CORE organic

Overview of farmers expected benefits of diversification Report on national stakeholder involvement

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Summary

Seven different European countries are participating in a transnational project SUREVEG (Strip-cropping and recycling of waste for biodiverse and resoURce-Efficient intensive VEGetable production). SUREVEG focuses on developing and implementing new diversified, intensive organic cropping systems using strip-cropping and fertility strategies from plant-based fertilizers for improved resilience, system sustainability, local nutrient recycling and soil carbon storage. This study focuses on providing references concerning benefits and drawbacks of strip-cropping and plant residues for soil fertility in field vegetable production at medium sized organic farms. Specifically to identify local stakeholders' knowledge and develop ideas in an iterative approach on benefits of diversification in space, time and genes, and plant-based fertilizers. Activities included workshops with stakeholder involvement, to increase awareness and dialogue on strip-cropping and identify local technical and practical knowledge on organic systems. A survey was developed as a tool for having a more systematic discussion with the stakeholders in the workshops. With a selection of questions to analysis the performance criteria of strip-cropping in farmers perspective a transnational comparison of the findings is presented,. The workshops and surveys were executed in six different European countries. In total approximately 140 farmers and other stakeholders were participating in the workshops and 38 farmers filled out the survey.

The outcome of the survey and workshops in the different countries suggests that most farmers think fairly equally about the added values of strip-cropping. Higher resistance of crops against plagues and diseases is ranked high in all countries. This is followed by soil quality and benefits from increased agroecosystem biodiversity. Only Belgian farmers mentioned higher yield as an important added value, however certain individual farmers in different counties have ranked it high as well. Divers answers were given on the question on the most suitable width of the cropping-strips. For farmers this depends mostly on the machinery farmers have available for their daily practices. For the importance of crop traits, the efficient use of nutrients and resilience against diseases and plagues scored high throughout all countries investigated. Only Italian farmers mentioned nitrogen-fixing capacity as an important trait. The farmers in all countries thought the same about expected bottlenecks for implementing strip-cropping system: harvesting, weed control and technical problems.

The information obtained by the survey and workshops in the different countries is input for the experimental design of field trials in each country. Some countries changed their set-up for following years.

To conclude, in the participating countries, the use of strip-cropping is still limited. The farmers participating, consider strip-cropping a promising innovation. However, a lot of basic questions about strip-cropping still need to be answered for farmers before implementing strip-cropping. Farmers in every country will benefit from a database of best crops combinations. In Finland, the farmers explicitly mentioned the need of good companion crops for Brassicaceae and Apiaceae vegetables (suitable trap crops).

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1. Introduction

1.1 Background

Organic vegetable production, in the top five of organic product sales (Willer and Lernoud, 2016), generally gives lower yield than the conventional one (ICROFS, 2015). Organic production is very intensive and specialized, and relies on high nitrogen (N) and phosphorus (P) inputs of external fertilizers. Competition between the two intercropped species is a critical factor that must be controlled to achieve acceptable production yields of both crops. Competition can be aboveground for light but also belowground on water and nutrients, and management options for competition control consist of e.g. species choice, displacement of sowing time and root cutting aiming to restrict the growth of the strongest competitor (Canali et al., 2017; Båth et al., 2008). Recent EU-wide studies documented innovative organic approaches by strip-cropping with yielding crops alternated with 'service crops', i.e. crops for building soil fertility. Approaches were based on control of plant competition and complementary ecological niches by e.g. legumes or deep rooted cover crops (Canali et al., 2017, Xie et al., 2017a,b).

Pests and diseases are often the main causes of yield and quality loss in organic production (Bouws et al., 2008). Continuous increases in scale of production induced the agro-ecological systems to become 'ecological deserts', even in organic ones, making them more dependent on biopesticides. Instead biodiversity can be a key-function in system resilience (Bommarco et al., 2013; Cardinale et al., 2006) and biodiversity of pollinators has been linked to increased yields in insect pollinated crops (Garibaldi et al., 2013). Agroecosystem diversification practices can support the agroecosystem services of natural biological control (Jonsson et al., 2014) and insect pollination (Garibaldi et al., 2013). Strip-cropping can be considered as the agronomically and economically most feasible proxy for natural plant diversity (Pardon et al., 2016), enhancing genetic diversity of local ecological communities and promoting overall biodiversity at the landscape level (Tscharntke et al., 2012). Strip-cropping potentiates beneficial crop traits and their interactions and complementarities within field plots, through (i) prevention of the pest or pathogen finding hosts and (ii) enhancement of antagonists and natural enemies by resource diversity Tylianakis et al., 2008). For the first mechanism, discontinuity of the host in time and space is important. For the second, continuity for the survival of antagonists and natural enemies is important.
Since knowledge is lacking of highly productive strip-cropping systems, seven different European countries are participating in a transnational project SUREVEG (Strip-cropping and recycling of waste for biodiverse and resoURce-Efficient intensive VEGetable production). SUREVEG focuses on developing and implementing new diversified, intensive organic cropping systems using strip-cropping and fertility strategies from plant-based fertilizers for improved resilience, system sustainability, local nutrient recycling and soil carbon storage.

Crop uniformity is necessary for the current large-scale mechanisation. Previous attempts to implement strip-cropping in the agricultural production have stranded on the lack of machinery that can handle the heterogeneity in time and space of strip-cropping systems. New machinery is needed based on state-of-the-art technology for automatization, sensors and digital solutions that facilitates 'diversity farming'. This could be autonomous crop management machines using camera or sensor recognition of crops.

1.2 Objectives

The overall hypothesis of SUREVEG is that intensive strip-cropping systems of two crops of vegetables grown together in alternating rows or small strips in combination with fertility strategies based on soil-improvers will (i) increase crop marketable yields, (ii) increase above- and belowground functional biodiversity, and (iii) increase soil fertility and C storage, nutrient use efficiency and agro-ecosystem cycling of nutrients.

To meet the interwoven needs of the organic vegetable sector comprising ecological intensification, resilience, fertilization and contribution to common goods, the aim of SUREVEG is to improve productivity,

biodiversity and soil fertility, decreasing use of non-organic fertilizers and bio-pesticides, and decreasing environmental and climate impact in intensive organic vegetable cropping systems.

The objectives of this study was to provide references concerning benefits and drawbacks of strip-cropping and plant residues for soil fertility strategies in field vegetable production at medium sized organic farms. Specifically to identify local stakeholders' knowledge and develop ideas in an iterative approach on benefits of diversification in space, time and genes, and plant-based fertilizers.

The specific objectives are to:

- Identify local knowledge about organic vegetable cropping and benefits of diversification in space, time and genes.
- Identify requirements for successful combination and pre-conditions in fertilizer use.
- Develop ideas for novel strip-cropping systems within an iterative co-design approach with stakeholders.
- To articulate stakeholder needs and identify agronomic and institutional barriers for adoption of strip-cropping of yielding vegetable crops and to implement results.

2. Methodology

2.1 Workshops

Activities included workshops with stakeholder involvement, to increase awareness and dialogue on strip-cropping and identify local technical and practical knowledge on organic systems. The multi-actor workshops in each country focused on local practices with a selected group of organic farmers within a region. Analysis of performance criteria discussed with the stakeholders were linked to i) growing crops in alternating rows or strips, ii) identify their choice of crops, species and management, iii) identify expected agroecosystem services and iv) composition of plant-based fertilizers. Farmer groups, advisors, and other relevant stakeholders were consulted.

2.2 Survey

For a more systematic discussion with the stakeholders in the workshop and for a transnational comparison, a survey was developed (Appendix 1). The survey included a selection of questions to analysis the performance criteria of strip-cropping in farmer's perspective.

Questions included:

- Growing crops in alternating rows or strips;
- Stakeholders choice of crops, species and management;
- Expected agroecosystem services, including subsequent crop effects;
- Influence of marketing options;
- Composition of plant-based fertilizers.

Due to very different pre-conditions in farmers' involvement in the research on strip-cropping, the number of farmers included in the survey differed per country. No quantitative analyses on the survey was intended but results were used to develop ideas for local adapted strip-cropping within an iterative multi-actor process in each country hosting a field experiment. This implies that farmers and stakeholders, who were present at the workshops, gave their expert knowledge about strip-cropping systems and plant-based fertilizers. Moreover, stakeholders could discuss among the group the advantages and disadvantages using the outcomes of the survey as a guidance. The output was used for a discussion on the design, monitoring and evaluation of the strip-cropping trial in each country. In some countries, the discussion led to an adjustment of the field trial for the following year like an adjustment of crops tested or change in time of sowing the crop.

3. Country reports

3.1 National report on Belgium – Joran Barbry

Description of the workshops in Belgium

In 2018, one workshop was organized October 10th. Additionally, two field visits were organized to the Belgian trial site at the trial farm of Inagro, respectively on June 27th and October 4th. Twice a year, open field days are organized at the trial farm of Inagro in Beitem, Belgium, to show interested farmers and other stakeholders which trials we are running, to inform them about first results and to get information from our target audience regarding new trial possibilities and methods.

