot et al. 2020). The management of ground covers in permanent crops aims to find a balance between the provision of ecosystem services and a low competition for soil and water resources with the main crop (Garcia et al., 2018). Given the increasing water limitation of crop growth under climate change, an adaptive management of ground cover is paramount in Mediterranean woody cropping systems, which underlines the need for specific research in each agro-climatic condition to find the most appropriate species and cover crop management practices (Delpuech and Metay, 2018; Robačer et al., 2016; Aguilera et al. 2020). Agricultural intensification of Mediterranean woody crops (vineyards, olive groves and fruit trees) has dramatically changed traditional landscapes that were relatively sustainable until the twentieth century. Olive groves (Olea europaea L.) are a quintessential example of agroecosystems suited for regenerative practices because they are perennial cultural systems currently degraded by erosion, desertification and biodiversity loss (Jiménez-Alfaro et al. 2020).

The maintenance of ground herb cover (main agri-environmental measure in olive orchards) is a cost-effective investment allowing recuperation of pollinators when targeting olive farms located in landscapes of intermediate complexity (Martínez-Núñez et al. 2020). Similarly, soil degradation in vineyards is an extremely favourable context for soil loss in comparison with other agricultural lands (Le Bissonnais et al., 2002, Brenot et al., 2006, Quiquerez et al. 2008). Climate change has already caused significant warming in most grape-growing areas of the world, and the climatic conditions determine, to a large degree, the grape varieties that can be cultivated as well as wine quality.

The use of cover crops remains hampered in Mediterranean areas, where low summer rainfall and high evaporative demand usually results in severe summer drought, because living ground covers compete for soil water, leading to higher grapevine water stress (Celette et al., 2009) and consequently to lower growth and yield. However, recent reports showed vineyards with native cover crops had significantly higher overall plant-dwelling species richness, compared to exotic cover crop and bare ground vineyards (Eckert et al. 2020). Nonetheless, spring water use by cover crops could help to control grapevine canopy development, improving bunch microclimate (Dokoozlian and Kliewer, 1996), and thereby grape and wine quality (Ingels et al. 2005). Therefore, the use of cover crops to control excessive vine vigour in spring could become an interesting agronomic tool for a more sustainable management of soil and water resources, that is, if reductions in yield are compensated by increases in grape and must quality (Matthews et al. 1990; Pou et al. 2011).

The use of fertilizers, the suppression of non-crop vegetation and modern irrigation practices have maximized crop production at the cost of soil health, compromising the sustainability of a strategic economic sector in Mediterranean countries (Gómez et al. 2017). In turn, the combination of tillage and herbicide use has led to large expanses of bare soil (Vicente-Vicente et al. 2016) through the loss of herbaceous layers that covered olive groves for centuries. These practices increase the dependence on water and the progressive loss of soil organic matter, leading to the need to restore ground covers and balance crop production with the preservation of natural and cultural services (Power et al. 2010). It has been widely suggested that commercial varieties used for ground covers are ill-suited for the Mediterranean climate and compete with the crop for soil moisture, while native species, especially winter annuals, might provide the benefits of ground covers without the negative aspects of exotic species (Nunes et al. 2016; Gómez et al. 2017; Jiménez-Alfaro et al. 2020).

1.5. Mediterranean grasslands

Grasslands are an important component of the landscape in the SUDOE area. These open lands were created by human utilization during the last several thousands of years.

These grasslands are mostly anthropogenic ecosystems maintained in dynamic equilibrium by cultivation and grazing (Henkin, 2016). At present, the conversion of cultivated parcels, e.g., abandoned vineyards, into functional grassland ecosystems with high resistance to grazing intensity and also important resilience in relation to climatic hazards (Sternberg et al. 2015) is an interesting option for many land owners.

The rehabilitation or restoration of grassland follows the natural succession stages, based on annual and biannual species during the first two years, which are followed by the establishment of perennial plant communities. Priority effects provide an advantage to early establishing species and significantly affect the course of succession. The long-lasting effect of the initial sowing confirms contingency of successional pathway on the propagule pressure in the time of start of succession due to the priority effects (Švamberková et al., 2019).

Frequently, the annual and biannual communities are particularly rich in flowers and thus of high interest for pollinators, other invertebrates and related predators. Thus, the restoration strategy should focus on the availability of native seeds not only for the perennial grassland as the mid-term objective, but also on the seeds for the early stages.

