Organic-PLUS evaluation meeting (web), 6.2.2023

WP 5: Soil research in Organic-PLUS

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Organic-PLUS has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774340

We fulfilled all our tasks and deliverables (5.1-5.12)

- D5.1 Current use and legal status of fertiliser, peat, plastic
- D5.10 Summary paper on alternative mulch materials
- D5.11 Technical report on using alternative mulch materials
- D5.12 Report and factsheets on barriers (WP SOIL)
- D5.2 Report on alternatives to contentious inputs (WP SOIL)
- D5.3 Technical paper on twin screw extruder processing technology
- D5.4 Technical paper on organic matter
- D5.5 Peer-reviewed paper on defibrated organic materials (peat replacement)
- D5.6 Summary paper on alternative fertilisers
- D5.7 Technical report on alternative fertilisers (arable and vegetables)
- D5.8 Report on trial with alternative growing media
- D5.9 Farmer-focused open days

We always had an excellent spirit in our WP

Web photos of all listed on the WP5 e-mail list by July 2022

Collaboration with our sister project RELACS functioned well

RELACS and Organic-PLUS collaborate to reduce contentious inputs

Researchers and stakeholders active in two European H2020 projects, RELACS and Organic-PLUS came together for a webinar on 8th April to share lessons learned from project activities since 2018. The main areas examined were: reducing the use of copper and mineral oils for plant protection, animal-derived fertilisers from conventional farming, peat in growing media and fossil fuel-derived plastics. The webinar was primarily for people active in the projects, to facilitate open discussion about experiences and outcomes.

ORGANIC PLUS

RELACS
IMPROVING INPUTS FOR ORGANIC FARMING

Some of the webinar participants in the 'conference hall'!

Collaborative, internal webinar on April 8, 2021

Collaboration on dissemination functioned well

- Various people presented on behalf of WP5
- Various topics were highlighted in various events
- Several partners arranged events for dissemination
- People active in the WP were always engaged in making summaries and conclusions on behalf of the WP, e.g. in the 24 M report
- We knew each other well enough that presenting other people’s results functioned OK
- Highly diverse activities in different countries were merged into reasonable blocks of outcome

5.1: Initial mapping of inputs - peat, plastic, fertilisers, (and Cu, S, mineral oil –with WP3)

- Organic growers use as much plastic and peat as conventional
- Broad use of conventional poultry manure enriched with vinasse + meat-and-bone meal
- Broad range of plant-based and animal-derived commercial fertilisers, varying between countries

Crops/ Countries	Apple	Broccoli	Cabbage	Carrot	Cereals	Citrus	Cucumber	Eggplant	Lettuce	Olive	Potato	Pepper	Straw-berry	Tomato	SUM
Denmark	1	1			1						1		1	1	6
France				1				1	1	1	1			4	9
Germany			1		2						1			1	5
Greece	1	1				1				1	1			1	6
Italy						3				2	2			2	7
Norway	1			1							1		1	1	5
Poland							1				1		1	1	4
Spain						3				3				3	9
Turkey						1		1		1	1	1	1	1	7
SUM	3	2	1	2	3	8	1	2	1	8	9	1	4	15	60
UK	2	2	2	2					1				1		8

Inputs in important organic crops in 10 European countries were recorded by asking experts (advisors, farm managers) to fill in a detailed questionnaire covering all inputs such as plant protection, fertilisers, peat and plastic. Autumn 2018.

D 5.1 (report)

Current use of peat, plastic and fertiliser inputs in organic horticultural and arable crops across Europe. Løes et al, 2018

5.2: Reviewing alternatives
to fertilisers from conventional farming, peat in growing media, and plastic for mulching

3.3.1 *Main characteristics of key alternative ingredients to peat in growing media*

Main peat alternatives are from wood, industrial by-products of organic materials, or composted plant materials (Eymann et al., 2015). Figure 5 illustrates various products and materials used in peat replacement that are described in Table 7.

