DIVERFARMING

Crop diversification and low-input farming across Europe: from practitioners' engagement and ecosystems services to increased revenues and value chain organisation

OUTCOMES OF THE MULTICRITERIA MODEL FOR DECISION MAKING

Deliverable D2.1
Version 2.0
Issue data: 28/02/2019
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This project has received funding from the *European Union's Horizon 2020 Research and Innovation Programme* under grant agreement No 728003

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Document summary	
Document title	Outcomes of the multicriteria model for decision making
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Lead beneficiary	Universidad Politécnica de Cartagena
Deliverable No.	D2.1
Work Package	WP2. Selection of sustainable diversified cropping systems
Dissemination type	Report
Dissemination level	Public
Deliverable due date	31/12/2017 (month 8)
Release date	28/02/2018
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Executive summary

WP2 contributes to all the other WPs by identifying the most suitable diversified cropping systems with low-input agricultural practices for each pedoclimatic region that will be experimentally validated in each field case study area, used as models for adaptation and optimisation of the value chain and considered for data analysis and upscaling, economic assessment and policy analysis. This report summarizes the methodology and results of all activities carried out within tasks 2.1 to 2.4 identify the most suitable crop diversifications and farming practices for each case study.

Potential crop associations and alternative agricultural practices and strategies were proposed for each pedoclimatic region by means of a thorough data mining of previous and ongoing projects and scientific databases, highlighting the strengths, opportunities, limitations and drawback for each association/practice/strategy with regard to crop production and quality, ecosystem services, economic expenses and economic revenues for different pedoclimatic regions, soil types, topography, cropping systems and farm types. After that, surveys were performed by end-users and stakeholders in each case study area and analysed, using a multicriteria decision methodology, to identify the best diversified cropping systems under low-input management practices for the different crop types and pedoclimatic regions.

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1. Background and objectives

The objective of WP2 is to identify, through the consultation to both scientific literature and stakeholders, sustainable diversified cropping systems and crop associations with low-input farming practices suitable for each pedoclimatic region that minimize their agronomic, environmental and socioeconomic problems. These diversified cropping systems with low-input farming practices will be validated in each case study area. The outcome of WP2 will thus be the basis for the design of the project's on-field experiments and consequently for the activities of WPs 3-9 (Figure 1).

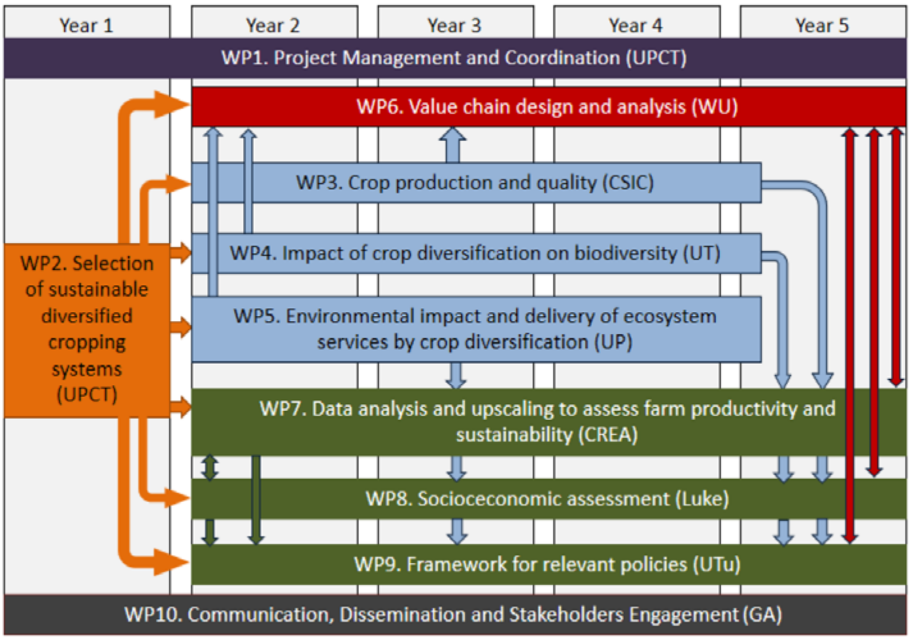

Figure 1. Interrelation of DIVERFARMING's Work Packages

WP2 activities have been performed at several sequential levels. First, an exhaustive data mining of the existing literature, done by each partner under CREA coordination (Task 2.1), allowed for a detailed description of the existing alternatives for crop diversification and environmentally-sound farming practices in each case study area (Task 2.2). These alternatives served as a basis for the consultation to stakeholders/experts, which in any case could propose other alternatives not identified in the data mining (Task 2.3). Then, stakeholders' answers were analysed using a multicriteria decision-making framework that therefore integrates both published scientific knowledge and stakeholders/experts practical experience (Task 2.4). Last, the results of the multi-criteria analysis in terms of the preferred types of diversifications, crops and farming practices for each study area (Figure 2) were presented to stakeholders in a participatory workshop in each region to engage them in a plenary discussion to make the final definition of the diversified cropping systems (Task 2.5) that will be the basis for the design of the experimental setup for the following WPs (Figure 2).

This deliverable summarizes the methodology and results of all activities carried out within tasks 2.1 to 2.4 to obtain the results of the multi-criteria analysis (identification of crop diversifications and farming practices), while the final definition of the diversified cropping systems agreed in the participatory stakeholders' workshops is presented in deliverable 2.2.

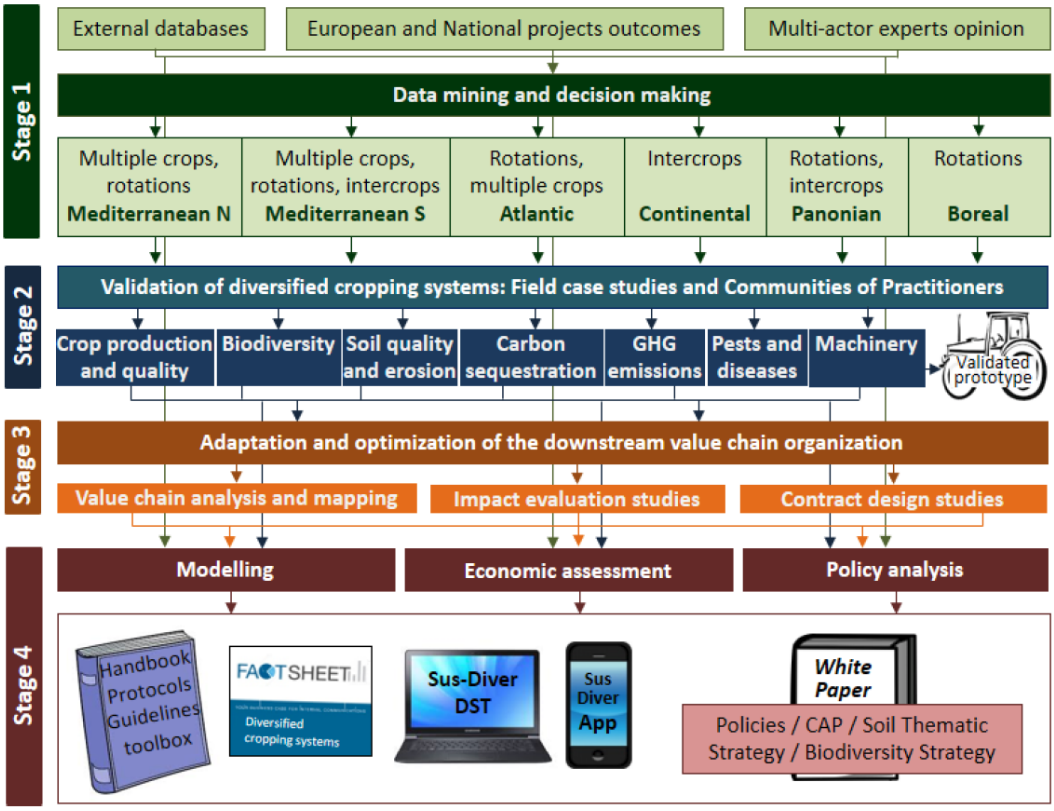

Figure 2. Time sequence and stages of DIVERFARMING's activities

2. Methodology

2.1. Data mining

The data mining process consisted of an exhaustive bibliographic review of scientific literature and EC project deliverables on crop diversification in all crop types and pedoclimatic regions considered in Diverfarming, including published articles and reports, databases and grey literature. All partners contributed to this activity.

To organize and facilitate the data mining process, case studies were grouped as follows:

1. Cereals in Mediterranean North and South region (Spain and Italy): CSIC, CREA, UTu, gathering case studies CS3, CS5, CS6, CS7 and CS7bis.
2. Fodder crops in Atlantic and Boreal regions (Netherlands and Finland): WU, LUKE, gathering case studies CS8, CS12 and CS13.
3. Horticulture crops in Pannonian region (Hungary): UP, ETH, case study CS10
4. Woody crops in Mediterranean South region (Spain): UPCT, UCO, gathering case studies CS1, CS2 and CS4.
5. Woody crops in continental and Pannonian regions (Germany and Hungary): UT, UP, ETH, gathering case studies CS9 and CS11.

Data obtained from the reviewed sources was compiled using an Excel spreadsheet template developed by CREA, as Task 2.1 leader. The template structure included the following information related to crop and diversification system:

- reference information;
- site and climate information;
- land use and management history information;
- treatments and experimental design;
- current main crop management;
- main crop growth and yield;
- main crop quality and nutritional evaluation;
- current secondary crop management;
- secondary crop growth and yield;
- secondary crop quality and nutritional evaluation;
- cover crop yield and biomass;
- soil initial and final parameters;
- GHG emissions;
- economic indicators;
- conclusions from the reference.

Data compiled in the data mining process was used to identify the best crop diversification systems and farming practices for each group characteristics, and discard those systems with negative results, based on scientific knowledge (Task 2.2). Additionally, statistical meta-analyses were carried out separately for some of the groups to assess the real overall knowledge of diversified cropping systems under low-input management practices up to date, as a starting point to allow Diverfarming to make contributions beyond the state of the art.

