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# DIVERSify: Designing InnoVative plant teams for Ecosystem Resilience and agricultural Sustainability

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## Synthesis report on national stakeholder meetings (Report, Public)

## Deliverable 1.1 (D1)

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Reviewer: Alison Karley (JHI)

THE ORGANIC RESEARCH CENTRE ELM FARM

| History of Changes | | |
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| **Version** | **Publication Date** | **Change** |
| Draft 0.1 | 17th March 2018 | Initial draft version sent to co-authors for comment |
| Draft 0.2 | 23rd March 2018 | Submitted to coordinator after review of comments/edits from contributing authors |
| Draft 1.0 | 28th March 2018 | Final version |

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## Executive Summary

The objective of DIVERSify Task 1.1 was to "Identify tacit knowledge, bottom-up innovations, strategies and current farmer best practice in diverse cropping systems". This was undertaken by a series of 15 participatory stakeholder workshops conducted by project beneficiaries in 11 different countries throughout the different pedo-climatic zones of the EU as well as Kenya and Palestine between June 2017 and February 2018. These workshops were facilitated by project beneficiaries who were 'buddies' to the stakeholders and ensured that the running of the workshop was participatory and appropriate for the local tradition and conditions. Workshops were carried out using a range of approaches such as face to face meetings on farms or at businesses and research/educational institutes as well as online or telephone surveys. The workshops were attended by 567 individuals, 65% of which were farmers, and over half of these farmers were either currently growing or had previously grown plant teams. A range of innovations and best practices were identified, including crop management approaches as well as 130 different plant teams, with the majority including cereals but a number from Kenya and Palestine also including vegetables. Barriers to uptake of plant teams were also identified with the complexity of production and harvesting as well as lack of information and advice being highlighted as the main barriers. A number of potential research topics were also identified which will be fed into the work of WP2, WP3 and WP4. A number of routes have been identified to allow feedback of report findings to key stakeholder groups, and these will be aligned with related project activities and deliverables for dissemination and knowledge exchange.



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## 1. Introduction

An important element of DIVERSify is to assimilate existing expertise of stakeholders in conventional, organic and integrated systems and to identify tacit knowledge, bottom-up innovations, strategies and current farmer best practice in diverse cropping systems. To facilitate this, a series of Participatory Stakeholder Workshops were held to discuss mixed cropping and plant team systems.

## 2. Methodology

The main approach to doing this was to undertake a series of National Stakeholder Workshops using an agreed, but flexible, participatory methodology based on the 'field lab' approach (MacMillan & Benton, 2014) which was outlined in the DIVERSify Stakeholder Guide (Annex 1) and Workshop Facilitation Guide (Seeds of Change, 2010). ORC provided training on running a workshop to all partners at the project kick-off meeting in Edinburgh in April 2017, and this was supplemented with support by phone, email and web-based meetings prior to each workshop as required. Fifteen


***Figure 1: Stakeholder participatory workshop locations. Blue pins represent face to face workshops, green represents telephone surveys and purple represents online surveys.***



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workshops were held between June 2017 and February 2018 in 11 different countries throughout the major pedo-climatic zones of Europe, plus Kenya and Palestine (Figure 1). Pre-existing information from a French survey was also included in the data collected.

Each stakeholder group was supported by a scientific partner 'buddy' from a project beneficiary to undertake the consultation and feedback to the WP1 leader using an agreed reporting template (Annex 2).

The aim of each workshop was to identify;

- Innovation and best practice
- Barriers to the take-up of plant teams
- Research topics to inform WP2 and WP4.

## 3. Workshop outcomes

### 3.1. Workshops & Stakeholder Attendee Typology

Fifteen workshops were held (see Table 1 and Figure 1) utilizing several approaches. Most used a form of face to face meeting or workshop either as a stand-alone event or part of a larger stakeholder gathering. The French Partner (ESA, 14) also contributed data from a survey of French farmers who applied biodiversity-based techniques including intercrops and mixtures. The farms were located within 26 districts in five regions in France (Nord-Pas-de-Calais, Aquitaine, Midi-Pyrénée, Pays-de-Loire and Rhone-Alpes region). The Swiss partner (ETHZ, 4) held an online survey/workshop using Survey Monkey.

***Table 1: Details of Stakeholder participatory workshops***

| Partner | Country | Workshop host (buddy) | Workshop location | Date | No. Attendees |
|---|---|---|---|---|---|
| OiB, SLU | Sweden | Helena Elmquist, Martin Weih | Västraby gård (near Helsingborg, Scania) | 27/06/2017 | 13 |
| SZG | Austria | Eveline Adam | Gleisdorf | 07/09/2017 | 34 |
| UNIVPM | Italy | Stefano Tavoletti | Località Cerrete Collicelli - Cingoli | 14/09/2017 | 12 |
| UNIVPM | Italy | Stefano Tavoletti | Isola del Piano | 25/09/2017 | 5 |
| LEAF | UK | Laura Tippin | Overbury Village Hall (near Tewkesbury, Gloucestershire) | 05/10/2017 | 13 |
| STC | UK | Jenifer Banfield-Zanin | Stockbridge Technology Centre (near Selby, Yorkshire) | 11/10/2017 | 17 |
| ORC | UK | Charlotte Bickler | Rushall Organics (near | 23/11/2017 | 49 |


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| | | | Pewsey, Wiltshire) | | |
| WWU | Germany | Christoph Scherber | Münster | 08/12/2017 | 20 |
| SEGES, ØL, UCPH | Denmark | Inger Bertelsen, Annette Olesen, Lars Kiær | Vejle, Denmark | 11/12/2017 | 31 |
| CSIC, ITQB, FSN | Spain, Portugal | Diego Rubiales, Carlota Vaz Pato, Ana Barradas | Herdade dos Esquerdos (Vaiamonte, Portugal) | 13/12/2017 | 45 |
| KEFRI | Kenya | John Ochieng Otieno, Charles Ndgege | KEFRI Lake Victoria Basin Eco-Region Programme, Maseno, Kisumu | 10/01/2018 | 13 |
| CORE | Palestine | Layth Sbaihat | Various farmer consultation and workshop | 03/02/2018 | 28 |
| ETH Zurich | Switzerland | Christian Schöb | Online | NA | 38 |
| ESA | France | Joëlle Fustec | Phone and on-farm interviews | N/A | 196 |
| | France | Joëlle Fustec | Angers, France | 22/02/2018 | 53 |

In total 567 individuals attended or contributed to the 15 workshops and events. These were drawn from a range of stakeholders but the majority (370 or 65%) self-identified as farmers (Figure 2). Of the overall attendees, more than half (52%) were either currently using or had previously used plant teams (Figure 3).

Motivations for attending the workshops were not always identified (other than the obvious one that stakeholders were interested in plant teams), but it was clear that many of the stakeholders were already experimenting with different crop combinations and agronomic approaches to try and maximise field performance. The general motivations to try intercropping were to encourage weed and pest control, improve soil and plant health, increase fodder quality, increase crop cover, spread risk and encourage biodiversity (e.g. pollinators and predators). The reducing availability and efficacy of chemical options was noted. Ultimately producers aim to increase cash crop yields and quality whilst, in some cases, increasing legume production in response to reducing profits from cereals. The specific traits that will contribute to improved yield and quality that were touched upon were mainly based around stress tolerance and increased competitiveness against weeds. Moreover, plant teams including cereals, where the harvested grain could be used for animal feed, were seen as solutions to extend crop choice in rotations and to re-establish a link between food and feed systems. However, generally, the described mechanism used to determine the success of the innovation was whether there was an increase in yield (and occasionally quality) of the desired crop.



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### 3.2. Innovation & Best Practice

Workshop attendees were asked to identify what innovations and best practices had worked, or not worked, if they are currently or had previously used plant teams. Not surprisingly as these workshops were about plant teams, in general, stakeholders felt that plant teams were a good thing, even by those who were not currently growing them. Despite the work of the facilitating buddies, attendees in some workshops were not always comfortable in discussing, or admitting to, cropping failures. However, both pros and cons of plant teams have been identified and there were no difficulties in identifying positive innovations.