Figure 5. Products and materials used in peat replacement

REPORT BITE

D 5.2 (report)

Report on alternatives to contentious inputs

Oudshoorn et al, 2019

5.3: Processing of woody residual materials for peat replacement, bedding and more

Pruning material from olives extruded to fibre

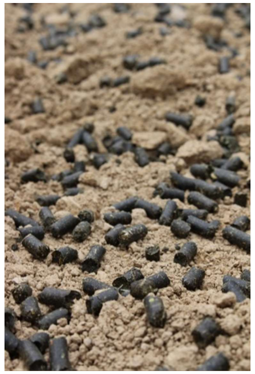
D 5.3 (tech paper)
Twin screw extruder processing technology for fibres as raw material for peat substitution
Dittrich et al 2019

D 5.4 (tech paper)
Technical paper on organic materials as peat substitute: Experimental investigation of different extruded lignocellulosic materials to determine a suitable substitute for peat
Dittrich et al 2020

D 5.5 (peer-reviewed paper)
Extrusion of different plants into fibre for peat replacement in growing media: adjustment of parameters to achieve satisfactory fibre-characteristics
Dittrich et al 2021, Agronomy (MDPI)

5.4: Fertilisers **Why do we need alternative fertilisers**?

- To decrease current dependency on contentious fertilisers from **conventional farming and food industries** (especially organic stockless farms and intensive organic fruit and vegetable producers)
- Increasing number of organic farms **without animal husbandry** (ethical, economic and environmental reasons)
- **Increasing political targets** for area under organic management 25%



Why are fertilisers considered contentious?

- Nutrients derived from **conventional animal husbandry**
- Fertilisers sourced from **distant countries**, often from the global South
- **Contamination risk:** veterinary drugs, pesticides

Structuring the alternatives: URBAN, VEGAN, RESIDUAL

- Closing the nutrient gap; recycling of nutrients from **URBAN** sources: composts, digestates
- Legume based and plant derived fertilisers for **VEGAN** growing
- **RESIDUAL**s from sustainable sources: organic food production and sustainably produced natural-derived (e.g., marine) materials

Country	Denmark	Germany	Norway	UK	Poland
URBAN	Source-separated organic household waste digestate	Source-separated organic household waste digestate			
VEGAN		Clover-grass silage; clover-grass digestate (with pig slurry); clover pellets		Comfrey extract, nettle extract, bean powder	
RESIDUAL		Tofu whey	Marine-derived residues (seaweed, wild fish)		Organic fish pond sediment
CONTROL	Pig slurry	Horn grit, solid cattle manure	Dried poultry manure	Liquid, plant based commercial fertiliser	

D 5.6 (summary paper)

Summary paper on alternative fertilisers
Zikeli et al, 2022

D 5.7 (tech report)

Technical report on alternative fertilisers (arable farming and vegetables)
Zikeli et al., 2022

Table 1: Nutrient concentrations and characteristics of biogas digestate used for the field vegetable trials (source-separated household waste used in trials in Germany).

	Dry matter (%)	N_{total} (g kg^{-1} FM)	NH_4^+-N (g kg^{-1} FM)	C (% DM)	N (% DM)	C:N ratio	P (g kg^{-1} DM)
Mean value	9.3	5.4	4.2	27.8	2.57	4.8	5.7
Range	(8.43-10.2)	(5.02-5.7)	(4.03-4.45)	(26.9-2.87)	(2.51-2.64)	(4.24-5.42)	(5.5-5.86)
No. of anal.	2	6	6	4	4	4	4

	K (g kg^{-1} DM)	S (g kg^{-1} DM)	Ca (g kg^{-1} DM)	Mg (g kg^{-1} DM)	Na (g kg^{-1} DM)	Cl (g kg^{-1} DM)	Zn (mg kg^{-1} DM)
Mean value	34.3	4.30	30.2	7.62	9.82	10.1	210
Range	(30.4-38.3)	(4.19-4.42)	(28.2-32.2)	(7.31-7.93)	(8.87-10.8)	(1.86-18.4)	(206-213)
No. of anal.	4	4	4	4	4	4	4