2.2. Description of alternatives for diversified cropping systems

In Task 2.1, partners carried out a bibliographical search on the state of crop diversification in Europe for each pedoclimatic region and group of crops. This ultimate knowledge produced by recent research was used in Task 2.2 to establish potential diversified cropping systems under low-input management practices. In Task 2.2 and in the following tasks, information has been organised by crop types and areas, thus grouping some of the case studies as shown in Table 1. Potential crop associations and alternative agricultural practices and strategies have been proposed as the most adequate ones for each case study based on data mining.

Table 1. Split of case studies for questionnaires and surveys

Case Study	Country	Crop
1	Spain	Almonds
2	Spain	Citrus trees
3	Spain	Rainfed cereals
3	Spain	Irrigated cereals
4	Spain	Olive groves
5,6,7, 7 bis	Italy	Rainfed cereals
5,6,7, 7 bis	Italy	Irrigated cereals
8	The Netherlands	Fodder crops
9	Germany	Vineyards
10	Hungary	Horticulture
11	Hungary	Vineyards
12,13	Finland	Conventional and organic fodder crops

Each case study's leader was asked to answer several questions regarding the description of the best alternatives for crop diversification and agricultural management practices based on the findings of the data mining from Task 2.1. The best alternatives for crop diversification type, crop associations, tillage system, irrigation, fertilization, pesticides and soil management, were identified from the data mining based on their higher impact on crop production, crop quality and delivery of ecosystem services and economic revenues. However, they were not only asked to indicate the best alternatives according to previous research studies, but also those that have not been studied yet, but partners consider worth being investigated (to go beyond the state of art). The specific questions the case study's leaders had to ask were:

1. **Which are the best diversification types for your case study?** intercropping, rotations and/or multiple cropping?
2. **Which are the best crop combinations within each diversification type for your case study?** e.g. intercropping vines and lavender; intercropping wheat, vetch and alfalfa; rotations between barley and fava bean
3. **Which are the best tillage systems?** e.g. zero tillage, reduced tillage, shallow tillage, deep tillage, etc.
4. **Which are the best irrigation systems? (only if applicable)** e.g. drip irrigation, regulated deficit irrigation, deep root irrigation, etc.
5. **Which are the best fertilization systems?** e.g. inorganic fertilizers, manure, compost, crop residues, mix of inorganic and compost, etc.
6. **Which are the best weed management systems?** e.g. herbicides, tillage, mulching, cover crops, tillage with herbicides, tillage with cover crops, etc.
7. **Which are the best pest management systems?** e.g. pesticides, integrated pest control, pest traps, etc.
8. **Which are the best land conservation systems?** e.g. cover crops, mulching, erosion barriers, vegetation barriers, etc.

All partners involved in the task contributed to it on time. The descriptions of alternatives provided for each case study were uploaded to Diverfarming cloud in OneDrive and fed the survey questionnaires developed in Task 2.3 for end-users and stakeholders in each case study.

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2.3. Development of surveys for compilation of information for selection and multicriteria analysis

Task 2.3 involved the compilation of the second level of information after data-mining, which is the opinion of relevant stakeholders on diversified cropping systems and crop management alternatives to enhance sustainability in the agroecosystems. UPCT developed a generic questionnaire to gather such information, taking into account the guidelines established in deliverables D11.2 POPD. Once the generic version of the questionnaire was tested with a small sample of Spanish stakeholders, it was adapted to the specificities of each group of case studies (Table 1) using the descriptions of alternatives elaborated in Task 2.2 and with the involvement of each corresponding partner. The final twelve questionnaires (one per each row in Table 1) were translated by each partner to each country's native language to reach all stakeholders in their regions. All survey questionnaires were provided both in English and the country's native language, except for Spain, where only Spanish was used (Table 2).

The questionnaire started with a brief explanation of Diverfarming and the purpose of the survey, the letter of consent (D11.2) and the consent form to be signed by the respondent, followed by several blocks of questions:

- The first block of questions aims to identify and characterise the interviewee (name, gender, type of stakeholder, etc.).
- The second block of questions asks for the identification and assessment of the most relevant agronomic, economic, environmental and social problems in the region (choice from an open list), as well as possible cropping systems, agricultural practices and policy measures to tackle the previously identified problems (choice from an open list).
- The third block deals with the identification of the type of diversification and diversification crops and associated low-input farming practices that the stakeholder consider as more appropriate for the area of study. The lists of diversifications and farming practices proposed to the interviewee are specific for each case study and come from the outcome of task 2.2. However, the list was open for the interviewee to propose additional practices.
- The last block assesses the effectiveness of the selected diversification types and farming practices to address the agronomic, economic, environmental and social problems previously identified in the area of study and identify opportunities and barriers/drawback.

The survey to stakeholders included some specific questions, related to the assessment of problems in the study area and to the identification of suitable farming practices, that provided additional information that was not intended to feed the analysis for the identification of diversification, crops and farming practices, but to oblige the respondents to think about the specific problems of his/her study area and about the practical feasibility of farming practices which will be used in the future, as it is explained at the end of the document.

A major feature of the developed questionnaire is that it evolves with the interviewee's answers, as several questions are built based on the answers provided to previous questions. This complex adaptive design has the advantage of simplifying the questionnaire by focusing only on the specific aspects that each interviewee finds relevant. This reduces the risk of the expert getting tired of answering the survey by avoiding irrelevant issues and shortening the duration of the survey.

Four major types of stakeholders were consulted separately in order to gather the opinion of each group: 1) farmers, agroindustry and technical agricultural advisors; 2) field technical officers from public agricultural administrations; 3) technical experts from NGOs with experience on farming; and 4) agricultural researchers. They were selected and contacted by each partner with help from farmers' associations and agricultural cooperatives and companies. Between 20 and 30 stakeholders/experts were intended to be consulted in each case study with the following approximate distribution as orientation: 12-15 farmers/technical advisors, 3-5 public officers, 2-5 NGOs experts and 3-5 researchers. Potential respondents were contacted by email or telephone to make the survey.

Surveys were implemented on a commercial online surveying platform (Survey Monkey). Interviewees could answer the survey online using a laptop/tablet/smartphone. A web link providing the access to the questionnaire in Survey Monkey was sent to them (Table 2). However, in some cases (e.g. in The Netherlands), partners had to directly interview the stakeholders in person and help them to fill out the survey to reach a satisfactory representation of stakeholders. The answers to the questionnaire provided by each person were directly received by the task leader (UPCT), in charge of the surveys data treatment (task 2.4), immediately after it had been filled. Survey answers were downloaded in Excel format template for its validation and analysis. All partners satisfactorily contributed to this task.

Table 2. Link to all survey questionnaires

Case Study	Country	Crop	Link in native language	Link in English
1	Spain	Almonds	https://es.surveymonkey.com/r/C35QD6K	-
2	Spain	Citrus trees	https://es.surveymonkey.com/r/NTL72S8	-
3	Spain	Olive orchards	https://es.surveymonkey.com/r/NTMRHKQ	-
4	Spain	Cereals	https://es.surveymonkey.com/r/698CHT5	-
5,6,7, 7bis	Italy	Cereals	https://it.surveymonkey.com/r/SWR9LJG	https://es.surveymonkey.com/r/NNJXHNR
8	The Netherlands	Fodder crops	https://nl.surveymonkey.com/r/DK97R3R	https://es.surveymonkey.com/r/DMGCW96
9	Germany	Vineyards	https://de.surveymonkey.com/r/56LDRMD	https://es.surveymonkey.com/r/NMHCBB8
10	Hungary	Horticulture	https://es.surveymonkey.com/r/PGZ9RB5	https://es.surveymonkey.com/r/NN8FJPR
11	Hungary	Vineyards	https://es.surveymonkey.com/r/LH8P85J	https://es.surveymonkey.com/r/NXGT2DS
12,13	Finland	Fodder crops	https://fi.surveymonkey.com/r/G3K97FQ	https://es.surveymonkey.com/r/67YB835

2.4. Selection of diversification, crops and farming practices

The main output of the survey to stakeholders (Task 2.3) is the identification of the most adequate type of crop diversification, combination of crops in the diversified cropping system and associated low-input farming practices. The criterion used for selecting the most adequate types of crop diversification and diversification crops for each region was the total number of answers from the consulted stakeholders. As stakeholders made a direct choice of diversification type and crops combination, the summation of answers, without discriminating between stakeholder groups, was considered as the most adequate method. Consequently, those types of diversification and crop combinations that were selected by most stakeholders were considered as the most adequate ones.

On the contrary, the assessment of farming practices consisted of a qualitative assessment, using linguistic labels, of their effectiveness to address the most relevant problems in the study area. Each consulted stakeholder selected several practices that considered as the most adequate for his/her region, and then qualitatively assessed their effectiveness to address the most relevant agronomic, economic, environmental and social problems. Stakeholder's answers were analysed by UPCT using decision-making support tools. More specifically we used multicriteria selection methods that allow to establish the order of preferences regarding farming practices both for each group of stakeholders and for all stakeholders.

Multicriteria Decision Making Methods (MCDM) were chosen because they allow to integrate the knowledge of experts who can enrich the decision with their judgments regarding the decision-making problem. The most common drawback of existing multicriteria methods, at least for some classes of problems, is the need to translate the decision makers' knowledge about a decision problem into numbers and functions, as it happens in this case. Consequently, the most convenient methodological choice is using models that incorporate qualitative variables (descriptive, linguistic, ordinal). Practical decision-making problems are often characterized by several no commensurable criteria, and there may be no solution satisfying all criteria simultaneously. Thus, the optimal solution would be a compromise solution according to the decision-maker's preferences. The information is to be found in a set of labels, and in a later step the decision-maker expresses his/her intuition about the meaning of these linguistic terms.

Any multi-criteria decision problem (MCDP) can be expressed by means of the following five elements:

$$\{C, D, r, I, \prec\}$$

Where:

- $C = \{C_1, C_2, ..., C_m\}$ It is the set of m criteria that represent the tools which enable alternatives to be compared from a specific point of view, in this study we have considered the preferences of the different stakeholders like criteria.

- $D = \{D_1, D_2, ..., D_n\}$ It is the set of feasible alternatives (farming practices) for the decision-maker, and from which the decision-maker must choose one. In this case, the sets C and D are finite sets. This allows us to avoid convergence, integrability and measurability problems.

