Maximising Organic Production Systems European Innovation Partnership (MOPS EIP) Project 2018-2021

Final Report

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MAXIMIZING ORGANIC PRODUCTION SYSTEMS

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AGRICULTURE & INNOVATION

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An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

Executive summary

The organic food sector in Ireland is important for the sustainability of Irish agriculture, and developing organic production will create business opportunities and jobs across the agri-food chain. The Irish organic horticulture sector, whilst relatively small at present, has been identified as one of the sectors with the greatest growth potential. Sales of organic vegetables and fruit continue to increase year-on-year in Ireland. Production of Irish grown organic horticultural produce, however, falls short of meeting current market demand, with a significant amount of produce imported. Scale and consistency of supply remain the main factors constraining the supply of Irish grown produce. There is a clear market for organic growers to expand the availability of Irish grown organic vegetables and fruit, and doing so will contribute to Ireland's move towards a sustainable food system.

The main aim of the Maximising Organic Production Systems (MOPS) European Innovation Partnership (EIP) project was to optimise the production of organic vegetables and fruit crops and improve supply consistency through the collaborative production of 11 organic growers located in Ireland. The specific objectives of the project were: develop and implement organic cropping programmes for each grower and provide better continuity of supply through collaborative production and trade; reduce surplus produce; provide a platform for trade and supply amongst the group of growers; establish current and future retail market demands and requirements for organic horticultural fresh produce; advise on using green manures to improve sustainable practices and to reduce reliance on imported nutrients; and build capacity, through the group and project activities, to produce a training video to disseminate to the wider community.

MOPS project headline results: organic horticulture production

- Optimised cropping plans were successfully developed to supply the demand for Irish grown organic vegetables and fruit. The crop programmes additionally facilitated collaborative production and trade amongst the group of MOPS project growers for improved supply consistency.
- The total crop production area for the group of project growers increased by 40% between 2019/2020 and 2020/2021 (the final year of the MOPS project).
- Total sales of all own-grown organic crops produced by the 11 MOPS project growers increased by +11% year-over-year by the final year of the project.
- Trade of organic horticultural fresh produce between the MOPS project growers increased by +62% year-over-year for the same period.
- In addition to increased trade between the MOPS project growers, purchasing of additional Irish horticultural fresh produce from other Irish and Northern Irish organic growers and suppliers increased by +371% year-over-year by the final year of the project.
- Whilst the purchase of imported produce, with an overall greater value, increased by +119% in the final year of the MOPS project, significantly, the project growers substituted 9% of non-Irish imported produce with Irish produce compared to the previous year.
- Total sales turnover generated from sales of organic vegetables and fruit by the 11 project growers increased +112% from €3.8 to €8.1 million between 2017 and 2020. The highest single year growth was in the final year of the MOPS project where total sales turnover increased by +40% year-over-year.
- Total sales turnover from produce sales to grocery retailers and supermarkets showed continued growth of +21% year-over-year between 2019/2020 and 2020/2021. Direct-selling, particularly online box scheme and farm shop-based ordering, delivery and/or collection, grew significantly by +81%. Sales turnover generated from restaurant and shop sales dropped by -40% in comparison with the previous year as a result of the COVID-19 pandemic.

- The MOPS project growers benefitted greatly from on-farm monitoring (farm business/crop performance and climate/weather), sampling and agronomic guidance, which all played a key role in crop planning, produce quality, and market decisions.
- Training, information sharing, dissemination and innovation facilitated by the MOPS project built capacity and advanced grower knowledge and on-farm and business practices.

MOPS project headline results: market research report

- For the five years up until 2020 there was steady growth of up to 20% every year in the volume of organic vegetables sold through Irish multiple retailers, and this increased further during 2020 to 25% with the onset of the COVID-19 pandemic. This growth is set to continue at a rate of 10-20% during 2021. The best-selling organic vegetables for grocery retailers in 2020 were onions, potatoes and carrots.
- Multiple retail buyers demonstrated a high level of support for Irish organic vegetable growers and are keen to further support the sector as they see the potential for increased growth. However, they and other trade stakeholders including consolidators and foodservice operators recognise that there are several challenges to the sector, notably in terms of a fragmented market, with a high number of small growers producing several crops in small quantities, and a relatively low number of large growers growing a higher volume of a limited number of crops. Increased scale and a higher level of expertise are necessary to support the commercial success of Irish organic growers.
- The Irish climate and seasonality pose challenges for consistent year-round supply of Irish grown organic vegetables which could be addressed by increased availability of cold storage. The formation of a producer group is a solution to addressing the need for an increased level of commercialisation of organic vegetable growers being called for by several trade buyers.

MOPS project headline results: green manure field trials

- Short-term green manures achieved consistent beneficial effects over the three years of the MOPS project green manure field trials associated with better weed control, more beneficial insects, more and greater functional diversity of soil bacteria, greater soil organic matter content and earlier-developing cash crops than in the control. Although no single factor was identified as the cause of the increased yield, the consistent improvement over the three years of the trial despite major differences in weather shows that the effect is robust.
- Cost-benefit analysis showed that extra financial returns were achieved for growing short-term green manures.
- The early development of all cash crops in response to green manure incorporation opens up the possibility of using green manures on part of the cropping space to spread the harvest period for a crop.
- These results suggest that short-term green manures can readily and profitably be incorporated into Irish organic vegetable production.

Headline results: dissemination and knowledge sharing

- Dissemination and communication of MOPS project activities and results was achieved through multiple methods including publications, social media and events.
- The MOPS project produced a growers report and videos that are being disseminated so that growing techniques may be replicated or used as demonstrative examples of the different approaches that the project growers use to optimise production of organic horticultural crops.
- A technical note on organic materials used in organic production was collated and included in the growers report to provide: information on the main types of organic materials, such as compost, that organic growers use; a guide to sampling organic materials and interpreting laboratory analysis reports; and examples of nutrient/composition analysis results for a range of organic materials that were sampled from the MOPS project farms during the project.

The key results from the MOPS EIP project have contributed to the EU's Common Agricultural Policy (CAP) Rural Development priorities on farm viability and competitiveness and food chain organisation and risk management. In addition to informing the relevant interventions under Ireland's CAP Strategic Plan, the project results can support the effective implementation of Ireland's Food Vision 2030. In particular, the Irish government's upcoming roadmap for the horticulture industry to 2030. Integrating the key findings from the MOPS project into these new policies can help the organic horticulture sector in Ireland to respond to growing market demand sustainably, and also deliver on the ambitions of the European Green Deal and Farm to Fork Strategy. Transition to a sustainable food system, including reducing food loss and waste and fair pricing, will need to go beyond production to involve all relevant stakeholders from processors, retailers and consumers to advisors, trainers and researchers for the changes in attitudes and practices that are required.

MOPS project team members

Operational Group Members	Project Team Members
Lead Partner Gillian Westbrook CEO Irish Organic Association	Project Manager/Industry Liaison/Sampling Gillian Westbrook
Consultant Agronomist John Hogan	Consultant Agronomist John Hogan
Academic Consultant (Agricultural Botany)/Green Manure Trial Prof Peter Jones	Academic Consultant (Agricultural Botany)/Green Manure Trial Prof Peter Jones
Field Data Collector/Green Manure Trial Supervisor Paula Pender	Lead Researcher/Data Analyst/Field Data Collector/Sampling William Deasy, PhD
Field Data Collector Mary Lynch	Field Data Collector/Communications Officer Grace Maher
Deirdre O'Sullivan Grower	Field Data Collector/Green Manure Trial Supervisor Paula Pender
Vincent Grace Grower	Field Data Collector Mary Lynch
Padraig Fahy Grower	Field Data Collector Noel Clinton
Kenneth Keavey Grower	Data Analyst Climate Monitoring Dr A.G. Westbrook
Desmond Thorpe Grower	Industry Liaison James Burke & Associates
Oliver Kelly Grower	Accounts and Data Protection Administrative duties by the Irish Organic Association
Patrick Frankel Grower	
Emmett Dunne Grower	
Liam Ryan Grower	
Janet Power Grower	
Nick Cullen Grower	

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1 Maximising organic horticultural crop production

1.1 Introduction

Maximising Organic Production Systems (MOPS) is a European Innovation Partnership (EIP) project that is co-funded by the Department of Agriculture, Food and the Marine (Government of Ireland) and the European Commission.

1.1.1 Organic horticultural crop production in Ireland

The organic food sector in Ireland is continuing to experience growth. Market research by Bord Bia, the Irish Food Board, shows that the organic retail market and direct sales are worth €206 million. Organic vegetables and fruit (horticultural fresh produce) valued at €54.7 and €28.3 million, respectively, have seen an increase in sales year-on-year. Commercial production of organic horticultural fresh produce in Ireland takes place on holdings varying in size from small market garden enterprises to field scale production. The key markets for organic fruit and vegetables are grocery retailers/supermarkets, wholesale, farmers markets, box schemes, farm shops and restaurants (DAFM, 2019; Teagasc, 2020).

Despite being one of the main food choices made by consumers of organic produce, organic vegetables and fruit continue to be the area of shortest supply in the organic sector. Bord Bia marketing research has established that, at present, Ireland imports 70% of organic horticultural fresh produce to satisfy the growth in demand from Irish consumers (DAFM, 2019; Bord Bia, 2020). Ireland has the potential to produce a great deal more quality organic horticultural fresh produce to meet the increased market demand, and the growing emphasis on sustainable food systems and short supply chains set out in EU policy such as the Farm to Fork strategy (European Commission, 2021). However, the Irish organic horticulture sector faces a number of challenges to its growth and development, and improving the availability of Irish grown organic fruit and vegetables, including the small scale of producers, many of whom operate independently, access to suitable land, labour and costs, the seasonal climate, and maintaining continuity of supply throughout the year.

Stakeholders including the organic horticulture industry and grower representatives, the Department of Agriculture, Food and the Marine (DAFM), organic certification bodies like the Irish Organic Association, Bord Bia, along with research, advisory and training agencies are directing efforts at addressing the challenges, and opportunities, in increasing the supply of Irish organic vegetables and fruit by identifying markets and promotion, encouraging import substitution, and increasing the area of land under production (DAFM, 2019). Furthermore, growers are being encouraged to co-operate with other growers in producer groups, or in EU recognised Producer Organisations to better co-ordinate supply to match demand, avail of improved marketing, promotion and investment as well as enhanced bargaining power and competitiveness, and to benefit from greater knowledge transfer, information sharing and innovation opportunities (DAFM, 2018; European Commission, 2021).

1.1.2 European Innovation Partnerships: opportunities for innovation, co-operation and knowledge sharing in practice

European Innovation Partnerships (EIP) for agricultural productivity and sustainability funds projects that allow farmers, scientists and other experts to collaborate together to develop practical innovative solutions to address a particular challenge or opportunity. In Ireland, EIPs fall within the remit of the Rural Development Programme 2014-2022 (RDP) under Commission Regulation (EU) 1305/2013 of the European Parliament and of the Council (European Commission, 2013). A key aim of EIPs is to test new ideas and practices that can then be shared and used more widely by farmers and others to improve productivity and enhance economic and environmental sustainability. EIP projects involve the establishment of an Operational Group composed of members that are best positioned to develop ideas and put them into practice to achieve the aims of the project. Innovation, co-operation and dissemination are key elements of EIPs (European Commission, 2021; DAFM, 2021).

1.1.3 The MOPS EIP project

The MOPS EIP project (June 2018-2021), involving 11 certified organic vegetable and fruit producers in Ireland (Figure 1), is a grower-focused innovative solution to increasing the supply of Irish-grown organic horticultural fresh produce through collaboration. The project was initiated by the Irish Organic Association when asked by some of its horticultural crop producer members to investigate how to sustainably increase the supply of Irish organic fresh produce to retailers/supermarkets and for direct-selling. A MOPS EIP project Operational Group was subsequently formed with the aim of optimising production of organic horticultural crops and improving continuity of short supply chains through the collaborative production of the 11 growers, producing as if they were one collective farm. The specific objectives of the MOPS project were:

1. Develop and implement organic cropping systems for each farm based on its characteristics to provide better continuity of supply through collaborative production and trade.
2. Reduce surplus production.
3. Provide a platform to formalise trade and supply amongst the group of growers.
4. Establish current and future retail market demands and requirements for organic horticultural fresh produce.
5. Advise on green cover crop trials to improve sustainable practices and to reduce reliance on imported nutrients.
6. Build capacity, via the group and project activities, to produce a training video to disseminate to the wider community.