	As (mg kg^{-1} DM)	Cd (mg kg^{-1} DM)	Cr (mg kg^{-1} DM)	Cu (mg kg^{-1} DM)	Ni (mg kg^{-1} DM)	Pb (mg kg^{-1} DM)	Hg (mg kg^{-1} DM)
Mean value	4.47	0.45	54.7	58.9	19.1	24.7	0.11
Range	(4.11-4.99)	(0.43-0.47)	(49.6-59.6)	(58.5-59.3)	(17.9-20.1)	(23.9-25.6)	(0.10-1.2)
No. of anal.	4	4	4	4	4	4	4

	pH *
Mean value	7.9
Range	(7.4-8.2)
No. of anal.	64

No. of anal.: number of analyses.
*pH value is cited from Möller and Schulth
Methods: **C, N and S**: Dry combustion; **N_{total} and NH_4^+-N:** Kjeldahl; **P, K, Mg, Ca, Na, Zn:** Microwave digestion with HNO_3, measurement with Inductively Coupled Plasma- Optical Emission Spectrometry (ICP-EOS); **As, Cd, Cr, Cu, Ni, Pb and Hg:** Microwave digestion with HNO_3; measurement with ICP- Mass Spectrometry (MS); **Cl**: Hot water extraction and ion chromatography.

REPORT BITE
Nutrient concentrations and other characteristics

Evaluation of the tested fertilisers

- **All can replace contentious ones,** but **no single alternative is a „one-size-fits-all“ solution**
- **URBAN** fertilisers: **often cheap; high fertilizer value** (NH_4); **contamination risks; need for treshold values**
- **VEGAN Legume: possibly applied to improve the internal N-cycle on-farm, but legume pellets demand high use of energy use = high costs**
- **RESIDUAL: technical issues (low DM, high pH..), often unbalanced**
- **How to make organic certification more efficient? 10 year process with dossiers and EGTOP treatment required for each single material? (struvite)**

Potentials and challenges for practical application

Fertiliser type	Fertiliser	Production type	Fertilisation effect	Contamination risk	Application	Availability	Costs
VEGAN	Clover-grass silage	Vegetable	medium-low	very low	machinery necessary	easy	low
	Clover pellets	Vegetable	High	very low	easy	easy	high
	Bean powder	Greenhouse	High	very low	easy	easy	high
	Comfrey liquid	Greenhouse	Medium	very low	easy	easy but labour intensive	medium
	Nettle liquid	Greenhouse	Medium	very low	easy	easy but labour intensive	medium
URBAN	Biogas digestate (source separated household waste)	Vegetable	very high	high* (depending on source)	easy	depending on location	low
	Biogas digestate (source separated household waste)	Arable	very high	high* (depending on source)	easy	depending on location	low
RESID	Biogas digestate (clover-grass & pig slurry)	Vegetable	very high	high* (depending on source)	easy	depending on location	low
	Tofu whey	Vegetable	medium-high	low	machinery necessary	depending on location	low-medium
	Algae fibre	Arable	Low immediate but high residual effect	not certified organic	splitting before or during application	only available near production site	free/low cost
	Acid-preserved fish bones	Arable	High immediate but low residual effect	high in P and N, may cause eutrophication	Should be incorporated in soil to avoid consumption by birds and animals	only available near production site	free/low cost
	Compost from organic fish pond sediments	Compost	medium-low	low	easy	depending on location	low

* Main contamination risk for quality controlled biogas digestates: Plastics

Outlook:what is needed?