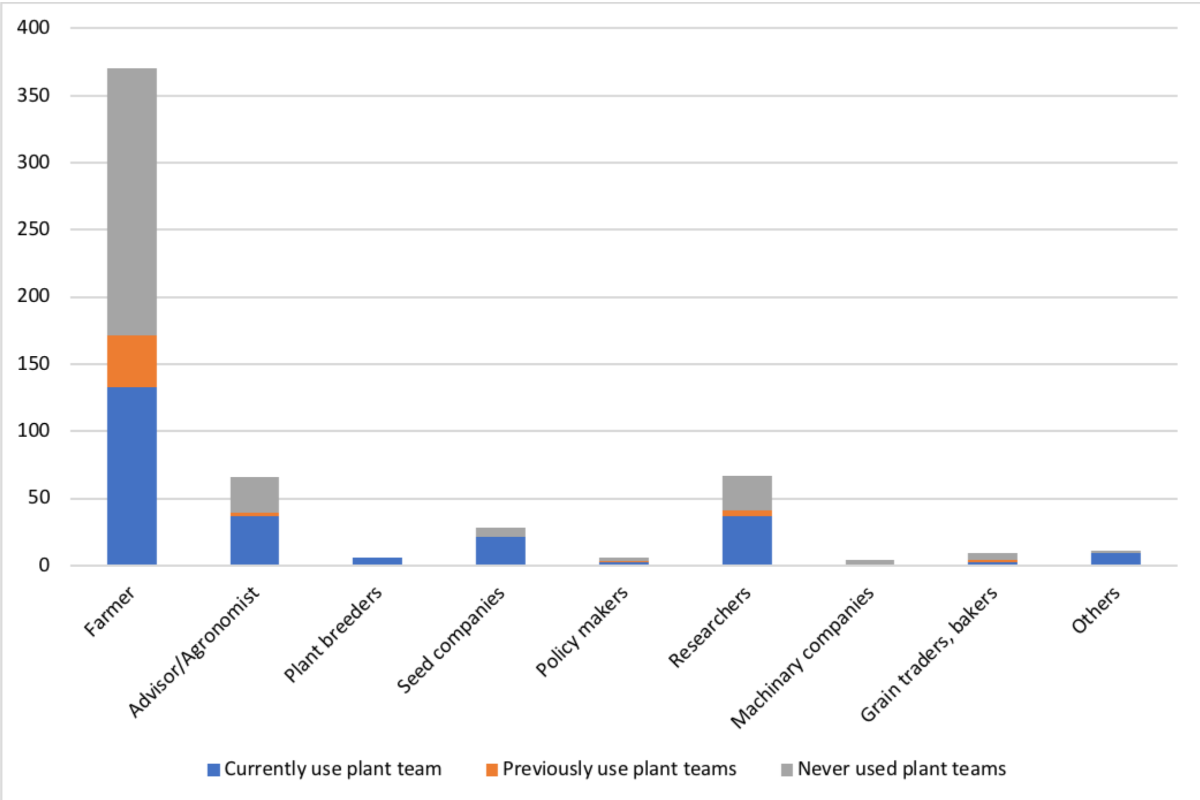


***Figure 2: Breakdown of stakeholder workshop attendees by type and their use of plant teams.***

The **German** workshop had an interest in lupine-cereal systems with a range of working and non-working plant teams identified, depending on lupine cultivar (erect or branching), where working teams were identified as not needing external inputs even in conventional systems.

In **Italy** the greatest interest was with plant teams including bread wheat and faba bean (*Vicia faba*) or field pea (*Pisum sativum*), where this team was also of interest as a feed for organic poultry. A barley-pea mixture was already in use by several organic farmers, and although successful, the workshop identified the requirement for more information on the optimization of crop ratios in mixtures. The barley-pea mix was also seen as a good component in crop rotations based on *durum*


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wheat, which is one of the most important crops in Central and Southern Italy. The Italian workshops also identified the need for finding good crops as potential choices for organic farmers to realize good crop rotations. *Durum* wheat and the barley-pea or barley-faba bean were suggested as candidates for this. Mixed crops for animal feeding were preferred by stakeholders but interest was also shown for mixed crops for food, such as wheat-grain legumes, where wheat grain (*durum* or *aestivum*) could supply the food chain and the grain legumes (pea or faba bean) to animal feed. However, more information was requested on mechanical separation of the two grain crops and further processing in two separate production chains before a positive acceptance of these plant teams on a larger scale could be obtained.

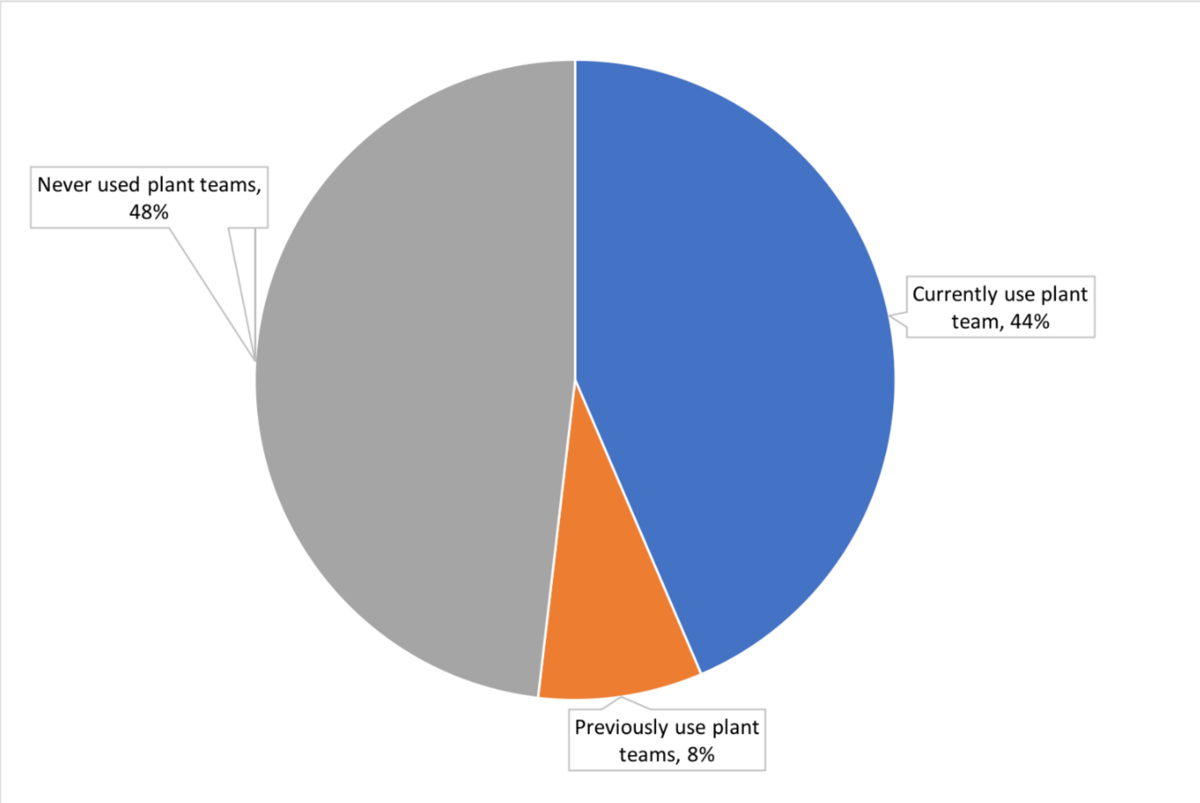


***Figure 3: Use of plant teams by attendees at stakeholder workshops***

In **Austria** innovations in plant teams of *Phaseolus coccineus* with maize as a supporting crop have been successful, with no special machinery needed, and the maize yield as an additional income. However, there were concerns that there was competition for light between the bean and maize, the system was not resistant against heat, there were big variations in harvestable yields and the team is risky if the harvest is delayed. There was also lower bean quality due to later maturity and mechanical damage that can occur at harvest. Sorghum is also being tried as a supporting crop, as it fits well in a rotation that already has maize with many of the benefits of the bean-maize team and the grains being easy to separate. However, late sowing is needed due to sorghum being frost sensitive and the sorghum is also very competitive so needs to be sown at a low seed rate. Other



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plant teams in Austria focused on under sowing for attracting pollinating insects using different row widths and a range of plant teams (Maize/*P. coccineus*/Phacelia; Maize/*P. coccineus*/Buckwheat; Sorghum/*P. coccineus*/Phacelia; Sorghum/*P. coccineus* /Buckwheat) which resulted in more pollinators when more flowers were available in the plot. Higher yields of scarlet runner beans (a variety of *P. coccineus)* were found in Sorghum mixed cultures than those generally obtained in maize mixed cultures. The highest scarlet runner bean yields were observed in maize with a wider distance between rows (100cm) and again in Sorghum with a wider distance between rows (75 cm). *Phaseolus coccineus* beans had shown reduced yield in currently used *Phaseolus*-maize teams if grown on a large scale. It was suggested this was because of competition for air currents (enhanced pathogen pressure due to high moisture/standing air in deeper parts of the *Phaseolus*-maize team culture field site) as well as a lack of pollinators in the inner parts of the field site (*P. coccineus* beans depend on insects for pollination). It was suggested that pollinators avoid flying deep into those areas with high biomass/narrow space and complex structure and focus on the outer rows of a mixed culture field site.

The Austrians also reported legume plant teams. Winter crops included different vetches and rye, pea and barley, pea and triticale, and pea and rye using different sowing densities. Summer crops included faba beans and grass pea (*Lathyrus sativus*), peluskins (or field pea, *Pisium sativum*) and barley, peluskins and oat, vetch and oat, and pea and barley. In the winter crops, the most successful mixture as regards yield was Pannonian winter vetch and winter rye and in the summer crops this was pea and barley.

Another innovation reported by the Austrian workshop was the use of borders of (mixed culture) flowering crops to attract insects. The seed mixture contained 31 different plants (mostly domesticated, e.g. buckwheat, different clover species, blueweed (*Echium vulgare*)) as ‘bumblebee plants’ and is sown as border around a field that has insect pollination requirements. When the main crop starts flowering, the border is mown down, so that the insects move to the main crop.

