DiverIMPACTS
Diversification through Rotation, Intercropping, Multiple cropping, Promoted with Actors and value-Chains Towards Sustainability

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DiverIMPACTS Network of Field Experiments

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DiverIMPACTS

The overall goal of DiverIMPACTS - Diversification through Rotation, Intercropping, Multiple Cropping, Promoted with Actors and value-Chains towards Sustainability - is to achieve the full potential of diversification of cropping systems for improved productivity, delivery of ecosystem services and resource-efficient and sustainable value chains. DiverIMPACTS receives funding of the European Union's Horizon 2020 programme. More information: www.diverimpacts.net

Contents

Experiment 1: Arable cropping systems, The Netherlands (Partner: DLO)

Location: Moer (51°27′ 6″N, 6° 38′ 27″E)

- Average rainfall: 825-900 mm
- Average annual temperature: 9.3-10.2
- Sandy soils; very sensitive to droughts

Start: 2012

Design

- Plots: 6 x 18 m
- All crops each year; 4 replications/system

Contact: Wijnand Sukkel, DLO, The Netherlands, wijnand.sukkel(at)wur.nl

Arable cropping systems – conventional – no irrigation

Reference: Rye (catch crop) - maize - rye (catch crop)

Maize monoculture: representative of current local farming practices

Drawbacks

- Soil quality degradation (decreasing soil organic matter (SOM) content, increase compaction sensitivity)
- Expected limitations in application of herbicides
- Higher risks of drought/excess water and increasing pest pressure

Diversification strategies

- Diversification within catch crops: Rye/Winter pea (catch crop) – maize – rye/winter – pea (catch crop)
- Crop rotation: Short season maize – grass clover – grass clover
- Intercropping: Maize strip intercropping with annual or perennial grass strips

Why use these strategies?

- To increase soil fertility by increasing the SOM with cover crops
- To test new practices to address expected limitations of herbicides and increased pest pressure

Potential added diversification strategies

- Extending crop rotation
- Additional spatial arrangements (mixed and row intercropping)
- Adding crops in rotation: grasses, cereals, fodder crops (e.g. field beans, soybeans, lupine)

Results already available

- Effect of soil practices and use of catch crops on soil fertility: http://edepot.wur.nl/4123

Expected limitations or knowledge gaps

- Shift in mind-set needed by maize growers to look at crop production differently
- Contract between workers and maize breeders
- Weed pressure in catch crops (if using mechanical control instead of Roundup/Titus)
- Catch crop destruction without herbicides (especially grasses) after a soft winter (with no significant frost)
- Potential of mixed or row intercropping based on maize

Interactions with different actors

- Farmers, breeders, contract workers, dairy industry representatives, water boards and advisory services

Network

- Public private partnership on fodder production and soil management
- Close relations with demonstration networks

Interactions with other case studies: 1, 3, 5.

Machinery issues

- Replacing heavy machines with light tools
- If row or strip intercropping becomes a viable solution, then harvesting tools need to be adapted
- Development of strip seeding machinery possibilities for seeding maize after the winter crop

Value chain issues

- Harvest and storage of annual and biannual fodder crops (instead of maize 1:1)

Experiment 2: Arable cropping systems, Germany (Partner: LWK)

Location: Hamerstorf (52°55′ 0.33″N, 10° 27′ 32″E) andThulsfelde (52°56′ 13″N, 7° 55′ 53″E)

› Average rainfall: 715mm – 756 mm

› Average annual temperature: 9.8– 8.7°C

› Risk of dry conditions in spring/early summer

Start: 2014

Design

› Plots: 9 x 12 m

› 3 replications for each system

Contact: Frank Schmädeke, LWK,
Frank.Schmaedeke(at)lwk-niedersachsen.de

Arable cropping systems - conventional - irrigation

Reference: Maize - winter rye - maize (site 1); potato - winter rye - silage maize - brewing barley (site 2)

- Potatoes and brewing barley are chosen as representative cash crops while silage maize and winter rye are used for bioenergy production in biogas plants.

