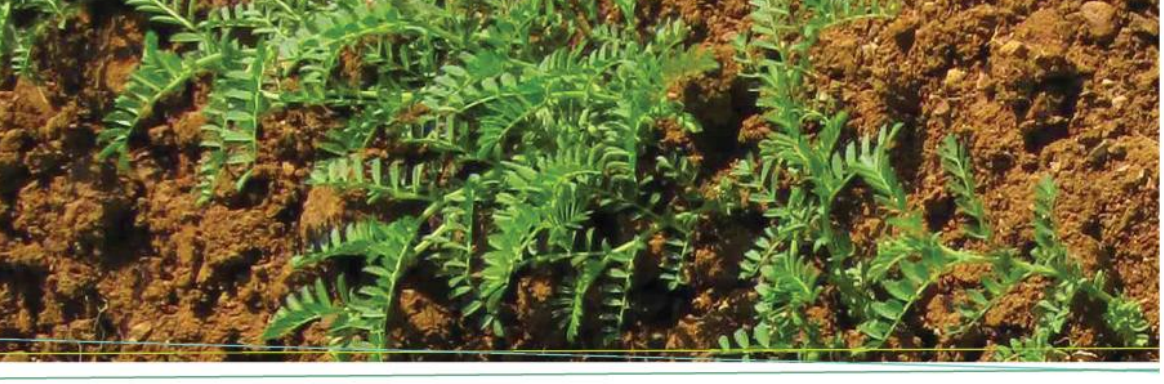

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Green mulching

DIMOS P. ANASTASIOU

Introduction

Several approaches of sustainable and ecologically based terrestrial ecosystem management focus on a careful study of natural processes and symbiosis between species, such as conservation agriculture for managing anthropogenic agro-ecosystems. A management aspect of CA focus on soil surface cover management, since nutrients and resources existing in the dry and green plant material can be used to maintain and enhance availability of resources to the main crops, and additionally provide several ecological, hydrologic, microclimate and organic matter benefits.

Practice briefs

Surface debris and mulch can come in several forms and as many methods exist for its production and application on a working farm soil. Deciduous tree leaves falling each autumn on the soil are a form of mulch. Naturally occurring plants cut or slashed during Spring, left to decay on site are a type of green mulch. Ex-situ transportation of green mulch can be also applied, but this document focuses on in-situ production using cover crops.

Various literature reports exist. Plantation tree legume leaves and pruning residues were prescribed as "green mulch" (1) on the soil surface (2 and citations within 3). The practice of cover crops is not new to farmers in the Mediterranean basin (4). Compared to other regions, CA and cover crops are less adopted in Europe (5). Cover crops can be grown in times of year when in monoculture systems soil is left bare, and cut to green mulch prior to seeding the main crop, or grown simultaneously with other crops.

Permanent tree crops, and arable lands, irrigated or not, are major agricultural land use categories (6) in Mediterranean countries where the proposed practice could be applied. One of the major CA principles focuses on the soil surface cover with plant material (7, 8), and surface crops under various management regimes can be used in this manner.

Mulching and cover crops need not be a permanent and persistent practice, but can be adjusted according to farmer needs; of course, achieving permanent uninterrupted "forest like" soil cover is an optimal solution, but sometimes an immediate change is not possible for established arable farmlands in transition towards a complete CA system.

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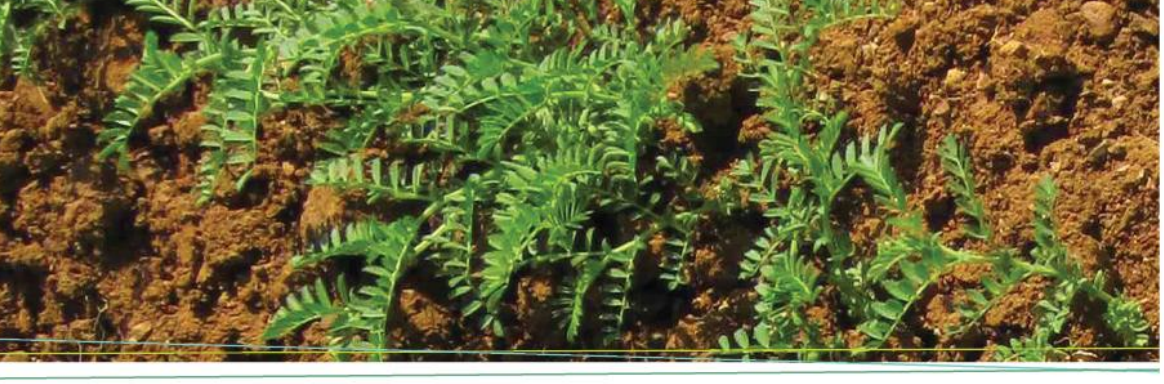

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Benefits and possible disadvantages

While the practice has many benefits that range from the local farm soil SOM increase, to overall ecology at the watershed level, up to quality food production, it needs attention on the timing of practices and overall management. More specifically, some benefits and possible drawbacks of the practice are:

- Provision of green and dry plant material and soil organic matter
- Higher water infiltration, water-holding capacity, lower evaporation compared to bare soil
- Nutrient mobilization and recycling
- Atmospheric carbon dioxide capture into the plants and eventually available to the soil (FAO CA)
- Cover crop conversion to green mulch is done at early growth stages. Late termination of the cover crop can reduce soil water storage (9), and generally compete with main crop. If cut at later stages, higher in dry matter mulch on soil during summer months is a wildfire hazard, but, this hazardous, dry, slowly decomposing mulch could reduce summer bare soil evaporation at the same time.