In the **UK STC** workshop, several innovations and best practices were identified. These included the use of a strip-till to simultaneously sow both Oil Seed Rape (OSR) and clover in strips, the application of a small amount of nitrogen to help establish the clover (although there is a need to be wary of nitrogen application rates, as too high a rate will kill the clover), and the use of drone technology that allowed observation of where there are gaps in the clover so that this information could be used to over-sow these barer areas. Best practices identified were to sow a mixture of clover varieties, as insurance against establishment failure, and an application of a low-rate herbicide that can help control excessive weeds without lasting or extensive damage to the clover. An observation reported by the buddy was that, initially, the farmer was concerned about the performance of the clover, as it remained very small under the OSR, however once the main crop was harvested the clover grew rapidly.

STC also reported on lucerne as a secondary, understory crop that can be undersown into standing spring barley. `There was no ‘rule’ *per se* as to sowing times, due to variability of climate, etc. year on year, but there was generally rapid establishment, as long as moisture is present. Another best



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practice noted was that damaging a clover crop (through rolling, or grazing, etc.) can be useful to encourage nitrogen-enhancing activity.

At the **UK ORC** workshop, cash crop mixtures and cover crop mixtures were identified (for summary see section 3.3 and Annex 3 below). A general problem was noted when using peas in the team in the harvesting of ripe, or a large quantity of, peas. Also, pea seed is expensive, so low return can put farmers off trying intercropping with peas, as well as the problem of lodging in wet climates. Several stakeholders had identified increases in yield when using plant teams, including a 15% yield increase with spring oats and beans and no need for herbicide after planting. As bean vegetation is very open, weeds can be a problem, but the oats soak up excess nitrogen and grow quickly providing weed competition. Also in a mixture of spring oats, birds-foot trefoil and two white clovers, a three quarter of a tonne increase in yield was found as a result of the team. As a cover crop, buckwheat and berseem clover was identified as a best practice as the stakeholder has not used insecticide for 4 years after the plant team's introduction. They also observed that spring barley volunteers help with reducing flea beetle pressure (which was identified as a problem by another organic stakeholder with stubble turnip and berseem clover). A large percentage of stakeholders were undersowing with a variety of clovers: white, red, berseem and birds-foot trefoil. This was generally considered a successful practice although red clover has been observed to grow too high and damage straw in some cases. Lucerne and all cereals were thought to be a good plant team, although it can lead to volunteer plants in an organic system despite ploughing.

UK Stakeholders have tested various seed sowing rates (i.e. densities) and ratios. For example, for spring oats and peas, one stakeholder tried a ratio of 80:20 and found that the oats were still green at harvest, whilst another participant found a 50:50 ratio worked well on their farm. For spring oats and beans, a detailed protocol was discussed: oats at 20% of normal seed rate (350 seeds per square metre = 60kg/ha approx.) and a full seed rate for the beans. The stakeholder reported that they had been cautious and reduced the oats in 2016/17 (to 30kg/ha) but they are now going to go ahead with the full 60kg/ha and hope for a 30% increase in yield (as they had a 15% increase in yield before). The oats and beans were drilled at the same depth (approx. 2 cm) but they have applied for a grant to buy a cross-slot drill to allow for different drilling depths as well.

Various equipment and machinery was mentioned during the workshop. Stakeholders have both broadcast seeded and direct drilled. One stakeholder stated that kit is "out there". They outlined that a cultivator type drill or weaving drill can be used over ploughed (rough) ground and will drill a variety of seeds, and there are seeders on the market that will drill into anything but grass. Alternatives to stale seed beds in organic production were discussed and one stakeholder recommended waiting as late as possible to plough and then to drill on the same day. They have observed that the crop comes up quickly in the warmer weather and can therefore be more competitive. However, this will depend on soil type e.g. timing of ploughing is more restrictive in clay soils. There was a consensus that by tweaking the timing and depth of drilling, benefits can be maximised. For example, drilling one crop (e.g. clover, cereals) as shallow as possible will ensure that it comes up more quickly and is competitive against weeds or other crops within the mixture. Cross


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slot drills can be used to drill at different depths but are expensive (£110k second hand). The System Cameleon allows for inter-row cultivation but is, once again, an expensive piece of kit.

The **UK LEAF** workshop identified successful approaches including the undersowing of spring barley, red clover and rye. This plant team was found to be more reliable in spring than autumn and summer. Success is still mixed, with red clover growing larger than the spring barley in 2017 while also failing to establish in one field in 2017. One stakeholder has used OSR, vetch and buckwheat (can also use berseem clover) for companion cropping with seed rates of OSR 25kg/ha, vetch 15kg/ha and buckwheat 7kg/ha. Pre-emergence herbicides have not been used, but ASTROkerb was used to take out the companion crop. They have found that vetch can out-compete the OSR when ASTROkerb is not applied. In general, they have found that establishment and plant vigour is better in companion crop systems. One stakeholder had trialled companion cropping of mustard, OSR and lucerne this year. Another new approach was being tested this year with home-grown vetch and buckwheat used as a break crop in rotations following on from cereal crops. Using home-grown seed helped to reduce costs associated with seed mixes. Volunteer vetch has been identified as a problem in the following cereal crops and the farmer has also noted that he cannot terminate the vetch break crops without chemical inputs. One stakeholder reported that poor establishment of a cover crop had adversely affected the establishment of the following cash crop.

The **Danish** workshop identified best practices with mixtures containing oilseed crops to add fatty acids to feed. They used winter cereals, with legumes sown in spring, and found that this works well in relation to hoeing and weed control. Furthermore, lupin/spring wheat mixtures were also useful, as lupin is a good grain legume for sandy soils, due to good drought tolerance, and can compensate for wheat, while wheat makes the lupine mature earlier. They also reported utilizing different sowing requirements as an approach for extra weed control, such as sowing the grain legume (deep) first, then waiting 1-2 weeks before sowing the cereal (shallow). A plant team of spring barley/field pea works well as the field pea has something to support it, resulting in less lodging. Premature crimping of spring wheat/lupin can secure simultaneous harvest. Faba bean/spring oat (or triticale) can reduce uneven maturing and provides better weed control.

A number of other concerns/caveats were highlighted. There is a need to ensure that the plant team is adjusted in respect to the previous crop, which was thought to be more important than seed rate, as this requires an adjustment with respect to the soil nitrogen level. Also discussed was the correct sowing depth of different crops in mixtures: e.g. challenges with the right sowing equipment available.

In **Sweden**, growing a plant team of grass and clover is very common. It is seen as a simple and effective way to grow feed. It is also climate smart and most economic for most Swedish farmers. However there have been discussions to combine different plants (i.e., to grow plant teams) for food production. But there is concern about this as buyers have so far shown no interest to purchase products from “plant teams”.

The **Kenyan** workshops identified a host of approaches that Kenyan farmers are already using.



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**Push-Pull technology**: This is a cropping system aimed at simultaneous control of stem borers and striga weeds in drier agroecologies. Farmers use drought-tolerant Mulato grass (*Brachiaria* sp.) and Desmodium (*Desmodium uncinatum*) legume for management of these pests in their maize or sorghum fields. Desmodium is planted in between the rows of maize or sorghum based on advisor (ICIPE) inputs. The legume produces green leaf volatile organic compounds that repel and ''push'' away the stem borer moths from the maize or sorghum crop. The Desmodium also produces allelochemicals that are released into the soil, which induce germination of striga seeds and inhibit attachment (formation of haustoria) of the germinated striga to the roots of the cereals (suicidal germination), thereby ensuring effective and sustainable management of the deleterious weed. Brachiaria or Napier grass is planted around the maize or sorghum crop as trap plants. The two grass species are more attractive to the stem borer moths than the cereals and ''pull'' the moths to lay eggs on them. Brachiaria does not allow the stem borer larvae to develop on it due to poor supply of nutrients to the stem borer larvae, while Napier grass exudes a sticky substance that trap and kills the larvae. Very few stem borer larvae and striga weeds survive under this cropping system, hence higher maize yields.

**Mixed cropping**: The farmers identified mixed cropping as a better way of ensuring enough yield for home consumption and income generation. The plant teams named the following species: Maize, common beans, millet, cassava, groundnuts, sweet potatoes, bananas, papaya and other fruit farming. Depending on the farm size, all the plant species are organized as monocultures or planted as mixed stands. Common beans, groundnuts and sweet potatoes are mainly planted as under-storeys among the rest of the plant species. Cultivars used in the region are selected, or bred, to match local site conditions. Planting materials are distributed by certified seed companies. Crop rotation is practiced for soil fertility (especially where crop legumes are involved) and pest and disease management.

**Mixed farming**: Apart from mixed cropping, farmers also pointed out farm forestry, animal and bee keeping as a combination of farming that generates high income, at different times of the year, for sustainability. Plant teams mostly used include maize, common beans, millet, cassava, groundnuts, sweet potatoes (crops) and calliandra, tephrosia and eucalypts (tree species). Sesbania (*Sesbania sesban*), an important multipurpose nitrogen-fixing tree was voted out (rejected) by farmers because they are an important host to nematodes, which are also pests to many crop species within the plant teams practiced in the Lake Victoria Ecosystem region.