Drawbacks

- Huge nitrogen losses
- High costs for fertilization and high N leachates

Diversification strategies:

- Use of catch crops in winter and undersown grasses in maize

Why use these strategies?

- To minimize N-leachate and to increase N uptake after potatoes
- They can also be used for bioenergy production

Results already available

- Effect of crop rotation and fertilizer management on water quality

Expected limitations or knowledge gaps

- No irrigation possible (site 2): water efficient crops are needed
- Undersown grasses in maize: impossible without irrigation

Interactions with castes studies: 3, 1, 5.

Machinery issues

- High investment costs for specialized machinery (potatoes, silage), so it is not possible to significantly change the required machinery

Value chain issues

- Increasing bioenergy production in the area of Hamerstorf since 2008, in addition to well established potato chains
- Due to greening, catch crops are not allowed to be harvested and special mixtures are prescribed

Experiment 3: Arable cropping Systems, Belgium (Partner: CRA-W)

Location: Gembloux (50°33′ 54″N, 4° 41′ 18″E)

- Average rainfall: 751 mm
- Average annual temperature: 10.2

Start: 1959

Design:

- Plots: 10 x 72m
- All crops each year; 6 replications for each system

Contact: Donatienne Arlotti, CRA-W, d.arlotti(at)cra.wallonie.be

Arable cropping systems - conventional - no irrigation

Reference: Winter barley - maize - winter wheat - winter barley - sugar beet

- Representative of current local farming practices

Drawbacks

- high level of inputs

Diversification strategies:

- A service crop before maize and before sugar beet: Winter barley - phacelia/clover - maize - winter wheat - winter barley - phacelia/clover - sugar beet
- Intercropping: Wheat intercropped with a legume (to be defined)
- Rotation: Replacement of wheat by a legume sole crop

Why use these strategies?

- To increase soil fertility with the inclusion of legumes
- To increase the diversity of cultivated species through multiple cropping and intercropping
- To increase the organic matter in soil
- To reduce N needs
- To limit pest and disease pressures

Results already available

- Impact of organic matter management on soil C evolution

Interactions with case studies: 13, 14, 17

Expected limits or knowledge gaps

- Choice of legume species to be associated with wheat
- Interest in grazing intercropping

Experiment 4: Arable cropping systems, France (Partner: ACTA)

ACTA coordinates a network of field experiments named SYPPRE at 3 sites: Berry, Champagne and Bearn

Location: Berry (46°50′ 49.9″N, 1° 32′ 14.4″E); Champagne (49°17′ 7.5″N, 4° 3′ 50.7″E); Bearn (43°17′ 51″N, 0° 15′ 36″W)

- Soils: Clay-limestone, low water storage capacity (Berry); chalky soils, high pH, sensitive to crusting (Champagne); loamy soils (Bearn)
- Average rainfall: 718 (Berry); 618 (Champagne); 1127 mm (Bearn)
- Average annual temperature: 12.1°C (Berry), 10.9°C (Champagne), 12.2°C (Bearn)

Start: 2015

Design

- Plots: 1680 (Berry, Champagne); 600 m² (Bearn)
- All crops each year; 3 replications for each system

Contact: Gilles Espagnol, ACTA, g.espagnol(at)arvalisinstitutduvegetal.fr

Arable cropping systems – conventional – no irrigation

Berry

Reference: Winter oilseed rape - winter wheat - winter barley

Drawbacks

- Shallow, clay limestone soil
- Crop rotation mainly based on winter crops and with reduced tillage because of the presence of stones
- These cropping systems are favourable to pests, weeds and diseases which are difficult to control. Farmers also observe yield stagnation or decrease over time