27/06/2018
Approximately 80 people attended the first open field day of 2018, on the 27th of June. At the start of the meeting, survey documents concerning strip-cropping were distributed to spike the interest of the attendees. During the visit to the strip-cropping field, different topics concerning strip-cropping were discussed. Most farmers are interested in the idea of strip-cropping, especially concerning the possible benefits for both crop performance and biodiversity. However, they are not sure that strip-cropping is feasible on a large scale with regard to efficiency of labor, weed management and harvesting. The width of the strips is clearly an interesting point of discussion and most farmers would opt for strips with the width of the machines they are using for weeding to gain efficiency. They feel that new machines and techniques are needed to be able to grow crops in narrow strips or in alternating rows.

04/10/2018
During the second open field day of 2018, the trial was revisited by approximately 90 visitors. At that time, the crops were almost ready to be harvested. No visible differences with regard to crop status were found between the monocropped plots and the strip-cropping plots. The attendees were very interested to know how we had taken care of the two crops in the trial and how we were planning on harvesting. The same thoughts and remarks concerning fear for loss of efficiency and need for new technology in a strip-cropping system with alternating rows were repeated.

10/10/2018
Since a couple of years, we have so-called “organic enterprise networks” in Flanders, Belgium. These networks bring farmers with similar crops, farm sizes and target markets together at several times each year to discuss the course of the season and different, interesting topics. One network is focused on small-scale farms that produce mainly for the short-chain market. These farms typically have a much diversified crop scheme and use a bedding system as growing method, which resembles to a strip-cropping system. A second network focuses on medium to large-scale farms that produce for the long chain market or for the frozen food industrial firms. The workshop was organized during a session of the second network at a farm of a participant in Moeskroen.

Strip-cropping was chosen as the topic of discussion for this session. 12 farmers attended this workshop. We used different simple questions to start of the discussion. 8 farmers think strip-cropping could be beneficial for organic cropping systems and the most important benefits are higher yield, more resilient crops and a higher soil and above ground biodiversity. The main problems for the implementation of strip-cropping on a larger scale are, according to the participants: loss of efficiency, cost of implementation (RTK GPS necessity), implementation of irrigation, different needs for weed management may lead to more passes with heavy machinery, loss of scaling efficiency and rotation limitations.

The workshop participants think that research should focus on finding suitable crop combinations, custom technology (mechanisation and robotization) and on the economic impact of implementing strip-cropping systems.

General information

The survey was held among stakeholders involved to (1) identify their knowledge, (2) identify stakeholder's ideas on benefits of diversification, and (3) identify pathways towards increased use of strip-cropping. In Belgium, 11 farmers filled out the survey. Of these, nine had heard about strip-cropping before and four would like to know more about it. Five did not think strip-cropping is feasible and two hadn't heard of strip-cropping before the survey.
Two participants would like to try strip-cropping on their farm, 4 answered 'maybe' and 5 are not prepared to try out strip-cropping.

Added value

When asked about the expected added value of strip-cropping, most farmers chose the higher resistance of crops against pests and diseases as the most important added value. Higher yield and higher biodiversity were also chosen as important expected added values. Three farmers chose improved soil quality as an important gain.

Crops

Participants had the option to write down suitable combinations for strip-cropping and to give a reason why they think the combination would be beneficial (Table 1). Not all participants had suggestions for suitable combinations.

Table 1: Suitable combinations according to the Belgian farmers.

Combination	Crops	Reason
1	Parsley + bunch onion	-
2	Carrot + onion	To control damage by the carrot fly.
3	Potato + leek	-
4	Leek + celeriac	Same inter row spacing, same growth season.
5	Maize + courgette	The maize could act as a windscreen to avoid wind damage on courgette.
6	Wheat + potato	Feasible weed control in wheat with harrowing machine.
7	Combinations of different varieties of 1 crop	To maintain resistance to certain diseases.

Some suggestions were made as to which crop traits are important when considering combinations of crops. Overall, all suggested the farmers marked crop traits as quite important. The most important trait is the resilience against diseases and plagues, followed by satisfactory root system and efficiency of nutrient use and the stability of the yield. Nice taste and water use efficiency given the lowest mean score of 3 out of 5.

Management

When asked about the suitable width of strips, three farmers chose 3 metres as the best width, two farmers chose six, one person thinks alternating rows is the best option and one person chose a width of more than 12 metres.
The most important bottleneck for the implementation of strip-cropping is the harvesting, followed by customized techniques, planting, and sowing. Weed control, pests, and diseases is each chosen one time by a farmer. Some farmers added extra bottlenecks: more soil compaction due to more actions, efficiency, irrigation, use of netting.

Cover crops

Most farmers use cover crops as an intermediate crop in their rotation. The farmers who answered "no" either have too little acreage or are planning to start using cover crops. Improving soil quality is the main reason for the use of cover crops followed by the suppression of weeds and the prevention of soil erosion. All farmers use different types or mixtures of cover crops. All suggested cover crops were chosen at least once (except for Westerworld's ryegrass): Fodder radish, English ryegrass, Yellow mustard, Italian ryegrass,

Red clover, Fodder winter rye, White clover and Phacelia. Some farmers added other crops: Alexandrine clover, Vetches, Japanese oats, Leaf rasas, other grasses.

Specific country remarks

In Belgium, there are quite a few rather small “Community supported” farms. These farms are special because they want to provide their customers with fresh produce during the entire year. This means that they have a lot of different crops on a small scale at any given time in the year. This combined with the typical bedding cropping system, means that the crop system of these farmers is closely resembling to strip-cropping. Until now, the combinations of crops, which are put next to each other, are not always based on compatibility of the crops, but are either arbitrary or based on different types of crops, which are put together, different cropping seasons. These farmers could benefit from the output of our project to implement the best possible combinations of crops on their farms.
The medium and larger scale farmers in Belgium are interested in strip-cropping for the added value of resilience and biodiversity, but they are quite sceptical with regard to efficiency and other important aspects such as irrigation, mechanisation. The output of the project will surely help these farmers to understand and to successfully implement strip-cropping.

Many Belgian farmers are already using cover crops and are trying new mixtures of crops to find the best solution for their crop rotation, soil requirements etc.

Conclusion and implementation of the outcome in the field

Higher resilience of crops or of the cropping system is the most important expected added value of a strip-cropping system according to the participants. The inherent resilience against pests and diseases of the crops was chosen as the most important crop trait. The Belgian participants mainly use cover crops to improve the soil quality.

In 2018, a split plot trial with two factors was conducted in Belgium. The main factor was the cropping system: monocropped leek and celeriac and a strip-cropping object with alternating rows of leek and celeriac. The subfactor was a differentiation in fertilizers products, a purely plant based compost, a plant and straw manure based compost and straw manure. This trial design will be repeated in 2019.
In Belgium, most farmers are interested in strip-cropping as a new cropping system, but they have many basic questions and are sceptical about the easiness of implementation. With these trials, we hope to be able to show the importance and the added value of strip-cropping on some aspects: quality, pest and disease resilience, yield and higher biodiversity

The workshop and the survey show that, for Belgian farmers, a lot of basic questions about strip-cropping still need to be answered. Small-scale farmers would benefit from an easy to use database of compatible crops for strip-cropping in different environments and seasons. Larger scale farmers could be helped with guidelines, advice and a list of needs to successfully implement strip-cropping. Therefore, more research and trials are needed to fuel this advice and to establish useful information, targeted at specific cases.

3.2 National report on Italy – Alessandra Trinchera

Description of the workshop in Italy
In 2018, one workshop about strip-cropping was organized in Italy.

05/07/2018
The Info Day *"Development in organic production: the research meet the organic operators"* was organized in field, at the Council for agricultural research and economics – Centre for horticultural and fruit crops (CREA–OF) in Monsampolo del Tronto (AP, Italy), with the aim to i) promote the crop diversification through strip-cropping, intercropping, cover crops, etc.; ii) propose alternative fertilization approaches in Mediterranean organic vegetable systems, and iii) increase more and more researchers and stakeholders interaction for innovation of the organic farming sector.