The **Swiss** 'workshop' was undertaken using a successful online survey. This identified plant teams but also drivers for the different stakeholders, and what worked and did not work for them.

**What worked: Breeders** suggested synergistic effects led to reduced risks with two species. **Seed suppliers** identified increased yield stability, reduced weed pressure and higher absolute yield. **Processors** suggested that in cereal-legume mixtures, the legume provides nitrogen for cereals. **Farmers' associations** identified stable yield, fewer weeds, and high ecological and aesthetic value. **Advisors** suggested higher stability of pea in pea-barley mixtures, good soil cover with oat-faba bean mixtures, good weed suppression (e.g. with cover crops in OSR), in general good for fodder



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production, dual use, green bridge, better nutrient use, reduced pests, works well for household gardens, and a good protein source. **Farmers** identified ease of cultivation, less fertiliser required, more yield, good in rotation with maize, higher physical stability, higher drought resistance, yield stability, good harvest and yield, good soil coverage, positive feedback from the public including neighbours, and high fodder quality.

**What didn't work**: **Breeders** suggested difficulties in the market (i.e. difficult to find a customer for the product), harvest difficulties (set up of the combiner for the harvest, differences in maturation timing). **Seed suppliers** suggested difficulties in crop rotation, and that increased know-how was necessary. **Processors** suggested that a similar time of maturation was needed, otherwise costs for drying can be high and/or reduced quality for one of the species e.g. in oat and faba bean mixtures the oat is often of reduced quality (hectolitre mass, mycotoxin infection). Cereal-legume mixtures can reasonably be used only as fodder due to high investment for separation (because pieces of legumes are retained with the cereal using standard separation tools). **Farmers' Associations** identified difficulties in crop rotation, no secure yield, and difficulties with phytosanitary measures. **Advisors** suggested that some mixtures do not work (e.g. soya-oat), there are difficulties in finding customers for the products, difficulties with weed control (mechanically and chemically), difficulties with crop rotation, no market, no customers, unequal maturation timing, difficulty with harvest, difficulties with pests, no crop-specific fertiliser application, no crop-specific herbicide application (e.g. for weed suppression), difficult for planning (as it is difficult to predict timings), difficult for industrial production, too much Phaseolus biomass can break maize plants, and difficulties with cleaning and separation. **Farmers** identified no marketing, lack of knowledge about best practice for species proportions and fodder proportions, harvest issues, Phaseolus pulls down the maize, weed problems when wet, difficulties with harvest and further use/processing of pea, difficulties with storage, problems with lodging of the crop, difficulties with maturation timing, difficulties with mechanical weeding (organic), concerns by customers, more work in particular when the farmer lacks experience, costly, a lot of work during the whole year and the market is still very resistant to mixed grain products.

In **France** a Stakeholder workshop was held and added to information provided from a telephone survey of French farmers who applied biodiversity-based techniques including intercrops and mixtures. This survey found that the drivers for using plant teams were improving soil structure, limiting soil tillage, controlling weeds, respecting regulations, benefiting from crop complementarity, providing companion to the main crop, homogenising the crop performance (resilient system), pest control, market, fewer inputs and higher yields. Insight from one of the regions surveyed showed that 73% of the farmers were satisfied with the cover crops they had used while 10% were moderately satisfied, and 3% were not satisfied. This might have been related to the finding that 55% of farmers thought it had increased their workload while 39% thought there had been no change, and 6% thought it decreased the workload (sowing and destruction). With intercropping, 62% of the farmers were satisfied with intercropping, 29% were moderately satisfied, and 9% were not satisfied, with the findings that there was an increase of work for 33%, no change for 39%, and a


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decrease for 9%. The **French** workshop identified that stakeholders currently use a wide range of plant teams. Most of them mix more than two species with OSR for controlling weeds and pest insects, providing nitrogen to the soil and increasing crop diversification and biodiversity. They are satisfied with this practice with OSR. Some examples are two legumes (hairy vetch, common vetch, fenugreek, lentil, white clover, red clover and/or faba bean), sometimes with buckwheat. They often use BioMax mixture (sunflower, oat, radish, phacelia, buckwheat, field pea, faba bean), sometimes intercropped with OSR. A substantial number of stakeholders successfully grow maize with one or more legume species i.e. with white clover or hairy vetch/white clover/crimson clover for silage, or with *Lotus corniculatus* and faba bean, soya or lablab for grain. In Belgium, intercrops of sorghum with either Berseem clover, or with a mixture of oat/phacelia/berseem clover/moha were successful.

In **Italy** farmers were worried about harvesting mixed grain crops as they believed that they would not be accepted by the market as a mixture and the separation of the crop grains would be an additional cost. Moreover, a LER>1 was considered an important prerequisite to justify the adoption of mixed cereal-legume crops (durum wheat, bread wheat or barley mixed with faba bean or pea).

The Iberian partners (**Spain, Portugal**) undertook a joint stakeholder workshop in Portugal with stakeholders from both countries. Their stakeholders already clearly see the benefit to the following crop of using grassland mixture plant teams, and this awareness has increased among users. In relation to the cereal-legume intercropping, although these are traditional crops (like Vicia and Avena), it is not yet clear for farmers the benefits that these intercrop systems bring to crop rotations.

The **Palestinian** workshop identified that the wheat-vetch team is quite an innovation; vetches are the main crop and wheat is planted at a lower planting density, vetches climb on the wheat and are more exposed to the sun resulting in better vegetative growth and less rotting. Wheat is (manually) harvested at the milky stage, for Freekeh production, leaving a "clean" vetch produce. Also, the vetch-barley team was identified as a successful team by some farmers and proved – according to their experience – to have higher productivity than one sole crop, less rotting of lower stems of the vetch, and not complicating harvest and processing efforts (used for feed as mixed product, or using mixed seeds for subsequent seeding in mixture). This was not wholehearted endorsed by others as another farmer who tried the same team did not notice the mentioned improvements and stopped using it.

### 3.3. Plant teams

Stakeholders were forthcoming with innovations in plant team combinations where 130 different plant team combinations (two or more crops) were identified (for full list see Annex 3**Error! eference source not found.**). These included;

- 71 with cereals as the main crop
- 17 with pseudo grains as the main crop
- 5 forage/grass



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- 22 vegetables
- 8 agroforestry
- 6 other systems

Although a long list, it is by no means exhaustive, but it probably does represent the range of plant teams that are currently being utilised across partner countries. When plant teams were looked at within and between the pedo-climatic zones, there was considerable overlap, with many crops - in particular cereals (i.e. barley) - being part of a plant team in all zones other than Kenya. However, maize was generally found in Kenya with some Alpine and Continental examples.

### 3.4. Barriers to Plant Teams

The second aim of the workshops was to identify what the barriers were to the uptake of plant teams by stakeholders. We asked stakeholders whether they believed these barriers to be 'solved', 'unsolved' or 'perceived', and to begin the discussion and thinking we provided buddies with a list of possible barriers (see list in Annex 2: Stakeholder workshop report template). As would be expected with the range of stakeholders, regions, countries and likely farm and business types attending the workshops, all areas where barriers were identified fell within all three criteria. Figure 4 shows the consolidated list of barriers identified by the stakeholders. The first 12 were provided within the reporting template while the remaining 13 were identified by stakeholders.

**Harvest complexity** was seen as the main barrier, where, in particular concerns of asynchrony of maturity between the plant team components, damage to one or more of the components, correct adjustment of combine harvester and uneven size of grains were identified.

**Lack of available advice/knowledge** was identified in nearly all the workshops as a barrier to uptake. There clearly is a desire to diversify farming systems from the stakeholders who attended our workshops, but it is being constrained by their lack of confidence and access to advice. There is a need for simple solutions and straightforward guidelines but the unique nature of each farm and system could end up dissuading farmers from trying to use plant teams. The lack of a clear picture on what to do, what to use, and when to do so, and furthermore on matters such as business structures useful/required for implementation, was exacerbated by the feeling that there was no source of independent advice or knowledge (suspicion towards big companies and their potential additional motives, e.g. selling of seed or product, was expressed). It is not only the farmers who are short of knowledge and advice, as it was suggested that agronomists and advisors also lack sufficient knowledge.

**Seeding/drilling complexity** was confusing to many of the stakeholders. The best approach to seeding and drilling was seen as a major barrier due to the importance of the correct establishment of all crops in the plant team. For example, stakeholders felt unsure whether plant teams should be mixed before sowing, or should it be sown as different rows etc. There were also numerous barriers identified with sowing equipment.



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**Processing complexity** was an important barrier. In particular, the expense of drying after harvest, the separation of the different plant team components post-harvest and uneven product that is difficult to sell to the feed industry etc. were discussed. Much of this will depend on the use of the end product and the plant team components. If the plant team is to be used on farm (i.e. as feed) then separation may not be needed. There are also existing technologies to separate some products of different size or colour, but there are cost implications to this.