- r: D × C $\rightarrow$ R is a function where a real interval corresponds to every decision d_i and to every criterion C_j.

$$\left(D_i, C_j\right) \rightarrow r\left(D_i, C_j\right) = r_{ij}$$

Once that set of criteria and alternatives have been selected, then we need a measure of the effect produced by each alternative with respect to each criterion. By means of linguistic terms, the decision-maker represents the goodness of an alternative; the different values of *r* can be represented by means of a matrix called the Matrix of decision-making. A relation of preferences $\prec$ by the decision maker. We shall suppose a coherent decision-maker; therefore, he shall try to maximize his profits or else minimize his losses. In this case, the decision-maker needs to obtain the best alternative set. The decision-maker gives linguistic information about the importance for each alternative. In this specific case, and by means of direct assignment, the importance for criteria was obtained, being the valuation scale: Very low: 1; Low: 2; Medium-low: 3; Medium-high: 4; High: 5; Very high: 6. For example, one of the questions posed to stakeholders reads "*In the case of diversification X, value, according to your criterion, the effectiveness of the practice Y" (Very low; Low; Medium-low; Medium-high; High; Very high)*.

Mathematical calculation of the aptitude of each alternative provided by the surveys was done by the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The TOPSIS technique is based upon the concept that the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS). The final ranking was obtained by means of the closeness index. In this study, calculations were carried out separately for each type of stakeholder within each group of case studies (defined in Table 1), to latter proceed with their aggregation to obtain a single value of the priorization of the farming practices for each group of case studies (group decision). In this case, each type of expert was equally weighted in the group decision.

3. Results

3.1. Data mining

In addition to providing information for the description of alternatives for diversified cropping systems (Task 2.2), data compiled in the data mining on groups 1, 2 and 4 (section 2.1) were analysed using statistical meta-analysis techniques: these were the three groups of case studies where a sufficient number of available information existed to perform the statistical analyses. The other groups had no significant studies dealing with crop diversification to proceed with meta-analysis. Two scientific papers have been written including results from the meta-analysis for arable crops in Mediterranean South, Mediterranean North, Atlantic and Boreal regions and for woody crops in Mediterranean region respectively, with the following titles:

- Francaviglia et al. Crop production, soil organic carbon and total nitrogen as affected by diversified cropping practices in Europe. A review.
- Linares et al. The impact of intercropping, cover cropping and management practices on soil and woody crops yield under Mediterranean conditions: a meta-analysis of field studies.

The first paper consists of a data-analysis to evaluate the effectiveness of the existing alternatives for crop diversification and environmentally-sound farming management for arable crops in four selected European pedoclimatic regions and typical cropping systems. The dataset included site-specific environmental data, soil tillage, crop rotation, fertilization, crop production (CP), initial and final soil organic carbon (SOC) and total nitrogen (Ntot) concentration from 83 references. The results of the data-analysis point to the direction that conversion from the traditional monocropping systems with intensive tillage and mineral fertilization to alternative systems based on cropping diversification through the use of crop rotations together with no-tillage and organic fertilization results in a better crop performance and in the accrual of soil C and N in European arable systems. Increase in crop yields were observed especially when longer crop rotations (≥3-years) and no-tillage were adopted, and particularly on silty clay loam soils. Furthermore, the results suggest that organic fertilization is a recommendable practice to enhance crop productivity in European agroecosystems, with the greatest positive impact in Mediterranean areas and on loamy soil textures. Similarly, crop rotation, no-tillage and organic fertilization had a positive effect on SOC accumulation.

However, in the case of NT, the positive effect was only observed in the first 15 cm soil depth. For soil N, despite the limited information found, a positive trend of increasing soil N levels with organic fertilization was observed mostly with the addition of manure plus crop residues. For tomato crop, fruit yield changes were positively correlated with water restoration supplied with regulated deficit irrigation. Consequently, in European arable agroecosystems, the diversified cropping systems and the adoption of environmentally-sound farming management are good strategies to increase crop performance and SOC levels. However, the results pointed out many regional differences and soil texture specific responses that could be considered when targeting measures aiming at improved soil management.

The second paper consists of a meta-analysis on olive, almond and citrus crops conducted to evaluate the changes in soil nutrients, soil organic carbon (SOC) and crop yield under Mediterranean climate which are affected by (i) crop characteristics (crop type, crop diversification, cover crops, tillage, fertilization); (ii) environmental characteristics such as aridity; (iii) clay content; and (iv) study length. The aim was to assess the benefits of crop diversification and sustainable tillage or fertilization as an alternative for intensive monocropping in field case studies. The results of the meta-analysis highlighted the variation of soil properties and crop yield depending on the diversification type, agricultural management practice, study length, aridity class and clay content in woody crops under Mediterranean climate. With regard to crop yield, the best combination was a monocrop with mineral or organic fertilization and conventional ploughing. However, this management system should not be recommended since it can have negative effects on SOC and nutrient levels. Conservation tillage was the tillage system that better contributed to increases in soil organic matter and soil nutrient contents, while organic fertilizers and permanent cover crops led to increases in soil organic matter. According to the meta-analysis, one of the best agricultural management practices to increase soil quality in olive orchards is the combination of permanent cover crops, organic fertilization and conservation tillage, particularly when the soil clay content is high. However, aridity could negatively affect this cropping system. One of the best agricultural management practices in almond orchards developed under semiarid conditions could be the application of organic fertilizers with cover crops with conservation tillage. Since citrus are strongly water demanding compared with the rest of orchard types, the most sustainable alternative would be the cultivation of this crop under subhumid or humid conditions. The best agricultural management practice for citrus would be intercropping with permanent cover crops without tillage.

These two papers have been submitted to the *European Journal of Agronomy* and are currently under review. All the spreadsheets with the raw data complied through the data mining were uploaded in the shared Diverfarming cloud in Microsoft OneDrive. They will be uploaded to Zenodo to make data FAIR once the articles are accepted for publication, following the Diverfarming Data Management Plan (deliverable D1.1). In addition to the two papers, four Practice Abstracts were prepared and published in EIP-Agri website (https://ec.europa.eu/eip/agriculture/en/find-connect/projects/diverfarming-crop-diversification-and-low-input).

3.2. Description of alternatives for diversified cropping systems

The descriptions of alternatives provided for each grouping of case studies (Table 1) were uploaded to Diverfarming cloud Microsoft OneDrive and are presented in Annex 1. We briefly summarise the main findings below.

In all woody crops (almond, citrus, olives and vineyards), the best alternative for diversification was intercropping (or the so-called agroforestry), with cultivation of annual crops (most literature has only tested cereals) or small perennial crops such as aromatics in the alleys, but very few information is available with this regard. Regarding low input management practices, the proposed suitable tillage practices are reduced or no tillage. In the case of irrigated woody crops, drip/subsurface irrigation techniques were the best alternatives. The most recommended fertilization practices were organic amendments (using crop residues, compost, manure, etc.) or a combination of mineral fertilizers and organic amendments. Weed management would be best performed by combination of reduced tillage and cover crops, and pest control by integrated pest management. Suitable soil conservation strategies were more diverse, including maintaining vegetation cover between in the alleys, reducing the use of machinery and improving drainage systems.

For arable crops (cereals in Italy and Spain, fodder crops in Finland and The Netherlands, and horticulture in Hungary), the most used diversification type, and the one with best results, was rotation. Few studies have attempted to apply and test multiple cropping and intercropping, and therefore an opportunity for Diverfarming is detected with this regard. Regarding management practices, the best alternatives for ploughing are minimum or no tillage. In the case of irrigated crops, drip/sprinkler and regulated deficit irrigation techniques were the best alternatives. The most recommended fertilization practices for arable crops were the same as for woody crops (organic amendments or a combination of mineral fertilizers and organic amendments). Weed management and pest control would be best performed by combination of reduced tillage with application cover crops and integrated pest management. In humid climatic conditions (such as in the Boreal region), drainage systems should be improved, as excess water hampers plant growth and poses risk to soil structure.

3.3. Selection of crop diversification systems, crop combinations and farming practices

Table 3 summarizes the number of survey respondents per case study and type of stakeholder. In two case studies (2 and 8) there were difficulties to reach the minimum of 20 stakeholders because many respondents left most questions unanswered, claiming that they do not have enough knowledge about intercropping practices in their area of study and thus, they did not feel confident to answer them. Similar problems occurred in other case studies with technical officers from public administration and NGOs.

As previously commented, the criterion for selecting the most adequate types of diversification and crops for each study area was the arithmetic sum of the answers from the consulted stakeholders. As stakeholders made a direct choice of both the type of diversification and the combined crops, the summation of answers, without discriminating between stakeholder groups, was considered as the most adequate method.

Table 3. Number of survey respondents by case study and country

Profile	Farmers and technical advisers (12-15)	Public administrations field technicians (3-5)	NGO technicians (2-5)	Researchers (3-5)	Total
Case study 1 Rainfed perennial crops (almonds) in Spain	12	3	2	3	20
Case study 2 Irrigated perennial crops (citrus) in Spain	12	3	1	3	19
Case study 3 Irrigated field crops in Spain	11	4	2	5	22
Case study 3 Rainfed field crops in Spain	16	4	2	5	27
Case study 4 Rainfed perennial crops (olive grove) in Spain	19	7	2	13	41
Case study 5, 6, 7 y 7bis. Italy. Irrigated	12	4	2	5	23
Case study 5, 6, 7 y 7bis. Italy. Rainfed	11	4	2	7	24
Case Study 8. Fodder in the Netherlands	12	1	1	4	18
Case Study 9. Perennial crop (vineyard) in Germany	29	2	1	4	36
Case Study 10 Horticulture in Hungary	13	2	2	3	20
Case Study 11 Vineyard in Hungary	19	2	2	3	26
Case Studies 12 and 13. Conventional and organic fodder crops in Finland	12	3	2	4	21

Consequently, those types of diversification and diversification crops that were selected by more stakeholders were identified as the most adequate ones. The results by case study are shown in Table 4. The number of answers for each type of crop diversification and combination of crops are detailed in Annex 2. It must be highlighted that stakeholders could indicate a maximum of two possible crops for diversification, so the number of answers regarding diversification crops doubles that of the responses regarding the type of diversification.