European pastures, particularly in Mediterranean environments, are under a dual process of abandonment in the less productive areas and intensification in the more productive or accessible ones. Grazing abandonment affects floristic composition, functional traits such as canopy height, leaf dry weight, onset of flowering, life-form and seed mass, the overall functional diversity of communities and many environmental aspects such as light quality and intensity and soil characteristics (reviewed by Carmona et al. 2012). However, the ecological impacts of grazing depend on the type of ecosystem, plant community, and conditions of a particular site. One of the ecological impacts of grazing is overgrazing, which is widely known to have an effect on composition and structure of plant communities and of biological soil crusts by reducing biomass, soil nutrient enrichment and overall regeneration.

1.6. Why use locally sourced wild plants?

Our approach is based on the premise that native plants may be ideal ground covers because they have a better ecological fit with the system, assuming they can be farmed to produce an adequate amount of seeds for establishing and restoring ground covers, as well as they are able to establish resilient perennial grassland communities. As stated by Jiménez-Alfaro et al. (2020), all the studies on native plants assessed ecological traits relevant to their value as ground covers (for example, self-sowing, height development, growth form, herb cover, root development or nitrogen fixation), none of them considered seed-farming potential. This is an important research gap because the need for a seed supply is a priority for establishing ground covers (Nunes et al. 2016; Gómez et al. 2017; Jiménez-Alfaro et al. 2020).

The identification of functional markers related to service provision may help us to select species or communities that could perform interesting trade-offs between multiple services due to a suited combination of related markers. The functional traits may also provide insights for plant selection in order to select native plant species that are optimal for different types of agrosystems with the aim of providing agroecosystem services.

The commercial seed varieties offered in the trade, and used for most of the agrosystems ground covers, are ill-suited for the Mediterranean climate and compete with the crop for soil moisture, while native species, especially winter annuals, might provide the benefits of ground covers without the negative aspects of exotic species. The commercial seed varieties weaknesses or the risks associated with them are revealed very quickly:

- Plant cover which does not reconstitute itself in a sustainable manner;
- Low germination rate
- The need for large doses of seeds and fertilizers and other chemicals;
- Competition with the local wild flora that can lead to local disappearances, with an increased risk when plants originating from other climatic regions are introduced;
- Risks of hybridization or genetic contamination with wild flora leading to a loss of adaptation to local pedoclimatic conditions;
- Less interest for the local pollinators and other animals that interact with the vegetation.

It is therefore recommended to manage agrosystems and to restore either annual as well as perennial grasslands with wild plants of local origin.

1.7. Collecting and Production of Native Seeds

The European Union 2020 Biodiversity Strategy aims at restoring at least 15% of degraded ecosystems by 2020 and highlights the significance of the native seed sector as well as the need to improve the large-scale production and availability of quality native seeds. For such ambitious objectives, a shortage of native plant material has been recognized as a critical limitation to carry out ecological restoration at the scale needed (Tischew et al. 2011; Merritt, et al. 2011). Within Europe, trade and use of herbaceous seeds are less regulated when compared to forest reproductive material (Vander et al. 2010; De Vitis et al. 2017)

Seed farming of native plant species is crucial to meet restoration goals, but may be stymied by the disconnection of academic research in seed science and the lack of effective policies that regulate native seed production/supply. To illustrate this problem, Ladouceur and co-workers (2017) identified 1,122 plant species important for European grasslands of conservation concern and found that only 32% have both fundamental seed germination data available and can be purchased as seed. The “restoration species pool,” or set of species available in practice, acts as a significant biodiversity selection filter for species use in restoration projects.

To implement the use of local seed origins, the geographic delineation of seed zones, within which seeds are to be collected, propagated and sown, may be critical (Nevill et al. 2016; Durka et al. 2017). In Europe, the first attempts to delineate national seed zones for herbaceous plants have been made only recently (Durka et al.

2017). The definition of transnational seed zones may be crucial to ensure ecological adaptation of plant species instead of the current fixation on administrative borders that often bear little relevance in an ecological or biological sense. A recent evaluation of the European native seed industry (De Vitis et al. 2017) concluded that native plant material production seems to be limited by the high production costs and the lack of propagation/production experience. In particular, the production of site-specific seed mixtures requiring purebred lines is significantly more expensive and riskier than for conventional seed production (Krautzer et al. 2010). On the other hand, many problems in seed production, storage and use have been overcome by practice and experience, but many shortfalls in knowledge remain, which require further scientific research (Merritt et al. 2011; De Vitis et al. 2017).The private sector of native seed production has recently organized itself by creating the ENSPA (European Association of Native Seed Producers), bringing together under a code of conduct the European initiatives committed to this production method and its limitations.