**Crop management complexity, weed control complexity, pest/disease complexity** relates back to the lack of knowledge and advice. Growing 'plant teams' increases the number and variety of decisions that have to be made, and this can be overwhelming, especially when combined with the complexity of a range of on-farm processes such as drilling and harvesting. There is a common belief that the management of intercrops is complex which can be off-putting to farmers who see the approach as time consuming, unpredictable and unreliable. However, stakeholders suggested that many of the reservations farmers have in regard to complexity are often resolved once they start intercropping and experience that the complexity of intercropping is similar to, or the same as, their conventional approaches.

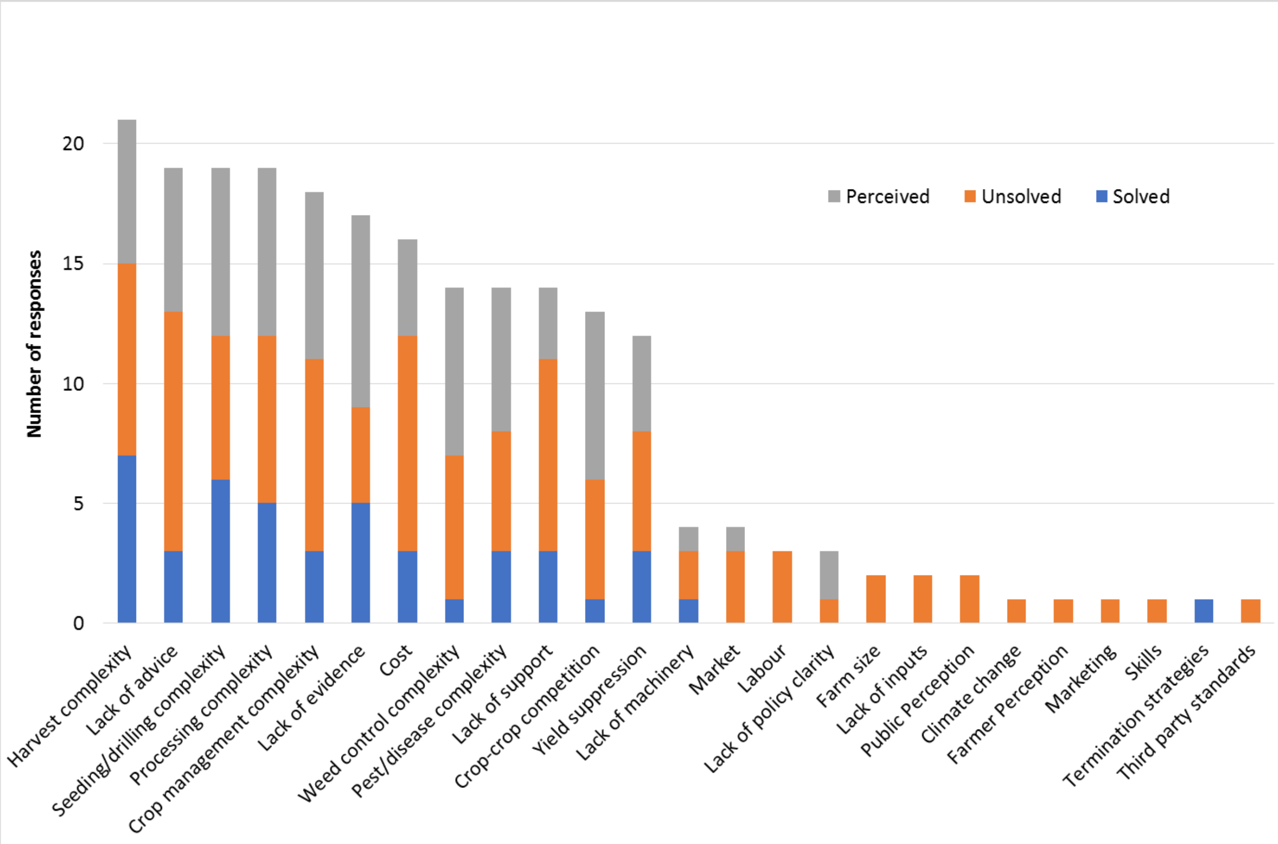


***Figure 4: Barriers to uptake of plant teams identified by stakeholders.***



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**Not enough evidence supporting effectiveness** was identified as a barrier. There was a perceived lack of independent research and evidence supporting the use and efficacy of plant teams. Increasing the visibility and availability of such research to stakeholders, and most importantly ensuring that such research is relevant commercially (i.e. shown to work on a commercial scale) would be necessary, as would be dissemination by independent advisors (historically the extension services, though this is no longer the case in some partner countries) and access to monitor farms to showcase research and evidence.

The **expense/cost of implementing** plant teams was seen as a barrier, in particular the cost of seed mixes required. Although more diverse seed mixes can cost more to purchase, farmers also need to take into account the fertiliser, pesticide and other savings made due to the benefits of intercropping.

**Lack of support** and the lack of knowledge of agronomists in relation to intercropping were identified as barriers. In some cases, agronomists are also ‘on the journey’ alongside the farmer, with both learning from the mistakes and developing best practices together. This can result in the farmer feeling unsupported. Research and knowledge exchange around intercropping therefore also needs to be targeted at advisors as well as farmers.

**Crop-crop competition & yield suppression** is seen as a major barrier to farmers. This could be due to incorrect design of the team. For example, the interaction between seed rate and availability of nutrients can affect the degree of competition between crops. As another example, the interaction between cereals and grain legumes and the balance between barley and pea is very sensitive to precipitation levels. Also sowing densities or suitable team components (e.g. in Denmark it was suggested that spring triticale and lupin yield poorly on sandy soils) or management practices are not always adapted to plant team systems.

Whether **Lack of machinery** is solved but perceived, or unsolved, depends on the plant team in question. Regardless it needs to allow for variable drilling and harvesting requirements. For some plant teams, there are various machinery solutions available, although these can be expensive for some farmers; therefore supporting demonstration to help de-risk investment, simple solutions, multi-functional machinery solutions and financial support for investment would help. In the case of other plant teams, however, solutions are not available. For harvest, the same is also true, but can also be additionally dependent on whether a farmer has access to post-farm-gate processing methods and equipment to separate/manage the harvest. The cost of investment in machinery, and machinery suitable for use in the specific farmer’s conditions was also a considerable concern. While some machinery is available for some plant team systems in some areas, it nonetheless represents a significant investment for a farmer. Several potential solutions to help counteract the expense were identified, for example the development of sub-contractor options, co-operatives or machinery rental. The expense and shortage of good, skilled labour to use machinery and manage the system as a whole was also noted as a barrier to uptake. A suggestion was made that the use of robotics or miniaturisation of equipment could be a means of improving management potential in the field. However, the point was raised that such solutions might be limited in success as changing industry



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norms, for example down-sizing of machinery, may be difficult due to industry enthusiasm for large machinery.

**Market** and supply chain was raised several times. There is clearly not an established market or supply chain for most plant teams and current supply chains are used to receiving products harvested from monocultures and a more consistent and regular product. However, in Austria the Phaseolus/maize mixed cultures are a success story of the state of Styria. Here, a complete new value chain was built by Alwera AG and other stakeholders working together (e.g. the Chamber of Agriculture, who protected the traditional bean cultivar as Protected Designation of Origin) and the state of Styria (participated in trials). Most of the bean/corn cultivations were grown under contract and the harvested products from many farmers is delivered to one single point of access where the machines for separation/post-harvest processing are provided. Due to this, a lot of knowledge/best practice examples were gathered and are shared to all who were interested in growing that system (e.g. irrigation and fertilization trials, how to modify the machines for harvest or sowing). The interest of farmers in this system is high, because of a good price for the beans and a relatively low work input to the mixed culture system. Another example was raised during one the UK workshops, where a miller refuted that plant teams (mixed varieties in this case) were a problem as they were willing to take plant teams (assuming they knew what they were). It was reported in the UK that public perception and supermarket standards contribute to the market barriers. It was felt that while public perception of environmental mitigation and sustainability was increasing, this might not lead to profitability and market potential due to supermarket standards. The standards set by supermarkets were thought to, typically, be incompatible with the likely produce outcome of plant team usage. Frequently, farmer stakeholders felt that consumers wanted environmental responsibility while still demanding flawless produce, as encouraged by the supermarkets, and that the two were incompatible. A concerted shift in public perception may help add pressure on supermarkets. Revision of supermarket standards and acceptance of product (not just by supermarkets but also by consumers) was deemed critical.

**Labour** was associated with the belief that the added complexity of plant teams will take more time but also required more knowledge and advice. The labour force does not have the expertise to grow plant teams.

**Policy support** was a barrier that was not included on our list for discussion but did come up at a number of workshops. There is a real or perceived barrier that plant teams do not have policy support (i.e. through CAP).

The top 12 barriers were then grouped into five higher order categories of advice/education, agronomy, crop (i.e. plant-plant competition, yield suppression), and processing and economics (Figure 5), which showed that advice/education and agronomy each accounted for nearly a third of identified barriers. The remaining issues to do with crop competition (16%), processing complexity (12%) and the cost & economics (10%) were also evidently important but maybe not as close to the front of the stakeholder’s minds as advice and agronomy. Clearly these are not distinct areas as agronomy would be an important area for advice and education, as would be processing.