In the case of farming practices, each consulted stakeholder selected several practices that he/she considered as the most adequate for his/her study area, and then qualitatively assessed their effectiveness to address the most relevant problems in the study area. As previously commented, the answers were analysed using Multicriteria Decision Making Methods (MCDM) to establish the order of preferences regarding farming practices both for each group of stakeholders and for all stakeholders. The definition of the multicriteria model consisted of a group of alternative agricultural practices/strategies to be selected taking into account the different point of views of the stakeholders (criteria), in which the performance of each alternative was measured. A decision process was carried out separately for each stakeholders' profile, to later proceed with the aggregation of the four type of experts, obtaining a single result for each crop and country (group decision). Mathematical calculation of the aptitude of each alternative was done by the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The outcome of the calculus is the establishment of the order of preferences of all alternatives (i.e. farming practices) for each case study.

Those practices with the highest ranking were selected as the most adequate ones (Table 4). The numerical ranking of preferences for all farming practices in each case study is detailed in Annex 2.

Table 4. Results of diversification and crop options by crop and country

Case Study	Country	Crop	Diversification	Crop option 1	Crop option 2
1	Spain	Almond trees	Intercropping	Aromatic plants such as thyme, lavender or rosemary	Oats, alfalfa and / or vetch as feed
2	Spain	Citrus	Intercropping	Horticulture (lettuce, melon, broccoli, artichoke, etc.)	Aromatic plants like thyme, rosemary or lavender
3	Spain	Olive orchards	Intercropping	Oats, alfalfa and / or vetch (mix of legumes) as feed	Aromatics such as thyme, lavender, sage or rosemary
4	Spain	Rainfed cereals	Crops in rotation	Barley or Wheat – vetch or pea	Vetch or pea - wheat - sunflower
		Irrigated cereals	Multiple cropping	Barley - maize	Pea or vetch - maize
5,6,7	Italy	Rainfed cereals	Crops in rotation	Alfalfa	Faba bean
		Irrigated cereals	Crops in rotation	Processing tomato	Corn
8	Holland	Fodder crops	Intercropping	Wheat, clover, broad bean, vetch, flax, phacelia, oat, pea,	Corn, phacelia, buckwheat
9	Germany	Vineyards	Intercropping	Mixture of Poaceae, Leguminosae and Cruciferae as fodder	Aromatics for food and industrial products
10	Hungary	Horticulture	Rotations	phacelia (*Phacelia tanacetifolia*)	Spring barley (*Hordeum vulgare*)
11	Hungary	Vineyards	Intercropping	Mix of legumes as feed	Oats, alfalfa and / or vetch as feed
12,13	Finland	Fodder crops	Crops in rotation	Legumes and cereals	Legumes and grass

The final recommendations in Tables 3 and 4 have also been included in 13 Practice Abstracts, already published on the EIP-AGRi website (https://ec.europa.eu/eip/agriculture/en/find-connect/projects/diverfarming-crop-diversification-and-low-input).

UPCT delivered the outcomes of task 2.4 (Tables 3 and 4) to all Regional Coordinators to initiate Task 2.5. Regional Coordinators organized, in collaboration with partners, a participatory workshop with stakeholders and end-users in each case study area to present the results of the surveys and the multicriteria decision making. The outcomes of this workshop for each case study has been the final list of diversified cropping systems with low-input practices that are presented in Deliverable D2.2, which are the basis for the design of the experimental setup for the following WPs.

Table 4. Results of farming practices selected by crop and country

Case Study	Country	Crop	Farming practice 1	Farming practice 2	Farming practice 3
1	Spain	Almond trees	Addition of organic matter (manure, compost, etc.)	Tillage according to level curves	Maintenance of the natural vegetation on the edges of the plots
2	Spain	Citrus	Addition of organic matter (manure, compost, etc.)	Use of green manure	Integrated pest control
3	Spain	Olive orchards	Integrated pest control	Mulching with crushed offcuts from pruning, etc.	Addition of organic matter (manure, compost, etc.)
4	Spain	Rainfed cereals	Addition of organic matter (manure, compost, etc.)	Minimum tillage	Integrated pest control
		Irrigated cereals	Sprinkler irrigation	Precision agriculture to optimise fertilisation	Integrated pest control
5,6,7	Italy	Rainfed cereals	Addition of organic matter (manure, compost, etc)	Use of green manure	Changes in the rotations of crops
		Irrigated cereals	Precision agriculture to optimise fertilisation	Addition of organic matter (manure, compost, etc.)	Use of green manure
8	Holland	Fodder crops	Minimum tillage	Addition of organic matter (manure, compost, etc.	Maintenance of vegetation cover (natural or cover crops)
9	Germany	Vineyards	Minimum tillage	Mulching (with crushed offcuts from pruning, etc.)	Maintenance of the natural vegetation on the edges of the plots
10	Hungary	Horticulture	Harrow discs to incorporate crop residues into the soil	Use of green manure	Tillage without heavy implements
11	Hungary	Vineyards	Mulching (with crushed offcuts from pruning, etc.)	Use of green manure	Construction of slopes or margins with vegetation
12,13	Finland	Fodder crops	Addition of organic matter (manure, compost, etc.	Maintenance of the natural vegetation on the edges	Minimum tillage

As previously commented, the survey to stakeholders generated additional information that was not directly necessary for the analyses performed within WP2 activities. Gathering and analysing such information was beyond the scope of WP2 and the financial resources allocated to it. However, UPCT will complete its analysis to complement the results presented here. All these results will be integrated in 8 scientific papers that are under preparation, and that will be submitted to peer-review journals before the end of the project. These articles will show the preference of relevant stakeholders for different diversification types, crop associations and management practices to tackle the identified agronomic, environmental, economic and social problems, with identification of opportunities, barriers and drawbacks for the implementation of diversified cropping systems with low-input management practices. The provisional titles of the papers are the following:

1. Identification of stakeholders' preferences towards crop diversification systems in Mediterranean tree crops.

2. Identification of opportunities and barriers for the implementation of sustainable farming practices in Mediterranean diversified perennial cropping systems.
3. Assessment of stakeholders' preferences towards crop diversification systems in Mediterranean field arable crops
4. Assessment of farming practices in diversified field arable systems: identification of opportunities and barriers.
5. Identification of stakeholders' preferences towards crop diversification systems in vineyards under Continental climate.
6. Identification of opportunities and barriers for the implementation of sustainable farming practices in Continental diversified vineyards.
7. Assessment of stakeholders' preferences towards crop diversification systems in north European fodder crops.
8. Assessment of farming practices in diversified cropping systems in north European fodder crops: identification of opportunities and barriers.

4. Concluding remarks

The results presented allowed to identify relevant strengths and drawbacks for the implementation of diversified cropping systems under low-input agricultural practices in the different pedoclimatic regions. A major strength came from the fact that the crop alternatives selected for the diversification of the main crops are already cultivated in the areas of study (as monocultures), and are adapted to the local pedoclimatic conditions. So, farmers have the knowledge and skills to grow those crops, but they have to learn to do it in combination as rotations, multiple cropping or intercropping. Additionally, the identified low-impact farming practices are easy to implement, are not costly, do not require major investments in new machinery nor great farming skills to learn them. This suggest a significant potential for their successful implementation, at least at the technical level. The questionnaire used to survey stakeholders was designed to make them think carefully about the specific problems of each study area and about the feasibility of the possible solutions. We believe that this, together with the use of published scientific evidence as the basis for the design of the questionnaire, has helped for a realistic and practical identification of the most suitable diversified cropping systems and farming practices.

On the other hand, a major weakness found is that there are few experts in crop diversification in Europe. Most stakeholders are experts on the main crops of their study area as monocultures or short rotations, but have little or no real practical experience with crop diversification, mostly for intercropping and multiple cropping, which is barely applied. Consequently, there have been problems to find stakeholders with enough knowledge to answer the surveys with this regards. This problem is especially remarkable in the case of technical officers from public administrations and NGOs. This fact remarks the need of comprehensive training and knowledge dissemination strategies that go beyond theoretical courses. Providing adequate training for public officers and agricultural technical advisors is key for the successful diffusion of diversified cropping systems among farmers.

DIVERFARMING

Crop diversification and low-input farming across Europe: from practitioners' engagement and ecosystems services to increased revenues and value chain organisation

OUTCOMES OF THE MULTICRITERIA MODEL FOR DECISION MAKING

Deliverable D2.1

Annex 1. Questionnaire on the description of alternatives

Table of Contents

First paragraph in all the questionnaires

Respond to the following questions taking into account benefits related to crop production, economic revenues and/or ecosystem services

Below we include some questions you need to respond with regard to the description of the **best alternatives for your Case Study** after the performance of a data mining and literature review.

Have in mind that the alternatives you provide here will be the ones to **feed the survey for end-users and stakeholders** related to your Case Study. Include here all alternatives with regard to diversification and low-input management practices that need to be included in the surveys, so that they are an option for participants.

Indicate the best alternatives according to the best results in previous research studies, and also those that have not been studied yet, but you consider their investigation is worthy/needed (go beyond the state of the art).