Native seed sourcing, collection, production, and storage is more challenging than for agricultural species (Bischoff et al. 2010; Broadhurst et al. 2008) for which cultivars have been bred to be stable, uniform, and distinct (Ladouceur et al. 2017). According to Pedrini et al. (2020), three main approaches for supplying native seeds for restoration projects are available: (1) seed collection from natural/wild populations, (2) harvest from managed populations, and (3) cultivated seed production systems (such as native seed farms). These three seed supply strategies lie along a continuum where increasing inputs are required. Similar approach should be followed for supplying native seeds for use in agrosystems and restoration of grasslands.

The establishment of native seed crops, where seeds are produced in cultivation settings (akin to agricultural or horticultural production), has the potential to meet the rising demand for native seeds (Delpratt & Gibson-Roy 2015; Nevill et al. 2016; Jiménez-Alfaro et al. 2020; Pedrini et al. 2020). Multiplication of native seeds using cultivated production approaches employing agricultural and/or horticultural practices is now an emerging sector in many parts of the world (De Vitis et al. 2017; Gibson-Roy 2018; Hancock et al. 2020). Although in the biogeographic regions of this project intervention the production is almost non-existent. The development of cultivated native seed production systems, from small-scale to large field-scale farms, allows for the multiplication of initially small collections which greatly enhance native seed supply and prevent or reduce impacts of overharvesting from natural populations (Kiehl et al. 2014; Gibson-Roy and Delpratt 2015; Pedrini et al. 2020).

Seed yields and germination of wild species can be naturally low and variable (Fenner, 2000), and while cropping of native species can facilitate controlled production, some seed ecological traits can determine obstacles to harvesting (Fenner and Thompson 2005). Not all wild species are candidates for commercial production as variation in seed morphological traits necessitates the use of appropriate harvesting and conditioning equipment, the costs of which can be very high if a large number of species are being produced.

Proper seed management from collection to post conditioning storage is essential to maintain seed viability, which is variable between suppliers and can be very low (Marin et al. 2017, Ladouceur et al. 2017).

Thus, the great challenge is to promote biodiversity associated with agriculture - agrobiodiversity - which will reinforce the resilience of ecosystems but mitigate some of the impacts that prevent agro-ecosystems from providing more goods and services. The incorporation of scientific principles associated with ecology in agricultural practices, such as conservation agriculture, or integrated pest management, has shown that intensification of production can be improved through sustainable management of ecosystems and the use of ecosystem services for the benefit of agriculture (Branquinho et al. 2017).

1.8. The SUDOE region threat status of vascular plants

The first Red List of Vascular Plants for Mainland Portugal (Carapeto et al. 2020), which was conducted only for about one fifth of the vascular flora of mainland Portugal, are alarming: 381 plant species were classified in one of the three IUCN threatened categories – Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) – and 19 species were considered extinct in Portugal, of which two are globally extinct. The causes of these figures are human activities, in their multiple forms, are the major threat that is causing important declines and that caused extinctions of many species. Examples are the urban and infrastructures development (mainly in the coast), the fast expansion of industrial agriculture in the last decade (mainly in Alentejo and Algarve, but also in the west and north) and harmful vegetation management practices (e.g. use of herbicides and recurrent shrub clearing practices). Other more natural threats also constitute important problems for many species. Of these, climate change and the expansion of exotic invasive species are among the most important threats, since they severely alter the environmental and ecological conditions in many areas of the country, gradually causing the decline of the habitat of many species. Climate change may be especially threatening to species inhabiting mountains and marshes due to the expected decrease in snowfall and the increased severity of droughts. Invasive species impact a variety of environments, but are especially serious in areas strongly affected by human disturbances, like areas repeatedly devastated by wildfires and/or subjected to intensive forestry practices, and also along the coastal environments. This highlights the importance of preserve and increase the biodiversity, particularly in agroecosystems with intense human disturbances.

Spain hosts a large proportion of species that are threatened at the European level. European Red List of Vascular Plants indicates that 26% of the 839 vascular plant species assessed in Spain are considered threatened at the European level. The 2008 red list of Spanish Vascular Flora, indicates increased threats for 229 plants compared with the 2000 Red List. In addition, there have been cases of plants that have seen a very sharp increase in their risk level during this interval. For example, there are 31 taxa that have climbed from the VU to the CR category and 56 with previously little information on (DD) and now consider as CR or EN. The main causes for plants biodiversity decreases are the same as reported above.