Diversification strategies

- Oilseed rape + legumes crops (winter destruction by frost) (no-till) - mulching of legumes volunteers (reduced tillage) maize (Strip-till) - sunflower (reduced tillage) - winter wheat (no-till) - winter pea/winter wheat intercrop (No- plough) - Buckwheat as catch crop (harvested if sufficient yield) (no-till) - Winter wheat (no-till) - winter barley (soil tillage depends on annual conditions) - phacelia + oat - lentils (deep tillage) - durum wheat (no-till)
- Addition of cover crops, new crops (grain legumes, spring crops), intercropping

Champagne

Reference: Winter oilseed rape - winter wheat - spring barley - sugar beet - winter wheat

Drawbacks

- Low dynamic of mineralization in chalky soils, and sensitivity to erosion
- Industrial production (sugar beet, potatoes) is valuable but they contribute to making cropping systems pesticide and fertilizer dependent. They also require the use of heavy materials that degrade soil structure.

Diversification strategies

- Sugar beet (strip till) - spring pea (plowing) - oilseed rape (strip till) + clover (till) - winter wheat (no-till) + clover (+ phacelia, radish) - spring barley (no-plough) - cover crop - sugar beet (strip till) - winter wheat (no plough) - winter pea/winter barley (no till) - energetic cover crop - sunflower (strip till) - winter wheat - energetic cover crop (no till)
- Addition of cover crops, new crops (grain legumes, summer crops, energetic cover crops), intercropping

Bearn

Reference: maize monoculture with mulching

- The high rainfall in winter makes winter crops and spring crops difficult to sow in heavy loam soils.
- Maize is very well adapted, thanks to wet and hot summers, but wireworms could become a serious threat for its productivity with prospective neonicotinoides restrictions.
- If expected pesticide restrictions are implemented, weed control will likely become an issue due to maize monocropping that is very frequent in this area.

Diversification strategies

- Maize - winter barley and soybean (multiple cropping) - winter wheat - energetic cover crop
- Addition of summer crops and energetic cover crops
- Use of multiple cropping

All Sites

Why use these strategies?

- To improve economic robustness (high valuable crops in the rotation)
- To improve soil fertility
- To increase organic nitrogen (cover crops, legume crops in the rotation and during intercropping periods)
- To improve productivity in biomass (energetic cover crops)
- To decrease dependency on mineral nitrogen and pesticides use (by using alternative practices – mechanical weeding for instance) and diversification of the rotation (introduction of spring and summer crops).

Results already available

- Toqué et al. - 2015. SYPPRE: A project to promote innovations in arable crop production, mobilizing farmers and stakeholders, and including co-design, ex ante evaluation and experimentation of multi-service farming systems matching regional challenges. 5th International Symposium for FSD: 7–10 September 2015.
- Toupet et al, 2016 - Co-design of agro-ecological cropping systems reconciling global and local issues. 14th ESA Congress: 5-9September

Expected limitations or knowledge gaps

- Impact on the development of the next crop (seed bed quality, soil humidity) after catch crops and after soybean (Bearn)
- New crops: More difficult to manage and the performance is uncertain (all sites)

Interactions with different actors

- To build the tested cropping systems, the methodology of ‘de novo’ co-design of cropping systems was applied to reconcile global issues and local constraints (Reau et al. 2012). Workshops have been set up with farmers, local advisors, researchers, crop specialists, and also grain collectors to keep a view on new production opportunities.

Network

- The French Group of Scientific Interest for arable crops
- The Joint Network of Technology for Innovative Cropping Systems

Interactions with case studies: Berry (14), Champagne (13), Bearn (5, 1, 3)...