CASE STUDY No. 1. Rainfed perennial crops (almonds) in Spain

QUESTIONS:

1. **Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?**

    - Intercropping

2. **Which are the best crop combinations within each diversification type for your case study?**

    - Intercropping with *Thymus* hyemalis
    - Intercropping with *Thymus zygis*
    - *Lavandula sp.*
    - Intercropping with legumes such as *Vicia faba* or *Vicia sativa*
    - Intercropping with fodder such as *Avena sativa* and *Vicia sativa*
    - Intercropping with *Medicago sativa and Vicia sativa*

3. **Which are the best tillage systems?**

    - Reduced tillage
    - Reduced shallow tillage

4. **Which are the best irrigation systems? (only if applicable)**

- Not applicable

5. **Which are the best fertilization systems?**

    - Crop residues/ green manure
    - Organic amendments (compost, manure, bocashi)

6. **Which are the best weed management systems?**

    - Reduced tillage
    - Cover crops with a mixture of Leguminosae, Gramineae and/or Cruciferae
    - Grazing

7. Which are the best pest management systems?

- Integrated pest control with increased vegetation biodiversity

8. Which are the best land conservation systems?

- Cover crops with a mixture of Leguminosae, Gramineae and/or Cruciferae
- Green manure
- Erosion vegetation barriers
- Vegetation strip barriers
- Key-lines
- Swales on contour

DIVERFARMING

CASE STUDY No. 2. Irrigated perennial crops (citrus) in Spain

QUESTIONS:

1. **Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?**

- Intercropping

2. **Which are the best crop combinations within each diversification type for your case study?**

- Intercropping with fodder such as *Medicago sativa, Avena sativa* and *Lolium sp*. (Gramineae and Leguminosae)
- Intercropping with fodder such as *Avena sativa* and *Vicia sativa* (Gramineae and Leguminosae)
- Intercropping with *Thymus* hyemalis
- Intercropping with *Thymus zygis*
- Intercropping with *Lavandula sp*.
- Intercropping with *Vicia faba*
- Intercropp*ing with Ocimum basilicum* (high water demands)
- Intercropping with *Petroselinum crispum* (high water demands)

3. **Which are the best tillage systems?**

- Reduced tillage
- Reduced shallow tillage

4. **Which are the best irrigation systems? (only if applicable)**

- Regulated deficit drip irrigation
- Partial root-zone drip irrigation
- Micro sprinklers

5. **Which are the best fertilization systems?**

- Crop residues/ green manure
- Organic amendments (compost, manure)
- Inorganic fertilizers + crop residues/green manure

- Inorganic fertilizers + compost/manure

6. Which are the best weed management systems?

- Cover crops with a mixture of Leguminosae, Gramineae and/or Cruciferae
- Reduced shallow tillage
- Grazing

7. Which are the best pest management systems?

- Integrated pest control with increased vegetation biodiversity

8. Which are the best land conservation systems?

- Vegetation strip barriers
- Cover crops with a mixture of Leguminosae, Gramineae and/or Cruciferae
- Green manure
- Key-lines
- Swales on contour

CASE STUDY No. 3. Irrigated and rainfed field crops in Spain.

QUESTIONS:

1. **Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?**

- **Rainfed systems**: crop rotations
- **Irrigation systems**: crop rotations and multiple cropping

2. **Which are the best crop combinations within each diversification type for your case study?**

Rainfed systems, crop rotations with:

- Barley (*Hordeum vulgare*)
- Wheat (*Triticum aestivum*)
- Triticale (*Triticosecale*)
- Pea (*Pisum sativum*)
- Vetch (*Vicia sativa*)
- Rapeseed (Brassica napus)

Irrigation systems, crop rotations with:

- Corn (Zea mays)
- Barley
- Wheat
- Alfalfa (*Medicago sativa*)
- Sunflower (*Helianthus annuus*)
- Sorghum (*Sorghum*)

Irrigation systems, multiple cropping with:

- Corn
- Sunflower
- Barley

- Vetch
- Rapeseed
- Pea

3. Which are the best tillage systems?

Rainfed systems: Zero tillage is clearly the best option.

Irrigated systems: Less information available. Depending on the preceding crop and the irrigation system the best tillage option may vary. Zero tillage performs better in sprinkler systems than in flooded irrigation systems. Also, after high residue crops, such as corn, tillage is necessary when it is rotated.

4. Which are the best irrigation systems? (only if applicable)

Sprinkler irrigation is better option than flooded irrigation. Basically, it performs better in terms of crop yield (about 20-30% compared to flooded irrigation) and it also uses less water. Furthermore, it is easy to use since it may be automated requiring less workforce.

5. Which are the best fertilization systems?

Organic fertilization with animal manures, has been demonstrated to be an excellent option in both irrigated and rainfed systems. Also, in irrigated systems, the combination of mineral and manure has been showed to have excellent results.

6. Which are the best weed management systems?

The use of herbicides is the most extended option since with the implementation of no-tillage is the most used weed management system used.

7. Which are the best pest management systems?

In field crop systems, the use of pesticides is the most effective system to control pests.

8. Which are the best land conservation systems?

The best land conservation technique is the maintenance of crop residues on soil surface. For this reason, the use of no-tillage systems and the avoidance of harvest residue removal from the field are the most effective techniques. Also, the use of cover crops is a very effective system since also use to cover soil surface during the fallow season.

DIVERFARMING

CASE STUDY No. 4. Rainfed perennial crops (olive grove) in Spain

QUESTIONS:

1. **Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?**

- Intercropping

2. **Which are the best crop combinations within each diversification type for your case study?**

- Intercropping with *Thymus sp*
- Intercropping with *Lavandula sp*
- Intercropping with *Salvia sp*
- Intercropping with a mixture of Leguminosae
- Intercropping with fodder such as *Avena sativa* and *Vicia sativa* (Gramineae with Leguminosae)
- Intercropping with *Aloe sp*
- Intercropping with saffron (*Crocus sativus*)
- Intercropping with *Vicia faba*

3. **Which are the best tillage systems?**

The best tillage system for our case is reduced tillage in the influence zone of the olive tree and zero tillage for intercropping (cover crop).

- No tillage
- Reduced shallow tillage

4. **Which are the best irrigation systems? (only if applicable)**

- Rainfed with support irrigation.

5. **Which are the best fertilization systems?**

- Pruning residues
- Manure (8 Mg ha^{-1} $year^{-1}$)
- Olive mill waste (≤ 27 Mg ha^{-1} $year^{-1}$).

- Compost

6. Which are the best weed management systems?

- Herbicides
- Cover crops with a mixture of Leguminosae, Gramineae and/or Cruciferae
- Grazing

7. Which are the best pest management systems?

- Pesticides
- Integrated pest control with increased vegetation biodiversity

8. Which are the best land conservation systems?

- Cover crops with a mixture of Leguminosae, Gramineae and/or Cruciferae
- Green manure
- Vegetation strip barriers
- Key-lines
- Swales on contour

DIVERFARMING

CASE STUDY No. 5. Arable land. Diversified annual crop rotations in Italy.

CASE STUDY No. 6. Arable land. Diversified annual crop rotations in Italy.

CASE STUDY No. 7. Arable land. Diversified annual crop rotations in Italy.

CASE STUDY No. 7bis. Crop rotations. Diversified annual crop rotations in Italy.

QUESTIONS:

1. Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?

Rainfed cropping systems:

- Crop rotations

Irrigated cropping systems:

- Crop rotations and multiple cropping

2. Which are the best crop combinations within each diversification type for your case study?

Rainfed cropping systems, crop rotations with:

- Wheat (*Triticum aestivum, Triticum durum*)
- Faba bean (*Vicia faba*)
- Alfalfa (*Medicago sativa*)
- Grass-clover mixtures (*Hordeum vulgare* + *Trifolium alexandrinum*)

Irrigated cropping systems, crop rotations with:

- Wheat (*Triticum aestivum, Triticum durum*)
- Corn (*Zea mays*)
- Processing tomato (*Solanum lycopersicum*)

Irrigated cropping systems, multiple cropping with:

- Wheat (*Triticum aestivum, Triticum durum*)
- Short cycle corn (*Zea mays*)

3. Which are the best tillage systems?

Conventional/Organic rainfed and irrigated systems:

- Ploughing is the most adopted tillage practice tested.
- The best option in terms of soil fertility, crop yield maintenance, and economic benefits is conservation tillage (minimum tillage and no-tillage). No-tillage preserves soil fertility in the long-term because reduces soil organic matter mineralization rate.

4. Which are the best irrigation systems? (only if applicable)

- Irrigation system effects are strongly affected by pedo-climatic features.
- Sprinkler and drip irrigation with high water efficiency are the best and more effective options to increase crop yield and biomass and to preserve soil fertility.
- Regulated deficit irrigation improves fruit quality in tomato and preserves crop yield and soil quality.

5. Which are the best fertilization systems?

- The use of mineral fertilizers is the most adopted management option in Southern and Central Italy. To contrast the higher mineralization rate and preserve soil fertility, higher levels of N fertilization rate must be applied to increase C input.
- Mixed fertilization management could be a viable option to maintain crop yield and to reduce the potential risk of soil and water pollution due to N fertilization excesses.
- Organic fertilization management is the main option under organic systems.
- Animal manure and slurry and their mixed combination with mineral fertilizer are excellent options in maize intensive-based systems, typical of Northern Italy.

6. Which are the best weed management systems?

- The use of herbicides is the most adopted weed management option under conventional and reduced tillage systems.
- Physical weed management is adopted under low-input durum wheat 2-yrs rotation.

- Mixed (chemical and mechanical) weed management is adopted under low-input and integrated maize monoculture.
- Mechanical (tillage) weed management is adopted under organic arable system.

7. Which are the best pest management systems?

- The use of pesticides is the most adopted pest management option under conventional management and reduced tillage systems.
- Biological control is adopted under organic arable system.

8. Which are the best land conservation systems?

- Practices such as conservation tillage, appropriate management of residues, and organic material addition can enhance soil organic carbon sequestration and soil fertility.
- The best land conservation systems are residue management techniques and cover crops management. The positive effects of these practices are strongly affected by pedo-climactic features, type of crop residue, and agronomical practices adopted.

Crop residue management:

- Leaving crop residues in the field after harvest is the best and more effective option to preserve and stabilize soil fertility.

Cover crops:

- The use of cover crops is a very effective strategy to increase C inputs in intensive durum wheat-based rotation.
- Cover crops (used as green manure or flattened) are useful in weed control and soil fertility conservation.
- The introduction of high productive cover crops helps the maintenance of adequate C inputs to reduce soil mineralization rate.

CASE STUDY No. 8. Fodder in the Netherlands

QUESTIONS:

1. **Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?**

- Crop rotation

2. **Which are the best crop combinations within each diversification type for your case study?**

- Crop rotation of maize (*Zea mays*) and phacelia (*Phacelia tanacetifolia*) and buckwheat (*Fagopyrum esculentum*)
- Crop rotation of maize (*Zea maiys*) and winter pea (*Pisum sativum*)
- Crop rotation of ryegrass (Lolium westerwoldicum) and phacelia (*Phacelia tanacetifolia*)
- Crop rotation of spring wheat (*Triticum aestivum*), mixture of cover crops (*Trifolium alexandrinum*), faba bean (*Vicia faba*), vetch (*Vicia sativa*), flax (*Linum usitatissimum*), phacelia (*Phacelia tanacetifolia*), oat (*Avena sativa*), green peas (*Pisum sativum*) and maize (*Zea mays*).