During the morning, a number of research projects were presented to the farmers by several researchers from Italian Institutes and Centres, international network, national and European organic associations, all with the aim to identify the best strategies to overcome challenges imposed by the current climatic change, taking into consideration the crop diversification coupled with alternative fertilization approaches. In particular, among the others (such as LIVESEED, INNOVABIO and DIVERIMPACTS), the SUREVEG project *"Strip-cropping and recycling of waste for biodiverse and resource-efficient intensive vegetable production"* was described to the audience by the CREA researchers: the main SUREVEG objective is to develop and implement organic vegetable strip-cropping systems, applying fertilizers and soil improvers of plant origin for increasing the resilience of the agroecosystem, the nutrient recycle, the rhizosphere interactions and the landscape biodiversity. In the afternoon, the group of farmers and researchers went outside to visit the fields of the MO.VE.LTE. long-term experiment of Monsampolo del Tronto (AP, Italy) of the CREA. The SUREVEG field trial was shown, by describing the considered two factors to be evaluated: i) the effect of strip-cropping (faba bean - tomato), compared to both the monocrops, and ii) the fertilization by compost of plant origin, compared to the dried animal manure, usually applied in Italy. The legume flattening under the tomato strips was performed as valuable choice to support nitrogen supply to the cash crops.
As expected from SUREVEG participatory approach, during the Info Day many organic farmers, organic associations representative, fertilizers producers and researchers discussed a lot in field, bringing an active contribution based on their personal experience and taking information on potential advantages and disadvantages of proposed agronomic practices.
At the end, the farmers were pushed to participate to the SUREVEG survey, which was sent to them in the following days.

General information

In Italy, a survey was held among farmers who accepted to participate. We asked them to give us information on their knowledge on alternative crop diversification strategies, the most promising plant-plant combinations and management of strip-cropping, but also on the obstacles and bottlenecks, they found in their everyday field experience. The survey was filled out by a total of five organic farmers, two from Marche and one from Lazio Regions (mainly vegetables production, Central Italy), two from Apulia Region (mainly cereal production, Southern Italy).
The 40% of the interviewed farmers had heard about strip-cropping and were interested in implementing it in the future, while the other 60% already applies the strip-cropping in their farms.

Added value

The farmers were asked to give their opinion about the expected added value of strip-cropping.
They considered as most important added values:
i) the increase of agroecosystem biodiversity (80%);
ii) the improved system/crop resilience (60%);
iii) the highest resistance of crops against plagues and diseases (60%).
Less importance was given to the role of strip-cropping on improving soil quality (40%) and crop yield (20%).

Crops

The farmers had to propose suitable crop combinations in strip-cropping on their experience or knowledge, giving also a reason for those choices. In Table 2, the crops combinations selected by the interviewed farmers are reported. Some of the farmers suggested three different crops alternating each other (combinations 5 and 8).

Table 2: Suitable combinations according to the Italian farmers.

Combination	Crops	Reason
1	Alfalfa + wheat on bare soil	Foliar systems of both the crops are non-invasive, alfalfa cycle is lengthened, and the field is cleaned up by weeds thanks to the medical. They are threshed together and only after the seeds are separated
2	Bean + corn	Corn sustains the bean and the bean improves soil fertility
3	Pea + barley	They are similar in dimension and harvesting time
4	Clover + wheat	N-fixation by clover
5	Perennial legumes + sunflower	Similar fertilization and field coverage
6	Tobacco + corn	The corn acts as a windbreak and protects tobacco leaves.
7	Marjoram + tomato	The marjoram has a repellent action against insects
8	Tomato-pumpkin-string beam Lettuce-carrot-chicory Fennel-cauliflower- radicchio	To increase the agroecosystem resilience

Regarding the potential effect of crop traits to be considered in selecting combination for strip-cropping, the most relevant crop trait mentioned were ability of foliar system to be non-invasive, N-fixing capacity, comparable nutrient demand, field coverage and harvesting time, repellence action against insects. Crop traits related to water use efficiency and root apparatus development were not considered as key-factors.

Management

Regarding the mechanisation in strip-cropping cultivation, farmers had to answer to a question regarding the most suitable system (alternating rows or bed-by-bed). Only one farmer selected the alternating rows, while the other selected 3 m and 12 m strip widths as the most suitable systems.
Regarding the second question about the foreseen difficulties with implementing strip-cropping as a management strategy, 80% of farmers indicated firstly the crop harvest and secondly the weed and plant disease control. One of them solicited the improvement of cultivation techniques in strip-cropping, while another one underline the potential need to treat with plant protection products to limit the drift effect.

Cover crops

All the interviewed farmers use cover crops as an intermediate crop in rotation.
In Italy, the two main reasons to utilize cover crops are:
1) To improve soil quality
2) For weed control

The farmers used different types and mixes of cover crops:

- Solanaceae (tomato, pepper, potato);
- Cocurbitaceae (zucchini, melon, watermelon)
- Umbrelliferae (carrot, fennel, parsley);
- Chenopodiaceae (red beets, beets, spinach);
- Brassicaceae (cauliflower, broccoli, mustard, turnip)
- Asteraceae (lettuce, endive chicory, artichoke)

- Legumes: white clover, Alexandrian clover, hairy vetch, broad bean, alfalfa, faba bean, field bean, chickpea
- Cereals: rye, spelt, barley, wheat
- Aromatic plants (rosemary, thyme, mint, oregano, fennel, dill, marjoram).

Specific country remarks

In Italy, the crop diversification concept is broadly accepted by farmers, particularly by organic ones involved in vegetable production. This is due to the constant decrease of soil fertility induced by climate change on long term, that forces the farmers to support the soil C-sink by reducing soil organic matter mineralization and increasing the soil aboveground and belowground biodiversity introducing the crop diversification.
In Italy, while the use of cover crops in organic rotations is considered a common practice among the organic farmers, the application of strip-cropping it is not yet so widespread, even if the farmers showed to be highly interested on. In our survey, we perceived that organic farmers ask for increasing knowledge on strip-cropping, particularly on:

- Definition of crop traits for identification of the best crops combinations to exploit at the best any advantageous plant-plant interactions (especially for containing weed and reduce crop diseases and pests);
- The cultivation techniques and implemented mechanisation (transplanting and seeding machines) for the following application of strip-cropping in their own experiments.

During the Info day, several Italian organic farmers asked for suggestions, guidelines, and leaflets, videos that could report all useful recommendations to make the strip-cropping a crop diversification technique easily viable and implementable.

Conclusion and implementation of the outcome in the field

The Italian organic farmers identified as most important benefits deriving from the strip-cropping, when coupled with the application of plant-based fertilizers:

- The increase of soil quality, resilience and biodiversity;
- The chance to contain weed;
- The possibility to reduce the off-farm nutrient inputs by recycling their own green wastes.

The most important crop traits mentioned were the plant growth, architecture and habit, nutrient use efficiency, the ability to repel insects and disease.

Italy started its research station trial at the MO.VE.LTE., the long-term experiment of Monsampolo del Tronto (AP, Italy) of the Council for agricultural research and economics (CREA). The Italian SUREVEG strip-cropping experiment started in 2018 and will be repeated in 2019: faba bean and tomato were chosen as strip crops, both representative of the Italian food production (tomato sauce and flour of dried faba bean). Faba bean was introduced since taking into account the importance of legumes as N-fixing plants, very often used by Italian farmers to increase soil N pool. Considering the preferred strips widths claimed by the farmers (3 m or 12 m), tomato and faba bean were cultivated on alternate strips of 2.8 m. Because of the different harvesting time, on May 2018 rows of tomato were transplanted on strips of flattened faba bean, alternating with not-flattened faba bean. From May to end of July, both the faba bean (as dry grains) and tomato (on flattened faba bean strips) were contemporary in the field, and thus should be both considered as two spatially-alternated yielding crops. Regarding the fertilization strategy, given the absence of cattle or poultry farms in Marche Region, the farmers do not use animal effluent, but only desiccated animal manure, partially stabilized. For this reason, in SUREVEG trail we compared a plant-based, stabilized compost from organic row starting materials to the pelleted, mixed animal manure (local “business as usual” fertilization).

The positive outcomes coming from the first Info Day with the farmers and their answers to the SUREVEG survey suggested to repeat the experience next year, presumably on June-July 2019.
On results coming from the 2018 SUREVEG field trial, we will make the farmers aware of the positive effect induced on selected crops’ yield and quality, on soil C-N-P cycles and on belowground functional biodiversity, supporting them in exploiting such information by producing a leaflet on strip-cropping, to be duly widespread.

3.3 National report on Latvia – Liga Lepse

Description of the workshop in Latvia
Two workshops on strip-cropping and organic growing issues were organized in Latvia in 2018 – the 1st one was in August 30 in Kaibala, organic farm "Puteņi" and the 2nd one was in December 3 in Dobele, Institute of Horticulture. 14 people were attending the 1st workshop and 29 – the 2nd. In the introductory part of both seminars presentations of researchers and advisory service representatives related to organic cropping, strip-cropping, green manure and cover crops, soil biological activity, and plant nutrition took place. Later discussions on the topic were initiated between farmers and researchers, advisors. Experience was shared among participants – some farmers (and researchers) were sceptic about possibility of strip-cropping and fertilization strategies by using plant material. Contrary, more experienced (educated) organic farmers supported idea of strip-cropping and including of green manure and plant based fertilizers in organic vegetable growing. One of the main discussion points was related to complicate using of different cultivation machines (sowing/planting, weeding, fertilizing) in strip-cropping.