- Adapted fertilisation strategies in organic growing
- Increased interest/acceptance by farmers
- Regionalisation of fertiliser sourcing
- More efficient certification of fertilisers - change of administrative processes
- All categories (URBAN, VEGAN, RESIDUAL) must be utilised to reach 25% organic land

Denmark: Application of digestate from source-separated organic household waste in large-scale field trial, 2019

UK: Comfrey plants grown next to a polytunnel with a fertilisation trial with tomatoes, enabling on-farm nutrient acquisition for intensive organic protected cropping

5.5 peat in growing media

7/6/2021 Sales of peat compost to gardeners to be banned from 2024 | Climate change | The Guardian

News Opinion Sport Culture Lifestyle

Climate change

Sales of peat compost to gardeners to be banned from 2024

Damian Carrington *Environment editor*

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Tue 18 May 2021 06.00 BST

Sales of peat compost to gardeners will be banned from 2024, the government has said. Ministers will also give £50m to support the restoration of 35,000 hectares of peatland by 2025, about 1% of the UK's total.

The UK's peatlands store three times as much carbon as its forests. But the vast majority are in a degraded state, and are emitting CO_2, which drives the climate crisis.

Why do we need to phase out peat use?

- Peat are valuable areas, need protection
- Organic growing should be a front-runner
- Compost is a good alternative and composting is common in organic farming
- UK a leading country

HTA | The Responsible Sourcing Calculator

Horticultural Trades Association HTA

- energy use
- water use
- social compliance
- habitat and biodiversity
- pollution
- renewability
- resource use efficiency

To replace peat in growing media, O+ tested left-over plant materials for extrusion or composting

September 8, 2022:
Judith Conroy interviewed by BBC:

Is there a good alternative to peated compost? - BBC Future

Alternative growing media were tested for seedlings and transplants

Various extruded wood (poplar, forest residue, vineyard) tested alone or mixed with compost with tomato, lettuce and/or pepper in Catalonia

(pure) woodchip compost from ash tree tested in lettuce, cabbage and leeks in UK; addition of vermiculite and extruded poplar

Composts of horse manure and leaves tested with lettuce and cauliflower in Norway

Cocoa shells with soil decomposed in Greece

Local compost (horse manure and forest residue woodchips) tested with lavender in Catalonia

Local compost (chopped olive prunings) tested with olive saplings in Turkey

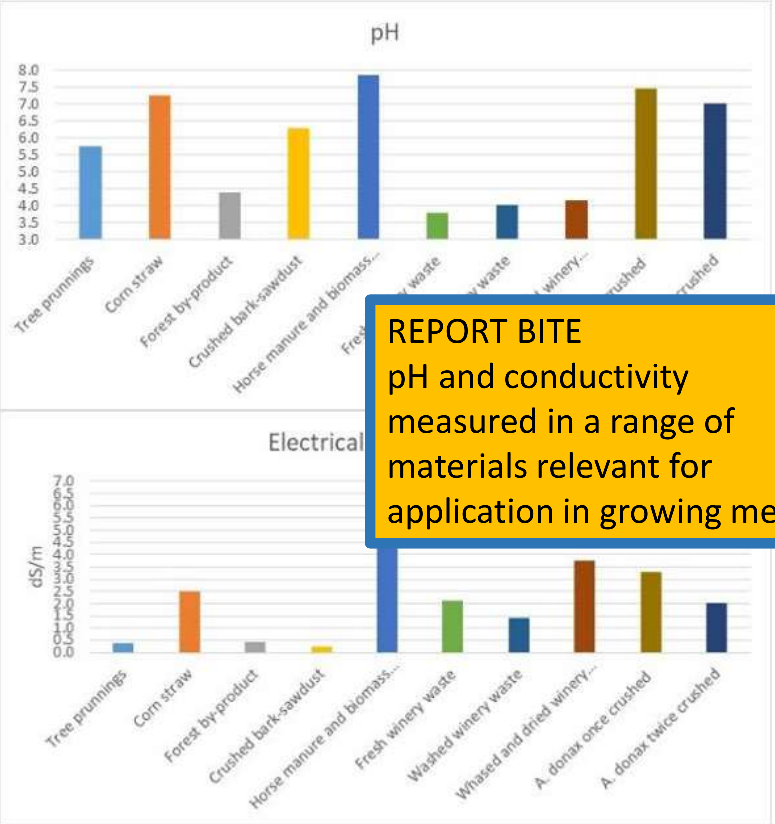
D 5.8 (report)