Machinery issues

- Limiting equipment investments for specific machinery needed for new crops, in order to stay competitive
- Harvesting and storing biomass production for energy
- Sowing and harvesting intercrops

Value chain issues

- Developing new value chains for biomass production for energy, and according to commercial rules
- Developing the capacity to sort intercrops

Experiment 5: Arable cropping systems, France (Partner: APCA)

Location: Saint Fort (47°47′ 45″N, 0° 43′ 12″W)
- Average rainfall: 720 mm
- Average annual temperature: 12.5°C

Start: 2009

Design: Plots - 12 x 100 m

Contact: Aline Vandevalle, APCA, aline.vandewalle(at)pl.chambagri.fr

Arable cropping systems – conventional – no irrigation

Reference: silage maize - wheat

- Representative of current systems in farms with livestock (dairy cows) to meet straw fodder needs and to use effluents
- A long and diversified system was designed: Winter wheat - *mixed catch crops* - spring barley/pea - oilseed rape/buckwheat (or rapeseed/white clover depending on the harvest date of barley/pea) - winter wheat - vetches/oat/faba bean- silage maize - *rye grass/clover* - hemp – winter wheat – *catch crop* - sunflower/alfalfa - alfalfa - alfalfa

Drawbacks

- Weed selection
- Reduced possibility of low inputs without poor economic results
- Need to increase livestock protein autonomy

Diversification strategies

- Rotation length: Adding several crops (legumes, hemp, oilseed rape, sunflower)
- Mixed catch crops
- Multiple cropping: 2 harvests of fodder crops in the same year (vetches/oat/faba bean harvested early, and maize after)
- Undersowing
- Intercropping

Why use these strategies?

- To add cash crop with high margins and new markets (hemp), maintain fodder crops and add crops protein-rich crops with several potential uses (grain, forage, seeds)
- To reduce inputs and associated environmental impacts (at least 50% of pesticide use and external N inputs thanks to legumes and herbicides through maximization of cover and intercropping)

Results already available

- Innovative cropping systems to reduce the use of pesticides: http://www.pays-de-la-loire.chambres-agriculture.fr/publications/publications-des-pays-de-la-loire/detail-de-la-publication/actualites/systemes-de-culture-innovants-sdci/; http://ecophytopic.fr/sites/default/files/actualites_doc/Fiche_Projet_2-28.pdf

Expected limitations or knowledge gaps

- Need references to:
- Secure and increase yield of grain legumes for feed through intercropping
- Secure fodder production (several ways of cultivating forages)
- Increase soil fertility through diversified rotations.
- Partners of this experiment are also involved in projects dealing with these subjects to acquire relevant references to be used in DiverIMPACTS

Interactions with different actors

- Co-conception workshop in April 2017 to modify the field experiment with: advisers, researchers, value chain actors, etc.

Network

- DEPHY EXPE network, French “innovative cropping systems” Joint Network of Technology

Interactions with case studies: 11, 13, 14, 17…

Machinery issues:

- Hemp harvest:
- Seed and fibber
- Sewing intercropping with specific material
- Mechanical weed control
- Links with CUMA (groups of farmers who buy machinery in common)

Value chain issues

- Value chain for intercropping in conventional farming (currently only possible in organic farming)
- Local value chain for hemp to be consolidated
- Each forage crop could possibly be harvested on livestock farms or on arable crop farms (cover crops for methanization, alfalfa for seed production).

Experiment 6: Arable cropping systems, Sweden (Partner: SLU)

Location: Alnarp (55° 39′ 21″N, 13° 03′ 30″E)

› Average rainfall: 670 mm

› Average annual temperature: 8°C

Start: 2017

Design

› Plots: 4 x 15 m

› All crops each year; 4 replications for each system

Contact: Erik Steen Jensen. SLU, erik.steen.jensen(at)slu.se

Arable cropping systems -organic -no irrigation

Reference: Winter oilseed rape-winter rye-oat and undersown red clover for seed production-red clover for seed-winter wheat-spring pea

- Scanian crops on highly fertile soils
- Six crops in rotation for organic production with clover and spring pea as nitrogen suppliers

Drawbacks

- The rotation contains crops which require high inputs (e.g. winter oilseed rape) and depend heavily on external inputs for improving soil fertility (N, C).
- It will mine the soil resource and will be unsustainable, given the price of organic manures and fertilizers, which are increasingly steeply.