General information
In Latvia 6 questionnaires of stakeholders were filled out – 5 organic growers (4 – vegetables, 1- grasses) and one advisor/grower (mostly uses integrated growing approach).
4 of them are using strip-cropping already (one of them does not like it), and two of them have heard about it, but do not use. Consequently, 5 of them are willing to use it also in future.

Added value
Majority of farmers as the most important benefit from strip-cropping see in improving of soil quality and increased biological diversity. Two expectations are related to increased yield.

Crops
Only two farmers are really using strip-cropping. Table 3 lists some of the combinations mentioned in questionnaire:

Table 3: Suitable combinations according to the Latvian farmers.

Combination	Crops	Reason
1	Crucifers/lettuce	to defend cabbage from cabbage fly
2	Fruit trees/vegetables	weed limitation
3	Tomato/lettuce	lettuce uses extra nitrogen in soil, so reduces nitrates in tomato
4	Onion/carrot	superficial and deep rooted
5	Cabbage/common bean	nitrogen fixing
6	Cucurbits/clover	nitrogen fixing
7	Vegetable crop/living mulch	weed control

Regarding the sowing of one crop after other one farmer mentioned that he was trying to sow buckwheat after carrot sowing (as green mulching). Other mentioned to sow cucurbits after *Trifolium repens.*
When farmers were asked to tell about the crop suitable to sow after harvest of the main cash-crop, they referred to phacelia, buckwheat, cereals (mostly winter rye), faba bean, mustard, mixture of grasses.

Management
Majority of farmers as most preferable strip width were referring to 3 m or somewhere between 3 and 6 m wide strips. The main criteria is machines used for interrow management. Regarding the foreseen difficulties with implementing strip-cropping majority of farmers referred to technical difficulties (5) and planting/sowing (3) difficulty if sowing/planting time differs between crops. In this case strips of width of sowing/planting technique are preferable.

Cover crops

Majority of farmers are using cover crops as intermediate crop in rotation (autumn/winter period). The main aims of using these crops are improving of soil fertility, protecting from erosion, and weed limitation. The plants used for cover crop were mentioned following: red clover, winter rye, phacelia, mustard, oil radish (*Raphanus sativus* L. var. *oleifera* Metzg.).

Specific country remarks

There are only some organic farmers using strip-cropping. In general, such practice is not broadly used. People know about this method, but do not relate it with themselves. Our workshops, field days and publications will encourage people to use intercropping (particularly strip-cropping). In addition, practical technological (machinery) solutions would promote introducing strip-cropping in practical life.
Cover crops are coming into crop rotations more and more often, since publications in popular magazines are appearing more often and seminars/workshops related to cover crops/green manure are organized and well attended. Mostly organic farmers are open to new ideas, integrated growers are more conservative.

Conclusion and implementation of the outcome in the field

Organic farmers see benefits of diversification and they see it as a reduction of pests and diseases, increasing of diversity of beneficial pests. Some people know about allelopathy effect. Introduction of cover crops and catch crops in the crop rotation is related with increasing of soil fertility and nutrients availability.

Before SureVeg project some trials in intercropping were performed in Pūre Horticultural Research Centre (in the frame of EUROLEGUME project). Strip-cropping trials of SureVeg project were performed in 2018 in LatHort experimental fields. It is planned to continue trials in LatHort in 2019. Organic farmers expressed interest in strip-cropping.

Article in popular newspaper were published in order to give an idea to try strip-cropping in their farms. In the workshop, farmers were encouraged to try strip-cropping in their farms, to find the best solutions for their crops and machines. Some tips for good neighbouring plants were given in the workshop from “grey literature”. Advises for crop combinations based on research results are necessary to publish in flyer or brochure in order to promote strip-cropping technology.

3.4 National report on The Netherlands – Merel Hondebrink

Description of the workshops in the Netherlands

Two workshops about strip-cropping were organized in the Netherlands in 2018.

11/07/2018
The first workshop was at a commercial farm in Strijen, south of Rotterdam. Six farmers came to Strijen to get to know more about strip-cropping. The farmers had different reasons to visit the workshop. Most of them wanted tips and tricks on how to start with strip-cropping, mechanisation, crop combinations and to get more inspiration for their own enterprise.

Different topics were discussed during the workshop, like which crop growths best next to the other and the impact of strip-cropping on biodiversity. Some farmers were sceptical about the feasibility of strip-cropping on a large scale. Another point of concern of strip-cropping mentioned by the farmers was the method to get the arable land free of weeds. In addition, more technical topics were considered in the conversation, like the width of the strips. The most convenient width of the strips depends on the machineries used at specific farms for weeding, planting and harvesting of the crops. At the end of the session, the group went outside to have a look at the strip-cropping trial of the Louis Bolk Institute and Wageningen Research at this commercial farm.

28/09/2018
Together with Bejo Zaden (Dutch breeding company for vegetable seeds) a second workshop was organized. The case discussed was a situation with three different stakeholders (Bejo Zaden, a bulb and flower grower and a biodynamic vegetable farm), who want to design a plot of 4 hectares with strip-cropping. The reason of implementing strip-cropping by farmers involved was the expectation of the suppression of diseases and plagues in the crops. Diseases and plagues are especially in the organic seed cultivation a considerable challenge. The 2 farmers explained the difficulties about implementing strip-cropping. The biggest challenge was to figure out the best rotation in crops and width of the strips that suits all agricultural entrepreneurs.

The vegetable grower explained that they have a broad crop rotation on sandy soils and on clay and a real flexible crop rotation. Strip-cropping has an intensive, fixed crop rotation, which means that it had advantages for soil structure and soil fertility, but the disadvantage is that there is less flexibility. Another advantage of strip-cropping mentioned by the grower is the fact that the soil is covered most of the year. This has a positive effect on sand drift, especially on sandy soils with open landscapes. The wind will have less influence on the dispersion of sand. The 3 different stakeholders would like to cooperate with a livestock farmer. In the strip-cropping idea, the grass clover will be mowed and brought as fodder for cows. The manure from the livestock farmer will be placed in the strips. This will help the circularity.

The other grower is experimenting with different cover crops to get a healthy soil and more biodiversity in the soil. He chooses the cover crops by the needs of the next crop. He is still searching for a cover crop before the daffodil bulbs are planted. In his own fields with flowers and bulbs, he applies strip-cropping. He explained that strip-cropping needs an accurate way of cultivating the soil. For example, if the strip is shifted 10 cm, this will be visible in the crop and visible the year after. Advice of the grower: practical ideas for mechanisation and cultivation for strip-cropping can be found in the precision farming.

At the end of the workshop, the group went outside to visit the field trials.

General information

In the Netherlands, a survey was held among stakeholders involved to (1) identify their knowledge, (2) identify stakeholder's ideas on benefits of diversification, and (3) identify pathways towards increased use of strip-cropping. The survey was filled out by six farmers. All farmers had heard about strip-cropping. Half of farmers would like to implement strip-cropping, the other half answered 'maybe'.

Added value

The farmers were asked to give their opinion about the expected added value of strip-cropping. The most important foreseen added value is the higher resistance of crops against plagues and diseases. Moreover, the improvement of soil quality and higher biodiversity scored high as gains after implementation of strip-cropping. Higher yield was of less importance for the farmers. One farmer answered with another expected added value: dust control. To prevent the wind from carrying the sand.

Crops

The farmers had to consider suitable crop combinations in strip-cropping. Moreover, they were asked to give a reason for these combinations. An example for a reason could be alternating superficial rooting crops with more deep-rooting crops. Table 4 summarizes the crop combinations mentioned by the stakeholders. Some of the farmers suggested three different crops alternating each other (combination 3, 4 and 5). Or 4 different crops that are suitable to combine (combination 6), but not especially all 4 alternating one another.

Table 4: Suitable combinations according to the Dutch farmers.

Combination	Crops	Reason
1	Pumpkin (bush type) + Leek	Driving distance of 75cm. When the pumpkin is harvested, grass clover can be sown. In this way, it gives carrying capacity of the soil. After harvest of the leek, grass clover can be sown.
2	Celery + Cabbage	Driving distance of 50 cm. Ideal for hoeing. Harvest of different crops can be independently.
3	Celery + Cabbage + Leek	-
4	Carrot + Onion + Beetroot	-
5	Strips with apple trees, berries and cereals	Strips have to be wider than 6 meter, with a maximum of 15 meter.
6	Cabbage + Chicory + Potato + Cereals	-
7	Strips with grass clover	Grass clover can be mowed and/or be used as green manure

To get a better idea about combining different crops and the suitability of the crops for strip-cropping the question was asked about the importance of crop traits. The most important crop trait mentioned was the efficiency of nutrient use by the crop. After this trait, efficiency of water, satisfactory root system, high crop yield, stable crop yield and resilient against diseases and plagues were put as second important. Lastly, nice taste was put as the least important crop trait.