In-situ production of cover crops towards green mulch, compared to ex-situ transportation and dispersion of green mulch requires less energy (C release) and related effort/costs.

Site microclimate improved, smoother extreme temperatures. Attention is needed on wet sites, since green mulch and generally mulch can delay evaporation of soil water and keeps soil temperature lower, then needed for the main crop.

Enhances structural biodiversity (trees and crops, or different kind of crops), species diversity, influence soil biota and micro fauna. On the other hand, surface plants or mulch could host pathogens and pests to main cash crop, or negatively affect main crop yield (10).

Similar neighboring and landscape "radiating" positive effects.

Depending on appropriate combinations of surface crops-weed species, allelopathic effects can suppress weeds (11, 28, 29).

Legume cover crops can substitute at least partly nitrogen input with legume surface crop mulch, under appropriate management. This nitrogen input is important in Mediterranean stockless agricultural systems (33, and citations within (12)). In case nitrogen-fixing rhizobacteria will not develop as expected to maximize N, inoculation may be needed (13).
Costs of seeds and establishment of cover crops is an additional management step.

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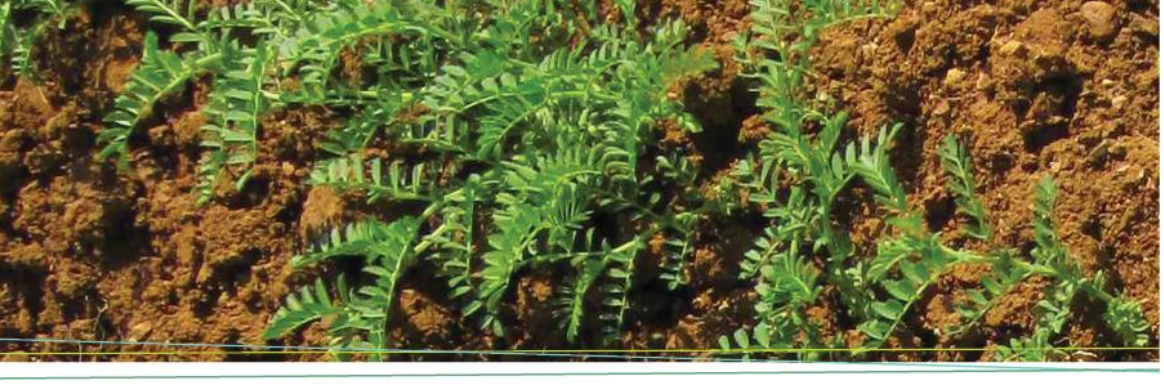

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Agroecosystems

Tree orchards and permanent crops

At certain intensively managed orchards, soil is kept free of any surface cover, for several months every year, with management goal to have only the woody crop as a monoculture.

The practice of ploughing at such woody permanent crop systems is applied for various reasons: to eliminate weeds, improve soil aeration, recover from, if any, vehicle soil compaction (for example, vineyard rows may have an increased vehicle and human worker traffic during certain year periods for maintenance works and harvesting purposes), and generally cleaning up soil according to farming management.

Conservation of soil and water at woody crop systems with green cover is of interest to Mediterranean country research (14) since it also covers significant area (6). Vineyards and olive groves are studied in several countries (15 16) and also no-tillage practices and cover crops of common grain species in strips (17), and water regime changes in vineyards with cover crops (18).

Surface plants can naturally (fao from beginning) exist under tree orchards as a permanent soil floor, which is an observed regime especially at marginal lands, with relatively low-income olive orchards (19). Competition with the tree crop is studied (20), and careful management can minimize antagonism for water resources, while in certain cases cover crops are observed to reduce woody crop yield (21). Suitability of cover crops has been studied for various woody crop agro-ecosystems in Mediterranean environments (22), and recommendations for their management is provided.

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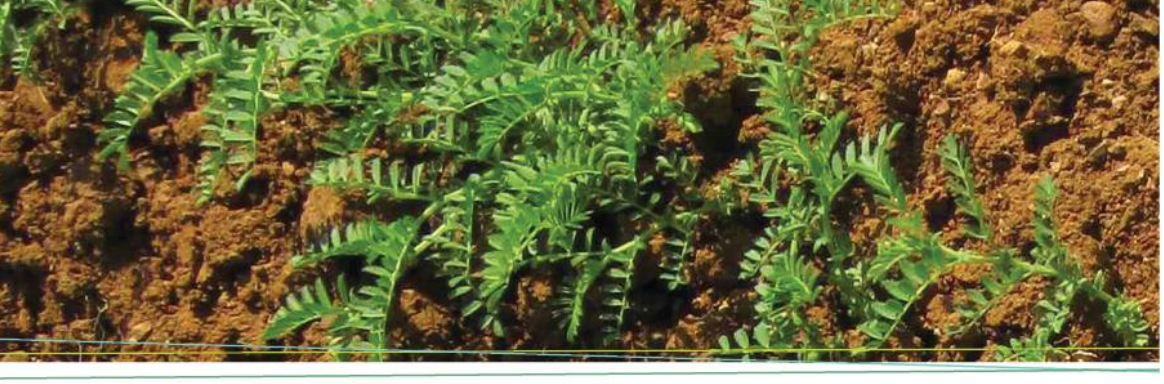