1.1.4 The MOPS project growers

At the outset of the MOPS project, the participant growers produced on certified organic farms ranging in size from circa 1 hectare (ha) to over 100 ha. Own-grown field and protected (polytunnel/glasshouse) crop types under production included brassica crops, root/tuber/bulb crops, leafy/herb crops and other minor/specialised crops. The main routes to market across the group of growers were grocery retailers/supermarkets, wholesale, direct selling (farm shops, farmers markets, box schemes), restaurants and independent shops. Several of the project growers were already familiar with one another and engaged in trade. A number of the growers were trading with other Irish/Northern Irish organic growers and suppliers outside the MOPS project group, and importing organic produce to supplement their own-grown organic vegetables and fruit to satisfy consumer demand and for continuity of supply, particularly out of season. In addition to holding organic certification, some of the growers have achieved quality assurance certification through the Bord Bia Quality Assurance Scheme. Total sales turnover for the group of MOPS project growers in 2017 and 2018 was €3.8 and €4.3 million, respectively.

1.1.5 The MOPS project approach: a brief overview

To address the overall aim of the MOPS project and tackle the specific objectives, each grower in partnership with a leading Irish consultant agronomist, supported by the project team, focused on developing optimised cropping systems to meet forecasted demand for their markets. The cropping systems were additionally designed to facilitate collaborative production and trade amongst the group of growers to improve supply continuity and for greater market opportunities. Through meetings and farm visits, particular focus was placed on establishing individual grower and group production capacity, crop planning, improving existing practices and using crops and cultivars suitable for each farm location that enhanced produce quality and season extension whilst reducing losses and waste. Decision-making was assisted by assessment of both market and grower needs through industry liaison, and the performance monitoring of each farm by the project team. The data and information collected from industry and the farm monitoring fed directly into the development of the cropping plans. The on-farm climate/weather monitoring data additionally assisted with better understanding incidence of crop pests and diseases during the growing seasons and decisions on management to minimise crop losses and waste. Agronomic improvements were aided by laboratory nutrient analysis of soil, organic material inputs and crop leaf tissue samples coupled with best practice guidance on nutrient management. An on-farm green manure trial provided the growers with information, in an Irish context, about which green manures influence soil quality, crop yields, weed pressure and biodiversity. In addition, a technical note on the use of compost and other organic materials in organic production was collated to produce a guide for farmers on the main types of organic materials being used by organic growers, sampling and interpreting laboratory analysis reports, and example nutrient/composition analysis results for a range of organic materials including those collected from MOPS project growers. Videos on growing techniques and insights from the project growers and consultant agronomist were captured for dissemination to the wider community as examples of the different approaches that the project growers use to optimise production of organic horticultural crops. Key to the collaborative approach was facilitation of discussion and open dialogue amongst the project growers relating to crop production techniques, equipment/machinery and crop planning along with trade, markets and supply needs, while all the time respecting the commercial confidentiality wishes of each individual farm business.

Within this context, this final report for the MOPS EIP project sets out in detail how the objectives of the project were addressed, and presents practical findings and outcomes from the project that can serve to improve the productivity and supply of Irish organic vegetables and fruit, thereby contributing to enhancing sustainable organic horticultural fresh produce supply chains in Ireland. The report is divided into sections, each addressing the specific objectives and key performance indicators of the project. The present section reports on the findings relating to one of the key project objectives, maximising organic production and better continuity of supply through collaborative production and trade between the organic growers that participated in the MOPS project. The next section presents the findings of the MOPS project market report. The subsequent sections describe: the method used for on-farm climate/weather monitoring during the project with examples of data; the results and recommendations of the green manure trial; the technical note that was produced during the project on organic materials that are used in organic production along with a guide to sampling and interpreting analysis results; and the dissemination and communication strategy for the project activities and results. The final section presents concluding remarks.

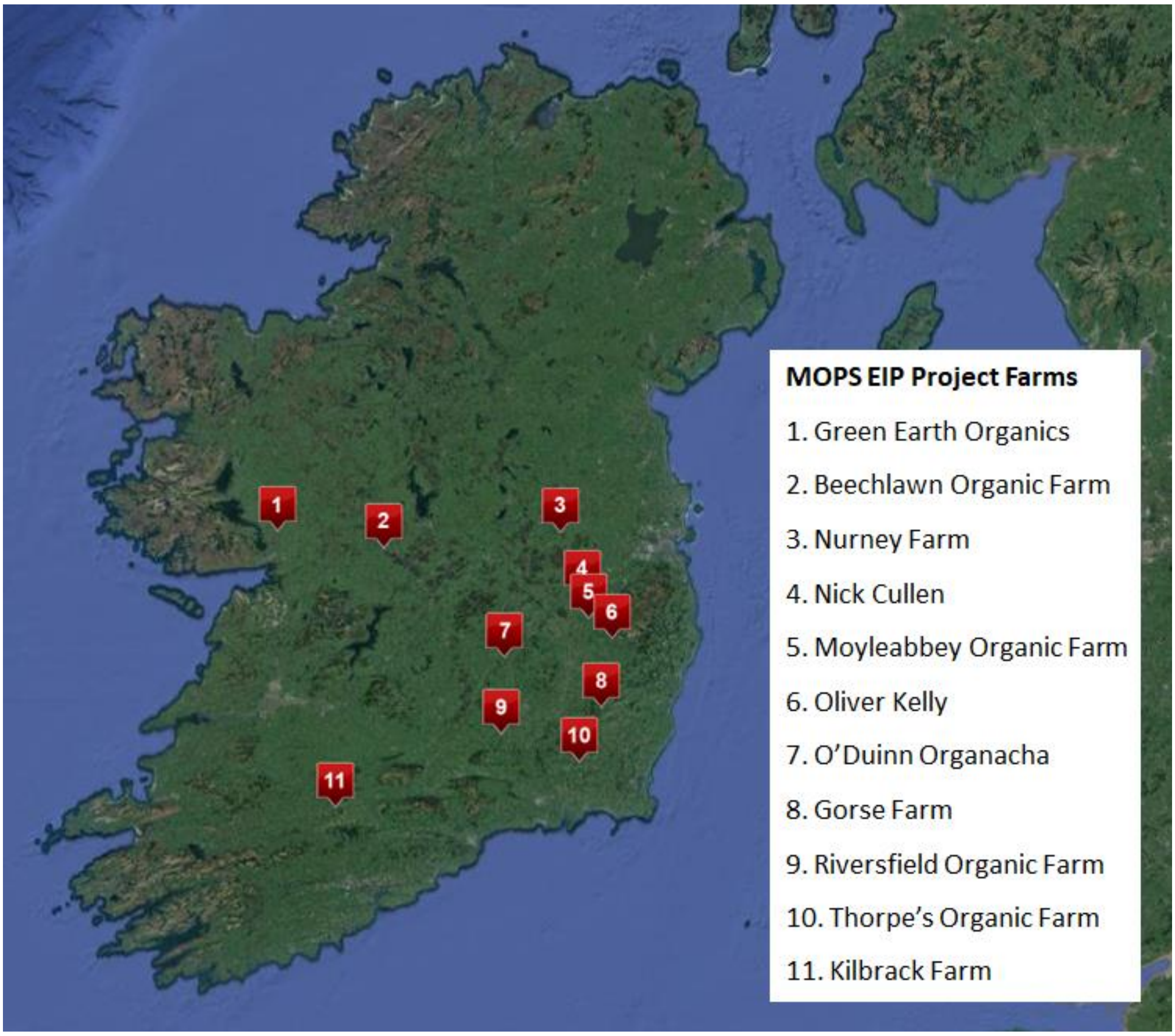

Figure 1 Locations of the MOPS EIP project farms in Ireland. Image source Google Maps annotated using Scribble Maps (Scribble Maps, 2021).

1.2 Materials and methods

A project procedures manual containing detailed methodology on all project activities and policies was produced as a guide for the MOPS project. Outlined below are methods and approaches specific to this section of the report. See following sections and methodology contained therein for procedures that relate directly to that section.

1.2.1 Initial visits to MOPS project farms

1.2.1.1 Baseline information and data

For the purpose of reporting, information and data collected at the preliminary stages of the project are hereinafter referred to as baseline information and data.

Baseline information and data on the 11 MOPS project farms were obtained at the outset of the MOPS project through initial farm visits comprising structured interviews and questionnaires that were based on the aims and objectives of the project.

A SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) was carried out on the information that was extracted from the questionnaires/interviews with the 11 participating growers. The SWOT analysis was conducted to aid planning during the MOPS project by identifying existing resources both internally (participating farm businesses) and externally that may have either positive or negative impacts on the project businesses. The information was subsequently collated with SWOT analysis results published in DAFM Review of organic food sector and strategy for its development 2019-2025 (DAFM, 2019) to place the MOPS project initial interview findings in the wider context of sector strategic planning and development policy.

Baseline crop production related information and data were collected from the 11 MOPS project growers during the same initial interviews. This information formed the basis for crop planning and guidance on growing practices involving the MOPS project growers and consultant agronomist over the course of the project. In addition, baseline data on total sales turnover in 2017 and 2018 for each project grower, years directly preceding the MOPS project, were obtained through the Irish Organic Association with the permission of the MOPS project growers. These key baseline financial data allowed for year-over-year analysis and evaluation of the performance of the MOPS project farms over comparable periods until completion of the project in 2021.

1.2.2 Planning visits

Planning visits to each MOPS project farm were conducted twice over each 12 month period to implement the aims and objectives of the MOPS project, specifically the development of optimised crop plans cognisant of collaborative production and trade between the MOPS project growers, and to impart best practice guidance for maximising crop production and quality, including minimising crop losses and waste. The planning visits involved: crop walking to monitor crops and production practices in order to make agronomic recommendations based on observations; crop planning and review of farm and climate/weather monitoring information and data records, previous crop plans and other key crop growing and quality factors influencing the marketing of the crops; and finally, documentation of the planning visits through video recording for dissemination of growing practices and agronomic expertise to a wider audience beyond the project.

1.2.3 Farm monitoring visits

1.2.3.1 Farm monitoring data collection

Each MOPS project farm was visited every 10 months in 12 for the duration of the project by assigned Field Data Collectors to carry out the following specific progress monitoring tasks linked to the project aims and objectives: collection and entering of information and data to templates;

downloading climate monitoring data from on-farm loggers; and sampling of crop leaf tissues as required.

1.2.3.1.1 Climate/weather monitoring data collection

As part of the monthly farm monitoring visits, Field Data Collectors downloaded weather data from HOBO dataloggers, set up at the start of the project on each participating farm, to a secure laptop using HOBOware software installed on the laptop. Data were subsequently sent to the Data Analyst for data processing, interpretation, visualisation and reporting. See section 3 climate and weather monitoring in this report for further details on methodology.

1.2.3.1.2 Sampling crop leaf tissue and reporting analysis results from the laboratory

Crop leaf tissue sampling methodology was as per Yara and NRM guides. The following procedure was adhered to when sampling the crop leaf tissue:

- Samples were taken before application of nutrients, or a minimum of three weeks before the plant was sampled where nutrients were applied.
- Where deficiency symptoms were throughout the crop, samples were collected along a W type walk through the field/sampling area.
- In certain cases, both deficient and healthy plants were sampled in order to be able to compare analysis results.
- Specific sampling instructions for crops and varieties were listed in the Yara and NRM guides provided but where instructions do not exist for a crop or variety, a general rule was to select the upper most recently matured leaves.
- Samples consisted of 200 g of material by selecting more plants than fewer as recommended.
- Order books provided by the project assigned laboratory (Yara) were used when sending samples to the laboratory for analyses. Crop details were recorded in the order form.
- Analysis results report(s) returned from the laboratory were sent promptly to the relevant project grower and consultant agronomist.

1.2.4 Sampling soil and organic material inputs

Sampling soil and other organic material inputs was conducted as per Yara, NRM and Teagasc guides. The procedures below were followed when taking the samples:

1.2.4.1 Sampling soils and reporting analysis results from the laboratory

- A sample consisted of 0.25-0.5 kg of soil, which represented the sampling area or field being sampled.
- Soil sampling was carried out using a soil corer.
- Soil cores were taken at the correct sampling depth of 100 mm (4”) every 2 to 4 ha (upper scale of field sampling area). Representative soil samples were collected by walking in a W shaped pattern across the sampling area/field.
- Separate samples were collected from areas that were different in soil type, previous cropping history, slope, drainage or persistent poor yields. Unusual areas were avoided such as old fences, ditches, drinking troughs, dung or urine patches or where fertiliser/manures or lime had been heaped or spilled previously.
- Samples were typically not collected from a field until 3 to 6 months after the last application of P and K and 2 years where lime was applied as per guide recommendations.
- A sample for laboratory analysis consisted of a minimum of 20 soil cores, mixed together, and representatively sub-sampled into a sampling bag.
- Where possible, samples were taken at the same time of the year to aid comparisons of soil sample results. Sampling under extremes of soil conditions e.g., waterlogged or very dry soils was avoided.

- Order forms provided by the project assigned laboratory (Yara) were used when sending labelled samples for analyses.
- Analysis results report(s) returned from the laboratory were promptly sent to the relevant project grower and consultant agronomist. Sample locations were mapped and included in the results report.