3. **Which are the best tillage systems?**

- Taking into account GHG emissions: No tillage.
- Without considering GHG emissions but for the best soil quality for farming: Reduced tillage.

4. **Which are the best irrigation systems? (only if applicable)**

Not applicable.

5. **Which are the best fertilization systems?**

- Green manure (crop rotation including catch crops).
- Organic amendments (compost, manure, residue)
- PK inorganic fertilizers

6. **Which are the best weed management systems?**

- Fungicide
- Weed-suppressive crop species.
- Cover crops.
- Winter pea rotation with maize cropping.

7. Which are the best pest management systems?

Not applicable.

8. Which are the best land conservation systems?

- Crop rotation with catch crops
- Agroforestry
- Light machinery (less soil compaction)

CASE STUDY No. 9. Perennial crop (vineyard) in Germany

QUESTIONS:

1. **Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?**

- Intercropping

2. **Which are the best crop combinations within each diversification type for your case study?**

- Intercropping with native grass and herb mixtures

3. **Which are the best tillage systems?**

- Reduced tillage
- shallow tillage every two years in interrow alternation
- deep tillage only for new vineyard installation and plantation

4. **Which are the best irrigation systems? (only if applicable)**

- Not applicable

5. **Which are the best fertilization systems?**

- Manure mixed with straw or wood shavings
- Compost mixed with biochar

6. **Which are the best weed management systems?**

- mulching
- tillage+cover crops
- hoeing to reduce tufts of grass or blackberry vines

7. **Which are the best pest management systems?**

- Pheromone dispensers to control vine moth distribution
- Integrated pest control with increased vegetation biodiversity
- Fences against damage by game and meshes to protect the grapes from birds

8. Which are the best land conservation systems?

- Cover crops (permanent interrow vegetation)
- Mulching with straw or/and chopped straw
- Anthropogenous rock fragment cover
- Avoiding soil compaction due to heavy machinery
- Avoiding wheel ruts

DIVERFARMING

CASE STUDY No. 10. Horticulture in Hungary

QUESTIONS:

1. **Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?**

   No proposals for crop diversification can be found in literature.

   Possible alternatives:

- Crop rotation with phacelia (*Phacelia tanacetifolia*)
- Crop rotation with spring barley (*Hordeum vulgare*)
- Crop rotation with leguminous crops (e.g. *Vicia alba*)

2. **Which are the best crop combinations within each diversification type for your case study?**

   No paper on intercropping of horticultural crops.

   Possible alternatives:

- Intercropping with leguminous crops
- Intercropping with aromatic crops (e.g. *Lavandula*)

3. **Which are the best tillage systems?**

   We found no paper specifically on tillage systems in horticulture.

   Possible alternatives:

- Minimum tillage
- Shallow tillage
- Disk harrowing to incorporate crop residues into the soil

4. **Which are the best irrigation systems?**

- Rainfed horticulture on clayey and loamy soils
- Drip irrigation on sandy soils
- Seasonally portioned deficit irrigation

5. Which are the best fertilization systems?

In Hungary manure was found the best. For vegetable large amount of mineral fertilization are suggested (e.g. for lettuce: "The fresh weight was highest in the 80 mg/kg and 160 mg/kg N treatments. The greatest dry matter production was found at 80 mg/kg N. The effect of ammonium nutrition on the fresh weight did not differ from that of NO_3^- + NH_4^+ nutrition. Dry matter production was maximal with NO_3^- + NH_4^+ nutrition. Above 320 mg/kg N the increasing N fertilizer rates gradually raised the N content of the lettuce leaves.") For beetroot: "The maximum 26–28 t/ha root yield was given on plots which had received no nitrogen or phosphorus fertilizer for 21 years and contained 80–100 mg/kg ammonium lactate (Al)-soluble P and 200–300 mg/kg Al-K in the ploughed layer. At Al- P contents of above 200 mg/kg there was a drastic decline in the yield. In fact, at extreme rates of PK over-fertilization the crop was practically destroyed and the ground became submersed in weeds."

Possible alternatives:

- Manure
- Compost
- Combination of manure and mineral fertilizers

6. Which are the best weed management systems?

Weeds generally decreased the nutrient content of green pea due to their intensive nutrient uptake. *S. arvensis* caused the strongest inhibition in the intensive nutrient uptake of the crops. The phosphorus and potassium content of wild mustard were not influenced by its density.

As, Cd, and Se proved to be toxic to spinach, but the % weed cover prior to hoeing for weed control significantly moderated the As, Cr and Se pollution.

Viability of chemical weed management - done only on crop rows and not on the whole surface was proved lowering total weed cover that means a more environmentally friendly and herbicide sparing solution. Higher total weed cover diminishing efficiency of hoeing and cultivator treatment, than of brush hoeing was pointed out.

Possible alternatives:

- Mulching
- Combination of tillage and cover crops
- Combination of cultivator tillage and herbicides

7. Which are the best pest management systems?

No information on pest management efficiency.

Possible alternatives:

- Integrated pest control
- Pheromone dispensers
- Biological pest control (e.g. predatory mites)

8. Which are the best land conservation systems?

Grass windrow was applied as mulch after one – two days, not as fresh as weed residue mulch. Lowest soil temperature measured at the soil surface was recorded under barley straw mulch.

Possible alternatives:

- Mulching
- Cover crops
- Crop rotation with fodder (Leguminaceae) crops (e.g. *Medicago*)
- Water drainage (grassed spillways)

CASE STUDY No. 11. Perennial crop (vineyard) in Hungary

QUESTIONS:

1. Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?

In the vineyards of Tokaj 10-13 % decrease of yield was found for covered inter-rows, and a 26% and 21% reduction in pruning weight, especially apparent in young plantations.

No other explicit statements on the economic benefits of crop diversification is available in literature.

Possible alternatives:

- Intercropping in alleys with grass
- Intercropping vines with aromatic crops
- Intercropping vines with fodder crops

2. Which are the best crop combinations within each diversification type for your case study?

In most of the cases the highest yield was measured in straw mulched plots. Straw mulch preserved soil moisture, increased the vegetative and generative performance of the vines. Straw mulch is to be applied in a thick layer and renewed regularly. The leguminous plants did not germinate because of dry weather conditions.

In case of the straw much the soil nitrogen content decreased. While the soil organisms incorporated the decaying straw into the soil, the nitrogen content was reduced.

Possible alternatives:

- Mulching with straw
- Intercropping with Leguminaceae
- Intercropping with aromatic crops

3. Which are the best tillage systems?

Mechanical cultivation (cultivator) cannot be avoided. Soil loosening advised in every 2-3 year.

Possible alternatives:

- Zero tillage
- Cultivator application

- Soil loosening

4. Which are the best irrigation systems? (only if applicable)

Possible alternatives:

- Rainfed cultivation (where annual precipitation is >600 mm)
- Regulated deficit irrigation
- Drip irrigation

5. Which are the best fertilization systems?

Possible alternatives:

- Compost
- Manure
- Combination of manure and mineral fertilizer

6. Which are the best weed management systems?

Lowest weed coverage was detected in the inter-rows sown with the grass-herb and legume mixtures, while in control and Biocont-Ecovin inter-rows increased weed coverage was observed.

Small-seeded species are expected to establish better than large-seeded species. A carefully designed high diversity cover crop seed mixture should contain both annual and perennial species. Sown annual species with fast establishment can suppress weeds already during the first year, and sown perennial plants provide an improved weed suppression during the later years.

Mulching with reed; natural grass cover presents competition for nutrients and water with the main crop and only to be applied in combination with other cultivation methods (grass between every other row).

Possible alternatives:

- Graminaceae-Leguminaceae mixtures
- Graminaceae mixtures
- Mulching (straw, reed)

7. Which are the best pest management systems?

Introduction of predatory mites (first of all, *Typhlodromus pyri*, a species native in Hungary) against phytophagous mites; sex pheromone dispensers against vine moth.

Possible alternatives:

- Introduction of predatory mites native in Hungary
- Feromon dispensers
- Integrated pest control

8. Which are the best land conservation systems?

Spring barley cover and straw mulch are evaluated and found efficient. Native grass/herb mixes are evaluated and found efficient.

Possible alternatives:

- Spring barley cover
- Mulching (straw)
- Native grass and herb mixtures
- Water drainage (grassed spillways)

DIVERFARMING

CASE STUDY No. 12. Conventional Fodder Crops in Finland

CASE STUDY No. 13. Organic Fodder Crops in Finland

QUESTIONS:

1. **Which are the best diversification types for your case study (intercropping, rotations and/or multiple cropping (intra-annual rotations)?**

   - ley production as part of crop rotations with annual crops
   - establishment of perennial grasses by undersowing with cereals
   - cover/catch crops to reduce the period of bare soil after spring cereals in autumn and winter
   - legumes and oilseed crops in rotations or as intercrops

2. **Which are the best crop combinations within each diversification type for your case study?**

   - Spring cereals with Italian ryegrass as undersown catch crop
   - legumes with other grass species
   - legumes with cereals
   - winter cereals and winter oilseeds in rotations instead of spring-sown crops as the growing season lengthens in warming climate

3. **Which are the best tillage systems?**

   - all forms of reduced tillage generally are beneficial for reducing erosion and nitrogen leaching losses; however, losses of dissolved reactive P may increase in reduced tillage
   - spring tillage is beneficial compared to autumn tillage, however, it may be problematic with clayey soils

4. **Which are the best irrigation systems? (only if applicable)**

   - not very relevant as irrigation is not needed every year and is applied rarely for the most common crops due to high cost; more attention should be paid to improving drainage since excess water hampers growth and poses risk to soil structure

5. **Which are the best fertilization systems?**

   - there should be more emphasis on achieving organic materials as soil amendments from outside of farms to slow down the decline of soil C stocks
   - manure should be more evenly distributed among animal and arable farms

- while organic fertilizers have good effects on crop growth and on soils, the moderate total input of nutrients in low-input farming may lead to low yields. Proper timing of the nutrient inputs, cropping sequence and other management incl. weed control are critical for achieving good yields.