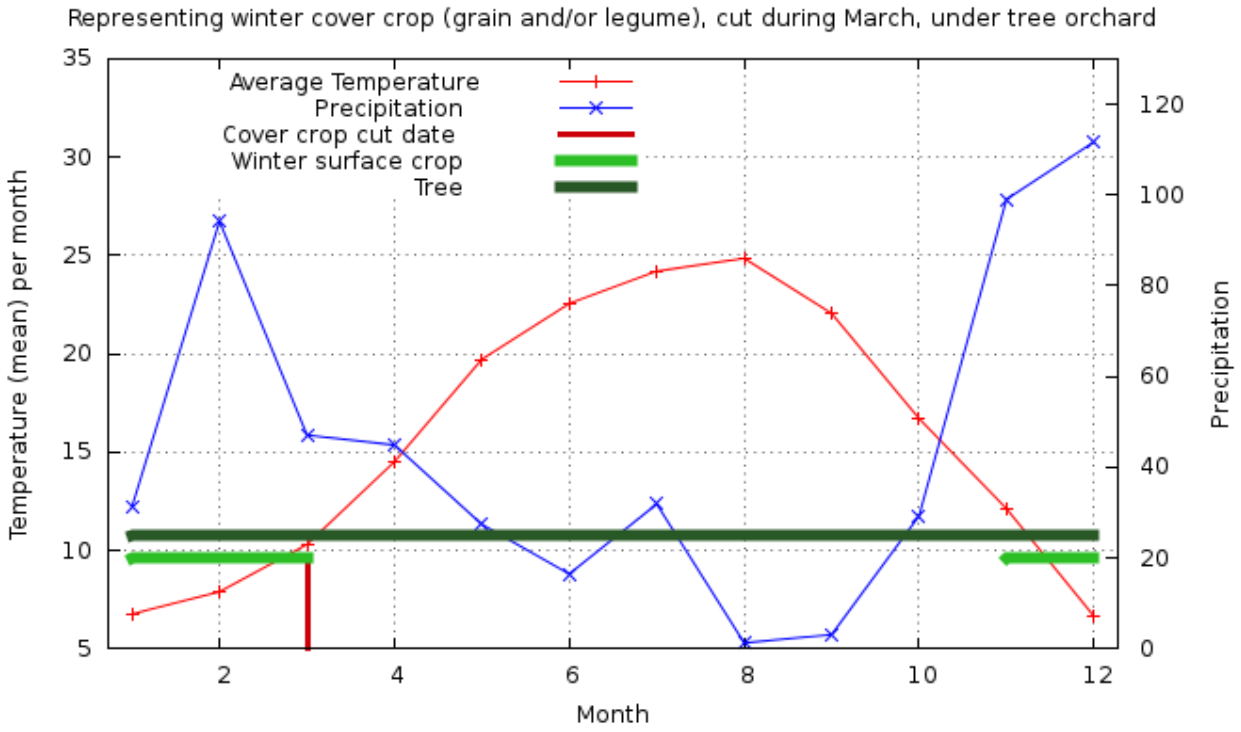

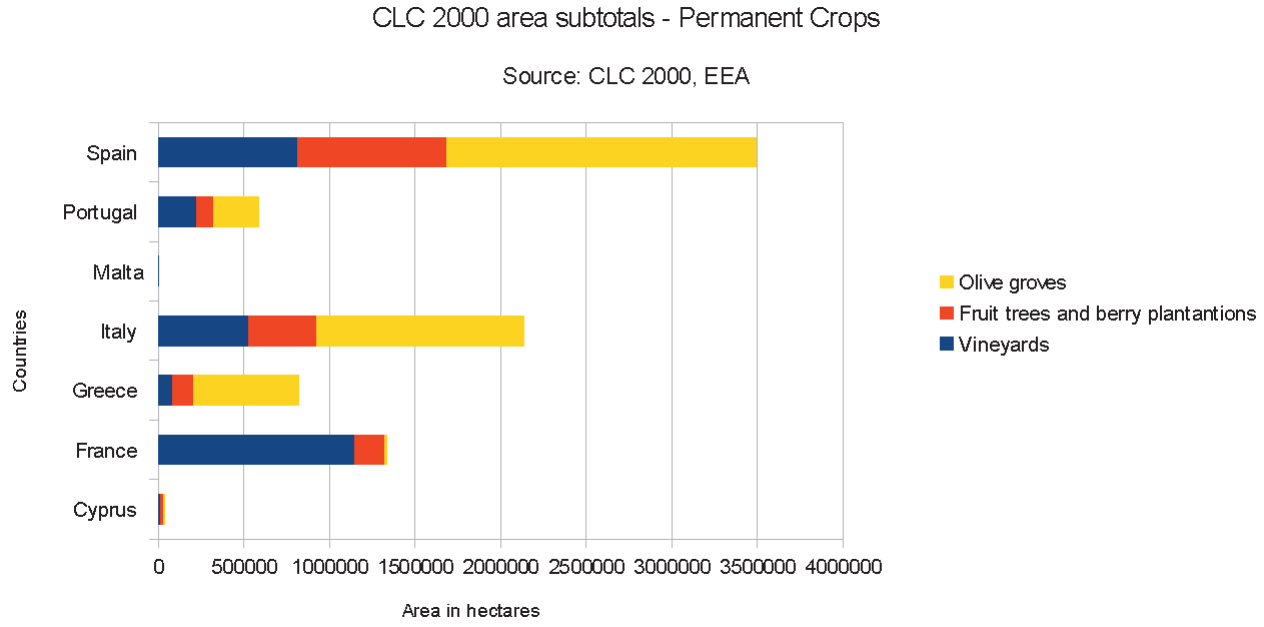

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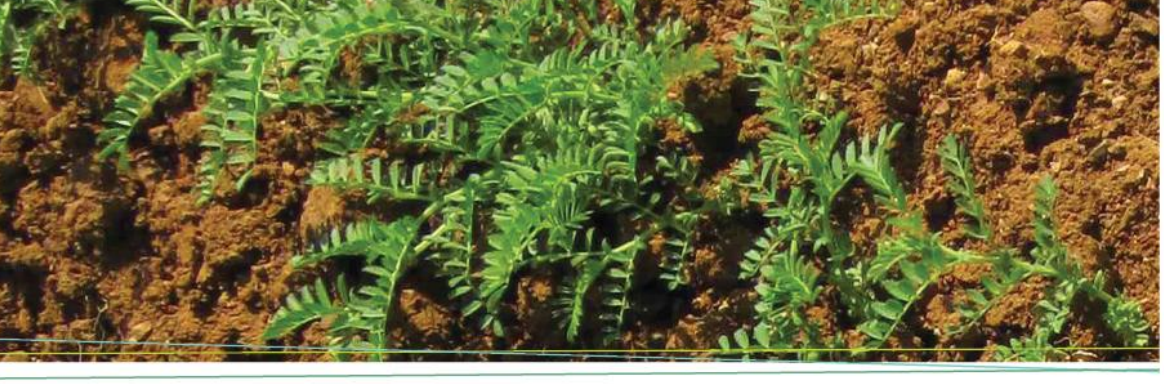

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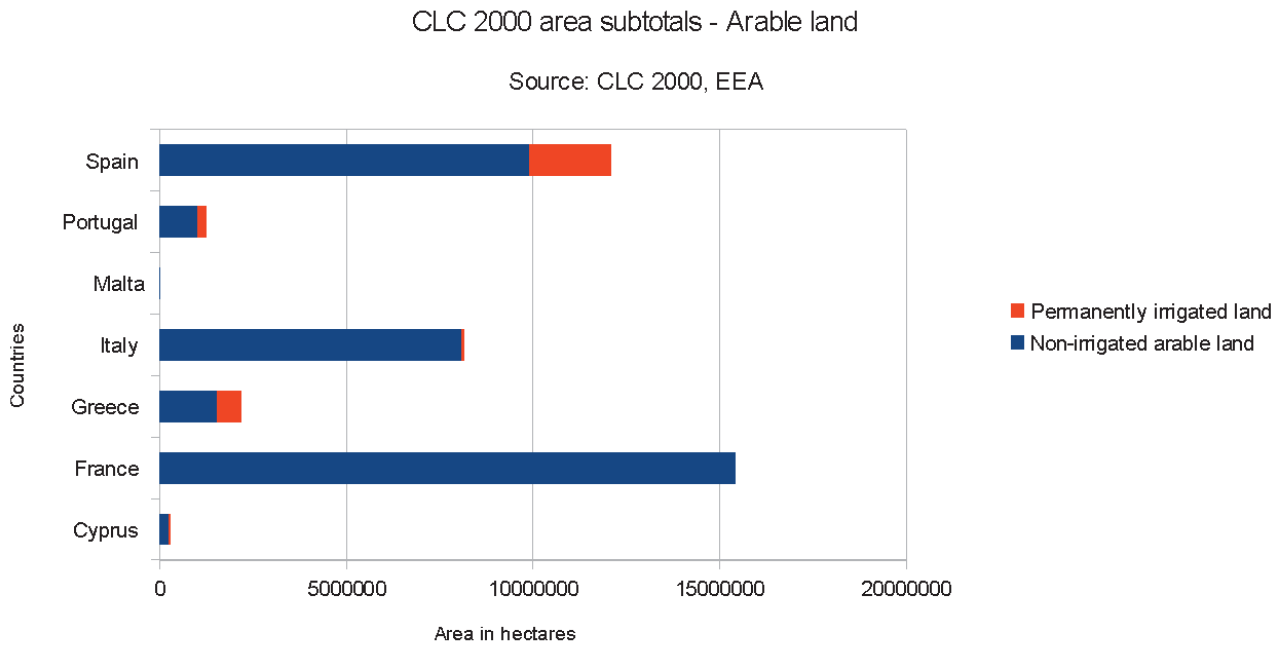
Seasonal crops - Irrigated and rainfed

CA tillage systems and rotations cover crops can benefit SOC and nitrogen (23). Reports exist for dryland wheat production systems with CA tillage practices, and cover crops (24).

Even if the green mulch cover crop is grown on rotations (for example a combination of a winter cover crop producing green mulch and a warm season cash crop) soil and overall biodiversity is higher than a management system focused on one plant species