1.2.4.2 Sampling organic material inputs and reporting analysis results from the laboratory
The sampling procedure for organic material inputs, e.g., compost, sampled from the project farms is set out in detail in section 5 technical note on using organic materials. Analysis results report(s) returned from the laboratory were promptly forwarded to the relevant project grower and consultant agronomist.

1.2.4.2.1 Technical note on using organic materials
A technical note on the use of organic materials in organic agriculture/horticulture production was collated to provide information on: the main types of organic materials, including green manures, that are used in organic horticultural crop production; sampling organic materials and interpreting the laboratory analysis report; sample analysis results including those from organic materials that were sampled from participant MOPS project growers; and relevant legislation, regulations, standards and guidelines.

1.2.5 Information and data management and analysis

1.2.5.1 Farm monitoring information and data
Data collected during the farm monitoring visits, both manually and electronically in Microsoft® (MS) Word- and Excel-based structured templates, were entered to Farmplan GateKeeper farm management software. An innovative new approach to record keeping and information/data management for the majority of the project growers. Additional data analysis and visualisation e.g., graphical representation of the project data was carried out using MS Excel.

There were some challenges with collecting certain data given the number of sources and range of data/information management systems on each farm. Where needed, limitations in the data are acknowledge and explained in the results section 1.3 of this report.

1.2.5.2 Climate/weather monitoring data
See section 3 climate and weather monitoring in this report for further details on methodology.

1.2.6 Platform for trade between MOPS project growers

The MOPS project Operational Group meetings provided a forum for discussion between the project growers but a specific WhatsApp group on WhatsApp Messenger owned by Facebook Inc. was used to facilitate more informal and regular ad hoc communication relating to trade and technical information (Figure 2).

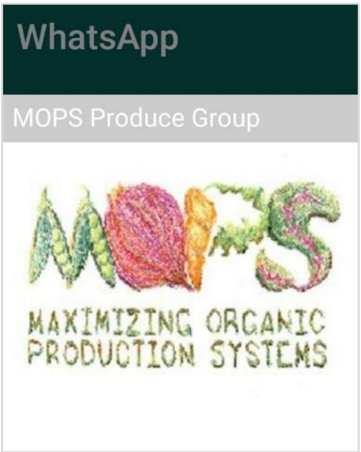

Figure 2 WhatsApp Messenger group set up for the MOPS project to facilitate trade and discussion.

1.2.7 Using refractometer (°Brix) as indicator of quality

Measurement of soluble solids or °Brix was used where relevant to assess crop/produce quality. The MOPS project growers were provided with training and specific methodology for measuring °Brix with a refractometer, including standard/typical °Brix values for vegetables/fruit fresh produce.

1.2.8 Dissemination

See section 6 dissemination in this report for further details on methodology.

1.2.9 Industry liaison

Section 2 MOPS project market report provides detailed methodology on the research and analysis that was carried out to establish market and farmer needs pertaining to the MOPS project aims and objectives.

1.2.10 Green manure trial

See section 4 green manure field trial for detailed methodology.

1.3 Results

1.3.1 Baseline information and data

1.3.1.1 Baseline: SWOT analysis

Table 1 presents the results of the SWOT analysis that was carried out following the initial farm visits with the 11 participant MOPS project growers.

Table 1 Results of SWOT analysis carried out on interview/questionnaire information collected through initial interviews with the MOPS project growers collated with SWOT analysis results presented in DAFM Review of Organic Food Sector and Strategy for Its Development 2019-2025 (DAFM, 2019).

SWOT analysis: Strengths
• Demand for organic produce, market available. Increased public awareness and interest in local and organic produce. Organic production well positioned to meet consumer buying choices based on health, environment and taste. High level of consumer trust in certified organic produce. The MOPS project growers are all certified organic producers. • Greater levels of policy, promotion, marketing and incentives to produce organically from EU, Irish government, state agencies, control bodies, supermarket retailers and other businesses and growers themselves. • Increasing availability of quality Irish organic produce in line with local and short supply chains policy. • Supermarket retailers and foodservice operators desire to sell organic produce. The MOPS project has participant growers with good scale and existing consistent trading relationship with supermarket retailer buyers. • Direct selling route to market allows simple trading transaction between producer and consumer and direct access to in-season produce regionally. Growers can make more profit selling directly to the consumer. Some growers therefore prefer to stay small scale and keep control of their markets. Having a flexible route to market through direct-selling gives growers the ability to pivot more readily in response to market changes. The MOPS project has participating smaller growers with excellent direct selling relationships with customers, restaurants, shops. • Both larger scale and smaller growers producing diverse, distinctive and unique range of produce. Economies of scale achievable as demonstrated by larger MOPS project growers. • Increased experience, skills, expertise and knowledge, particularly within cohort of established growers. The MOPS project growers are enthusiastic, motivated and committed growers reasonably familiar with each other, some already trading with one another. Open to peer-to-peer learning, knowledge exchange and innovation e.g., on technical information, machinery, technology/software and apps. Ability to plan and schedule crops. Growers with good plant raising expertise. Quality Assurance Scheme certified growers in the MOPS project particularly where required by market. Growers in the MOPs project with training in Lean Business Principles. Recognised apprenticeship scheme and organic training supported by growers in the MOPS project. • Improved investment in facilities, machinery and equipment to increase production and efficiency, reduce labour and input costs and waste. • Mechanisation improved and use of appropriate machinery matched to crops being grown. • Protected cropping being utilised to extend season and availability of produce and to create opportunities to grow quality crops that would otherwise not be possible in Ireland's climate. • Improved storage facilities (either rented or owned), logistics and transport infrastructure. • The MOPS project growers are positioned nationwide to avail of weather/climate, seasonality, land/soil suitability, markets benefits. • Retention of employees and workers with skills and experience. • Organic production delivers local employment in rural areas and benefits rural economies in line with rural development policy for Ireland.

SWOT analysis: Weaknesses
• Organic horticulture is still a relatively small market with less supermarket shelf space. • Producers spread over a wide geographic area. Transport infrastructure and connectivity still lacking in some regions of Ireland. Land and climate challenging for field vegetable production in some areas, and seasonal nature of Irish production.

SWOT analysis: Weaknesses

- Limited certified organic land for expansion opportunities and/or crop rotation, especially appropriate land for horticultural production. Cost of suitable land for growing some crops or long season supply of quality produce. Less suitable wet land with stones being used for e.g., root crops that impacts produce quality. Rented land away from packhouse creates logistics challenge for operations and moving workers and expense.
- Producing consistent volumes of produce to cover costs and make investments. Yields can be lower. Matching organic crop rotation with supply demands for produce. Can be difficult where crop growing has become specialised and intensive e.g., growing a limited number of crop types. Too diverse a crop range can reduce scale and can be difficult to manage all of the operations involved.
- Crop planning to make best use of land available and forecasting demand. No formal crop growing plan, beyond organic rotation, from year to year in some cases.
- Lack of formal trade arrangements with other growers, some issues with supply and quality consistency and reliability and pricing.
- Lack of clear commercial market for new entrants beyond direct selling e.g., box schemes.
- Securing agreement/formal contracts with buyers (including supermarkets, restaurants) to allow forward planning, purchase of inputs, land rental etc. Growers often typically only get one year supply deals with buyers.
- Understanding costs (e.g., production, marketing, delivery) in order to be able to price more accurately and competitively for negotiating and agreeing prices for produce, securing markets. Growing crops that have higher labour input that cannot be returned in market price. Cost awareness e.g., such as irrigation, which can vary and may not have been factored into pricing in advance of the growing season. Unrealistic (high) pricing between growers collaborating with each other, i.e., basing prices for Irish produce on cheaper imports and not accounting for different cost of production in Ireland.
- Shortage of farm workers and high labour costs. Organic crop production generally labour intensive, especially where not well mechanised compounded by challenges sourcing workers. Long working hours. Reliance on volunteers/casual labour with limited/no growing experience.
- Further investment in mechanisation and facilities, e.g., storage, required to obtain labour efficiencies and deliver year-round supply. Mechanisation need for some growers, especially smaller scale relatively new entrants. Insufficient machinery and irrigation systems. Lack of suitable storage resulting in waste arising in field stored crops during winter. Sourcing good contractors with suitable specialised machinery and plant raisers lacking in some locations. Variable propagation/plant raising, supply challenges. Limited "boots on the ground" advisory expertise.
- Manure availability, management and storage particularly on stockless farms. Uniform manure application. Time and labour involved in composting properly.
- Challenge for some growers meeting retailer demands and specifications. Growers not proactive enough with retail buyers and securing markets for their produce.
- Low processing capacity and small number of pre-packers for supermarkets.
- Need for consistent availability of incentives to convert to organic and to encourage capital investment (scheme opens intermittently).
- Record-keeping, paperwork, information management systems needs for some growers as business expands and/or become more complex.
- Farm succession planning.

SWOT analysis: Opportunities

- Growing demand for organic produce. Interest in local organic produce and producers has increased opportunity for short supply chains. Opportunities likely to come from produce where consumers perceive there to be added value in it being grown in Ireland i.e., support Irish jobs and the economy, more sustainable, better quality /freshness.
- Continue to educate consumers on quality and health of organic produce. Promotion e.g., Bord Bia increase consumer awareness of availability and seasonality. Promotion through retailers to grow profile of organic produce.
- Continued promotion of organic produce and fair price for growers. Retailers continuing to buy and look for organic produce (but downward price pressure identified by growers as an issue). Continued use of online tools for promotion and sales.
- Legislative/policy focus on increasing organic production, Government commitment and support.

SWOT analysis: Opportunities

- Further opportunities in local rural employment.
- Projects like MOPS can benefit other growers on optimising crop growing, varieties etc. Increases knowledge generation and sharing.
- Forming producer organisations or similar supported by policy and retailers. Cooperation between growers, producer organisations etc. to share information and resources, coordinator/technical resource, contract negotiation. Develop producer brands. Producer organisation, communication with growers to ensure continuity of supply, collaboration on both own-grown and imported produce.
- Efforts on sourcing and employing dedicated suitability skilled staff/workers.
- Continued investment in machinery, equipment and facilities to increase supply and to achieve labour saving efficiency and economies of scale. Expansion opportunities especially with mechanisation.
- Access to grants for capital investment including through Quality Assurance Schemes.
- Tailoring choice of crops and supply consistency and coordination. Growing key crops at a cost-effective level focusing on best-selling lines and on crops that expertise exists in at least initially. Grow small scale before scaling up.
- Retailer leniency with specifications can improve grower sales and reduce waste.
- Increase production e.g., field and protected.
- Scale-up fewer number of crops, particularly growers supplying retailers. Narrow down the range of crops grown for supermarkets. For retailers too much diversity results in breaks in supply. Not as relevant for direct selling. Increased field scale production to improve efficiencies especially for retail supply, current situation with Irish produced carrots highlighted as example. Marginal gains across multiple crops rather than one totally new crop. Extend season e.g., plant earlier to replace imports some crops, e.g., year-round supply e.g., salad crops. Organic fruit market particularly undersupplied.
- Increased protected cropping to extend growing season and availability. Significant income achievable from a relatively small area of land.
- For certain scale growers focus on direct selling rather than multiples especially for some crops. For smaller scale growers growing more distinct, unique varieties an opportunity when out-competed for main crops by scaled-up growers.
- Import substitution, particularly for crops that can be competitively produced i.e., key crops identified. For some growers, desire is to be more self-reliant, produce more of their own and import/purchase less.
- Connecting with foodservice operators to find route to market. Supplying foodservice companies but not used as a way to clear surplus produce. Public procurement/institutional demand. Needs engagement from growers and understanding from buyers.
- Looking at all aspects of crop growing to obtain efficiencies, choose optimum crops. Advancing advisory, education, research and training in organic production. Harvesting training e.g., broccoli, courgette, beetroot.
- Adopting technology to facilitate cost-effective production.
- Development, production and availability of organic seeds and organic plant raising.

SWOT analysis: Threats

- Land availability suitable for horticultural production. Land with water source in proximity to farm, suited to particular crops e.g., root crops, competing with other organic producers for available land, logistics of land too remote from packhouse, moving labour etc.
- Weather and climate impact on growing.
- High costs of producing Irish crops particularly relative to cheaper imports. Input cost and availability and quality of e.g., plants, fertility/manure/compost.
- Competition from cheaper imports. This has increased as Irish producers unable to keep up with demand. Lack of commitment to Irish organic produce at fair price by some buyers.
- Labour cost and availability. Labour skill shortage, lack of availability, over-reliance on casual/volunteer staff.
- Increased competition from other producers (organic and conventional) e.g., increased competition on smaller growers from established conventional producers with land and equipment.