Diversification strategies

- Addition of cover crops
- Addition of high value cash crops (lentils and malting barley)
- Intercropping at both the cash and cover crop level
- Winter oilseed rape intercropped with frost-sensitive legume (faba bean) - winter rye + cover crops (phacelia + buckwheat) - oat/lentil intercrop undersown red clover - red clover for seed - winter wheat + cover crops (oil radish + spring vetch) - spring pea/malting barley intercrop

Why use these strategies?

- Expected results: Reduced input, reduced N losses in autumn, increased associated biodiversity, increased C input, reduced soil erosion with high vegetative ground cover most of the year, improved soil structure from the root network of legumes and cover crops
- Promote plant-plant interaction for effective utilisation of resources
- More and better nutrient uptake from both the atmosphere and soil
- Better weed control and yield (e.g. intercropping pea with barley prevents late weed infestation and pea lodging)
- More diversified income sources (crops) against price and climatic shocks
- Ecological intensification with possible positive economic and ecological effects

Expected limitations or knowledge gaps

- Can be seen as complicated by farmers (knowledge)
- Extra labour and perhaps special machinery needed
- Frequent legume crops in rotation may risk more legume diseases/pests
- Extra cost to buy legume and cover crop seeds, which might not be paid-off
- Cover crops can become a habitat for pests and diseases as well as weeds, and can deplete soil moisture and have allelopathic effects on crops

Value chain issues

- The value chain of locally produced lentils may be quite new in Scania. However, this also provides an opportunity for a niche market, for a higher premium price.

Interactions with different actors

- The field experiment will evolve and there is continuous interaction with organic growers and advisors in Scania when designing and evaluating the experiment.

Interactions with case studies: 19, 16, 17, 18, 20

Experiment 7: Arable cropping systems, The Netherlands (Partner: WUR)

Location: Wageningen (51°59'30" N 5°39'50"E)
- Average rainfall: 780 mm
- Average annual temperature: 9.4°C

Start: 2014

Design
- Plots: 3 x 10 and 6 x 5 m
- All crops each year; 6 replications for each system

Contact: Walter Rossing, WU, walter.rossing(at)wur.nl

Arable cropping systems - organic - no irrigation

Reference: 2 years of grass/clover-winter oilseed rape-winter cereal-spring wheat-potato

- 1:6 rotation is, in practice, the minimum organic rotation
- Management will be crop-based rather than system-based
- Crops will be managed according to standard guidelines
- Reference will be more dependent on external control rather than natural/intrinsic control mechanisms, which lead to inefficient use of resources

Diversification strategies:

- Different levels of spatial diversification
- Strip cropping (3m or 6m)
- Strip + mixed cropping (oilseed rape/mustard; triticale/s wheat/rye/pea; spring wheat/ faba bean)
- Mixed catch crops (vitamax TR after oilseed rape; clovers/sunflower/pea/flax/faba bean/vetch before spring wheat, and betasola before potato)

Why use these strategies?

- Expected benefits of spatial diversification for pest, disease control, soil fertility, etc.
- Crop choice was based on European diet (Oomen et al,. 1998)[1], implying closed C and N- cycle at rotation level.
- Sequence was based on nitrogen management tool NDicea (www.ndicea.nl) and clustering of seasons (Anderson, 2015)[2] to combat weeds.
- Green manures are used to keep the soil covered year-round.
- Minimal tillage is used to maintain soil biodiversity.
- Mixtures are sown/harvested/managed similar as mono crop, but post-harvest separation should be possible.
- No external inputs other than energy.

Results already available

- Several student theses
- Farmer magazines
- Farm fairs on this experiment

Expected limitations or knowledge gaps

- Combinability of varieties/mixtures
- Timing and management
- Acceptable yields with low external inputs on sandy soils
- Benefits of narrow strips vs. increased traffic with heavy machinery

Network

- Dutch innovation programmes:
  - Stability through diversity and Improvement soil management (beterbodembeheer)
  - Strategic university investment theme resilience
- European project LEGVALUE.