only. An example can be perennial Medicago spp. followed by maize. These very productive legumes species can create soil nitrogen - to be used by the nitrogen demanding maize crop-, suppress weeds, maintain a year round surface cover, and increase carbon stock with the alive and decaying root system.

With available irrigation, options for available plants and time to establish on a site of interest are significantly increased in the Mediterranean where water availability is a limiting factor for plant survival and productivity. Crop growth models have been used to simulate crop-maize simulations (25); such results can aid field management.



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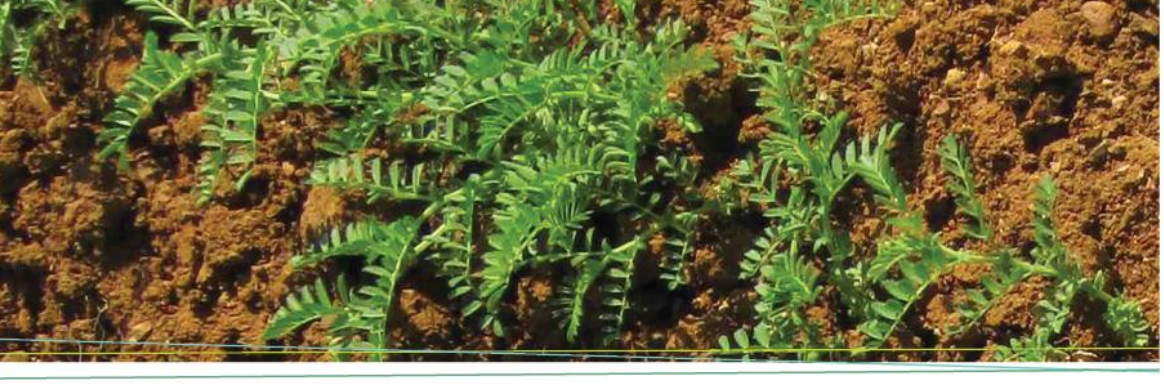