Management

To gain insight in the mechanisation of the cultivation with a strip crop system, two questions were asked. The first question was about the width of strips. The farmers had different opinions about the suitable width. All the possible answers were chosen and 9 meters was also added as a suitable width of strips. However, no one chose plants in alternating rows as the best-foreseen strategy.
The second question was about the foreseen difficulties with implementing strip-cropping as a management strategy. In order of importance, the farmers responded: 1, harvest; 2, technical difficulties and 3, to manage weed control.

Cover crops

All farmers use cover crops as an intermediate crop in rotation. The main reason to utilize cover crops is to improve soil quality. The farmers used all different types and mixes of cover crops. Two farmers were experimenting with different mixes. Cover crops mentioned were: Fodder radish, Phacelia, English ryegrass, Faba bean, Yellow mustard, Alfalfa, Red clover, Broad bean, Westerwold's ryegrass, Hairy vetch, White clover, Japanese oats, Alexander clover.

Specific country remarks

There is a lot of difference in knowledge about strip-cropping among the farmers. Farmers can think of the advantages of this management strategy. Some have already ideas about the mechanisation and perform their own experiments in this direction. Others are curious, but do not know where to start and have still a lot of questions concerning strip-cropping. These farmers are waiting and are helped with a manual with steps and recommendations of implementing strip-cropping.

In the Netherlands, many farmers are working with cover crops and are experimenting with it. This can be an advantage when explaining a strip-cropping system with cover crops.

Conclusion and implementation of the outcome in the field

The most important benefits of strip-cropping, according to the Dutch farmers, is higher resistance of crops against plagues and diseases. The most important crop trait mentioned was an efficient use of nutrients by the crop planted in combination. The main reason for Dutch farmers to utilize cover crops is to improve soil quality.

In the Dutch strip cropping experiment on the commercial farm in Strijen four different types of crops in strips alternated with strips of grass clover were examined. The crops in the experimental set-up of 2018 were pumpkin, parsnip, white cabbage and leek. The crops in strips (3 meter width) were compared with crops in a monoculture system (reference). In 2019 the field trail will continue with the strip cropping system containing strips of crops and grass clover. Grass clover is chosen again for the season of 2019 due to the fact that a lot of farmers are already working with it in their crop rotation in The Netherlands according to the survey. The possibility of growing cover crops in strips might become of importance in the future. Two crops, pumpkin and parsnip will not be examined in 2019. Only white cabbage and leek are taken into consideration, however in a larger amount of strips for a more accurate statistical comparison. Regarding the results of 2018, above ground biodiversity and yield of parsnip in strips compared to parsnip in a monoculture system didn’t show any differences. Pumpkin is not chosen due to the fact that there were no differences in above ground biodiversity. Also, pumpkins were not found to be a suitable crop in strips with grass clover due to the fact that pumpkin grew in the strips of grass clover. This fact made the mechanisation more intensive.

The workshops and survey show that there are still a lot of questions to be answered about strip-cropping. So farmers are experimenting themselves with strip cultivation, others would like to have a guidebook with steps about how to implement strip-cropping. Due to the outcome of this exercise, another workshop will be organized in 2019 for farmers to figure out step by step the rotation plan of their crops and the implementation of strip crop cultivation in the specific cases.

3.5 National report on Finland – Sari Himanen

Description of the workshop in Finland

During the first year of SUREVEG project, one workshop about strip-cropping was organized on 29th January 2019. In addition, a field day was held at the Luke research station in Mikkeli, on 2nd August 2018.

2nd August 2018

Farmer field day was organized together with several projects, some of them focusing on crop diversification and organic fertilizers, and included demonstrations of both field crop and vegetable trials. Appr. 60 people took part in the day. Luke Mikkeli research station has both organic and conventional fields at use, so both production line farmers participated. The two SUREVEG field trials there, both consisting of cabbage and Faba bean crops, one focusing on testing the fertilization strategies and the other on the above-ground biodiversity, were presented. Farmers had a chance to hear of the project, of the treatments and to freely see the trials and ask questions. Most of the participants were not very familiar with the strip-cropping method, so many questions on the technical feasibility (planting, harvesting, weeding) were asked. It was also mentioned that there has been earlier research back in 1990s with using green manure strips to fertilize vegetable crops with quite positive outcomes (Schäfer et al. 2001 Technique of green mulch spreading. Vakolan tutkimusselostus 79. Available at: https://jukuri.luke.fi/bitstream/handle/10024/440499/vtselostus79.pdf?sequence=1). Questions related to aboveground arthropod biodiversity were raised on e.g. how the trapping is done, which groups of arthropods there have mostly been, and on the most acute insect pest in Finland during summer 2018: the silver Y moth (*Autographa gamma*). Mass outbreaks of the moth were found to lead to total destructions of Faba bean and turnip rape fields in several sites in Finland. Farmers were curious if we had had problems with it, how to identify it from other Lepidopteran larvae and what could be done to prevent its spread. SUREVEG info leaflets as well as the questionnaire of the intercropping survey were delivered to interested vegetable farmers.

29th January 2019

A farmer workshop was held in Mikkeli and with the possibility to join online via video connections. Altogether 15 people took part in workshop, with nine of the participants being farmers, one teacher from vocational education and training school (horticulture) and five researchers. The workshop lasted for three hours and was started by introduction round of participants. Then the SUREVEG project main themes, strip-cropping and organic fertilizer strategies, and some results from first year in the research station and farm trials were presented to familiarize the participants with the project. Active discussion took place already during presenting SUREVEG and the results. Main topics of the following discussions were: which crop combinations would be good for strip-cropping systems for vegetables and why, which benefits and challenges the farmers would see for use of strip-cropping, and the organic fertilization strategies in strip-cropping.

Of specific 'good' or 'bad' crop combinations: Legumes (clovers and pea) were not considered to be good companions for carrot due to reduced storage quality, e.g. clover has been found to lead to increased amount of *Sclerotinia* rot in storage in carrot. Zucchini and common bean (green bean *Phaseolus vulgaris* var. *nanus*), maize and climbing bean (*Phaseolus vulgaris* var. *vulgaris*) were noted as good combinations when harvesting by hand. Potato has been used as their pre-crop and root vegetable such as red beet or carrot as the following crop.

For carrot, suggestions for good crops to add to strips in the middle of the cultivation areas were asked for. Carrot fly is not a big problem for organic carrots due to crop rotation, but for example wireworms (larvae of *Elateridae* click beetles) are. More knowledge on ways to manage it was asked for. Buckwheat and phacelia were mentioned as potential beneficial arthropod supporting crops.

It was mentioned that oil radish has been used as a fast-growing crop between rows or as an intercrop and as a catch crop after early vegetables. It only has the negative side of supporting cabbage fly population growth effectively and should not therefore be used in the same crop rotation with cabbages. In general oil radish should not be sown before the end of July to prevent its flowering and seed production. When used as a catch crop it should be sown at the latest in the beginning of August to have proper germination and

growth. If oil radish has been sown in the beginning of growing season, it should be mown in the beginning of flowering to prevent the increase of *Sclerotinia* disease.

The idea of utilizing the light and growth space more effectively with vegetables of different heights and perhaps other morphological characteristics is, in general, interesting. On the technical feasibility of intercropping, it was noted that if one wants to maximize the utilization of light, nutrients and growing space, then a row-by-row design would be most effective. However, it is not practically feasible to use it in large-scale production with mechanical harvesting. Planting is not a big problem, but mechanical harrowing and harvesting is. Thus harvesting technology needs to be developed to make row-by-row intercropping a feasible method to use. Also, for field crops it is often possible to harvest all intercrops together and then sort the different-sized seeds apart after harvesting. For vegetables this is not possible, at least not yet!

Another constraint of using intercropping is that growth conditions vary by year and impact different crops in a different way, plus the market demand guides the production a lot. One does not want to increase the complexity and associated risks with diversification in the same plot too much, so it is thus quite understandable why farmers prefer to use monoculture plots in large scale production. Strip width was regarded to be case-specific: it should be adjusted according to the machinery and management practice options at the farm.

Fertilization of the different crops according to their specific needs was seen quite difficult in strip-cropping systems. Permanent driving tracks at machine working width and permanent beds between them were also shortly discussed. Bed systems are good for manual harvest and with crops having similar maturation times. The potential to use strips for green manuring and incorporation into soil was also mentioned. Increased vegetation cover and catch crops were also mentioned as important. An alternating bedding system with ca. 1.5 m beds of alternating onion and cabbage plants and covered with biodegradable plastic and bean used in between were used in a school garden and question raised on a suitable catch crop after onion harvest. This could be rye capturing effectively nutrients or a fast-growing flowering plant to add biodiversity benefits. A question was asked on a suitable non-invasive, yet weed-suppressive plant to seed between broccoli or cauliflower rows: Italian ryegrass was suggested as such.