The 2012 red list of French Vascular Flora, covering a total of 878 species, showed similar results of Portugal and Spain, with 329 species classified in one of the three IUCN threatened categories (VU, EN and CR). The destruction and modification of natural environments are among the main threats to the flora of the France mainland.

1.9. The SUDOE region studies and projects

Different reports have addressed the use of ground covers with multiple ecosystem services (Corleto & Cazzato, 2008; Alcántara et al. 2011; Martínez-Sastre et al. 2017; Guzmán et al. 2019; Jiménez-Alfaro et al. 2020 and references herein). However, very few studies include native plant species (Jiménez-Alfaro et al. 2020 and references herein). Ecological restoration projects can also be found using native species, however experiments in agrosystems with ground covers constituted by native species are few and mostly restricted to academic studies (Liébanas & Castillo, 2004; Alcántara et al., 2009; Gómez et al., 2013; Jiménez-Alfaro et al. 2020). The latter authors present a comprehensive process for selecting regionally adapted species and emphasize considerations for seed production. Using olive groves as a target system, the authors concluded that 85% of the annual grasses and forbs evaluated (Table 1) exhibit a collection of ecological and production traits that can be tailored to meet the requirements of farmers, seed producers and environmental agencies.

Table 1. Suitability of 8 grasses and 27 forbs evaluated as ground covers in Mediterranean olive groves (from Jiménez-Alfaro et al. 2020)

Type	Species	Olive Farming	Seed Farming	Final suitability
Grass	*Bromus hordeaceus*	Good	Excellent	Excellent
Grass	*Bromus scoparius*	Good	Excellent	Excellent
Grass	*Anisantha madritensis*	Good	Fair	Good
Grass	*Anisantha rubens*	Good	Fair	Good
Grass	*Hordeum murinum*	Good	Fair	Good
Grass	*Trachynia distachya*	Fair	Excellent	Good
Grass	*Cynosurus echinatus*	Fair	Fair	Fair
Grass	*Lolium multiflorum*	Fair	Fair	Fair
Forb	*Capsella bursa-pastoris*	Good	Excellent	Excellent
Forb	*Misopates orontium*	Good	Excellent	Excellent
Forb	*Nigella damascena*	Good	Excellent	Excellent

Forb	*Salvia verbenaca*	Good	Excellent	Excellent
Forb	*Trifolium angustifolium*	Good	Excellent	Excellent
Forb	*Biscutella auriculata*	Good	Fair	Good
Forb	*Cleonia lusitanica*	Good	Fair	Good
Forb	*Glebionis segetum*	Fair	Excellent	Good
Forb	*Medicago orbicularis*	Good	Fair	Good
Forb	*Medicago polymorpha*	Good	Fair	Good
Forb	*Moricandia moricandioides*	Fair	Excellent	Good
Forb	*Papaver dubium*	Good	Fair	Good
Forb	*Silene colorata*	Good	Good	Good
Forb	*Stachys arvensis*	Fair	Excellent	Good
Forb	*Tordylium maximum*	Fair	Excellent	Good
Forb	*Trifolium hirtum*	Good	Fair	Good
Forb	*Trifolium lappaceum*	Good	Fair	Good
Forb	*Trifolium stellatum*	Excellent	Fair	Good
Forb	*Vaccaria hispanica*	Fair	Excellent	Good
Forb	*Anthemis cotula*	Fair	Fair	Fair
Forb	*Calendula arvensis*	Excellent	Poor	Fair
Forb	*Crepis capillaris*	Fair	Fair	Fair
Forb	*Echium plantagineum*	Fair	Good	Fair
Forb	*Scabiosa atropurpurea*	Fair	Fair	Fair
Forb	*Silene gallica*	Fair	Good	Fair
Forb	*Tolpis barbata*	Fair	Poor	Poor
Forb	*Anthyllis vulneraria*	Good	Poor/Fair	Fair/Good

Very few large projects using native seeds as ground covers in Mediterranean agrosystems have been implemented. One example is the CUVrEN-Olivar (Ground Covers of Native Species in Olive groves) aiming for the establishment of ground covers with Iberian wild seeds of winter annuals and early cycle plants in olive groves in Seville, Córdoba and Jaén provinces of Spain. Also the Interreg SUDOE project SOS Praderas uses native species, aiming to promote sustainable management of mesophile hay meadows in SUDOE territory. A similar work was accomplished in relation to mountain meadows of the French, Swiss and Italian Alps by the project Alp'Grain (FEDER ALCOTRA 2007-2013, Koch et al., 2015).

Finally, in the French Pyrenees an important work has been realized on production and certification of native plants for restoration of subalpine and alpine grasslands (Dupin et al., 2014).