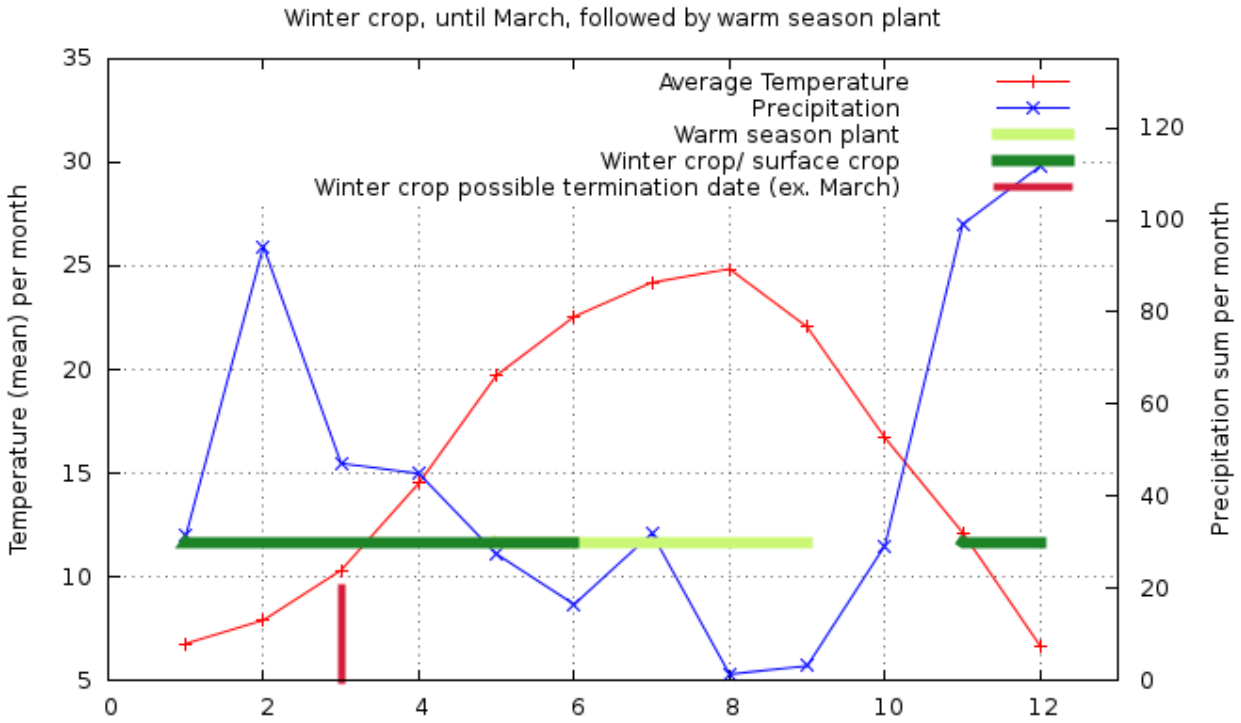

Species for Cover Crops/Green mulch

Several species are studied in literature for the temperate and the Mediterranean areas. Grain species, and also legumes are studied or a combination of them to provide both nutrient input and raw green biomass to the farm soil surface. Mediterranean is home to many forages and legumes, then introduced and used worldwide (4), and various species are suitable for the dry area of interest (26), and an extensive list of both grass and legume species are proposed for various agroecosystems (22, 26). A few examples of surface crops are given below:

Oats (Avena sativa, Avena spp.): Winter grain crop. Studied as cover crop prior to sunflower and sugar beet (33). Studied also as winter cover crop for vegetable production (27)
Barley (Hordeum vulgare): Studied as strip cover crop in Olive groves (17), but can be used as a cash or surface crop too. Reported for weed suppression when used in a barley-corn rotation (28) or as cover crop mulch in sugarbeet (29)
Rye (Secale cereale): Winter crop. Competes weeds (30, 29) and has high biomass production.
Trifolium spp.: Productive legume proposed for use, (4, 26) can re-seed (31) and proposed as cover crop (32) in Mediterranean (22). Studied as cover crop succeeded by sugar beet and sunflower (33). Reported also in trials with sunflower, maize and tomato (32)

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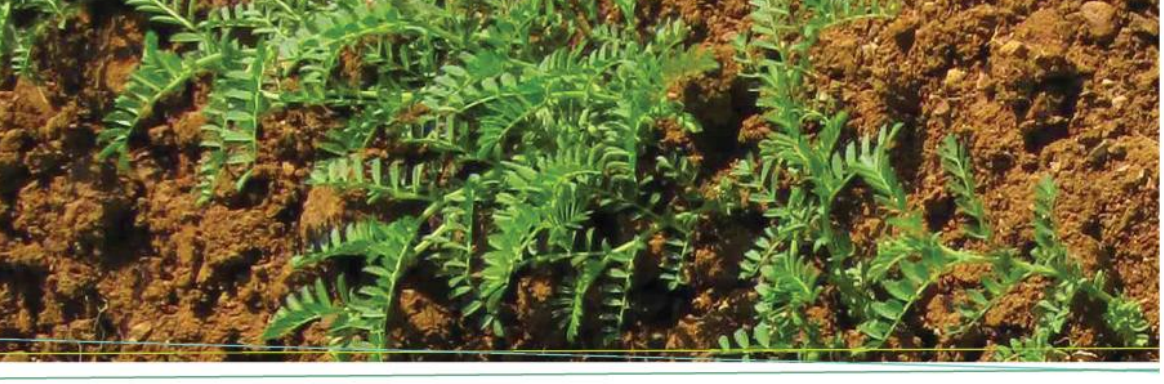