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When these grouped higher order categories[1] were separated into solved, unsolved and perceived, none were seen as predominantly solved although perceived barriers outweighed both solved and unsolved for crop interactions (Figure 6). Currently we would see a perceived barrier to be 'unsolved', as although there may be a solution, it has not yet found its way to the stakeholder who needs it. This does give an opportunity for DIVERSify (and our sibling project ReMIX) as technical guides and practice abstracts could focus on these areas where knowledge already exists but has not currently been made available to those who need it.

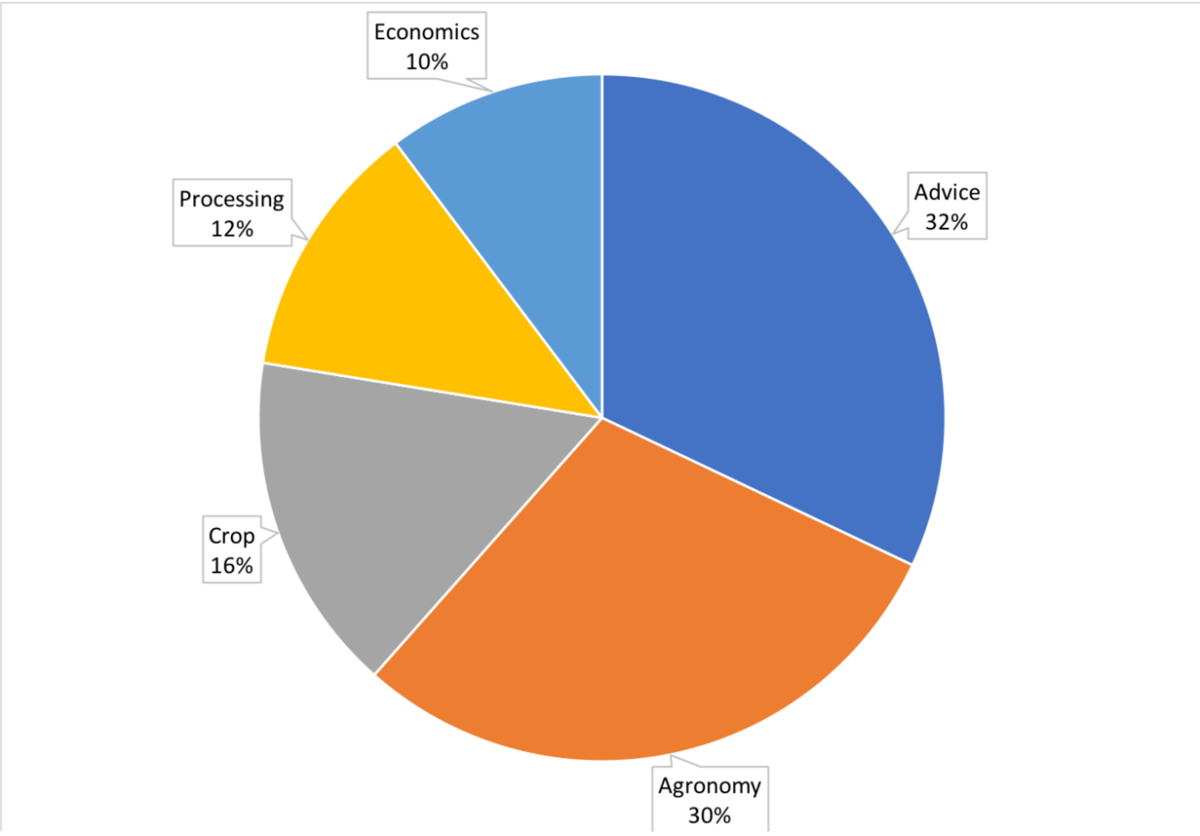


***Figure 5: The top 12 barriers to uptake of plant teams identified by stakeholders grouped into higher order categories.***

[1] Advice = Lack of advice, Lack of evidence, Lack of support; Agronomy = Harvesting complexity, Seeding/drilling complexity, crop management complexity, Weed control complexity, Pest/disease complexity; Crop = Crop-crop competition, Yield suppression; Processing = Processing complexity; Economics = cost.



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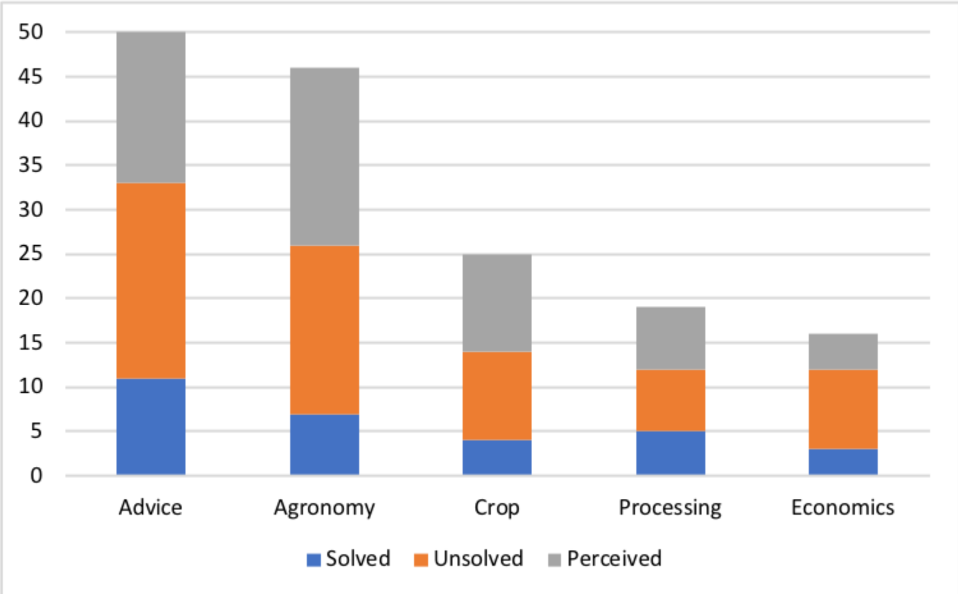


***Figure 6: The top 12 barriers to uptake of plant teams identified by stakeholders grouped into higher order categories showing if stakeholders believed these barriers to be solved, unsolved or perceived.***

### 3.5. Research Topics

The Participatory Stakeholder Workshops were also used to seek bottom up research themes and ideas from the stakeholders that would partly inform future research on experimental and theoretical approaches to optimise novel plant teams in WP2 (Task 2.4), WP3 (Task 3.2) and WP4 (Task 4.4). For WP4 the stakeholder workshops were the start of the process allowing the buddies to explain the participatory farmer (PF) research approach and to begin to build research teams and ideas that would then be submitted to WP4 PF research fund. Research ideas were identified at the workshops and can be found in Table 2 below where they are grouped broadly into themes.

***Table 2: Research ideas grouped by broad theme identified during participatory stakeholder workshops***

| **Research Topic** |
|---|
| **Crop Management** |
| Irrigation of barley/pea mixtures – when should this be done |
| Optimization of sowing strategy: species sowed separately or simultaneously (in relation to sowing depth and weed control) |
| Methods of cultivation |
| Identifying limits of mixture cropping without chemical inputs |
| Species mixtures of cereals: optimal proportions and properties |
| Phaseolus-maize mixtures, including harvest timings of the maize |
| Optimization of Cereal-Legume interaction to obtain LER>1 |



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| |
|---|
| How big should the difference be between maturing in different species (maximum) |
| Influence of species sown in separate rows or same rows on weeds and drought resistance |
| Do legumes mature faster in mixtures? |
| Identification of ideal varieties |
| Role in overcoming the 'yield plateau'. |
| Research which can clearly explain how and in what scenarios intercropping can maintain yield and improve soil health. |
| Yield quantity |
| Yield quality |
| Improved fodder quality |
| Harvest methods |
| Introducing innovative techniques to overcome harvest complexity of plant teams. |
| **Pest & Disease** |
| Potential of plant teams against ergot, mycotoxins. |
| Potential (or more specifically risk) of plant teams against slugs. |
| Plant teams as trap crops/companion plants, e.g. buckwheat, berseem clover or white mustard against flea beetle, and how to best manage the teams for this purpose |
| Dilution effect of mixed cropping on fungal pathogens and soil borne diseases |
| Soil borne diseases/crop rotation diseases |
| Synergies in relation to pests |
| Potato and radish mixes to reduce potato nematode prevalence |
| Identify species mixtures to include in vegetable rotations to help improve the establishment of the cash crop and reduce pests and disease to the crop. |
| Pest suppression |
| Crop rotations to control pests |
| **Weeds** |
| Weed management without chemicals in plant teams |
| Role in overcoming persistent weed issues, e.g. black grass, using companion cover-crops, e.g. berseem clover, to stabilise soil and suppress weed growth and establishment. |
| Use of diverse species mixtures which out-compete weeds (to benefit the cash crop). |
| Weed suppression |