Report on trials with alternative growing media (replacement of contentious input peat)
Caceres et al., 2022

D 5.9 (report)

Report on farmer-focused open days – including bio-economy supply chain actors (growing media manufactures and plant nurseries)
Caceres et al., 2022

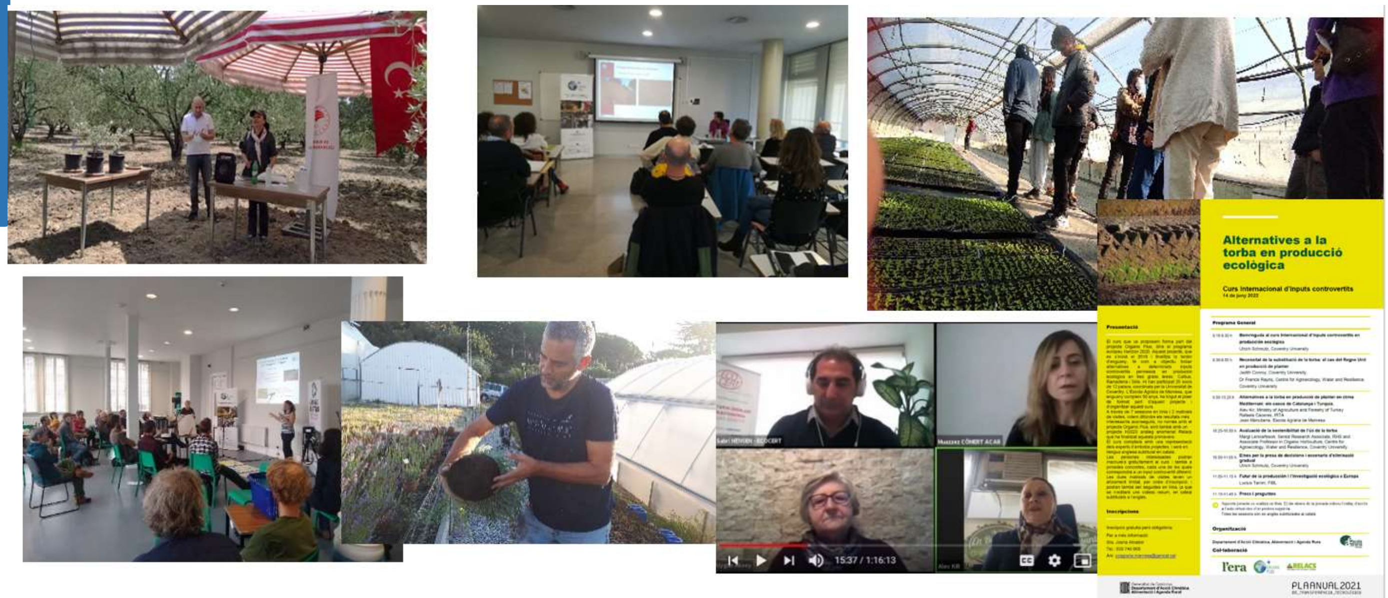
Figure 6. An interview with a leading organic farmer in Bostanlı, Karsiyaka (Izmir, Turkey) open organic market.



REPORT BITE
pH and conductivity measured in a range of materials relevant for application in growing media

Figure 7. pH (top) and electrical conductivity EC (bottom) measured in raw materials investigated by IRTA.

In Turkey, UK, Catalonia and Norway: visits to growers, workshops, fairs, surveys, interviews, conference sessions



Conclusions

- Different growing media for seedlings and larger plants
- Mature composts can replace peat
- Composted woody materials gave good results; N immobilisation needs monitoring
- Soil blocks may fall apart
- We need better fertiliser strategies! Struvite? Soon permitted in organic growing
- Significant N+P leaching observed from peat-based growing media
- More experiments are needed to confirm the results (with additional species and in commercial nurseries)

5.6: Completely biodegradable plastic foil for mulching, from renewable, non-GMO materials

D5.10
- Overview of biodegradable plastic mulches applied in horticulture and agriculture; prices, characteristics..
- Results of trial with loose mulches (hay etc.)