Trifolium repens White clover: Legume, studied for its effect on vegetable food crops (34) but could compete with olive trees (35), other species of clover are proposed instead (35).
Peas: Nitrogen fixing. Winter annual crop, can be combined with a grain species - usually oats- to provide both nitrogen and organic matter.

Vetch (Vicia spp): Legume, winter hardy plant. Several varieties are used as cover or forage crop. Can be used in mixture with other grains and legume species. Compete weeds as also Trifolium species (36). Used for weed control and yield improvement of tomato growing (37).

Faba spp: Winter legume, widely known worldwide as a pre-crop in crop rotations (38). Vicia faba was used as a winter crop succeeded by maize and fibre sorghum (39).

Beans: Warm season plant, usually irrigated, with high biomass production Nitrogen fixer. Could be used a cover crop too (35) (depending of course on local climate conditions).

Medicago: Highly productive legume species, usually perennial varieties are used. Can re-seed (35), has been studied also in tree crops/plantations (22). Used in research trials with sunflower, maize and tomato (32).

When intentional establishment of grain or legume species is not desired, or is not managerially possible due to several reasons, naturally occurring, existing in the soil seed bank, thus well adapted plants of local genotype, can be left to grow as a surface cover. Several species of Trifolium spp. are naturally occurring in Mediterranean, as also are vetches and wild oat varieties, which can be managed as physically occurring surface crop/green mulch.

Farm level management

Cover crops can be terminated using equipment such as knife-roller, chain, sledge or herbicides (26). Appropriate timing for this conversion is essential to benefit farm soil and crops.

When to convert surface crops to green mulch? A generic guideline is during the first stages of flowering period. Simple and effective management guidelines can help towards larger adoption of the practice from farmers, as provided in detail by a FAO publication for CA:

Legumes should be at the flowering stage, but not yet with mature pods, while vetches should be at a slightly later growth stage with some mature pods, rye and oats at the milk stage, while pigeon pea prior to the flowering stage.

Generally, the C/N ratio should be approximately between 10-30, depending on species.

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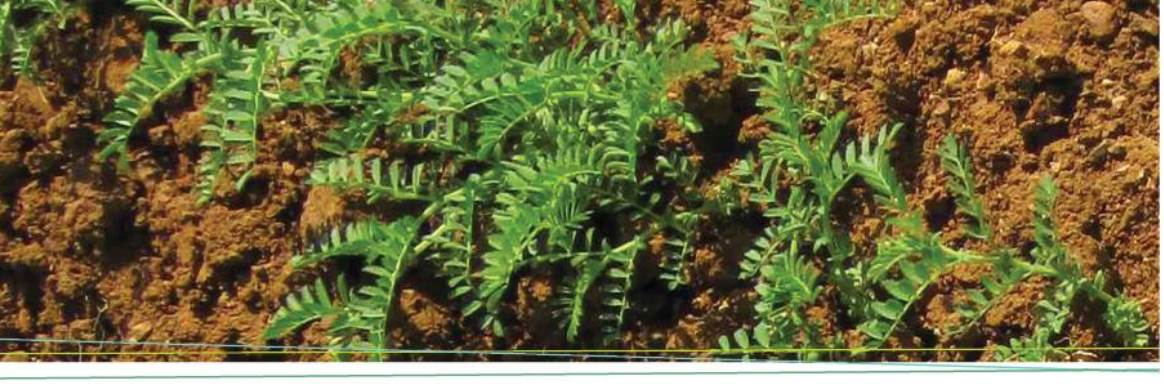

Also, technical details for no-tillage seeding, equipment and technology are discussed in relevant work and databases available for dissemination of information (40, 41).

Regional level

Applications for management and spatial planning

CORINE Land Cover dataset 2000 (6) Classification Level 3 dataset statistics can provide the applicable area for Mediterranean Countries. Management can be benefited due to the large spatial extend and diversity of the agricultural areas, and thus numerous suitable species, field practices and management options can be available to select from.
Available land cover data can be combined with existing methodologies (42) in assessing environmental impacts of conservation adoption at regional (43 and 44 45) or European level.
The assessed impacts of scenarios of hypothetical agricultural regime (46), cultivated soil erosion risks (47), results of which can be very useful to regional decision makers for spatial management and planning.

Monitoring at a regional level

Theoretically, monitoring for mulching/cover crops as an established management regime of agricultural ownerships at a regional, national or even at the EC level -for example as part of the LPIS-IACS/EC No. 1122/2009 - could be implemented as part of the regular monitoring systems.

For wide scale monitoring, either for research or management monitoring proposes, in mixed species systems, such as cover crop mulching in tree orchards, to estimate the presence of the practice with popular VIS/NIR broadband remote sensors can be challenging, due to spectral diffusion of the soil, tree, live and dry grass, since the responses are of relatively low spectral resolution compared to high resolution spectral libraries (50, 51, 52) or soil surveys (48, 49). But, it can be easier for single species rotation systems, when for example a summer cash crop succeeds an early spring surface legume, since the existence (or not) of a cover crop photosynthetic biomass can be detected by paired spatial/temporal observations of multispectral sensors.