SWOT analysis: Threats

- Blurring of identity of organic produce with other brands e.g., green, residue free produce etc. Improved standards in conventional production narrowing the gap between organic and conventional produce.
- National and global economics influencing household incomes.
- Discounting organic fresh produce. Low price retail multiples and downward price pressure. Price premium reduction and fall of produce price for growers from retailers especially below-cost selling. Growers need to be fully aware of their costs so that they can judge the fairness of their pricing.
- Retailers not willing to pay extra costs in prices to growers associated with producing during more challenging times of the season e.g., early and late carrots. Limiting factor in increasing production of some crops.
- Lack of commitment from buyers making longer term investment challenging for some growers, also impacts annual crop planning.
- Over supply, especially excessive imports.
- Negative headlines/insufficient promotion and marketing.
- Lack of organic seed/cultivars.
- Pest and disease, limited management options.
- Lack of new entrants limiting growth and aspiration in the industry.

1.3.1.2 Baseline: farm size

The total size of each of the farms participating in the MOPS project categorised in hectares (ha), including land area used for production other than horticulture crops, are shown in Figure 3. Farm size data displayed represent baseline information for the participant MOPS project farms and are presented with permission from the MOPS project growers and Irish Organic Association. See later section 1.3.3.1 in this part of the report for cropping area data that were collected during the MOPS project relating specifically to the production of own-grown organic horticultural crops.

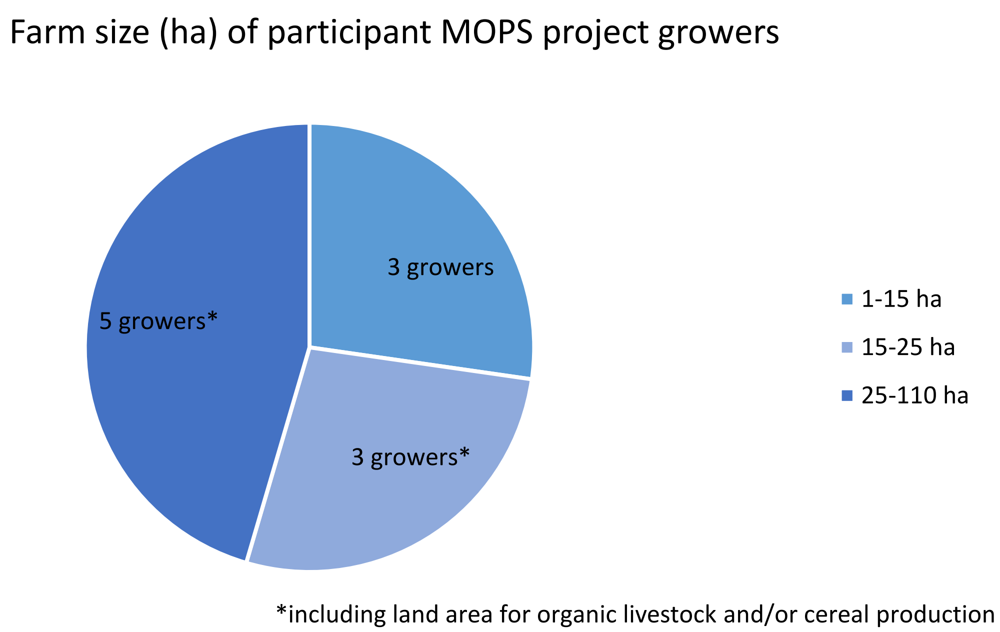

Figure 3 Farm size in hectares (ha) of the 11 participant MOPS project farms. Farm size land area (ha) data used with permission from the MOPS project growers and Irish Organic Association.

1.3.1.3 Baseline: farm soils

Table 2 shows the classification of the soils on each of the 11 MOPS project farms using the Irish Soil Information System (Teagasc, 2021). These soil descriptions are presented as baseline information about the soils on the MOPS project farms. Additional data on the fertility and composition of the soils on the MOPS project farms are also shown in Table 2. These data are from laboratory analysis of soil samples that were collected from the MOPS project farms.

1.3.1.3.1 Soil classification, fertility and composition

Table 2 Irish soil classification and soil series for the 11 farms participating in the MOPS project. Source: Irish Soil Information System (Teagasc, 2021). Selected soil fertility/composition ranges are from laboratory analysis results for soils that were sampled from the farms.

MOPS grower	Farm soils description	Soils fertility/composition range
Grower A	Brown Earth; Coarse loamy drift with limestones; Fine/coarse loamy texture; Mullabane (1100MB) Calcareous Brown Earth; Coarse loamy over calcareous gravels; Coarse loamy texture; Baggotstown (1150BG) Luvisol; Fine loamy drift with limestones; Fine loamy texture; Elton (1000ET) Peat soil; Peat (1xx)	P (ppm) 3->100 K (ppm) 28-147 pH 6.1-7.6 OM (%) 4.3-32.9 Sand (%) 40.7-80.6 Silt (%) 17.5-52 Clay (%) 1.9-8.1
Grower B	Calcareous Brown Earth; Fine loamy drift with limestones; Fine loamy texture; Faoldroim (1150FO)	P (ppm) 1.9->100 K (ppm) 45-304 pH 6.3-7.9 OM (%) 6.7-12.1 Sand (%) 37.3-68.8 Silt (%) 26.5-50.7 Clay (%) 4.2-12.8
Grower C	Luvisol; Fine loamy drift with limestones; Fine loamy texture; Elton (1000ET) Peat soil; Peat (1xx)	P (ppm) 5-82.3 K (ppm) 67->500 pH 6.3-8 OM (%) 3.5-13 Sand (%) 38.3-65.6 Silt (%) 28.7-48.9 Clay (%) 5.3-13.9
Grower D	Luvisol; Fine loamy drift with limestones; Fine loamy texture; Elton (1000ET)	P (ppm) 5.6->100 K (ppm) 6->500 pH 6.2-7.9 OM (%) 4.9-15.1 Sand (%) 43.9-81.9 Silt (%) 15.6-47.2 Clay (%) 2.5-8.9
Grower E	Brown Earth; Fine loamy drift with siliceous stones; Fine loamy texture; Clonroche (1100CL) Histic Lithosol; Peat over lithoskeletal acid igneous rock; Peat/coarse loamy texture; Carrighvahanagh (0410CV) Alluvial Gley; Silty river alluvium; silty texture; Boyne (0500BO)	P (ppm) 1-19.1 K (ppm) 98->500 pH 5.5-7.2 OM (%) 4.6-9.2 Sand (%) 50.7-75.8 Silt (%) 20.9-42.1 Clay (%) 3.3-7.3
Grower F	Luvisol; Fine loamy drift with limestones; Fine loamy texture; Elton (1000ET)	P (ppm) 1->100 K (ppm) 49->500 pH 5-7.5 OM (%) 5.3-12 Sand (%) 36.2-80.6 Silt (%) 17-52.7 Clay (%) 2.5-11.9
Grower G	Luvisol; Fine loamy drift with limestones; Fine loamy texture; Elton (1000ET)	P (ppm) 2.4-21.4 K (ppm) 41-173

MOPS grower	Farm soils description	Soils fertility/composition range
		pH 6-7 OM (%) 4.2-7.1 Sand (%) 43.1-67.9 Silt (%) 27.6-47.4 Clay (%) 4.5-9.5
Grower H	Gleyic Brown Podzolic; Coarse loamy drift with siliceous stones; Coarse loamy texture; Clonegall (0920CG)	P (ppm) 6.4->100 K (ppm) 43->500 pH 5.9-7.5 OM (%) 4.9-17.3 Sand (%) 51-73.3 Silt (%) 23.9-43.6 Clay (%) 1.9-5.6
Grower I	Brown Earth; Fine loamy drift with siliceous stones; Fine loamy texture; Clonroche (1100CL)	P (ppm) 0.7-2.9 K (ppm) 19-204 pH 5.7-6.6 OM (%) 5.6-9.4 Sand (%) 47.7-75.8 Silt (%) 19.8-43.1 Clay (%) 4.37-9.7
Grower J	Luvisol; Fine loamy drift with limestones; Fine loamy texture; Elton (1000ET) Alluvial Gley; Silty river alluvium; silty texture; Boyne (0500BO) Calcareous Brown Earth; Coarse loamy over calcareous gravels; Coarse loamy texture; Baggotstown (1150BG) Peat soil; Peat (1xx)	P (ppm) 8.6-60.5 K (ppm) 147-247 pH 6-6.9 OM (%) 3.3-4.3 Sand (%) 44.3-69.5 Silt (%) 26.5-43.1 Clay (%) 4-13.3
Grower K	Brown Earth; Coarse loamy drift with siliceous stones; Fine/coarse loamy texture; Clashmore (1100CM)	P (ppm) 5.4->100 K (ppm) 152->500 pH 6.2-8 OM (%) 5.5-15.6 Sand (%) 56.3-83.03 Silt (%) 14.6-38.1 Clay (%) 2.1-6.4

1.3.1.4 Baseline: crop production

Baseline crop production information and data for the MOPS project growers are presented in the following graphs. Figure 4 shows baseline data for the crop growing systems used for production by the 11 MOPS project growers, with eight of the growers producing their crops using both field and protected (polytunnel/cloche/glasshouse) growing systems and three growing field crops only.

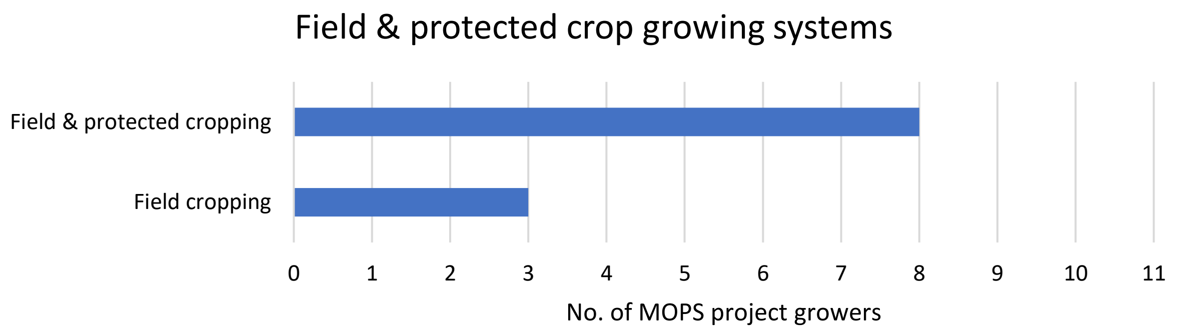

Figure 4 MOPS project baseline data showing the number of MOPS project growers producing field crops or both field crops and protected crops (polytunnel/glasshouse).

Baseline data for the types of crops grown by the project growers, and the number of growers producing each crop, are shown in Figure 5 (brassica crops), Figure 6 (leafy/herb crops), Figure 7 (root/tuber/bulb crops), and Figure 8 (other minor/specialised crops).

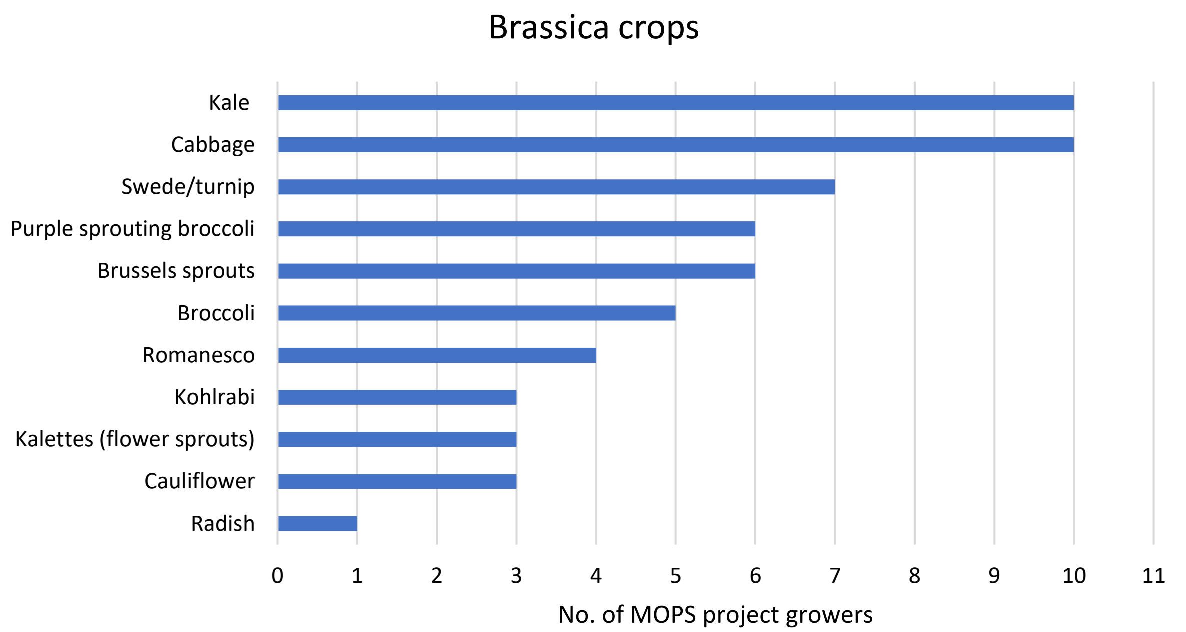

Figure 5 MOPS project baseline data displaying brassica crops being produced by the 11 MOPS project growers.