D 5.11
- Very impressive report about all materials produced in Poland and being tested in UK, Turkey (and Poland – not with crops), 101 pages!
- Ends up with very good practical recommendations; e.g., benefits such as 15-30% higher yields, less irrigation; but demands a good mixing with soil (ploughing) for complete degradation in field

D 5.10 (summary paper)
Summary paper on alternative mulch materials
Malinska et al., 2022

D 5.11 (tech report)
Technical report on using alternative mulch materials
Malinska et al., 2022

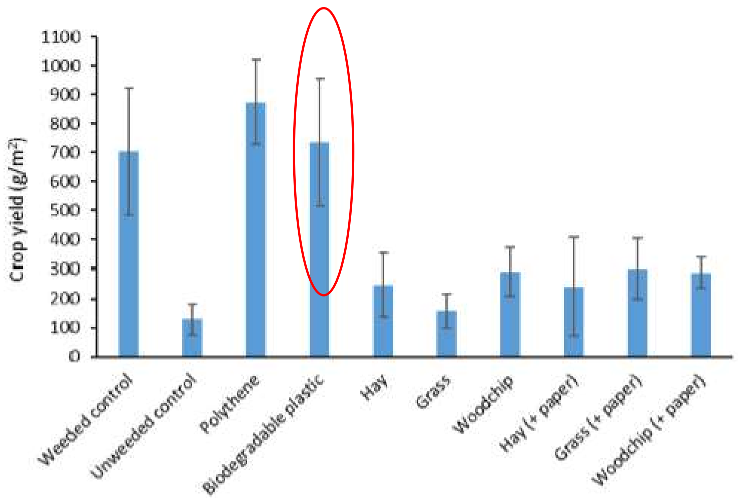


Figure 2. Yield of onions in the 2021 loose mulch trial. Values are the means of four plots +/- standard deviations.

Typical view of PE mulch films collected after plant harvesting

T3 Biodegradable mulch films after soil mixing

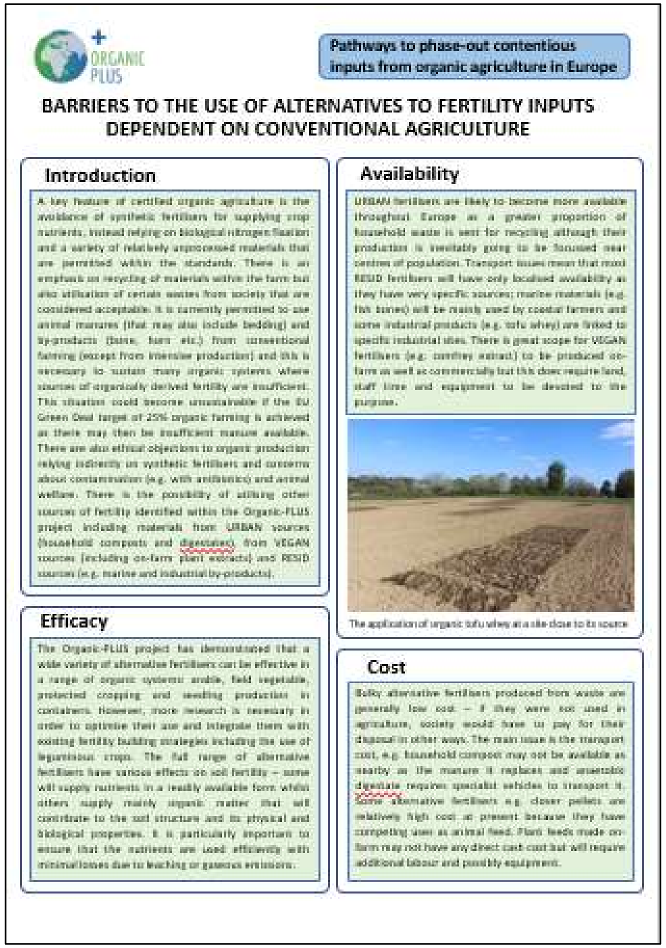
5.7 barriers to uptake of alternatives

..mapped via engagement with stakeholders

- **Efficacy**
- **Availability**
- **Cost** (economies of scale may reduce future prices; e.g. plastic mulch)
- **Knowledge** (training needed)
- **Practicality** (farmers “locked in” to current practices; e.g., transplant soil blocks demand peat for cohesion)
- **Regulatory restrictions** (acceptable limits for pollutants; e.g. digestate)
- **Consumer acceptance** (sustainable image of AO should not be compromised by use of contentious inputs)