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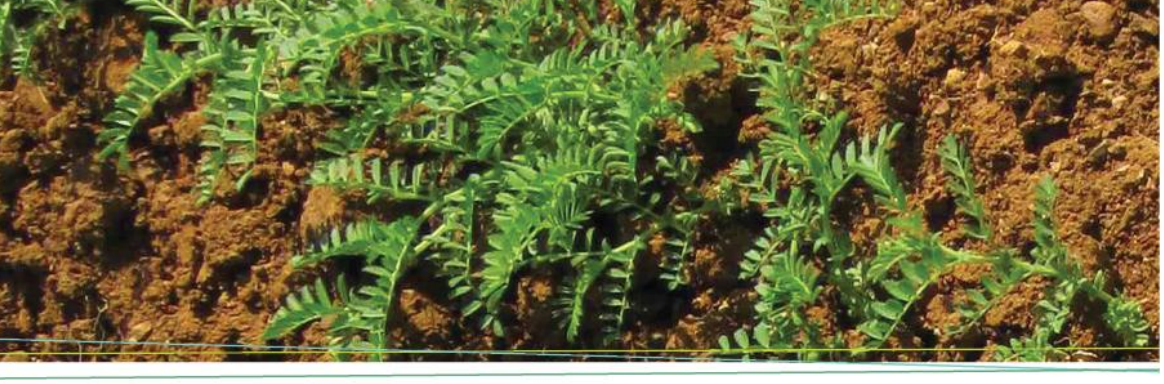