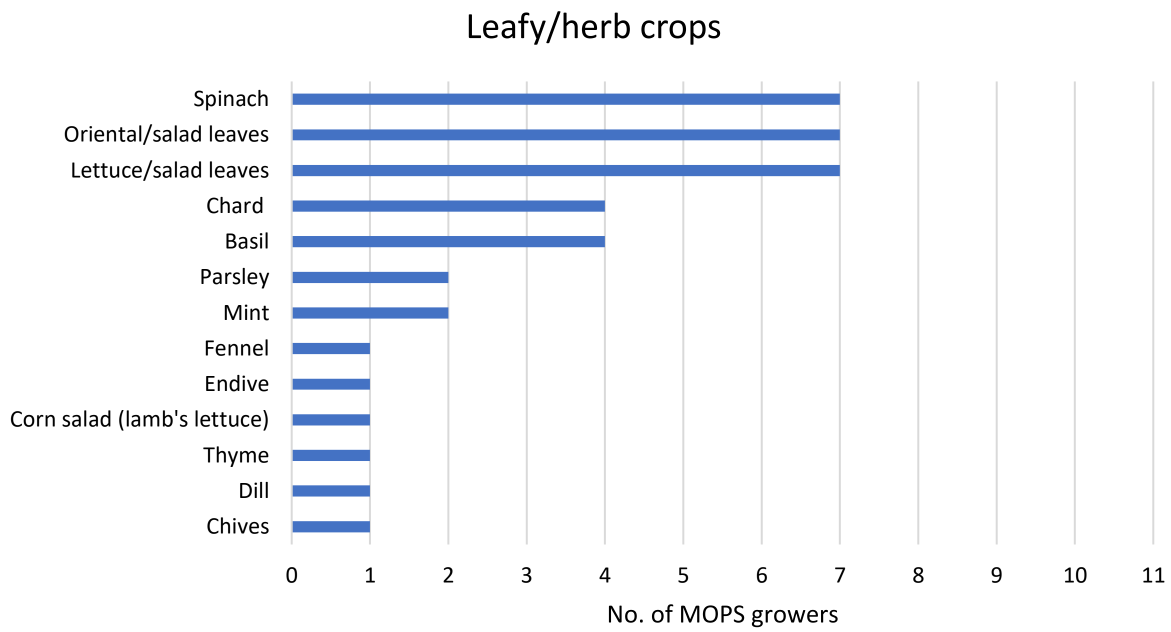

Figure 6 MOPS project baseline data showing leafy/herb crops being produced by the 11 MOPS project growers.

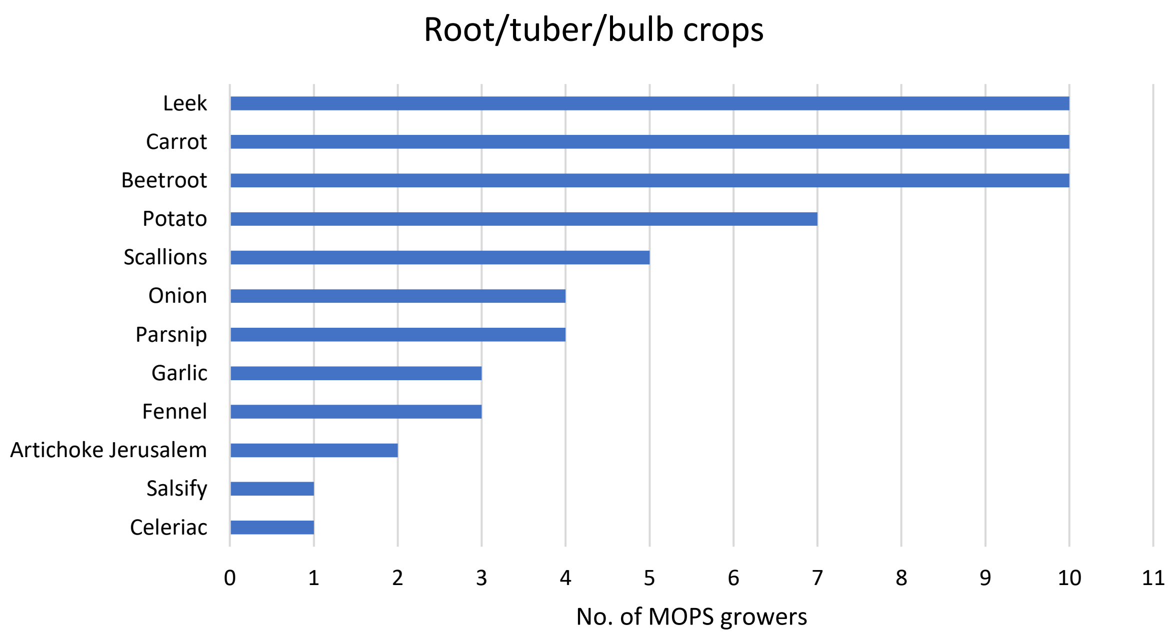

Figure 7 MOPS project baseline data showing root/tuber/bulb crops being produced by the 11 MOPS project growers.

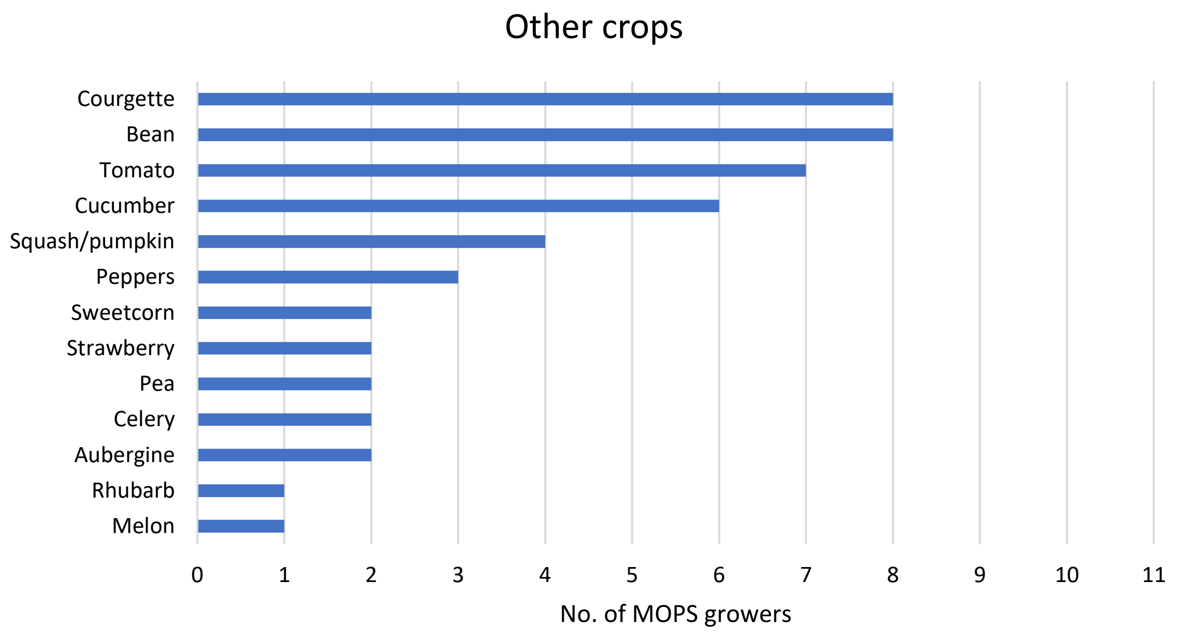

Figure 8 MOPS project baseline data displaying other crops being produced by the 11 MOPS project growers.

1.3.1.5 Baseline: market outlets

Baseline data shown in Figure 9 display the range of market outlets that the MOPS project growers supply with organic horticultural fresh produce and the number of growers that supply each market.

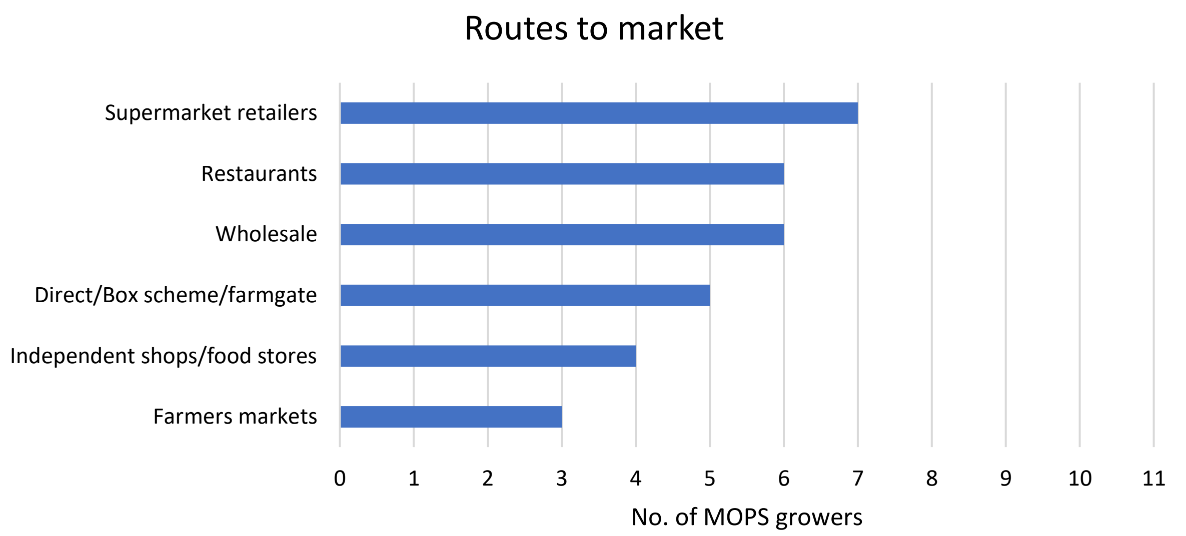

Figure 9 MOPS project baseline data showing routes to markets for the 11 MOPS project growers.

1.3.1.6 Baseline: trade by MOPS project growers

Figure 10 displays baseline information relating to trade (purchasing and selling) that the MOPS project growers were involved in at the commencement of the project. Nine of the 11 MOPS project growers were trading with other growers in the project.

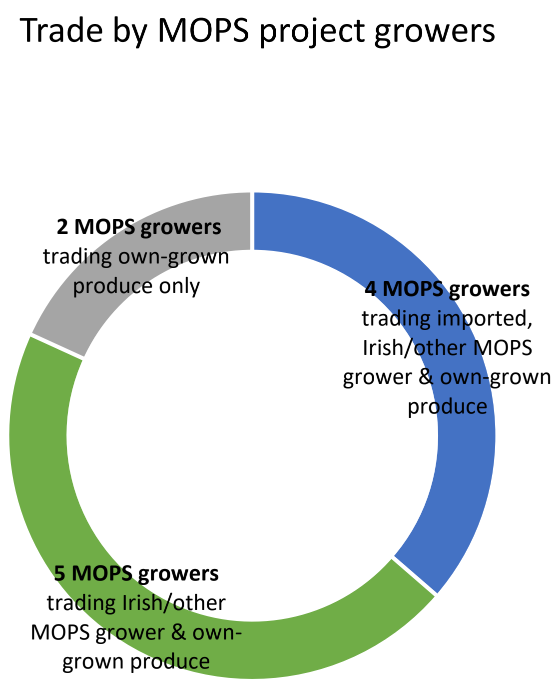

Figure 10 Existing trade between the growers participating in the MOPS project at the commencement of the project representative of baseline information on collaborative production and trade within the group of growers. Trade other than between the MOPS project growers is also shown i.e., importing, and purchasing of Irish horticultural fresh produce.

1.3.1.7 Baseline: certification achieved by MOPS project growers

Figure 11 shows the producer certification that the MOPS project growers had obtained by the commencement of the project.

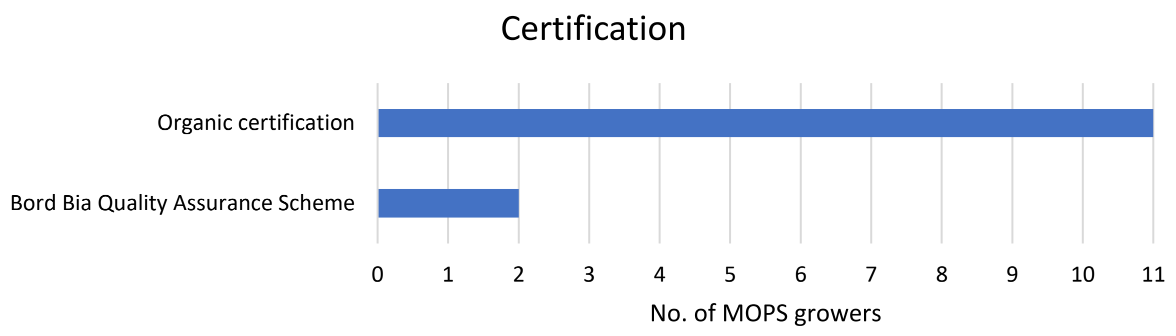

Figure 11 MOPS project baseline data showing certification achieved by the MOPS project growers.