Interactions with case studies: 16, 17, 18, 19, 20

Machinery issues

- Fixed traffic systems have different strips for field navigation
- Working width should match strip width
- Use of stubble as traffic lanes for transport of harvest
- Trade-off between light machinery with many passes vs. heavy machinery with fewer passes when working width is narrow

[1] Oomen, G J M, E A Lantinga, E A Goewie, and K W Van Der Hoek. 1998. "Mixed Farming Systems as a Way towards a More Efficient Use of Nitrogen in European Union Agriculture." *Environmental Pollution* 102 (SUPPL. 1): 697–704 ;

[2] Anderson, Randy L. 2015. "Integrating a Complex Rotation with No-till Improves Weed Management in Organic Farming. A Review." *Agronomy for Sustainable Development*. Springer Paris, 1–8. doi:10.1007/s13593-015-0292-3.

Experiment 8: Arable cropping systems, Switzerland (Partner: FiBL)

Location: Fislisbach (47°42’77’’, 8°29’05’’, 423m a.s.l.)

› Average rainfall: 1023 mm (2007-2016)
› Average annual temperature: 10.3°C (2007-2016)

Start: Spring 2018

Design

› 3 treatments
› Spatial replication: 4
› Total: 12 plots, 15 x 30 m

Contact: Maike Kraus, FiBL, Switzerland

Arable cropping systems – organic – no irrigation

Reference: 3 years rotation, starting with summer barley vs. barley/pea mixture

› Further crops will be determined later.

Reference

› 1) Simplified organic rotation: Represents an intensive organic arable rotation (without legumes and need of fertilizer input and mechanical weeding)
› 2) Maize monoculture (silage maize - catch crop)

Diversification strategies

› Mixed cropping, Intercropping

Why use these strategies?

› Mixed cropping and intercropping with legumes are of interest in terms of reduced fertiliser input, better yields through a better and more timely nutrient supply, and weed suppression
› We hypothesize that above- and belowground resources are more efficiently used and a more attractive habitat for above- and belowground organisms is provided, which is mirrored in increased weed, insect and microorganism diversity.

Interactions with case studies: 6, 7, 10, 16, 18, 20…

Network

› Collaboration with REMIX
› Exchange with DIVERFARMING partners in Switzerland

Expected limitations or knowledge gaps

› Increased complexity in management
› Yield stability
› Increase in biodiversity

Machinery issues

Normal farm machinery will be used

Experiment 9: Vegetable cropping systems, Italy (Partner: CREA)

Location: Monsampolo del Tronto (42◦ 53’ N, 13◦48’ E)

› Average rainfall: 564 mm

› Average annual temperature: 14.7

Start: 2017

Design

› Plots: 22 x 24 m

› All crops each year; 4 replications for each system

Contact: Gabriele Campanelli (CREA), gabriele.campanelli(at)crea.gov.it

Vegetable cropping systems – organic – with irrigation

Reference: A four year rotation with 6 cash and 3 cover crops (of different botanical families) (MOVE LTE MOnsampolo VEgetable organic - Long Term field Experiment) with no tillage and low off-farm inputs

- 1) Vetch as cover crop - Tomato/Sweet Pepper;
- 2) Barley as cover crop - Zucchini/Melon;
- 3) Fennel - Raphanus s. as cover crop - Lettuce;
- 4) Cauliflower - Bean/Chickpea.

Diversification strategies:

- The reference will be further diversified by implementing the strip cropping strategy
- Combination of multiple cropping and strip cropping
- Vetch will be replaced with faba bean as cash crop; faba bean is harvested for fresh product (sowing: October; harvest: April-May); then their plant residues will be flattened and the next tomato crop will be no till transplanted on them (transplanting: May; harvest: August) (multiple cropping: faba bean as fresh crop – tomato). Faba bean for dry grain harvest (sowing: October; harvest: July) is cultivated simultaneously (side strips)
- The cereal for dry grain is harvested (sowing: October; harvest: July). Simultaneously, in the side strips, the same cereal is used as a cover crop (sowing: October; flattened and not harvested: April-May) followed by Zucchini (no till transplanted: May; harvest: July)

Why use these strategies?