The farmers requested also more knowledge on suitable trap and repelling crops for the pests of *Brassicaceae* and *Apiaceae* vegetables: literature surveys on these topics were suggested to be pursued in SUREVEG. Solutions to reduce red beet storage diseases are also needed: would strip-cropping have something to offer for solving this?

Year 2018 Finnish farm trial (Faba bean strips added to cabbage plot) experiences were actively discussed in the workshop: increased arthropod diversity was obvious also to the farmer (lot of buzzing going on in Faba bean strips during flowering). Indeed the yellow trap results also showed that there were more insects, from several insect orders, in the field plot with Faba bean strips compared to the plot with no added Faba bean strips. One finding by the farmer was that in cabbage production often the border/edge rows of cabbage are more insect-damaged than the middle rows, but in this plot with the Faba bean strips, such difference was not apparent. Thus, it might indeed be that the strips offer some protection and food for the natural enemies. The negative sides noted by the farmers was that Faba bean had so strong growth (as fertilization level was equal to cabbage, which caused Faba bean to grow very fast and tall) that it seemed to result in slight reduction in cabbage yield near the strip due to competition for nutrients, water or light. Also, there were problems with a lot of weeds appearing between cabbage and Faba bean strips, so the Faba bean strips needed to be cut down in the end of July to prevent the weeds (e.g. *Chenopodium album*) from seeding. Year 2019 plans were discussed. Use of two yielding vegetable crops in the same field plot was not seen practical (requires too much driving times into the plot). If repeating the 2018 Faba bean strips, Faba bean would need to be shorter and less competitive against cabbage, so it should be sown later or at two time points to allow effective weed management in the strips. However, allocating more work time to several sowing times is not practical. Other potential crops to use on the strips, such as buckwheat or vetches, also producing floral and extrafloral nectar and with biological fixation of nitrogen, were discussed. A mixture of flowering plants could also work. Faba bean would have the advantage early production of extrafloral nectar and long flowering time, which would support its use.

The possibility to add also an additional intercrop with insect repelling properties, sown early and crushed, interested the farmers. However, more information on which crop would be effective for this, needs to be gathered. The possibility to add single rows of such repellent plants between cabbage rows, also interested

the farmers. Tagetes, marigold, dill, herbs or carrot were discussed as potential intercrops with such effect. Also, some small field areas that are difficult to cultivate effectively, could be used to build pest-buffering structures and support beneficials. Information on the most impactful crops or mixtures to use for such purposes is needed. Therefore, more information from scientific literature will be sought so the farmers can then decide which crops to use in 2019 in the strips or as rows between cabbages.

In 2019, leek will be grown in the plot which had the Faba bean strips in 2018, and cabbage will be grown in a near-by plot. Thus, it would be interesting to see whether the plot hosts higher beneficial insect diversity in the second year: trapping and observations for arthropods were then planned to be done in these plots in 2019. Since SUREVEG has studied leek-celeriac combination in Belgium, information on this is also interesting to the Finnish farmers: which benefits has the combination been planned for and how has it worked. Feedback on the 2018 fertilizer trial results (cabbage suffering significant yield loss when intercropped with Faba bean) included suggesting that the Faba bean could have been cut down earlier and used to fertilize cabbage instead of harvesting it.

General information

The SUREVEG survey to (1) identify stakeholder knowledge, (2) stakeholder ideas on benefits of diversification and (3) pathways towards increased use of strip-cropping, was filled out by 6 farmers in Finland. All farmers had heard about strip-cropping. One farmer used it at his farm, and all others (five) were interested to hear more of the technique. One farmer answered 'yes' to the question of having interest to use strip-cropping at their farm and all others answered 'maybe'.

Added value

The farmers were asked to give their opinion about the needed added value of strip-cropping for trying it: improved soil quality was ranked as most important value (all farmers choose 4 or 5 for importance), followed by more resilient system (mean 4.3) and higher biodiversity (mean 3.8). Higher yield was the least important value for the farmers, while there was high variation in its rating (valuations from 1 to 5). One farmer raised another added value important also: higher economic profit.

Crops

Since most respondents had not used strip-cropping before, only few suitable combinations for crops in strip-cropping were mentioned Table 5).

Table 5: Suitable combinations according to the Finnish farmers.

Combination	Crops	Reason
1	Garlic + green manure + cabbage in strips	green manure offers soil cover
2	Plants with high nitrogen demand + legumes	Nitrogen fixation
3	Zucchini + common bean (green bean Phaseolus vulgaris var. nanus)	
4	Maize + climbing bean (Phaseolus vulgaris var. vulgaris)	

On the question of most important crop traits for strip-cropping, resistance against diseases and plagues was found most important (4.6), followed by efficiency of nutrient use (4.5), satisfactory root system (4.5) and stable yield (4.4). High yield and nice taste were rated equally important (average rating 4, while taste showing variability for importance ratings 1-5). Least important trait was efficiency of water use.

Management

Most farmers thought wide strips are most suitable for use (12 m or wider) due to machinery and cropping practices. However, two farmers responded that alternating rows are most effective. Also, 3 m and 9 m were mentioned.

Most likely bottlenecks in strip-cropping were 1) technique (chosen by 4 farmers), 2) harvest and planting/sowing (both chosen by 3 farmers), 3) weed control (selected by 2 farmers). Additional challenges mentioned were insect pest management, narrow strips in harvesting, planning of crop rotation when acreages of different crops vary.

As equipment/sensors needed to be developed for strip-cropping, four farmers saw a need for adjusted ploughing machines and sowing/planting machines. Machinery for mowing were also mentioned.

Cover crops

Three farmers used cover crops as intermediate crops in rotation. The most often mentioned reason to use them was suppression of weeds (all farmers chose this). Other reasons were improving soil fertility, preventing soil erosion and soil structure maintenance. Cover crops mentioned were: Italian ryegrass, timothy grass, fodder radish, white clover, phacelia, oats.

Remarks for specific country

Strip-cropping was known by the participating Finnish farmers, but it was not practiced much. Most farmers thought that the highest benefits could be gained by using a row-by-row intercropping scheme, but it is not practical for use when harvesting crops mechanically. Using hand harvesting and in smaller acreages, it could work better. In the workshop, most interest and information needs were addressed towards crop combinations or good companion crop to use for insect pest management. It was requested that a literature survey on suitable trap crops for Brassicaceae and Apiaceae vegetables would be pursued. More information was also needed on suitable 'pest repelling' herbs and of potential beneficial arthropod supporting crops that could be used in field edges and small field parcels not that well suited for vegetables.

Conclusion and implementation of the outcome in the field

As the most important potential benefits of strip-cropping, the Finnish farmers rated resistance against diseases and plagues followed by efficiency of nutrient use, satisfactory root system and stable yield. Also insect pest management strategies based on crop traits: attractiveness and/or repellence and support for natural enemies were interesting to the farmers. Cover crops were used to suppress weeds. Fertilization strategies in strip-cropping were seen challenging, as different crops often require differential inputs. Green manure crops could, however, be strip cropped and used to protect soil.

Feedback on 2018 farm trial suggested that it should be either sown a bit later or replaced by another potential beneficial insect supporting plant with less vigorous growth or a mixture. However, the ability of Faba bean to produce extrafloral nectar, the overall positive effect it seemed to have on insect diversity and potential slight reduction of herbivore damage at field edges were encouraging. In terms of research, it would be beneficial to have another replicate year with Faba bean strips used. So the issue will still be discussed further with the farmers. In any case, observations for insects in the field parcel with faba bean strips in 2018 (with leek in 2019) and a neighbouring cabbage plot to see whether the use of strips could lead to some follow-up effects in insect dynamics was planned. Potential addition of a 'repellent plant' in the strips might interest the farmers also, but there is a need for more knowledge on which plant to use and against which particular pest.
In 2019, Faba bean will be replaced by onion in the fertilizer trial. Faba bean and cabbage strip-cropping experiment (using 3 meter strips) in Luke Mikkeli research station will be replicated, with Faba bean sown to last year's cabbage plots and vice versa.

Strip-cropping still carries a lot of uncertainties, which makes it difficult to transform the current monoculture plot based cultivation systems into being more diversified. Cover crops and their benefits are

much better known by farmers, easier to use and thus likely to expand both in use and crop diversity. The need to prevent major problems with pathogens and insect pests encourages vegetable farmers to try novel diversity-based control means such as trap crops. It is evident that more science-based information is needed to help farmers select the best crop traits and combinations that could be used towards particular targets such as improved pest management and fertilization strategies, and would have good market value also. Also the economic profitability of strip-cropping-system compared to monoculture system should be studied.

3.6 National report on Denmark – Hanne Lakkenborg Kristensen

General description of the workshop

One workshop was arranged in Denmark early in 2019.