1.3.1.8 Baseline: types of record keeping used by MOPS project growers

Figure 12 displays the types of record keeping that the MOPS project growers used at the start of the project.

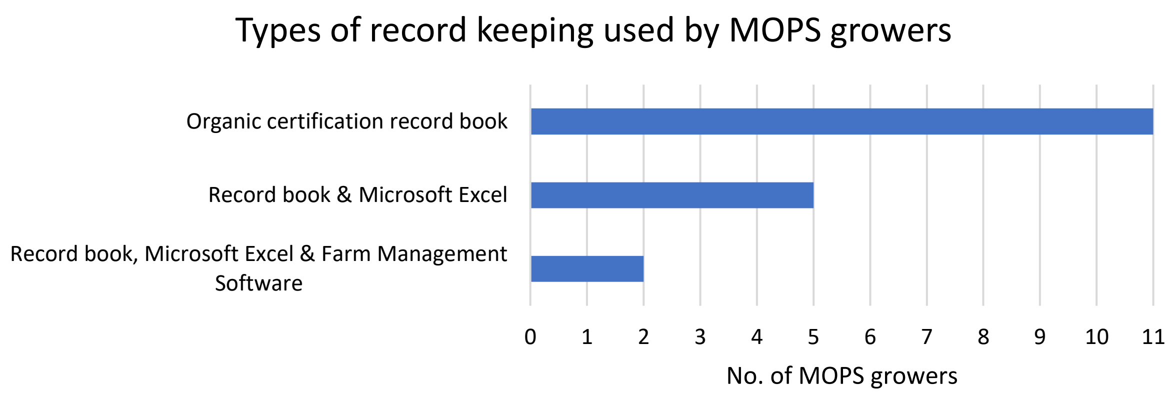

Figure 12 MOPS project baseline data showing types of record keeping used by the MOPS project growers.

1.3.2 Crop planning

1.3.2.1 Optimised cropping programmes at the end of the MOPS project

Cropping programmes for the 11 MOPS project growers, optimised over the course of the project for collaborative production and trade and greater continuity of supply, are shown in Table 3 (brassica crops), Table 4 (leafy/herb crops), Table 5 (root/tuber/bulb crops) and Table 6 (other crops).

Table 3 Cropping programmes for brassica crops for the 11 MOPS project growers.

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower A	Broccoli Parthenon	Early Feb	Early Apr	75 × 40	3.3 plants	90 +	Early Jul +
Grower A	Broccoli Parthenon	Mid Feb	Mid Apr	75 × 40	3.3 plants	90 +	Mid Jul +
Grower A	Broccoli Parthenon	Early Mar	Late Apr	75 × 35	3.8 plants	85 +	Late Jul +
Grower A	Broccoli Parthenon	Mid Mar	Early May	75 × 35	3.8 plants	80 +	Early Aug +
Grower A	Broccoli Parthenon	Early Apr	Mid May	75 × 35	3.8 plants	80 +	Mid Aug +
Grower A	Broccoli Parthenon	Mid Apr	Late May	75 × 35	3.8 plants	80 +	Late Aug +
Grower A	Broccoli Parthenon	Early May	Mid Jun	75 × 35	3.8 plants	85 +	Mid Sep +
Grower A	Broccoli Parthenon	Mid May	Early Jul	75 × 40	3.3 plants	90 +	Late Sep +
Grower A	Broccoli Larsson	Mid May	Early Jul	75 × 40	3.3 plants	100 +	Mid Oct +
Grower A	Broccoli Triton	Mid May	Early Jul	75 × 40	3.3 plants	105 +	Late Oct +
Grower A	Broccoli Parthenon	Late May	Mid Jul	75 × 40	3.3 plants	95 +	Early Nov +
Grower A	Broccoli Larsson	Late May	Mid Jul	75 × 40	3.3 plants	105 +	Mid Nov +
Grower B	Broccoli Parthenon	Buy plants	Mid Apr	75 × 45	3 plants	85 +	Early Jul +
Grower B	Broccoli Steel	Buy plants	Mid Apr	75 × 45	3 plants	90 +	Mid Jul +
Grower B	Broccoli Parthenon	Buy plants	Late Apr	75 × 45	3 plants	85 +	Late Jul +
Grower B	Broccoli Steel	Buy plants	Late Apr	75 × 45	3 plants	90 +	Early Aug +
Grower B	Broccoli Parthenon	Buy plants	Mid May	75 × 45	3 plants	80 +	Mid Aug +
Grower B	Broccoli Steel	Buy plants	Mid May	75 × 45	3 plants	85 +	Mid Aug +
Grower B	Broccoli Parthenon	Buy plants	Late May	75 × 45	3 plants	80 +	Late Aug +
Grower B	Broccoli Steel	Buy plants	Late May	75 × 45	3 plants	85 +	Late Aug +
Grower B	Broccoli Parthenon	Buy plants	Mid Jun	75 × 45	3 plants	80 +	Early Sep +
Grower B	Broccoli Steel	Buy plants	Mid Jun	75 × 45	3 plants	85 +	Mid Sep +
Grower B	Broccoli Parthenon	Buy plants	Late Jun	75 × 45	3 plants	85 +	Late Sep +
Grower B	Broccoli Steel	Buy plants	Late Jun	75 × 45	3 plants	90 +	Late Sep +
Grower B	Broccoli Parthenon	Buy plants	Early Jul	75 × 45	3 plants	95 +	Early Oct +
Grower B	Broccoli Steel	Buy plants	Mid Jul	75 × 45	3 plants	105 +	Mid Oct +
Grower G	Broccoli Parthenon	Late Feb	Mid Apr	55 × 40	4.5 plants	90 +	Mid Jul +
Grower G	Broccoli Steel	Late Feb	Mid Apr	55 × 40	4.5 plants	100 +	Late Jul +
Grower G	Broccoli Parthenon	Mid Mar	Early May	55 × 40	4.5 plants	85 +	Early Aug +
Grower G	Broccoli Steel	Mid Mar	Early May	55 × 40	4.5 plants	95 +	Mid Aug +
Grower G	Broccoli Parthenon	Mid Apr	Late May	55 × 40	4.5 plants	80 +	Late Aug +
Grower G	Broccoli Steel	Mid Apr	Late May	55 × 40	4.5 plants	95 +	Mid Sep +
Grower G	Broccoli Parthenon	Early May	Mid Jun	55 × 40	4.5 plants	85 +	Mid Sep +
Grower G	Broccoli Steel	Early May	Mid Jun	55 × 40	4.5 plants	100 +	Late Sep +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower G	Broccoli Parthenon	Late May	Early Jul	55 × 40	4.5 plants	90 +	Mid Oct +
Grower G	Broccoli Steel	Early Jun	Mid Jul	55 × 40	4.5 plants	110 +	Late Oct +
Grower I	Broccoli Parthenon	Buy plants	Mid Apr	60 × 45	3.7 plants	90 +	Mid Jul +
Grower I	Broccoli Parthenon	Buy plants	Late Apr	60 × 45	3.7 plants	85 +	Late Jul +
Grower I	Broccoli Parthenon	Buy plants	Mid May	60 × 45	3.7 plants	80 +	Early Aug +
Grower I	Broccoli Parthenon	Buy plants	Late May	60 × 45	3.7 plants	80 +	Late Aug +
Grower I	Broccoli Steel	Buy plants	Late May	60 × 45	3.7 plants	90 +	Mid Sep +
Grower I	Broccoli Parthenon	Buy plants	Early Jun	60 × 45	3.7 plants	85 +	Early Sep +
Grower I	Broccoli Steel	Buy plants	Early Jun	60 × 45	3.7 plants	90 +	Mid Sep +
Grower I	Broccoli Parthenon	Buy plants	Late Jun	60 × 50	3.3 plants	85 +	Late Sep +
Grower I	Broccoli Steel	Buy plants	Late Jun	60 × 50	3.3 plants	95 +	Early Oct +
Grower I	Broccoli Parthenon	Buy plants	Early Jul	60 × 50	3.3 plants	90 +	Mid Oct +
Grower I	Broccoli Steel	Buy plants	Early Jul	60 × 50	3.3 plants	105 +	Late Oct +
Grower J	Broccoli Parthenon	Mid Feb	Mid Apr	55 × 45	4 plants	90 +	Mid Jul
Grower J	Broccoli Parthenon	Early Mar	Mid Apr	55 × 45	4 plants	90 +	Late Jul
Grower J	Broccoli Parthenon	Early Mar	Late Apr	55 × 45	4 plants	85 +	Early Aug
Grower J	Broccoli Parthenon	Mid Mar	Early May	55 × 42	4.3 plants	80 +	Early Aug
Grower J	Broccoli Parthenon	Late Mar	Mid May	55 × 42	4.3 plants	80 +	Mid Aug
Grower J	Broccoli Parthenon	Late Mar	Mid May	55 × 42	4.3 plants	80 +	Mid Aug
Grower J	Broccoli Parthenon	Early Apr	Late May	55 × 42	4.3 plants	80 +	Late Aug
Grower J	Broccoli Parthenon	Mid Apr	Early Jun	55 × 42	4.3 plants	80 +	Early Sep
Grower J	Broccoli Parthenon	Late Apr	Early Jun	55 × 42	4.3 plants	85 +	Early Sep
Grower J	Broccoli Parthenon	Late Apr	Mid Jun	55 × 45	4 plants	85 +	Mid Sep
Grower J	Broccoli Parthenon	Early May	Late Jun	55 × 45	4 plants	85 +	Late Sep
Grower J	Broccoli Parthenon	Mid May	Late Jun	55 × 45	4 plants	90 +	Early Oct
Grower J	Broccoli Parthenon	Late May	Early Jul	55 × 45	4 plants	90 +	Early Oct
Grower J	Broccoli Parthenon	Late May	Mid Jul	55 × 45	4 plants	95 +	Mid Oct
Grower J	Broccoli Larsson	Late May	Mid Jul	55 × 45	4 plants	100 +	Mid Oct
Grower J	Broccoli Steel	Late May	Mid Jul	55 × 45	4 plants	105 +	Late Oct
Grower J	Broccoli Parthenon	Early Jun	Mid Jul	55 × 50	3.6 plants	95 +	Late Oct
Grower J	Broccoli Larsson	Early Jun	Mid Jul	55 × 50	3.6 plants	105 +	Early Nov
Grower J	Broccoli Steel	Early Jun	Mid Jul	55 × 50	3.6 plants	110 +	Early Nov
Grower A	Brussels sprout Neptuno	Late Mar	Late May	75 × 40	3.3 plants	180 +	Late Nov +