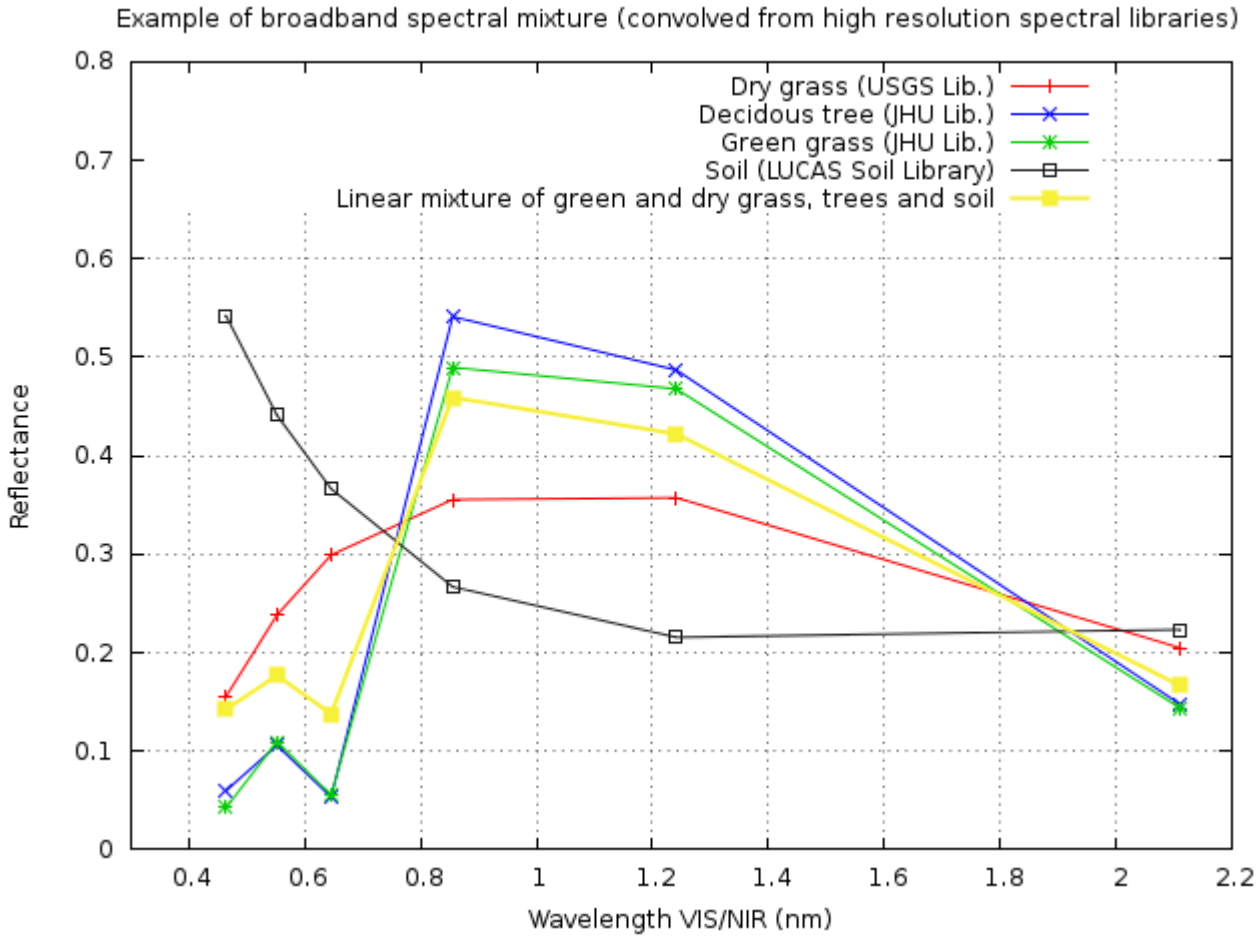

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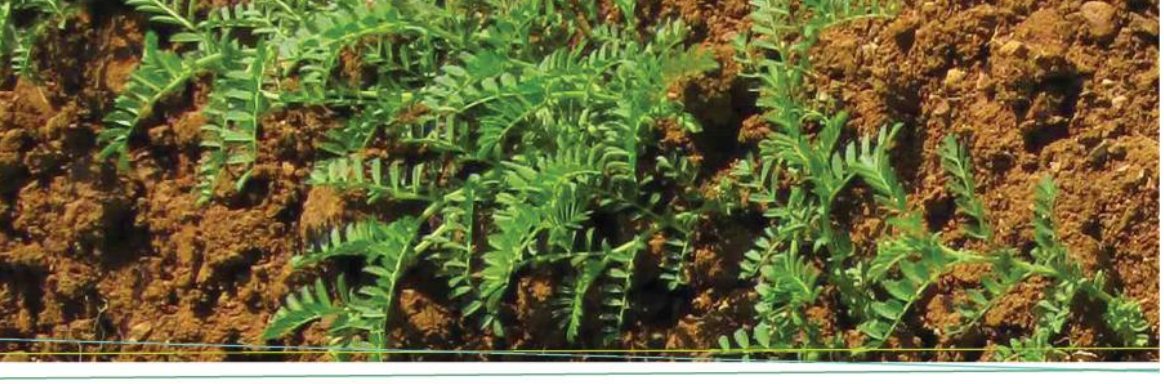

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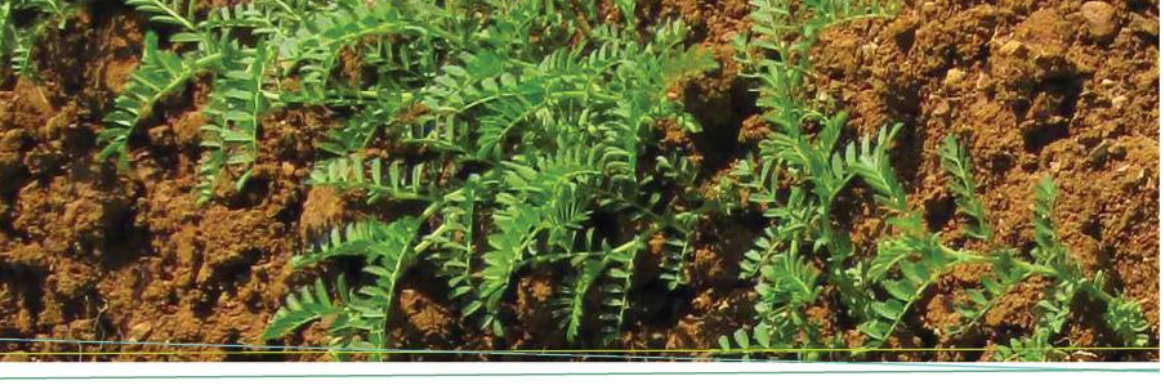

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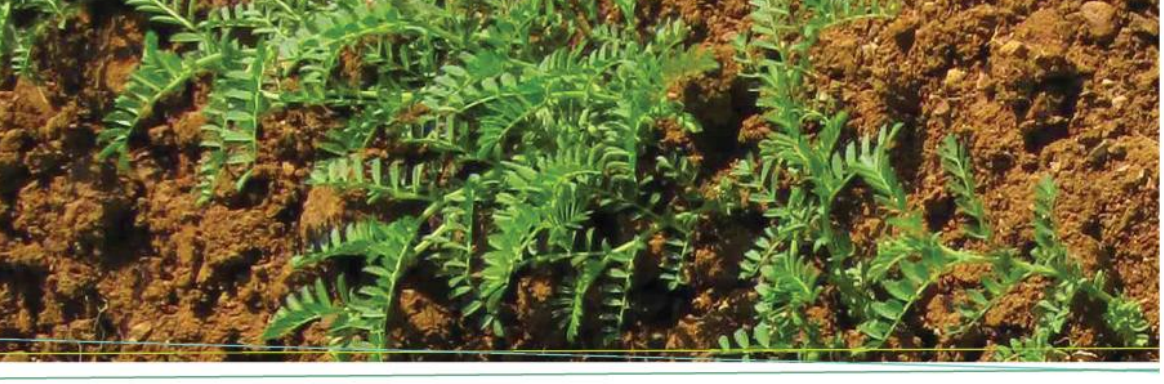

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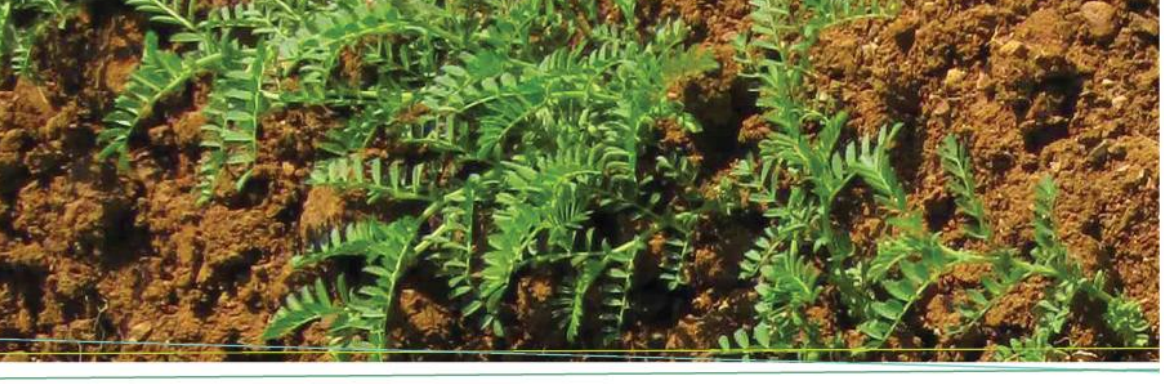

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