- Opportunity to have a wider range of products to deliver to the market
- Opportunity to further increase biodiversity and other ecological services (i.e. soil fertility) at the field and farm scale.

Results already available

- Results achieved in the MOVE LTE have been widely published since 2011:
- Effects on yield, product quality, biodiversity and soil fertility
- Effects of rotation, cover cropping and no tillage

Expected limitations or knowledge gaps

- The introduction of multiple and strip cropping in the local contest could be limited by technical constrains and an increased workload.

Interactions with different actors

- The design was based on the background knowledge of researchers who are used to interacting with local farmers and are aware of their needs
- Once the strip cropping system design was defined, local farmers were interviewed to get their comments

Network

- The MOVE LTE experiment is part of the “Italian Long Term Experiment Network” (Peronti et al., 2015)

Interactions with case studies: 22, 23, 24, 25

Experiment 10: Vegetable cropping systems under plastic tunnels, France (Partner: INRA)

Location: Alénya (42°38'15N 2°58'18E)

› Average rainfall: 557 mm

› Average annual temperature: 15.4°C

Start: 2012 (with major changes in 2017 for DiverIMPACTS expectations)

Design

› Tunnel cropping system - 8m x 50 m

Contact: Amélie Lefevre (INRA), amelie.lefevre(at)supagro.inra.fr

Vegetable cropping systems under plastic tunnels - organic - irrigation

Reference: Sole crop vegetables rotation with 2 to 3 crops a year

- 3 years rotation, dedicating a large amount of space to lettuce in the winter and to tomato or cucumber in the summer.
- Once every 3 years in summer, soil-borne pathogen control through solarisation, followed or preceded by green manure

Three diversified cropping systems:

1. Medium diversified sole crop rotation in organic vegetable system, with soil solarisation (MedDivSol)

- Sole Crop - vegetable rotation with 2 to 3 crops per year
- 3-year rotation at the botanical family level, which could include a longer return delay of the same species
- Reducing the relative amount of salad, improving soil use efficiency during crop sequence (limited periods of bare soil between cash crops)
- Cultivar mixes could be introduced
- Rotation of 3 to 4 botanical families
- Once every 3 years in summer, weed and soil-borne pathogen control through solarisation, followed or preceded by green manure.

2. Highly diversified row intercropped vegetable system in organic farming (HighDivRIC)

- Row intercropping - One crop specie per row (6 to 8 rows of 50m long under the tunnel)
- At least 3 commercial species per planting period
- 2 to 3 crops per year
- 2 mixed cultivars per crop companion plants in row and mixed spatial arrangement (not harvested)
- A mix of green manure to be buried before seed production every 2 years in summer
- No soil solarisation

3. Highly diversified mixed intercropped vegetable system in organic farming (HighDivMIX)

- 3 crop species per row in small patches of 3 to 6 plants (6 to 8 rows, 50m long under the tunnel)
- At least 3 commercial species per planting period
- 2 to 3 crops per year - same species as in HighDivRIC
- 2 mixed cultivars per crop companion plants in row and mixed spatial arrangement (not harvested).
- A mix of green manure to be buried once every 2 years in summer before seed production. No soil solarisation

Why use these strategies?

- These strategies will answers two questions:
- How do soil characteristics and vegetable production evolve through a medium diversification strategy, combined with solarisation?
- Considering the strong, but not selective, mid- and long term effect of soil solarisation, is the continuous intercropping with no soil solarisation strategy more resilient and/or is it more beneficial for natural regulation and production? With this diversification strategy, what is the more relevant intercropping spatial arrangement (row intercropping or patches mixed intercropping) to enhance expected benefits without adding too many unintentional effects?

Interactions with case studies: 25, 21, 22, 23, 24

Value chain issues

- In this field experiment, diversification is considered as a tool, which is integrated in a systemic agronomical strategy and value-chain.
- The commercial quality of each product will be considered