5/3/2019
The workshop was arranged as a winter meeting for growers at the AU-FOOD Research Centre at Aarslev, Funen under the title "News from research in plant-based fertilizers, cover crops and cropping systems in organic vegetables" ending with a walk to the field with a presentation of a trial with overwintering vegetables. There were approximately 35 participants including organic and conventional (considering conversion) farmers, advisors, advisor trainees, journalists and industry organisations.

The workshop included several presentations by researchers on the topic of organic cropping systems, among these a presentation of the SureVeg project. A more in-depth presentation was given of the preliminary results of the 2018-trial with strip-cropping of faba bean grown as a vegetable with pointed cabbage at AU-Aarslev. The faba bean is a new vegetable in Denmark with a potential as a niche product. There was some discussion of the results of the trial showing below-ground competition that benefitted the cabbage and restricted to some degree the growth and yields of faba bean. There was some indication of beneficial effects of the strip-cropping on nitrogen availability in the system. The survey was introduced and farmers were encouraged to fill it out the questionnaire.

General information

Four organic growers handed in the questionnaire representing small and medium sized growers having 30, 40, 70 and 75 ha of land. For some, not all were grown with vegetables. They had sandy, sandy loams and clay soil types growing 4, around 10 (two farms) and 40 different vegetable crops.
All four farmers had heard about strip-cropping, one did not think it is feasible, but would still like to hear more about it, the other three would like to hear more about it and one indicated to be using the technique already, but only little. One farmer would like to – may be – use strip-cropping. Two farmers would maybe like to use strip-cropping, and one farmer did not want to use it.

Added value

The farmers were asked to give their opinion about the expected added value of strip-cropping.
The most positive farmer rated highest (score 4 out of 5) biodiversity, resilient systems/crops and soil fertility to consider using strip-cropping. Then higher yields (score 3). The two 'maybe' users of strip-cropping rated the same four factors highest (score 3), and one had a special focus on soil fertility (score 5). The farmer being the least positive towards strip-cropping rated higher yields as the needed added value.

Crops

Only one farmer suggested a combination of crops, which was maize strip-cropped with beans (Table 6). The idea behind was that they are harvested at the same time. No one mentioned a more suitable crop for planting later in time. To increase diversity of the crop rotation by planting one crop extra after the first one in rotation, one farmer mentioned to grow pumpkins after potatoes.

Table 6: Suitable combinations according to the Danish farmers.

Combination	Crops	Reason
1	Maize + beans	they are harvested at the same time

The most important traits of crops identified (answered by two farmers) were efficient use of nutrients and water, satisfactory root systems, stable yields and resilience against diseases and plagues. High yields and nice taste had high rates too.

Management

Concerning the choice of the width of strips, the farmer with own experience replied to use 1.5 m width. The others replied that 3 m with would be the most promising technique. Regarding the bottlenecks expected, weed control was identified by all four farmers. Two identified technique, two planting/sowing and two harvesting. Sensors needed were for adjusted ploughing and adjusted planting/sowing machines. One remarked that not many sensors are available on the market.

Cover crops

Three out of the four farmers use cover crops. They use it to improve soil fertility, suppression of weeds and insects. The species used was fodder radish, English ryegrass, red clover, Westerwold's ryegrass, fodder winterrye, white clover and phacelia. The most popular was fodder winterrye and phacelia.

Remarks for specific country

Cover crops are well known and used a lot in Denmark. Strip-cropping is not due to low expectations to the effect and the bottlenecks foreseen. They are considered to increase the risk in production (lower yields due to competition, weeds etc.), more than to decrease it, despite this is what we think they should do in theory by increasing system resilience.

Conclusion and implementation of the outcome in the field

Danish organic vegetable farmers here represented by four small and medium-sized farmers are reluctant to implement strip-cropping. Therefore, demonstration and documentation are needed to implement strip-cropping in Danish farms along with advice on system design, crop choice and management.

The need for demonstration, documentation and development of advice services of the potential, challenges and management options of strip-cropping systems have been underlined by the results of this survey. Therefore, the use of the field trials at AU-Aarslev for open field days for farmers and advisors is important. Further, the importance of the dissemination of results, learnings and wider practise implications has been highlighted to cover the needs. This should be based on scientific documentation to secure the validity of the knowledge and the wider dissemination of knowledge. The survey results have no direct implications for the detailed design of the AU-FOOD trials, but emphasize the use of the trials for science-based dissemination directed towards farmers and advisors.

The workshop and survey indicate a very limited implementation of strip-cropping in Denmark, which is confirmed by our own knowledge of current practise among organic growers. Benefits for the system and yields need to be at least demonstrated, and preferably documented, to stimulate farmers' implementation. This would include advice on optimal design, species combinations and management. The interest is there, but it is not high. In addition, machinery solutions need to be available for strip-cropping.

4. Conclusions and recommendations

The workshops and surveys in six different European countries held in 2018 give insight in the knowledge of farmers about strip-cropping and the gaps of expertise and machinery to change to a strip-cropping system. In total approximately 140 farmers (and some other stakeholders like advisors) were participating in the workshops and 38 farmers filled out the survey. This acquired information will help to develop new ideas for strip-cropping systems, create guidelines and requirements for successful crop combinations.

Expected added value of strip-cropping

The farmers in six different countries were asked about the expected added values of a strip-cropping system compared to a monoculture system. The outcome in the different countries suggests that most farmers think fairly equally about the added values. Higher resistance of crops against plagues and diseases is ranked highest in all countries followed by improved soil quality and increase of agroecosystem biodiversity (Table 7).

Table 7: Expected added value of strip-cropping

Country	Expected added value
Belgium	Higher resistance of crops against plagues and diseases Higher yield Increase of agroecosystem biodiversity, improved soil quality
Italy	Increase of agroecosystem biodiversity Improved system/crop resilience Higher resistance of crops against plagues and diseases
Latvia	Improved soil quality Increase of agroecosystem biodiversity
The Netherlands	Higher resistance of crops against plagues and diseases Improved soil quality Increase of agroecosystem biodiversity
Finland	Improved soil quality Higher resistance of crops against plagues and diseases Increase of agroecosystem biodiversity
Denmark	Increase of agroecosystem biodiversity Improved systems/crops resilience Improved soil fertility

Promising techniques

During the workshops, it was clear that farmers are helped with the development of new or adapted machinery for strip-cropping. The farmers were asked about what they thought was the most promising strip width or if the systems works best with alternating rows. Different answers were given to this question, mostly depending on the machinery the farmers already use in their daily practice (Table 8). The alternating row option was not chosen often, however, in Finland it might be an option.

Table 8: Promising techniques and most promising strip width or alternating rows.

Country	Promising techniques
Belgium	3 m strip width 6 m strip width
Italy	3 m and 12 m. strip widths
Latvia	3 m or somewhere between 3 and 6 m.
The Netherlands	3, 6, 9, 12 m and wider strip width
Finland	12 m or wider or alternating rows
Denmark	1.5 m strip width 3 m strip width

Promising crop combinations

Farmer's knowledge let to crop combinations, which are promising due to practical experiences in the field (Table 9). The outcomes are used as input for developing a database on crop traits. The combinations of the crops depend on the climatic conditions within a country. A combination which is mentioned by farmers in different countries is to combine plants with a high nitrogen uptake demand with legumes. Carrot and onion is also mentioned by farmers. This combination is a well-known combination and already utilised by putting those crops adjacent or with the onion placed in carrot fields.

Table 9: Promising crop combinations

Country	Promising crop combinations
Belgium	Parsley + bunch onion
	Carrot + onion
	Potato + leek
	Leek + celeriac
	Maize + courgette
	Wheat + potato
Italy	Alfalfa + wheat on bare soil
	Bean + corn
	Pea + barley
	Clover + wheat
	Perennial legumes + sunflower
	Tobacco + corn
	Marjoram + tomato
	Tomato + pumpkin + string beam
	Lettuce + carrot + chicory
	Fennel + cauliflower + radicchio
Latvia	Crucifers + lettuce
	Fruit trees + vegetables
	Tomato + lettuce
	Onion + carrot
	Cabbage + common bean
	Cucurbits + clover
	Vegetable crop + living mulch
The Netherlands	Pumpkin (bush type) + Leek
	Celery + Cabbage
	Celery + Cabbage + Leek
	Carrot + Onion + Beetroot
	Strips with apple trees, berries and cereals
	Cabbage + Chicory + Potato + Cereals
	Strips with grass clover
Finland	Garlic + green manure + cabbage in strips
	Plants with high nitrogen demand + legumes
	Zucchini + common bean (green bean Phaseolus vulgaris var. nanus)
	Maize + climbing bean (Phaseolus vulgaris var. vulgaris)
Denmark	Maize + beans

Importance of traits

Farmers were asked to rate the different crop traits (Table 10). This understanding is important for the selection of crops for the database on good crop combination. The importance of crop traits was ranked however, different in each country. Efficient use of nutrient and resilience against diseases and plagues scored high throughout the different countries. The least important of the crop traits was a good taste. Only in Italy, the nitrogen-fixing capacity of crops was mentioned as an important trait.