O+ participants visiting Melcourt growing media, UK (above) and organic compost producer, Germany (below)

Findings summarised in factsheets (ferts, peat and plastic)



Pathways to phase-out contentious inputs from organic agriculture in Europe

BARRIERS TO THE USE OF ALTERNATIVES TO FERTILITY INPUTS DEPENDENT ON CONVENTIONAL AGRICULTURE

Introduction

A key feature of certified organic agriculture is the avoidance of synthetic fertilisers for supplying crop nutrients, instead relying on biological nitrogen fixation and a variety of relatively unprocessed materials that are permitted within the standards. There is an emphasis on recycling of materials within the farm but also utilisation of certain wastes from society that are considered acceptable. It is currently permitted to use animal manures (that may also include bedding) and by-products (bone, horn etc.) from conventional farming (except from intensive production) and this is necessary to sustain many organic systems where sources of organically derived fertility are insufficient. This situation could become unsustainable if the EU Green Deal target of 25% organic farming is achieved as there may then be insufficient manure available. There are also ethical objections to organic production relying indirectly on synthetic fertilisers and concerns about contamination (e.g. with antibiotics) and animal welfare. There is the possibility of utilising other sources of fertility identified within the Organic-PLUS project including materials from URBAN sources (household composts and digestates), from VEGAN sources (including on-farm plant extracts) and RESID sources (e.g. marine and industrial by-products).

Availability

URBAN fertilisers are likely to become more available throughout Europe as a greater proportion of household waste is sent for recycling although their production is inevitably going to be focused near centres of population. Transport issues mean that most RESID fertilisers will have only localised availability as they have very specific sources; marine materials (e.g. fish bones) will be mainly used by coastal farmers and some industrial products (e.g. tofu whey) are linked to specific industrial sites. There is great scope for VEGAN fertilisers (e.g. comfrey extract) to be produced on-farm as well as commercially but this does require land, staff time and equipment to be devoted to the purpose.

The application of organic tofu whey at a site close to its source

Efficacy

The Organic-PLUS project has demonstrated that a wide variety of alternative fertilisers can be effective in a range of organic systems: arable, field vegetable, protected cropping and seedling production in containers. However, more research is necessary in order to optimise their use and integrate them with existing fertility building strategies including the use of leguminous crops. The full range of alternative fertilisers have various effects on soil fertility – some will supply nutrients in a readily available form whilst others supply mainly organic matter that will contribute to the soil structure and its physical and biological properties. It is particularly important to ensure that the nutrients are used efficiently with minimal losses due to leaching or gaseous emissions.

Cost

Bulky alternative fertilisers produced from waste are generally low cost – if they were not used in agriculture, society would have to pay for their disposal in other ways. The main issue is the transport cost, e.g. household compost may not be available as nearby as the manure it replaces and anaerobic digestate requires specialist vehicles to transport it. Some alternative fertilisers e.g. clover pellets are relatively high cost at present because they have competing uses as animal feed. Plant feeds made on-farm may not have any direct cash cost but will require additional labour and possibly equipment.