6. Which are the best weed management systems?

- there were little published results on weed management but cover crop reduced weed in one study and legume undersowing increased weeds in another → the relation of cover crops and weeds should be studied further
- tillage is better than no-till for weed management

7. Which are the best pest management systems?

- we found no articles on pest management in fodder crops, the papers on pesticides usually deal with environmental monitoring of pesticides

8. Which are the best land conservation systems?

- There is lot of evidence that cover crops (established with undersowing in spring) have benefits in a climate with short growing season
- buffer zones as vegetation barriers
- no till (and spring tillage if suitable) vs. autumn tillage
- perennial grasses

Additional comment for the survey: it is not evident from all studies that the alternative management was beneficial or there are both beneficial and negative effects. Opinions on how to improve the practical implementation of the methods should be asked from the practitioners.

DIVERFARMING

Crop diversification and low-input farming across Europe: from practitioners' engagement and ecosystems services to increased revenues and value chain organisation

OUTCOMES OF THE MULTICRITERIA MODEL FOR DECISION MAKING

Deliverable D2.1

Annex 2. Results of crop diversifications and ranking of low-input practices

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CASE STUDY No. 1. Rainfed perennial crops (almonds) in Spain

DIVERSIFICATION	
Crops	**number of answers**
Simultaneous crops/Intercropping	9
Simultaneous crops plus rotation of said crops	8
Simultaneous crops plus multiple crops	3

CROPS	
Crops	**number of answers**
Aromatic plants such as thyme, lavender or rosemary	15
Oats, alfalfa and / or vetch for cattle or game	12
Broad bean	7
Caper	6

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Contribution of organic matter(/manure, compost, etc)	0.73
Tillage according to level curves	0.71
Maintain the natural vegetation on the edges of the plots	0.68
Integrated pest control	0.68
Use of green manure	0.58
Maintain strips of vegetation between lines	0.56
Install hedges on the edges of the plots	0.55
Mulching (with crushed offcuts from pruning, etc.)	0.51
Tillage without heavy implements	0.49
Minimal tillage	0.47
Construction of slopes or margins with vegetation	0.44
Use of biostimulants and biofertilisers	0.43
Design of keylines (canals/ditches to conduct the water) to make use of rainwater	0.35
No tillage without herbicides (with brush cutter)	0.35
No tillage or minimal tillage with pasture	0.33
Maintain vegetation cover (natural or cover crops)	0.28
Use of plastics	0.20
No tillage with herbicides	0.19
Construction of slopes or margins without vegetation	0.19
Construction of slopes or margins with vegetation	0.36
Deficit irrigation	0.32
No tillage with herbicides	0.22
Microsprinkling	0.20
Use of plastics	0.19
No tillage or minimal tillage with pasture	0.00
Construction of slopes or margins without vegetation	0.00

DIVERFARMING

CASE STUDY No. 2. Irrigated perennial crops (citrus) in Spain

DIVERSIFICATION	
Crops	**number of answers**
Simultaneous crops/Intercropping	11
Simultaneous crops plus rotation of said crops	6
Simultaneous crops plus multiple crops	2

CROPS	
Crops	**number of answers**
Aromatic plants like thyme, rosemary or lavender	11
Broad bean	11
Horticulture (lettuce, melon, broccoli, artichoke, etc)	9
Oats, alfalfa and / or vetch for livestock	8

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Aporte de materia orgánica (estercolado, compost, etc)	0.76
Uso de abonos verdes	0.76
Control integrado de plagas	0.75
Uso de bioestimulantes y biofertilizantes	0.66
Laboreo sin usar aperos pesados	0.65
Cambios en las rotaciones de cultivo	0.58
Mulching (con restos triturados de poda, etc.)	0.52
Riego controlado	0.48
Mantener franjas de vegetación entre líneas	0.47
Instalar setos en las lindes de las parcelas	0.47
Agricultura de precisión para optimizar la fertilización	0.46
Mantener cubiertas vegetales (natural o cover crops)	0.43
Irrigación subsuperficial (en raíz)	0.41
Diseño de keylines (canales/zanjas para conducir el agua) para aprovechar el agua de lluvia	0.41
Mantener la vegetación natural en las lindes de las parcelas	0.41
No laboreo sin herbicidas (con desbrozadora)	0.41
Laboreo según curvas de nivel	0.41
Mínimo laboreo	0.39
Combinación de fertilización inorgánica y orgánica	0.38
Construir taludes o márgenes con vegetación	0.37
Riego deficitario	0.33
No laboreo con herbicidas	0.20
Microaspersión	0.19
Uso de plásticos	0.17
No laboreo o mínimo laboreo con pastoreo	0.00
Construir taludes o márgenes sin vegetación	0.00

CASE STUDY No. 3. Irrigated and rainfed field crops in Spain.

Irrigated

DIVERSIFICATION	
Crops	**number of answers**
Rotations of crops	11
Double harvests: multiple crops	16

CROPS	
Crops	**number of answers**
Pea or vetch - maize	13
Alfalfa - maize - wheat	11
Barley - maize	11
Maize - wheat or barley	7
Barley or wheat - sunflower	2
Rapeseed - sunflower or maize	2
Wheat - rapeseed	2

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Sprinkler irrigation	0.92
Precision agriculture to optimise fertilisation	0.82
Integrated pest control	0.74
Minimal tillage	0.72
Diversification of crops	0.69
Combination of organic and inorganic fertilisers	0.68
Changes in the rotations of crops	0.67
Use of green manure, leave remains of harvest on the surface	0.62
Contribution of organic matter/manure	0.56
Tillage without heavy implements	0.55
No tillage with herbicides	0.55
Maintain the natural vegetation on the edges of the plots	0.50
Maintain vegetation cover (natural or cover crops)	0.39
Use of biostimulants and biofertilisers	0.36
Tillage according to level curves	0.26
Construction of slopes or margins with vegetation	0.24
Mulching (with crushed offcuts from pruning, etc.)	0.22
No tillage without herbicides (with pasture)	0.21
No tillage without herbicides (with brush cutter)	0.21
Install hedges on the edges of the plots	0.14
Construction of stone walls	0.11
Construction of slopes or margins without vegetation	0.10
Maintain strips of vegetation between lines	0.00

DIVERFARMING

CASE STUDY No. 3. Irrigated and rainfed field crops in Spain. Rainfed.

DIVERSIFICATION	
Crops	**number of answers**
ROTATION OF CROPS	27

CROPS	
Crops	**number of answers**
Barley or Wheat – vetch or pea	15
Vetch or pea - wheat - sunflower	9
wheat - barley - fallow	9
Fallow - wheat - vetch or pea	9
wheat or barley or oats - fallow	6
Barley or Wheat - rapeseed	6

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Contribution of organic matter/manure	0.92
Minimal tillage	0.82
Integrated pest control	0.77
Diversification of crops	0.74
Precision agriculture to optimise fertilisation	0.69
Combination of organic and inorganic fertilisers	0.69
Changes in the rotations of crops	0.69
Use of green manure, leave remains of harvest on the surface	0.67
No tillage with herbicides	0.63
Maintain the natural vegetation on the edges of the plots	0.54
Maintain vegetation cover (natural or cover crops)	0.50
Tillage according to level curves	0.49
Sprinkler irrigation	0.49
Tillage without heavy implements	0.46
Use of biostimulants and biofertilisers	0.31
No tillage without herbicides (with pasture)	0.30
Construction of slopes or margins with vegetation	0.28
No tillage without herbicides (with brush cutter)	0.27
Mulching (with crushed offcuts from pruning, etc.)	0.22
Construction of stone walls	0.20
Construction of slopes or margins without vegetation	0.11
Install hedges on the edges of the plots	0.10
Maintain strips of vegetation between lines	0.00

DIVERFARMING

CASE STUDY No. 4. Rainfed perennial crops (olive grove) in Spain

DIVERSIFICATION	
Crops	**number of answers**
Simultaneous crops/Intercropping	30
Simultaneous crops plus rotation of said crops	9
Simultaneous crops plus multiple crops	2

CROPS	
Crops	**number of answers**
Mix of legumes for livestock	27
Oats, alfalfa and / or vetch for cattle or game	21
Aromatics such as thyme, lavender, sage or rosemary	20
Legumes for human consumption	7
Aloe vera	6
Saffron	1

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Integrated pest control	0.96
Contribution of pruning offcuts	0.82
Contribution of organic matter (manure, compost, alpeorujo)	0.76
No tillage without herbicides (with brush cutter)	0.69
Mulching (with crushed offcuts from pruning, etc.)	0.65
Maintain vegetation cover (natural or cover crops)	0.61
Use of green manure	0.57
Maintain the natural vegetation on the edges of the plots	0.56
Maintain strips of vegetation between lines	0.53
Irrigstion if necessary	0.49
Minimal tillage	0.49
No tillage or minimal tillage with pasture	0.48
Use of biostimulants and biofertilisers	0.48
Tillage without heavy implements	0.45
Construction of slopes or margins with vegetation	0.44
Design of keylines (canals/ditches to conduct the water) to make use of rainwater	0.44
Tillage according to level curves	0.43
Install hedges on the edges of the plots	0.42

DIVERFARMING

CASE STUDY No. 5. Arable land. Diversified annual crop rotations in Italy. Irrigated

CASE STUDY No. 6. Arable land. Diversified annual crop rotations in Italy. Irrigated

CASE STUDY No. 7. Arable land. Diversified annual crop rotations in Italy. Irrigated

CASE STUDY No. 7bis. Crop rotations. Diversified annual crop rotations in Italy. Irrigated

DIVERSIFICATION	
Crops	**number of answers**
Rotation of crops	14
Multiple crops	6
Multiple crops	1

CROPS	
Crops	**number of answers**
Maize	11
Tomato for industry	9
Wheat	6
Field horticulture	2
Sunflower	2
Soya	2
Sorghum	2
Barley	1
Barley, rapeseed, pea	1
Peas for industry	1
Legumes, cereals and brassica	1
Tomato, hemp, sunflower	1