Grower A	Brussels sprout Pontus	Mid Mar	Mid May	75 × 40	3.3 plants	210 +	Mid Dec +
Grower A	Brussels sprout Petrus	Mid Mar	Mid May	75 × 45	3 plants	235 +	Mid-late Dec +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower A	Brussels sprout Petrus	Late Mar	Late May	75 × 45	3 plants	250 +	Jan +
Grower B	Brussels sprout Neptuno	Buy plants	Mid May	75 × 50	2.6 plants	185 +	Mid Nov +
Grower B	Brussels sprout Petrus	Buy plants	Mid May	75 × 50	2.6 plants	210 +	Late Nov +
Grower B	Brussels sprout Nautic	Buy plants	Mid May	75 × 60	2.2 plants	225 +	Mid-late Dec +
Grower D	Brussels sprout Neptuno	Early Mar	Early May	70 × 55	2.5 plants	180 +	Early Nov +
Grower D	Brussels sprout Trafalgar	Late Mar	Mid May	70 × 55	2.5 plants	190 +	Late Nov +
Grower D	Brussels sprout Petrus	Late Mar	Mid May	70 × 55	2.5 plants	210 +	Mid-late Dec +
Grower E	Brussels sprout Neptuno	Buy plants	Mid Apr	80 × 40	3.1 plants	180 +	Mid Oct +
Grower E	Brussels sprout Pontus	Buy plants	Mid May	80 × 38	3.3 plants	200 +	Mid Nov +
Grower E	Brussels sprout Petrus	Buy plants	Mid May	80 × 38	3.3 plants	230 +	Dec +
Grower E	Brussels sprout Petrus	Buy plants	Early Jun	80 × 40	3.1 plants	250 +	Late Jan +
Grower E	Brussels sprout Splendus	Buy plants	Early Jun	80 × 40	3.1 plants	270 +	Feb +
Grower A	Cabbage green Stanton	Mid Apr	Early Jun	75 × 40	3.3 plants	130 +	Mid Oct +
Grower A	Cabbage green Stanton	Mid May	Early Jul	75 × 40	3.3 plants	150 +	Dec +
Grower F	Cabbage green Stanton	Early May	Mid Jun	75 × 45	3 plants	130 +	Mid Nov +
Grower F	Cabbage green Stanton	Mid May	Late Jun	75 × 45	3 plants	140 +	Late Nov +
Grower A	Cabbage Jan King Deadon	Mid Jun	Early Jul	75 × 40	3.3 plants	130 +	Mid Oct +
Grower B	Cabbage Jan King	Buy plants	Early Jul	75 × 60	2.2 plants	110 +	Early Nov +
Grower D	Cabbage Jan King Deadon	Mid May	Mid Jul	70 × 45	3.1 plants	130 +	Dec +
Grower D	Cabbage Jan King	Early May	Early Jul	70 × 45	3.1 plants	100 +	Oct +
Grower F	Cabbage Jan King Deadon	Mid May	Late Jun	75 × 45	3 plants	120 +	Late Oct +
Grower I	Cabbage Jan King Deadon	Buy plants	Mid Jun	60 × 50	3.3 plants	110 +	Early Oct +
Grower A	Cabbage pointed Caraflex	Mid Feb	Early Apr	75 × 30	4.4 plants	80 +	Early Jul +
Grower A	Cabbage pointed Caraflex	Early Mar	Mid Apr	75 × 30	4.4 plants	75 +	Mid Jul +
Grower A	Cabbage pointed Caraflex	Mid Mar	Early May	75 × 30	4.4 plants	75 +	Late Jul +
Grower A	Cabbage pointed Caraflex	Early Apr	Mid May	75 × 30	4.4 plants	70 +	Early Aug +
Grower A	Cabbage pointed Caraflex	Mid Apr	Early Jun	75 × 30	4.4 plants	70 +	Mid Aug +
Grower A	Cabbage pointed Caraflex	Early May	Mid Jun	75 × 30	4.4 plants	75 +	Early Sep +
Grower A	Cabbage pointed Caraflex	Mid May	Early Jul	75 × 30	4.4 plants	75 +	Mid Sep +
Grower A	Cabbage pointed Caraflex	Early Jun	Mid Jul	75 × 30	4.4 plants	80 +	Early Oct +
Grower A	Cabbage pointed Caraflex	Mid Jun	Early Aug	75 × 30	4.4 plants	85 +	Mid Oct +
Grower B	Cabbage pointed Caraflex	Buy plants	Mid Apr	75 × 30	4.5 plants	80 +	Early Jul +
Grower B	Cabbage pointed Caraflex	Buy plants	Late Apr	75 × 30	4.5 plants	75 +	Mid Jul +
Grower B	Cabbage pointed Caraflex	Buy plants	Late May	75 × 30	4.5 plants	70 +	Mid Aug +
Grower B	Cabbage pointed Caraflex	Buy plants	Mid Jun	75 × 35	3.8 plants	75 +	Late Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower B	Cabbage pointed Caraflex	Buy plants	Late Jun	75 × 35	3.8 plants	80 +	Mid Sep +
Grower B	Cabbage pointed Monarchy	Buy plants	Late Jun	75 × 35	3.8 plants	90 +	Late Sep +
Grower G	Cabbage pointed Caraflex	Late Feb	Mid Apr	55 × 35	5.2 plants	75 +	Late Jun +
Grower G	Cabbage pointed Caraflex	Mid Mar	Early May	55 × 35	5.2 plants	70 +	Mid Jul +
Grower G	Cabbage pointed Caraflex	Mid Apr	Late May	55 × 35	5.2 plants	70 +	Early Aug +
Grower G	Cabbage pointed Caraflex	Early May	Mid Jun	55 × 35	5.2 plants	70 +	Early Sep +
Grower G	Cabbage pointed Caraflex	Early Jun	Mid Jul	55 × 35	5.2 plants	70 +	Early Oct +
Grower G	Cabbage pointed Caraflex	Early Jun	Late Jul	55 × 35	5.2 plants	80 +	Mid Oct +
Grower G	Cabbage pointed Regency	Early Jun	Late Jul	55 × 35	5.2 plants	95 +	Late Oct +
Grower G	Cabbage pointed Monarchy	Early Jun	Late Jul	55 × 35	5.2 plants	105 +	Mid Nov +
Grower J	Cabbage pointed Caraflex	Mid Feb	Early Apr	55 × 42	4.3 plants	80 +	Late Jun +
Grower J	Cabbage pointed Caraflex	Late Feb	Mid Apr	55 × 42	4.3 plants	80 +	Early Jul +
Grower J	Cabbage pointed Caraflex	Early Mar	Late Apr	55 × 40	4.5 plants	80 +	Mid Jul +
Grower J	Cabbage pointed Caraflex	Early Mar	Early May	55 × 40	4.5 plants	75 +	Late Jul +
Grower J	Cabbage pointed Caraflex	Mid Mar	Early May	55 × 40	4.5 plants	75 +	Early Jul +
Grower J	Cabbage pointed Caraflex	Late Mar	Mid May	55 × 40	4.5 plants	75 +	Mid Jul +
Grower J	Cabbage pointed Caraflex	Late Mar	Late May	55 × 40	4.5 plants	75 +	Late Jul +
Grower J	Cabbage pointed Caraflex	Early Apr	Late May	55 × 40	4.5 plants	75 +	Early Aug +
Grower J	Cabbage pointed Caraflex	Mid Apr	Early Jun	55 × 40	4.5 plants	75 +	Mid Aug +
Grower J	Cabbage pointed Caraflex	Mid Apr	Early Jun	55 × 40	4.5 plants	75 +	Late Aug +
Grower J	Cabbage pointed Caraflex	Late Apr	Mid Jun	55 × 40	4.5 plants	75 +	Early Sep +
Grower J	Cabbage pointed Caraflex	Early May	Late Jun	55 × 40	4.5 plants	75 +	Mid Sep +
Grower J	Cabbage pointed Caraflex	Early May	Early Jul	55 × 40	4.5 plants	80 +	Late Sep +
Grower J	Cabbage pointed Regency	Early May	Early Jul	55 × 42	4.3 plants	90 +	Early Oct +
Grower J	Cabbage pointed Monarchy	Early May	Early Jul	55 × 42	4.3 plants	100 +	Mid Oct +
Grower J	Cabbage pointed Regency	Late May	Mid Jul	55 × 42	4.3 plants	95 +	Late Oct +
Grower J	Cabbage pointed Monarchy	Late May	Mid Jul	55 × 42	4.3 plants	100 +	Late Oct +
Grower A	Cabbage red Integro	Late Feb	Early May	75 × 30	4.4 plants	90 +	Early Aug +
Grower A	Cabbage red Klimaro	Late Feb	Mid Apr	75 × 30	4.4 plants	135 +	Mid Sep +
Grower A	Cabbage red Klimaro	Late Feb	Mid May	75 × 45	3 plants	145 +	Oct +
Grower E	Cabbage red Integro	Buy plants	Mid Apr	80 × 40	3.1 plants	100 +	Late Jul +
Grower E	Cabbage red Klimaro	Buy plants	Early May	80 × 35	3.6 plants	140 +	Late Aug +
Grower E	Cabbage red Klimaro	Buy plants	Early May	80 × 40	3.1 plants	150 +	Late Aug +
Grower F	Cabbage red Buscaro	Mid Feb	Early Apr	75 × 30	3.3 plants	110 +	Early Aug
Grower F	Cabbage red Klimaro	Mid Mar	Early May	75 × 30	3.3 plants	135 +	Mid Sep