Table 10: Importance of traits of crops

Country	Importance of traits
Belgium	1. Resilience against diseases and plagues 2. Satisfactory root system, efficiency of nutrient use and the stability of the yield. 3. Nice taste and water use efficiency
Italy	1. Ability of foliar system to be non-invasive 2. N-fixing capacity 3. Comparable nutrient demand
Latvia	1. Efficiency of nutrient use 2. Resilience against diseases and plagues 3. Water use efficiency
The Netherlands	1. Efficiency of nutrient use 2. Efficiency of water, satisfactory root system, high crop yield, stable crop yield and resilient against diseases and plagues 3. Nice taste
Finland	1. Resistance against diseases and plagues 2. Efficiency of nutrient use 3. Satisfactory root system, stable yield
Denmark	1. Efficient use of nutrients and water 2. Satisfactory root system 3. Stable yields, resilience against diseases and plagues

Expected bottlenecks

To gain insight in the challenges of strip-cropping, farmers were asked to list their expected bottlenecks for practising strip-cropping (Table 11). Regarding the foreseen difficulties harvesting was notified as a major difficulty. The main raison is that different crops will mature at a different rate and have to be harvested at different times. To overcome this problem, the crops can be selected to have the same harvest time. However, the difficulty in this situation is that the different crops have to be separated from each other or cannot be harvested with the same machinery. This leads to the second obstacle: technique. Most machines are designed for monoculture. Customized techniques are a necessity to implement strip-cropping systems.

Table 11: expected bottlenecks for implementing strip-cropping systems.

Country	Expected bottlenecks
Belgium	1. Harvesting 2. Technical difficulties (Customized techniques) 3. Planting and sowing
Italy	1. Harvesting 2. Weed and plant disease control
Latvia	1. Technical difficulties 2. Planting/sowing difficulty if sowing/planting time differs between crops
The Netherlands	1. Harvesting 2. Technical difficulties 3. Weed control
Finland	1. Technical difficulties 2. Harvest and planting/sowing 3. Weed control
Denmark	1. Weed control 2. Technical difficulties, planting/sowing, harvesting

Overall conclusion

The workshops and surveys held in six different European countries gave insight into the knowledge of farmers about strip-cropping. Moreover, the knowledge and field expertise can be utilised for further research about the implementation of strip-cropping and the use of plant based fertilizers. In total

approximately 140 farmers (and some stakeholders like advisors) were participating in the workshops and 38 farmers filled out the survey.

The outcome of the survey on strip-cropping and workshops in the different countries suggests that most farmers think fairly equally about the added values. Higher resistance of crops against plagues and diseases is ranked high in all countries followed by improved soil quality and agroecosystem biodiversity. Only Belgian farmers mentioned higher yield as an important benefit however, certain individual farmers in other counties ranked it high as well. The answers to the question on the most suitable width of the strips were most diverse in all countries. Strip width depends for an important part on the machinery farmers have available for their practices. For the importance of crop traits, an efficient use of nutrients and resilience against diseases and plagues scored highest throughout the countries. Only Italian stakeholders mentioned nitrogen-fixing capacity as important. The farmers in all countries thought the same about expected bottlenecks for implementing strip-cropping system: harvesting, weed control and technical problems.

The information obtained by the survey and workshops in the different countries is input for the experimental design of strip-cropping research trials in each country. Some countries changed their set-up, however, for a valid comparison between the experimental trial years, some experiments remained the same.

To conclude, in the participating countries, the use of strip-cropping is limited. The farmers participating consider strip-cropping as a promising innovation. However, many basic questions about strip-cropping still need to be answered before farmers will implement strip-cropping. Farmers in every country will benefit from a database of best crop combinations. In Finland, the farmers explicitly mentioned the need of good companion crops for Brassicaceae and Apiaceae vegetables (suitable trap crops).

Recommendations

- Guidelines or handouts with advices about strip-cropping systems is needed. However, each country has its own characteristics (e.g. different soil type, crops, machinery) so that universal guidelines will not apply to every famer.
- Farmers are expecting benefits from a database on good crop combinations. For the dissemination of this knowledge, it is recommended to publish this in a flyer or brochure.
- Development of technological (machinery) solutions are a necessity to implement strip-cropping systems in practice.
- For strategic outreach activities, it is recommended to visit strip-cropping experimental fields with farmers. This way, farmers get inspired by their colleagues and develop their own vision and strategy.

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Appendix 1.
SUREVEG – Survey strip-cropping and cover crops

A. General information entrepreneur

Name:

Date:

Farm details

Name:

Crops:

Acreage:

Soil type:

B. Introduction

SUREVEG project

The CORE Organic Cofund project SUREVEG will develop and implement new diversified, intensive cropping systems using strip-cropping and fertility strategies combined from plant-based soil-improvers and fertilizers. The aim is to improve resilience, system sustainability, local nutrient recycling and soil carbon storage.

C. General practice

1. How would you describe your rotation which is practised at the moment? Crop rotation? Diversity in crops?

Year	Crop	Second crop
1		
2		
3		
4		
5		
6		

D. Strip-cropping

Strip-cropping is a technique in which crop are grown in alternating rows or strips. Strip-cropping mayl reduce pests and crop diseases and plagues. Pest and diseases are the main cause of yield reduction in organic farming. Systems with a higher biodiversity may be more resilient and may have higher disease suppressive capabilities.

2. To what extent are you familiar with strip-cropping?

☐ At my enterprise we work already with strip-cropping (skip question 3).
☐ I have heard of the technique and I would like to know more about it.
☐ I have heard of the technique, but I don't think it is a feasible system.
☐ Before the survey I hadn't heard from the technique of strip-cropping.

3. Would you be interested to use strip-cropping at your own farm?

☐ Yes
☐ Maybe
☐ No (as if so, would you be so kind to answer the upcoming questions as if you would apply strip-cropping)

4. Which added values should strip-cropping have before switching to this system? (circle 1-5; 1: not important. 5: really important)

☐ Higher yield	1 2 3 4 5
☐ Higher biodiversity	1 2 3 4 5
☐ More resilient system/crops	1 2 3 4 5
☐ Improved soil quality	1 2 3 4 5
☐ Other, namely:	1 2 3 4 5

5. What do you consider to be a promising technique?

☐ Plants in alternating rows
☐ In strips of 3 m wide
☐ In strips of 6 m wide
☐ In strips of 12 m wide
☐ Strips of more than 12 m wide

Please explain:

6. Which combinations of different crops would be suitable together in strip-cropping cultivation? Name 3 combinations (for example: superficial rooted with deep-rooted crops)

- Combination 1:
  Please explain:

- Combination 2:
  Please explain:

- Combination 3:
  Pleases explain:

7. Could you name suitable combinations of crops when the second crop is planted later in time than the first crop?

8. Could you name possibilities to enrich the diversity in your vegetable rotation by planting extra crops after harvesting the first crops?

9. Which bottlenecks would you anticipate when cultivating in strips? Bottleneck(s) is/are:
(more answers possible)

☐ Harvesting
☐ Planting/sowing
☐ Diseases and plagues
☐ Technique
☐ Weed control
☐ Other, namely:

Please explain:

10. To what extent do you think the different traits of crops are important in strip-cropping? (circle 1-5; 1: not important. 5: really important)

Efficiency of nutrient use	1 2 3 4 5
Satisfactory root system	1 2 3 4 5
Efficiency of water use	1 2 3 4 5
High crop yield	1 2 3 4 5
Stable crop yield	1 2 3 4 5
Resilient against diseases and plagues	1 2 3 4 5
Nice taste	1 2 3 4 5
Other, namely:	1 2 3 4 5

11. Which equipment/sensors are needed or have to be developed for strip-cropping? (more answers possible)

☐ Soil moisture sensors
☐ Soil temperature sensors
☐ Adjusted ploughing machines
☐ Adjusted sowing/planting machines
☐ Adjusted termination machines

☐ Other, namely:

Explanation:

D. Cover crops

In between the crops it is possible to grow cover crops, such as grass clover. This could be used as fertilizers.

12. Do you apply cover crops?

☐ Yes, as an intermediate crop in rotation
☐ Yes, in strips
☐ No, I don't think it is necessary (go to section E. other points of discussion)

13. What is the reason you apply cover crops? (more answers possible)

☐ Improvement of soil fertility
☐ Prevention of soil erosion
☐ Suppression of weeds
☐ Other, namely:

14. Which cover crops do you use? (more answers possible)

☐ Fodder radish
☐ English ryegrass
☐ Yellow mustard
☐ Italian ryegrass
☐ Red clover
☐ Westerwold's ryegrass
☐ Fodder winter rye
☐ White clover
☐ Phacelia
☐ Faba bean
☐ Alfa alfa
☐ Broad bean
☐ Hairy vetch
☐ Other, namely:

E. Other points of discussion (remarks, suggestions, examples)