The possibility of improving pastures in marginal lands by sowing wild Lucerne (*Medicago sativa* L.) and annual medics (*M. polymorpha* L., *M. truncatula* Gaertn. and *M. rigidula* All.) was studied on uncultivated land in several countries like Spain and France (Henkin, 2016).

1.10. Seedbanks and producers' native seeds

In Portugal, to the best of our knowledge, the ground covers established in the agrosystems use almost exclusively non-native varieties. This may result from the small market of seeds form native species. The A.L. Belo Seed Bank (https://www.museus.ulisboa.pt/pt-pt/colecao-banco-de-sementes) is the largest and oldest seed bank of native species in mainland Portugal, with more than 1200 species and subspecies of native plants from Portugal. More oriented to agriculture genetic resources, the Portuguese Bank of Plant Germplasm (BPGV- https://www.iniav.pt/bpgv) has the mission of collecting, conserving, characterizing, documenting and valuing genetic resources, in order to ensure biological diversity and sustainable agricultural production. Although these two public institutions keep an extensive catalogue of species, their role is not supply native seeds for either ecological restoration or agricultural use. The market should assure native seed supply, although only 2 producers were identified in Portugal (De Vitis, et al. 2017). The "Fleurs locales" project objective of identifying the stocks of native seed species available in the seed banks and producers resulted in the knowledge of their inexistence in Portugal for restoration proposes.

The Redbag (Spanish network of genebanks for wild plants) with more that 25 seed banks associated, was created and developed in response to the necessity of conserving phytogenetic resources such as crops, local varieties and wild relatives. Although its role in establish mechanisms for the transfer of information regarding biological characteristics related to reproduction, propagation systems, germination protocols, cultivation techniques, distribution and demography, extinction risks, conservation methods, restitution programs and legal framework for conservation of Spanish plant Germplasm, any information is available in the organization site. The European native seed industry characterization by De Vitis, et al. (2017) indicates 10 native seed producers in Spain, indicating a more active market than in Portugal. Despite the considerably high number of native seed producers, the supply of suitable native seeds needed towards the establishment of herbaceous ground covers in Mediterranean woody crops is currently still small considering the needs.

Contrary of Portugal and Spain, the native seed market in France is regulated under the “Végétal local”, a simple collective brand that was created on the initiative of three networks: the National Botanical Conservatories, l’Afac-Agroforesteries and Plante et Cité in 2015. It is the result of a call for projects from the Ministry in charge of ecology launched in 2011 as part of the National Strategy for Biodiversity and entitled "Conservation and sustainable use of native plant species to develop local industries". The “Végétal local” brand is a tool for tracing wild and local plants naturally present in the region of origin considered. This brand as 61 seed producers associated from the 11 biogeographical regions defined within the framework that have very typical ecological, pedological, geological and climate characteristics (https://www.vegetal-local.fr/vegetaux-producteurs/recherche).

1.11. Native species adaptable to agroecosystems under the influence of the Mediterranean

While in Mediterranean grasslands perennial native species are more drought tolerant than Mediterranean annuals (Vaughn et al. 2011), in perennial crop agrosystems ground covers compete for soil water with the main crop. Thus, a discerning selection of native species to be used as green covers in the different targeted agro systems is needed. For perennial woody crops such as vineyards or olive groves, annual plants are desirable since they will naturally senesce at the onset of the summer dry season and persist as seeds. This reduces competition with the crop for soil moisture and reduces the requirement that farmers actively manage the ground cover, which regenerates from the seed bank at the onset of the autumn rains, when protection from erosion is needed. As already mentioned above, the Mediterranean region is rich in plant biodiversity although the decrease in plant diversity may endanger the functioning of services provided by the ecosystems. Any ecosystem works well only if there is a diverse mix of plants across the landscape. Hence a successful strategy lay in the “design” and use of species mixtures in function of different environments and agrarian systems. Due to the important role of ground covers, it’s essential to continue investigating/considering new solutions for the different systems and environments in order to maintain their benefits but at same time reduce the costs of management, i.e. reduce costs for cutting down the biomass produced. In spite of this, it will be necessary to create species seed mixtures that in addition to have a short life cycle (with senescence earlier than the time of production of the main crop) present a high capacity for covering the soil and a moderate to reduced vegetative vigour, prostrate habit, low phenotypic plasticity, adaptation to corrected fertility soils.

The native species suitable for agrosystems with perennial crops need to be competitive for covering the soils and to resist the grazing or mowing indifferent seasons.

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