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| |
|---|
| Winter mixtures to increase weed suppression (organic farmers) |
| Managing intercrops and cover crops for controlling weeds and increasing soil fertility without increasing worktime. |
| Introducing plant teams that can reduce weed emergence and the need to till soil. |
| Identifying crop teams effective in reducing chances of pest infestations in olive and almond orchards. |
| **Processing** |
| Methods to separate grains |
| Separation of cereals and legumes for human food production |
| Processing methods |
| Seed cleaning after harvest (equipment for this) |
| **Economics** |
| Economic aspects (costs) |
| Cost-benefit analyses |
| Interesting seeds are often expensive (legumes), and difficult to find in quantity (minor species often interesting for constraining conditions....). |
| Take into account planning and mechanisation, including cost-benefit analyses, in research |
| **Market** |
| Profitability and market availability study: assess the role of potential future subsidisation (e.g. after Brexit) to incentivise use of plant teams; examine market potential for plant team crops; role of plant teams as a means of overcoming the expense of more conventional ‘mixtures’. |
| Better cooperation with regards to sales |
| Marketing possibilities |
| Inclusion of the whole value chain, in particular processors |
| Added value for famers |
| Use of mixture products (difficulties in finding customers) |
| No market for mixed crops, and politics ask farmers to produce for the market |
| **Environment** |
| Erosion and chemical leaching control and reduction |
| Impact on soil structure (e.g. compaction, workability), and soil profile and general productivity (e.g. chemical balance, organic matter and moisture content, and management thereof). |
| Role of plant teams as a ‘feed’ for soils (industry currently feeds crops, but not soil). |
| N-dynamics: Does the N-uptake of the cereals stimulate the N-fixation of legumes? |



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| |
|---|
| Effect of inoculation on legume nodulation, nutrient uptake, yield and quality |
| Drivers for sustainability (again, in policy after Brexit). |
| Assess sustainability of mixtures |
| **Advice** |
| Wanted: New alternative mixtures/ Intercropping of many species/ More varieties in the same mixtures |
| More knowledge of mixing ratio between species in mixture (coupled to soil type, drought sensitivity, mutual competition) |
| More experience with new/different species combinations |
| Identification of ideal partner species (numerous requests), also depending on the soil types |
| Mixtures for mountainous regions |
| Cultivars more adapted to intercrops and to the new context (drought, less herbicides, P and N economy) |
| Mixed vegetal covers for other crops (orchards, vineyards,…) and for the recovery of burned areas after fires. |
| Identifying crop teams effective in building soil fertility in olive and almond orchards, while at the same time productive. |
| Introducing crop/s to team with wheat that can improve its productivity without limiting mechanical harvest. |
| Identify the best wheat, barley, faba bean and pea varieties for farms located in the inner part of the Marche Region |
| The best composition for the 3 Sisters (Corn/Bean/Pumpkin) |
| Identify species mixtures that require less chemical inputs in order to destroy them. |
| Evidence that it is working |
| Tool for exchanging practices and knowledge between farmers and with researchers |

## 4. Discussion

The objective of Task 1.1 was to identify tacit knowledge, bottom-up innovations, strategies and current farmer best practice in diverse cropping systems. We set about doing this by undertaking an ambitious series of participatory stakeholder workshops across the EU, Kenya and Palestine where we have identified and gathered a range of tacit knowledge including best practice (and practices to avoid) in the design and management of plant teams.

The numbers of stakeholders we accessed and engaged with the process (567) is significant and the range of consultation approaches devised to meet the local needs has meant that we have been able to get the best out of each individual area we worked in. It is also significant that the overwhelming majority of those who attended the workshops self-identified as farmers (or advisors), which also



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meant that we had access to the stakeholder groups that we were most interested in consulting. It was also interesting that only about half of these farmers were currently growing or had previously grown plant teams, which suggests that there is an interest from other farmers in diversifying their systems by growing plant teams.

The process that we undertook with each workshop was successful to a lesser or greater extent, but we were able to identify innovations, barriers and research from all workshops. The reasons why it was more successful at some than others are not easily identifiable, but could be due to experience of the buddies at running such workshops; for many, this participatory approach is a new way of working, and although training and information was provided, it is a skill that improves over time and practice. We identified a range of innovations across the different pedo-climatic zones, in particular many plant teams (130) that are already being used by farmers and a range of approaches that worked and some that were not so successful. Most of these involved cereals of some type, but in both Kenya and Palestine vegetable and agroforestry plant teams were more common and could inform work within WP2, WP3 and WP4 of DIVERSify. There were some conflicting successes and failures with the same plant teams, reflecting the complexity of farmed systems, which depends not only on peo-climatic zone, but also on individual farm characteristics, soils and other local conditions, as well as the farmer's experience, skills and knowledge.

Barriers to uptake of plant teams were nearly as diverse as the plant teams themselves. What is very clear is that there is a pent up desire to use plant teams from the stakeholders who engaged with the workshops, but that a lack of evidence and advice in crop production is a major barrier to the uptake, and stakeholders want this advice to be tailored to their own situation and conditions. Clearly it would not be possible for DIVERSify to provide tailored information, but there is already a lot of information available on yield effects, agronomy, pest, disease and weed management in plant teams that we could synthesise into practice abstracts and other outputs from the project (see below). The costs of production and machinery were also often raised. We will gain more insight into the costs of production from Task 1.2 of DIVERSify, while the potential for machinery adaptations to overcome barriers to plant team cropping will be examined in WP4 (Task 4.5). However, we know there is likely to be machinery already available in many areas, so this could be a focus of our field days during the project. Policy support was raised as a barrier to the uptake of plant teams. Our work within DIVERSify will produce policy recommendations that will hopefully provide evidence to policy makers for reasons why policy (e.g. CAP) support should be directed towards plant team cropping, but before that a practice abstract could be produced to provide information on what support currently exists.

Markets for plant teams were also seen as barriers to uptake. Clearly this will be dependent on the individual plant teams, their intended use and the local market. The Austrian workshop identified a successful marketing approach and DIVERSify will work closely with DiverIMPACTS and Diverfarming to ensure that the information from DIVERSify informs their work and their work informs our stakeholders.



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The participatory stakeholder workshops also provided a range of research ideas that will feed-in via this report (and the workshop reports) to WP2, WP3 and WP4. The ideas were wide ranging from production barriers, pest, disease and weed management issues, and marketing and information/advice problems. The workshops were the start of the process and many groups of participatory farmers have already come together and submitted funding applications to the DIVERSify Participatory Farmer fund (in WP4), while others are using their own resources or seeking other funding mechanisms (e.g. the Innovative Farmers programme in the UK[2]) to support farmers who wish to pursue and develop plant team cropping approaches.

In summary, the national stakeholder workshops have, therefore achieved the key objective to identify strategies and best practice for cropping plant teams to inform work in WP2, WP3 and WP4. Further, the workshops have facilitated the engagement of 'Citizen Science' participatory research farmers (PFs) to carry out participatory research projects (in WP4, Task 4.3) through on-farm experiments and demonstrations. At an additional meeting of the UK Innovative Farmers programme, farmers were consulted on the standard protocols for use by PFs, developed by WP4 in collaboration with WP1, which provided useful feedback on important revisions to the protocols. The workshops also provided an array of knowledge exchange material in the form of images and audio-visual recordings of example plant teams from across the project partners for use in Task 1.3.

The findings of the national stakeholder meetings will be shared with target audiences in several ways. In recognition of their role of in co-producing the report content, the reports from individual workshops are being shared with meeting attendees. This synthesis report (D1) will become publicly available after it has been approved, and will be made available on the DIVERSify project website. Workshop buddies are starting to plan follow-on activities to facilitate two-way benefits sharing by feeding information back to stakeholders, for example by running a second workshop to provide updated information as the project progresses, or via regional and national industry and stakeholder events (WP4, Task 4.6). These will be aligned with other project deliverables for dissemination and knowledge exchange, including EIP-AGRI Practice Abstracts (D1.4), project mini-documentaries (D1.3), a farmer guide on plant teams (D1.5), and a 'trouble-shooting matrix' of precision-agriculture solutions to plant team cropping (D4.6). The findings presented in this synthesis report will also be shared with related projects in the 'Crop Diversification' cluster (SFS-2, SFS-26, RUR-6) and other interested projects via project communication links being established in WP6 (Task 6.4) to ensure information flow on activities that are relevant across projects.

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[2] https://www.innovativefarmers.org/find-a-field-lab/



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## Annex 1: DIVERSify stakeholder workshop & participatory guide

# DIVERSify

# Stakeholder Workshop & Participatory Research Guide

# V1.4

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## Annex 2: Stakeholder workshop report template

DIVERSify T 1.1 Stakeholder Workshop Report

WORKSHOP INFORMATION

**Partner short name and number:**

**Lead investigator (Buddy):**

**Date of workshop:**

**Location of meeting (Town/Country):**

**Numbers attended:**

**Type and experience of stakeholders (please ask stakeholder to self-identify one type and whether they currently, previously or never used plant teams):**

| Type | Currently use plant team | Previously use plant teams[1] | Never used plant teams |
|---|---|---|---|
| Farmer | | | |
| Advisor/Agronomist | | | |
| Plant breeder | | | |
| Seed company | | | |
| Policy maker | | | |
| Researcher | | | |

WORKSHOP APPROACHES USED:

*Please give a brief description of what facilitation tools and approaches you used. In your opinion, what was successful and what was not so successful – refer to the "DIVERSify Stakeholder Guide" and the "Facilitation Tools for meetings and workshops" document).*

[1] where stakeholders have stopped using plant teams please find out why.