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Precision agriculture to optimise fertilisation	0.76
Contribution of organic matter/manure	0.62
Use of green manure, leave remains of harvest on the surface	0.56
Changes in the rotations of crops	0.55
Integrated pest control	0.55
Minimal tillage	0.54
Maintain vegetation cover (natural or cover crops)	0.53
Contribution of organic matter/manure	0.46
Tillage without heavy implements	0.43
Mulching (with crushed offcuts from pruning, etc.)	0.33
Use of biostimulants and biofertilisers	0.31
Tillage according to level curves	0.31
No tillage without herbicides (mechanical or manual weeding)	0.30
Construction of slopes or margins without vegetation	0.26
Maintain the natural vegetation on the edges of the plots	0.26
Install hedges on the edges of the plots	0.26
Construction of anti-erosion barriers or margins with vegetation	0.25
No tillage (with pasture)	0.24
No tillage with herbicides	0.20
Maintain strips of vegetation between lines	0.13

CASE STUDY No. 5. Arable land. Diversified annual crop rotations in Italy. Rainfed

CASE STUDY No. 6. Arable land. Diversified annual crop rotations in Italy. Rainfed

CASE STUDY No. 7. Arable land. Diversified annual crop rotations in Italy. Rainfed

CASE STUDY No. 7bis. Crop rotations. Diversified annual crop rotations in Italy. Rainfed

DIVERSIFICATION	
Rotation of crops	23
CROPS	
Crops	**number of answers**
Mix of gramineas and legumes	10
Alfalfa	13
Broad bean	12
Wheat	7
Clover	1
Protein pea	1
Spring-summer crops that allow to increase the number of families	1

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Contribution of organic matter/manure	0.78
Use of green manure, leave remains of harvest on the surface	0.68
Changes in the rotations of crops	0.62
Minimal tillage	0.61
Maintain vegetation cover (natural or cover crops)	0.55
Integrated pest control	0.49
Contribution of organic matter/manure	0.46
Precision agriculture to optimise fertilisation	0.42
Install hedges on the edges of the plots	0.40
Tillage according to level curves	0.38
No tillage with herbicides	0.35
No tillage without herbicides (mechnical or manual weeding)	0.33
Tillage without heavy implements	0.31
Mulching (with crushed offcuts from pruning, etc.)	0.30
Maintain strips of vegetation between lines	0.29
Maintain the natural vegetation on the edges of the plots	0.25
Construction of slopes or margins without vegetation	0.20
Construction of anti-erosion barriers or margins with vegetation	0.19
Use of biostimulants and biofertilisers	0.19
No tillage (with pasture)	0.10

DIVERFARMING

CASE STUDY No. 8. Fodder in the Netherlands

DIVERSIFICATION	
Crops	**number of answers**
Simultaneous crops/Intercropping	6
Rotation of crops	6
Multiple crops	5
Simultaneous crops/Intercropping	1

CROPS	
Crops	**number of answers**
Wheat, clover, broad bean, vetch, flax, phacelia, oat, pea, c	29
Corn, phacelia, buckwheat	4
Corn and winter pea	2
Herbaceous plants and phacelia	1

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Minimal tillage	0.77
Contribution of organic matter (/manure, compost, etc)	0.73
Maintain vegetation cover (natural or cover crops)	0.70
Mulching (with crushed offcuts from pruning, etc.)	0.68
Install hedges on the edges of the plots	0.63
Integrated pest control	0.50
Use of green manure	0.49
Precision agriculture to optimise fertilisation	0.47
Tillage without heavy implements	0.47
Application of intermediate crops	0.41
Use of plastics	0.41
Application of organic or inorganic fertilisers	0.34
Changes in the rotation of crops	0.33
Maintain strips of vegetation between lines	0.24
No tillage with herbicides	0.23
Weed supressing crop species	0.21
No tillage without herbicides (with brush cutter)	0.19
Tillage according to level curves	0.18
Use of biostimulants and biofertilisers	0.16
Construction of stone walls	0.14
Maintain the natural vegetation on the edges of the plots	0.14
Construction of slopes or margins with vegetation	0.13
Construction of slopes or margins without vegetation	0.00

DIVERFARMING

CASE STUDY No. 9. Perennial crop (vineyard) in Germany

DIVERSIFICATION	
Crops	**number of answers**
simultaneous crops/Intercropping	25
Simultaneous crops plus multiple crops	10

CROPS	
Crops	**number of answers**
Mix of grasses, legunes and cruciferous vegetables as forage	47
Aromatic plants for food and industrial products	14
Local pasture as forage	9

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Minimal tillage	0.80
Mulching (with crushed offcuts from pruning, etc.)	0.79
Maintain the natural vegetation on the edges of the plots	0.75
Use of green manure	0.74
Maintain strips of vegetation between lines	0.70
Maintain vegetation cover (natural or cover crops)	0.68
Contribution of organic matter/manure	0.60
Integrated pest control	0.59
Precision agriculture to optimise fertilisation	0.49
Fences or nets to protect the vines	0.47
Superficial tillage	0.47
Control of feromones	0.46
Lighter machinery for soil relief	0.46
Use of biostimulants and biofertilisers	0.44
Install hedges on the edges of the plots	0.42
No tillage with herbicides	0.41
No tillage without herbicides (with brush cutter)	0.41
Construction of slopes or margins with vegetation	0.40
Cover of stone (stone mulch)	0.21
Tillage according to level curves	0.05
Construction of slopes or margins without vegetation	0.00

DIVERFARMING

CASE STUDY No. 10. Horticulture in Hungary

DIVERSIFICATION	
Crops	**number of answers**
Rotation of crops	12
Simultaneous crops/Intercropping	5
Multiple crops	3

CROPS	
Crops	**number of answers**
phacelia (Phacelia tanacetifolia)	14
Spring barley (Hordeum vulgare)	10
Aromatic crops (eg. Lavender)	8
Legumes (e.g. Vicia alba)	8

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Harrow discs to incorporate crop residues into the soil	0.82
Use of green manure	0.74
Tillage without heavy implements	0.74
Mulching (with crushed offcuts from pruning, etc.)	0.66
Maintain the natural vegetation on the edges of the plots	0.65
Precision agriculture to optimise fertilisation	0.59
Integrated pest control	0.58
Drip irrigation in sandy soils	0.57
Construction of slopes or margins with vegetation	0.45
Combination of manure and mineral fertilisers	0.42
Contribution of organic matter (manure, compost, etc)	0.41
Water drainage	0.41
Controlled/drip irrigation	0.40
Maintain vegetation cover (natural or cover crops)	0.39
Seasonally divided deficit irrigation	0.38
Maintain strips of vegetation between lines	0.37
Minimal tillage	0.37
Use of biostimulants and biofertilisers	0.36
Diversification of crops	0.36
Changes in the rotations of crops	0.35
Tillage according to level curves	0.33
Surface tillage	0.32
Construction of slopes or margins without vegetation	0.30
Install hedges on the edges of the plots	0.26
No tillage without herbicides (with brush cutter)	0.25
No tillage with herbicides	0.24
Construction of stone walls	0.17
Dryland horticulture in clay soils and clay	0.04
Spring barley cover	0.00

DIVERFARMING

CASE STUDY No. 11. Perennial crop (vineyard) in Hungary

DIVERSIFICATION	
Crops	**number of answers**
Simultaneous crops/Intercropping	30
Simultaneous crops plus rotation of said crops	9
Simultaneous crops plus multiple crops	2

CROPS	
Crops	**number of answers**
Mix of legumes for livestock	27
Oats, alfalfa and / or vetch for cattle or game	21
Aromatic plants such as thyme, lavender, sage or rosemary	20
Legumes for human consumption	7
Aloe vera	6
Saffron	1

RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Mulching (with crushed offcuts from pruning, etc.)	0.86
Use of green manure	0.82
Construction of slopes or margins with vegetation	0.75
Maintain strips of vegetation between lines	0.75
Integrated pest control	0.72
Maintain the natural vegetation on the edges of the plots	0.71
Contribution of organic matter/manure	0.69
Combination of manure and mineral fertilisers	0.68
Use of biostimulants and biofertilisers	0.66
Loosening the soil	0.61
Maintain vegetation cover (natural or cover crops)	0.59
Use of compost	0.57
Ilnstall hedges on the edges of the plots	0.56
Precision agriculture to optimise fertilisation	0.56
Changes in the rotation of crops	0.54
Tillage according to level curves	0.54
No tillage without herbicides (with brush cutter)	0.51
No tillage with herbicides	0.48
Water drainage (reliefs with pasture)	0.47
Construction of stone walls	0.44
Construction of slopes or margins without vegetation	0.35
Controlled irrigation	0.30
Lighter machinery to loosen the soil	0.26
Dryland cropping (where the annual precipitation is > 600 mm)	0.24
Drip irrigation	0.23
Minimal tillage	0.22
Diversification of crops	0.21
Mixes of grasses and native grasses	0.17

DIVERFARMING

CASE STUDY No. 12. Conventional Fodder Crops in Finland

CASE STUDY No. 13. Organic Fodder Crops in Finland

DIVERSIFICATION	
Crops	**number of answers**
Rotation of crops	11
Simultaneous crops/Intercropping	2
Rotation of crops	3
CROPS	
Crops	**number of answers**
legumes and cereals	16
legumes and grass	8
cereals and oilseeds	5
Spring cereal and pastures	3
RANKING RESULTS FROM THE MULTICRITERIA DECISION MAKING	
Contribution of organic matter/manure, compost, etc)	0.84
Changes in the rotations of crops	0.79
Maintain the natural vegetation on the edges of the plots	0.78
Construction of slopes or margins with vegetation	0.73
Minimal tillage	0.64
Integrated pest control	0.64
Tillage without heavy implements	0.63
Application of organic or inroganic fertilisers	0.61
Improvements in drainage	0.59
Use of biostimulants and biofertilisers	0.58
Maintain vegetation cover (natural or cover crops)	0.55
Use of green manure	0.55
Precision agriculture to optimise fertilisation	0.52
Tillage according to level curves	0.52
No tillage with herbicides	0.43
Install hedges on the edges of the plots	0.40
Spring tillage	0.39
Mulching (with crushed offcuts from pruning, etc.)	0.38
Maintain strips of vegetation between lines	0.36
No tillage without herbicides (with brush cutter)	0.21
Construction of slopes or margins without vegetation	0.13