Pathways to phase-out contentious inputs from organic agriculture in Europe

BARRIERS TO THE USE OF PEAT ALTERNATIVES IN GROWING MEDIA

Introduction

Although certified organic crops must be grown in field soil, many fruits and vegetables are propagated as transplants grown for a short period in containers. This requires a growing medium – over the past 50 years peat has been widely used for this purpose as it has ideal physical and chemical properties. Unfortunately the mining of peat has adverse environmental consequences including habitat destruction, interference with water movement leading to landscape flooding and the release of greenhouse gases. Peat is currently permitted for use within organic growing but there is increasing pressure for this to change to ensure that organic agriculture remains a leader in environmental sustainability. Many materials have been considered as alternatives and research within the Organic-PLUS project has evaluated the potential of some of these to phase out the use of peat from organic horticulture.

Peatlands are important habitats that have been much degraded

Efficacy

Peat-free growing media have been commercially available for many years and are widely used by growers in several countries. Their performance can be as good as peat-based counterparts although there continue to be reports of problems with individual batches. One of the characteristics of peat is its consistency; in composted materials consistency can be difficult to control because of inherent variations in the feedstock. Although there been much success with the development of growing media suitable for the production of vegetable transplants in modular plastic trays attempts to produce peat-free 'blocking media'

have been less successful; blocks are particularly suitable for raising transplants of lettuce and other salad crops as they can be handled more easily by machine without damage. Peat-free media do not generally have enough cohesion and this is one area where further research is required.

The physical properties of peat make it well suited to blocking

Availability

Most peat-free growing media are currently made from coir (from coconut husks), various forestry by-products (bark or wood-fibre processed in different ways) or green compost (made from park and garden waste). At present there is good availability of commercial media (key manufacturers trade these internationally) and also opportunities for small scale production for on-farm use. However, as the use of peat is phased out the supplies of some products may become more restricted and interruptions to trade caused by global disruptions may make reliance on materials transported over great distances such as coir a less resilient approach.

Pathways to phase-out contentious inputs from organic agriculture in Europe

BARRIERS TO THE THE USE OF ALTERNATIVES TO FOSSIL-DERIVED PLASTIC MULCHES

Introduction

Effective weed control is frequently a major problem in organic vegetable production, especially in crops that are not very competitive or slow to establish. Although there have been developments in sophisticated weeding machinery, the use of this is frequently not an option for small farmers who may be forced to resort to hand labour and this can result in the price of the produce becoming prohibitive for many potential customers. Plastic film mulches to cover the soil are an effective way of suppressing weeds and they have been increasingly used in recent years – they may also assist with moderating soil temperatures and conserving soil moisture. However, plastics such as polythene and polypropylene, although permitted in organic farming, present problems of disposal as they are difficult to recycle and can break down to release microplastics into the environment. The Organic-PLUS project explored alternatives including both biodegradable plastic biobased film mulches and 'loose mulches' made from on-farm sourced materials such as hay and chipped wood.

Crops are planted through lengths of plastic mulch

Efficacy

The Organic-PLUS project demonstrated that black biodegradable film mulches, made from starch, could be very effective in both northern and southern European climates and in some cases crop yields were higher than in hand weeded plots, probably because they helped retain soil moisture. The performance of loose mulches was more varied - they were particularly successful when annual rather than perennial weeds

weed seeds could actually be introduced. They could also have an effect on soil nutrient dynamics, either locking up nitrogen (e.g. chipped wood) or making it more available (e.g. grass mowings).

Assessment of cabbages planted through a range of mulches

Availability

Biodegradable film mulches are already commercially available throughout Europe although they are only made in a few locations so timely delivery may be an issue. Work within Organic-PLUS explored innovative multilayer films that have not yet reached the market – these could be tailored to have specific suitability for various cropping situations. Work with the loose mulches showed that it was important that they were applied relatively thickly which could make sufficient quantities difficult to source and so this approach may be more suitable for smaller farms. Their use is particularly compatible with a diverse agroforestry system, using multifunctional mulches to move nutrients from one zone to rather than just thinking of them as a means of weed control.

Cost

At present, biobased biodegradable film mulches are much more expensive than the established fossil-fuel derived plastics that they could replace. It is likely, owing to economies of scale, that this price difference could be reduced if demand increases but they will still be industrialised inputs produced in specialist facilities.

Barriers should be lifted by more research, development of regulations, and policy development