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## Annex 3: List of plant team innovations identified during the participatory stakeholder workshops

| Plant Team | Group |
|---|---|
| Barley (spring)/lucerne | 1. Cereal |
| Barley (spring)/pea (spring) | 1. Cereal |
| Barley (spring)/red clover/rye | 1. Cereal |
| Barley (winter)/pea (winter) | 1. Cereal |
| Barley variety mixtures | 1. Cereal |
| Barley/faba bean | 1. Cereal |
| Barley/field pea | 1. Cereal |
| Barley/field pea (whole crop). | 1. Cereal |
| Barley/lupin | 1. Cereal |
| Barley/oat/field pea | 1. Cereal |
| Barley/oat/field pea/lupin/mustard/linseed (whole crop/to provide fat) | 1. Cereal |
| Barley/oat/pea | 1. Cereal |
| Barley/pea | 1. Cereal |
| Barley/pea/bean | 1. Cereal |
| Barley/vetch | 1. Cereal |
| Barley/wheat/vetch | 1. Cereal |
| Cereal/lentil | 1. Cereal |
| Cereal/lupin | 1. Cereal |
| Maize/bean/cassava/bananas/soya bean | 1. Cereal |
| Maize/bean/cowpea | 1. Cereal |
| Maize/bean/cowpea/calliandra (*Calliandra calothyrsus*)/lucaena (*Lecaena leucocephala*)/Gravillea (*Grevillea robusta*) | 1. Cereal |
| Maize/bean/Cowpea/Groundnut/ Calliandra (*Calliandra calothyrsus*)/ Luceana (*Luceana lucocephala*)/ Grevillea (*Grevillea robusta*). | 1. Cereal |
| Maize/bean/Cowpea/Groundnut/Calliandra (*Calliandra calothyrsus*)/ Luceana (*Luceana leucocephala*)/ Grevillea (*Grevillea robusta*). | 1. Cereal |
| Maize/bean/Ipomea (*Ipomea batatas*) Tephrosia (*Tephrosia candida)*/vogelii) | 1. Cereal |
| Maize/bean/Ipomea (*Ipomea batatas*)/Tephrosia (*Tephrosia candida)*/vogelii). | 1. Cereal |
| Maize/bean/millet/sorgum/ground nuts/soya bean | 1. Cereal |
| Maize/bean/millet/sorgum/ground nuts/soya bean. | 1. Cereal |
| Maize/bean/Napier grass/Mulato grass (*Brachiaria* sp.)/Desmodium (*Desmodium uncinatum*) - push/pull | 1. Cereal |


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| Maize/*Phaseolus vulgaris* | 1. Cereal |
| Maize/*Phaseolus coccineus* | 1. Cereal |
| Maize/*Phaseolus coccineus*/Buckwheat | 1. Cereal |
| Maize/*Phaseolus coccineus*/Phacelia | 1. Cereal |
| Maize/Phaseolus/pumpkin | 1. Cereal |
| Maize/sorghum | 1. Cereal |
| Maize/soya bean/groundnuts/bean/cowpea/ pigeon pea (*Cajanus cajan*) | 1. Cereal |
| Maize/squash | 1. Cereal |
| Oat (spring)/bean | 1. Cereal |
| Oat (spring)/birds-foot trefoil/two white clovers | 1. Cereal |
| Oat/barley | 1. Cereal |
| Oat/barley/wheat/triticale/field pea | 1. Cereal |
| Oat/chickpea | 1. Cereal |
| Oat/faba bean | 1. Cereal |
| Oat/lentil | 1. Cereal |
| Oat/lupin | 1. Cereal |
| Oat/pea | 1. Cereal |
| Oat/phacelia/berseem clover/moha | 1. Cereal |
| Oat/triticale | 1. Cereal |
| Oat/vetch | 1. Cereal |
| Oat/vetch/linseed/berseem clover/buckwheat | 1. Cereal |
| Rye (winter)/pea (winter) | 1. Cereal |
| Rye (winter)/vetch (winter - hairy vetch) | 1. Cereal |
| Rye (winter)/vetch (winter - Pannonian) | 1. Cereal |
| Rye/vetch/pea | 1. Cereal |
| Sorghum/Phaseolus coccineus | 1. Cereal |
| Sorghum/Phaseolus coccineus/Buckwheat | 1. Cereal |
| Sorghum/Phaseolus coccineus/Phacelia | 1. Cereal |
| Triticale (winter)/pea (winter) | 1. Cereal |
| Triticale (winter)/vetch (winter - hairy vetch) | 1. Cereal |
| Triticale (winter)/vetch (winter - Pannonian) | 1. Cereal |
| Triticale/faba bean | 1. Cereal |
| Triticale/lupin | 1. Cereal |
| Triticale/pea | 1. Cereal |
| Triticale/wheat | 1. Cereal |
| Wheat (bread)/faba bean | 1. Cereal |
| Wheat (durum)/faba bean | 1. Cereal |
| Wheat/alfalfa | 1. Cereal |
| Wheat/barley/vetch/clover | 1. Cereal |



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| Wheat/clover | 1. Cereal |
| Wheat/faba bean | 1. Cereal |
| Wheat/lupin | 1. Cereal |
| Wheat/pea | 1. Cereal |
| Wheat/vetch | 1. Cereal |
| Buckwheat/berseem clover | 2. Pseudo-grains |
| Buckwheat/faba bean | 2. Pseudo-grains |
| Buckwheat/vetch | 2. Pseudo-grains |
| Oilseed rape/berseem clover/buckwheat | 2. Pseudo-grains |
| Oilseed rape/camelina/white clover | 2. Pseudo-grains |
| Oilseed rape/clover | 2. Pseudo-grains |
| Oilseed rape/fenugreek/lentil | 2. Pseudo-grains |
| Oilseed rape/lucerne | 2. Pseudo-grains |
| Oilseed Rape/Mustard/Lucene | 2. Pseudo-grains |
| Oilseed rape/oat/fenugreek | 2. Pseudo-grains |
| Oilseed rape/pea/faba bean/red clover/berseem clover | 2. Pseudo-grains |
| Oilseed rape/vetch/buckwheat | 2. Pseudo-grains |
| Oilseed rape/white clover | 2. Pseudo-grains |
| Oilseed rape/fenugreek | 2. Pseudo-grains |
| Soya/false flax | 2. Pseudo-grains |
| Sunflower/buckwheat | 2. Pseudo-grains |
| Sunflower/clover | 2. Pseudo-grains |
| Cereal/field pea/lupin (whole crop) | 3. Forage/grassland |
| Clover/grass | 3. Forage/grassland |
| Grassland mixtures | 3. Forage/grassland |
| species rich leys | 3. Forage/grassland |
| Stubble turnips/berseem clover | 3. Forage/grassland |
| Cabbage/radish | 4. Vegetable |
| Camelina/nigella | 4. Vegetable |
| Cauliflower/faba bean | 4. Vegetable |
| Cauliflower/tomato | 4. Vegetable |
| Faba bean/cauliflower | 4. Vegetable |
| Faba bean/grass pea | 4. Vegetable |
| Faba bean/onion | 4. Vegetable |
| Lentils/camelina | 4. Vegetable |
| Lettuce/faba bean | 4. Vegetable |
| Lettuce/fennel | 4. Vegetable |
| Onion/faba bean | 4. Vegetable |
| Onion/garlic | 4. Vegetable |
| Onion/radish | 4. Vegetable |



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| Onion/spinach | 4. Vegetable |
| Pea/faba bean | 4. Vegetable |
| Pea/false flax | 4. Vegetable |
| Peas/faba bean | 4. Vegetable |
| Potato/faba bean | 4. Vegetable |
| Potato/parsley | 4. Vegetable |
| Safflower/peas/spinach | 4. Vegetable |
| Sesame/faba bean | 4. Vegetable |
| Zucchini/eggplant | 4. Vegetable |
| Cover crops 3/5 spp | 5. Other |
| Intercropping | 5. Other |
| Safflower/pea | 5. Other |
| seed mixture contains 31 different plants (most domesticated/e.g. buckwheat/different clover species/blueweed | 5. Other |
| Tithonia (*Tithonia diversifolia*)/Calliandra (*Calliandra calothyrsus*)/Sesbania (*Sesbania sesban*) | 5. Other |
| undersowing with a variety of clovers: white/red/berseem/birds-foot trefoil | 5. Other |
| Wine/legume/tree | 6. Agroforestry |
| Agroforestry | 6. Agroforestry |
| American red oak/dogwood/cherrywood | 6. Agroforestry |
| Banana/papaya/cassava/ Ipomea (*Ipomea batatas*)/Crotalaria spp./water melon/courgettes | 6. Agroforestry |
| Bananas/papaya/water melon/oranges/mangos | 6. Agroforestry |
| Crotalaria (Crotalaria spp.)/Gliricidia (*Gliricidia sepium*)/ Soya bean/Cassava | 6. Agroforestry |
| Dogwood/crop | 6. Agroforestry |
| Oak/crop | 6. Agroforestry |



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