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower G	Cabbage red Klimaro	Mid Mar	Early May	55 × 35	5.2 plants	135 +	Early Oct +
Grower I	Cabbage red Buscaro	Buy plants	Early May	60 × 40	4.2 plants	110 +	Late Sep +
Grower I	Cabbage red Klimaro	Buy plants	Early May	60 × 40	4.2 plants	135 +	Early Nov +
Grower J	Cabbage red Klimaro	Late Mar	Mid May	55 × 40	4.5 plants	140 +	Dec +
Grower A	Cabbage savoy Ovasa	Mid May	Early Jul	75 × 40	3.3 plants	110 +	Mid Oct +
Grower A	Cabbage savoy Cantasa	Mid May	Early Jul	75 × 40	3.3 plants	120 +	Early Nov +
Grower A	Cabbage savoy Paresa	Mid May	Early Jul	75 × 40	3.3 plants	180 +	Dec +
Grower B	Cabbage savoy Famosa	Buy plants	Late Jun	75 × 40	3.3 plants	80 +	Mid Sep +
Grower B	Cabbage savoy Cantasa	Buy plants	Late Jun	75 × 45	3 plants	125 +	Late Oct +
Grower B	Cabbage savoy Paresa	Buy plants	Late Jun	75 × 45	3 plants	180 +	Late Dec +
Grower B	Cabbage savoy Bakel	Buy plants	Late Jun	75 × 45	3 plants	200 +	Feb-Mar
Grower B	Cabbage savoy Cantasa	Buy plants	Early Jul	75 × 60	2.2 plants	130 +	Mid Nov +
Grower B	Cabbage savoy Paresa	Buy plants	Early Jul	75 × 60	2.2 plants	195 +	Mid Jan +
Grower D	Cabbage savoy Robin	Mid May	Mid Jul	70 × 45	3.1 plants	120 +	Nov +
Grower F	Cabbage savoy Cantasa	Early Apr	Early Jun	75 × 45	3 plants	120 +	Early Oct +
Grower F	Cabbage savoy Paresa	Early Apr	Early Jun	75 × 45	3 plants	140 +	Late Oct +
Grower F	Cabbage savoy Paresa	Mid May	Late Jun	75 × 45	3 plants	160 +	Late Nov +
Grower G	Cabbage savoy Famosa	Mid Mar	Early May	55 × 40	4.5 plants	75 +	Late Jul +
Grower G	Cabbage savoy Famosa	Mid Apr	Late May	55 × 40	4.5 plants	75 +	Mid Aug +
Grower G	Cabbage savoy Cantasa	Mid Apr	Late May	55 × 40	4.5 plants	125 +	Mid Oct +
Grower G	Cabbage savoy Cantasa	Early May	Mid Jun	55 × 40	4.5 plants	130 +	Mid Nov +
Grower G	Cabbage savoy Barbosa	Mid May	Early Jul	55 × 45	4 plants	145 +	Dec +
Grower G	Cabbage savoy Paresa	Mid May	Early Jul	55 × 45	4 plants	190 +	Jan +
Grower G	Cabbage savoy Bakel	Mid May	Early Jul	55 × 45	4 plants	225 +	Feb +
Grower I	Cabbage savoy Famosa	Buy plants	Late Apr	60 × 40	4.2 plants	75 +	Mid Jul +
Grower I	Cabbage savoy Famosa	Buy plants	Mid May	60 × 40	4.2 plants	75 +	Early Aug +
Grower I	Cabbage savoy Famosa	Buy plants	Mid Jun	60 × 40	4.2 plants	80 +	Mid Sep +
Grower I	Cabbage savoy Melissa	Buy plants	Mid Jul	60 × 50	3.3 plants	90 +	Early Oct +
Grower I	Cabbage savoy Paresa	Buy plants	Mid Jun	60 × 50	3.3 plants	180 +	Mid Dec +
Grower I	Cabbage savoy Paresa	Buy plants	Mid Jul	60 × 50	3.3 plants	190 +	Late Jan +
Grower J	Cabbage savoy Firenza	Early May	Late Jun	55 × 45	4 plants	140 +	Mid Nov +
Grower J	Cabbage savoy Cantasa	Mid May	Early Jul	55 × 45	4 plants	160 +	Mid Dec +
Grower J	Cabbage savoy Paresa	Mid May	Early Jul	55 × 50	3.6 plants	210 +	Mid Jan +
Grower J	Cabbage savoy Bakel	Mid May	Early Jul	55 × 50	3.6 plants	220 +	Mid Feb +
Grower A	Cabbage white Kaluga	Late Feb	Early May	75 × 30	4.4 plants	130 +	Mid Sep +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower A	Cabbage white Lennox	Late Feb	Early May	75 × 45	3 plants	150 +	Early Oct +
Grower E	Cabbage white Kaluga	Buy plants	Early May	80 × 35	3.6 plants	130 +	Early Sep +
Grower E	Cabbage white Passat	Buy plants	Early May	80 × 45	2.7 plants	115 +	Mid Aug +
Grower E	Cabbage white Krautkaiser	Buy plants	Early May	80 × 45	2.7 plants	140 +	Mid Sep +
Grower E	Cabbage white Lennox	Buy plants	Early May	80 × 45	2.7 plants	150 +	Late Sep +
Grower G	Cabbage white Kaluga	Mid Mar	Early May	55 × 35	5.2 plants	130 +	Early Oct +
Grower I	Cabbage white Lennox	Buy plants	Early May	60 × 40	4.2 plants	140 +	Early Oct +
Grower J	Cabbage white Kaluga	Late Mar	Mid May	55 × 40	4.5 plants	120 +	Mid Sep
Grower F	Cauliflower Telde	Mid May	Early Jul	75 × 50	2.7 plants	100 +	Mid Oct +
Grower F	Cauliflower Benidorm	Mid May	Early Jul	75 × 50	2.7 plants	125 +	Early Nov +
Grower F	Cauliflower Telde	Late May	Mid Jul	75 × 50	2.7 plants	105 +	Late Oct +
Grower F	Cauliflower Benidorm	Late May	Mid Jul	75 × 50	2.7 plants	130 +	Late Nov +
Grower G	Cauliflower Liria	Late Feb	Mid Apr	55 × 50	3.5 plants	85 +	Mid Jul +
Grower G	Cauliflower Liria	Early Mar	Late Apr	55 × 50	3.5 plants	85 +	Late Jul +
Grower G	Cauliflower Liria	Late Mar	Early May	55 × 50	3.5 plants	80 +	Early Aug +
Grower G	Cauliflower Liria	Early Apr	Mid May	55 × 50	3.5 plants	80 +	Mid Aug +
Grower G	Cauliflower Liria	Mid Apr	Late May	55 × 50	3.5 plants	80 +	Late Aug +
Grower G	Cauliflower Liria	Late Apr	Early Jun	55 × 50	3.5 plants	80 +	Early Sep +
Grower G	Cauliflower Skywalker	Early May	Mid Jun	55 × 50	3.5 plants	90 +	Mid Sep +
Grower G	Cauliflower Benidorm	Late May	Early Jul	55 × 55	3.2 plants	125 +	Early Nov +
Grower G	Cauliflower Skywalker	Early Jun	Late Jul	55 × 55	3.2 plants	95 +	Mid Oct +
Grower G	Cauliflower Benidorm	Early Jun	Late Jul	55 × 55	3.2 plants	125 +	Late Nov +
Grower G	Cauliflower Navalo	Early Jun	Late Jul	55 × 55	3.2 plants	135 +	Early Dec +
Grower G	Cauliflower Triomphant	Early Jun	Late Jul	55 × 60	3 plants	145 +	Mid-late Dec
Grower G	Cauliflower Belot	Early Jun	Late Jul	55 × 60	3 plants	155 +	Mid-late Dec
Grower I	Cauliflower Paciano	Buy plants	Late Jun	60 × 80	2.1 plants	150 +	Mid Jan +
Grower I	Cauliflower Baterno	Buy plants	Late Jun	60 × 80	2.1 plants	165 +	Early Feb +
Grower I	Cauliflower Medallion	Buy plants	Mid Jul	60 × 80	2.1 plants	180 +	Late Feb +
Grower I	Cauliflower Gerona	Buy plants	Mid Jul	60 × 80	2.1 plants	190 +	Early Mar +
Grower I	Cauliflower Tempest	Buy plants	Mid Jul	60 × 80	2.1 plants	200 +	Late Mar
Grower I	Cauliflower Carantic	Buy plants	Mid Jul	60 × 80	2.1 plants	220 +	Late Mar
Grower I	Cauliflower Vogue	Buy plants	Mid Jul	60 × 80	2.1 plants	240 +	Early Apr
Grower I	Cauliflower Jerome	Buy plants	Mid Jul	60 × 80	2.1 plants	230 +	Late Mar +
Grower I	Cauliflower Chester	Buy plants	Mid Jul	60 × 80	2.1 plants	250 +	Mid Apr +
Grower I	Cauliflower Fletcher	Buy plants	Mid Jul	60 × 80	2.1 plants	255 +	Apr +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower I	Cauliflower Tenfold	Buy plants	Mid Jul	60 × 80	2.1 plants	265 +	Apr +
Grower I	Cauliflower Cartagena	Buy plants	Mid Jul	60 × 80	2.1 plants	275 +	Mid May +
Grower A	Kale curly Oldenbor	Mid Feb	Early Apr	75 × 35	3.8 plants	85 +	Early Jul +
Grower A	Kale curly Oldenbor	Late Mar	Mid May	75 × 35	3.8 plants	80 +	Early Aug +
Grower A	Kale curly Oldenbor	Early May	Mid Jun	75 × 35	3.8 plants	90 +	Mid Sep +
Grower A	Kale curly Oldenbor	Early Jun	Mid Jul	75 × 35	3.8 plants	120 +	Mid Nov +
Grower B	Kale curly Oldenbor	Buy plants	Mid Apr	75 × 45	3 plants	90 +	Mid Jul +
Grower B	Kale curly Oldenbor	Buy plants	Early Jun	75 × 45	3 plants	85 +	Late Aug +
Grower B	Kale curly Oldenbor	Buy plants	Early Jul	75 × 50	2.7 plants	95 +	Early Oct +
Grower D	Kale curly Oldenbor	Early May	Late Jun	70 × 45	3.1 plants	90 +	Mid Oct +
Grower D	Kale curly Oldenbor	Early Jun	Mid Jul	70 × 45	3.1 plants	130 +	Mid-late Dec +
Grower E	Kale curly Reflex	Buy plants	Mid May	80 × 35	3.2 plants	85 +	Early Jul +
Grower E	Kale curly Reflex	Buy plants	Mid Jun	80 × 35	3.2 plants	100 +	Early Oct +
Grower F	Kale curly Reflex	Mid Feb	Mid Apr	75 × 45	3 plants	100 +	Early Aug +
Grower F	Kale curly Reflex	Mid Mar	Mid May	75 × 45	3 plants	90 +	Late Aug +
Grower F	Kale curly Reflex	Mid Apr	Mid Jun	75 × 50	2.7 plants	90 +	Late Sep +
Grower F	Kale curly Reflex	Mid May	Mid Jul	75 × 50	2.7 plants	120 +	Late Nov +
Grower G	Kale curly Oldenbor	Mid Apr	Late May	55 × 45	4 plants	120 +	Late Sep +
Grower G	Kale curly Oldenbor	Late May	Early Jul	55 × 45	4 plants	135 +	Early Dec +
Grower I	Kale curly Reflex	Buy plants	Late Apr	60 × 50	3.3 plants	115 +	Mid Aug +
Grower I	Kale curly Oldenbor	Buy plants	Mid May	60 × 50	3.3 plants	110 +	Early Sep +
Grower I	Kale curly Reflex	Buy plants	Late May	60 × 50	3.3 plants	110 +	Mid Sep +
Grower I	Kale curly Oldenbor	Buy plants	Mid Jun	60 × 50	3.3 plants	120 +	Early Oct +
Grower I	Kale curly Reflex	Buy plants	Late Jun	60 × 60	2.7 plants	130 +	Early Nov +
Grower I	Kale curly Oldenbor	Buy plants	Late Jun	60 × 60	2.7 plants	140 +	Mid Nov +
Grower J	Kale curly Reflex	Early Feb	Early Apr	55 × 45	4 plants	85 +	Mid Jun +
Grower J	Kale curly Reflex	Early Apr	Mid May	55 × 40	4.5 plants	80 +	Early Aug +
Grower J	Kale curly Reflex	Early Jun	Mid Jul	55 × 45	4 plants	140 +	Mid Dec +
Grower K	Kale curly Westland Winter	Mid Feb	Mid Apr	25 × 45	9 plants	100 +	Mid Jul +
Grower K	Kale curly Westland Winter	Mid Mar	Mid May	25 × 45	9 plants	90 +	Mid Aug +
Grower K	Kale curly Westland Winter	Mid May	Mid Jul	25 × 45	9 plants	110 +	Mid Nov +
Grower D	Kale green Pentland Brig	Early Jun	Mid Jul	70 × 50	2.8 plants	230 +	Mar +
Grower H	Kale green Pentland Brig	Early May	Mid Jun	45 × 40	5.5 plants	65 +	Late Aug +
Grower A	Kale heritage Uncle John's	Buy plants	Mid Jul	75 × 35	3.8 plants	180 +	Dec +
Grower A	Kale heritage Red Russian	Early Jun	Mid Jul	75 × 35	3.8 plants	110 +	Mid Nov +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower B	Kale heritage Red Russian	Buy plants	Early Jul	75 × 50	2.7 plants	100 +	Early Oct +
Grower D	Kale heritage Red Russian	Early Jun	Mid Jul	70 × 50	2 plants	100 +	Mid-late Dec +
Grower E	Kale heritage Uncle John's	Buy plants	Mid Jun	80 × 35	3.2 plants	230 +	Feb +
Grower H	Kale heritage Red Russian	Early Mar	Mid Apr	45 × 40	5.5 plants	70 +	Late Jun +
Grower H	Kale heritage Red Russian	Early Apr	Mid May	45 × 40	5.5 plants	65 +	Late Jul +
Grower H	Kale heritage Red Russian	Early May	Mid Jun	45 × 40	5.5 plants	65 +	Late Aug +
Grower K	Kale heritage Red Russian	Mid Feb	Mid Apr	25 × 45	9 plants	100 +	Mid Jul +
Grower K	Kale heritage Red Russian	Mid Mar	Mid May	25 × 45	9 plants	90 +	Mid Aug +
Grower K	Kale heritage Red Russian	Mid May	Mid Jul	25 × 45	9 plants	110 +	Mid Nov +
Grower D	Kale red Redbor	Early Apr	Late Jun	70 × 45	3.1 plants	90 +	Sep +
Grower D	Kale red Redbor	Early Jun	Mid Jul	70 × 45	3.1 plants	120 +	Mid-late Dec +
Grower E	Kale red Redbor	Buy plants	Mid May	80 × 35	3.2 plants	90 +	Mid Aug +
Grower E	Kale red Redbor	Buy plants	Mid Jun	80 × 35	3.2 plants	100 +	Mid Sep +
Grower F	Kale red Redbor	Mid Feb	Mid Apr	75 × 45	3 plants	110 +	Early Aug +
Grower F	Kale red Redbor	Mid Mar	Mid May	75 × 45	3 plants	100 +	Late Aug +
Grower F	Kale red Redbor	Mid Apr	Mid Jun	75 × 50	2.7 plants	100 +	Late Sep +
Grower F	Kale red Redbor	Mid May	Mid Jul	75 × 50	2.7 plants	120 +	Late Nov +
Grower G	Kale red Redbor	Late May	Early Jul	55 × 40	4 plants	120 +	Mid Nov +
Grower H	Kale red Redbor	Early May	Mid Jun	45 × 40	5.5 plants	65 +	Late Aug +
Grower I	Kale red Redbor	Buy plants	Mid May	60 × 50	3.3 plants	120 +	Mid Sep +
Grower I	Kale red Redbor	Buy plants	Late Jun	60 × 50	3.3 plants	120 +	Late Oct +
Grower K	Kale red Rote Krauser	Mid Feb	Mid Apr	25 × 45	9 plants	100 +	Mid Jul +
Grower K	Kale red Rote Krauser	Mid Mar	Mid May	25 × 45	9 plants	90 +	Mid Aug +
Grower K	Kale red Rote Krauser	Mid May	Mid Jul	25 × 45	9 plants	110 +	Mid Nov +
Grower A	Kale Tuscan Black Magic	Mid Feb	Early Apr	75 × 35	3.8 plants	90 +	Early Jul +
Grower A	Kale Tuscan Black Magic	Early May	Mid Jun	75 × 35	3.8 plants	100 +	Late Sep +
Grower B	Kale Tuscan Cavolo Nero	Buy plants	Mid Apr	75 × 45	3 plants	100 +	Late Jul +
Grower B	Kale Tuscan Cavolo Nero	Buy plants	Mid Jun	75 × 50	2.7 plants	120 +	Mid Oct +
Grower D	Kale Tuscan Black Magic	Early Apr	Early Jun	70 × 45	3.1 plants	90 +	Sep +
Grower D	Kale Tuscan Black Magic	Early Jun	Mid Jul	70 × 45	3.1 plants	120 +	Mid-late Dec +
Grower E	Kale Tuscan Cavolo Nero	Buy plants	Mid May	80 × 35	3.2 plants	90 +	Late Jul +
Grower E	Kale Tuscan Cavolo Nero	Buy plants	Mid Jun	80 × 35	3.2 plants	100 +	Early Oct +
Grower F	Kale Tuscan Nero di Toscana	Mid Feb	Mid Apr	75 × 45	3 plants	100 +	Early Aug +
Grower F	Kale Tuscan Nero di Toscana	Mid Mar	Mid May	75 × 45	3 plants	100 +	Late Aug +
Grower F	Kale Tuscan Nero di Toscana	Mid Apr	Mid Jun	75 × 50	2.7 plants	120 +	Late Sep +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower F	Kale Tuscan Nero di Toscana	Mid May	Mid Jul	75 × 50	2.7 plants	120 +	Late Nov +
Grower G	Kale Tuscan Cavolo Nero	Late May	Early Jul	55 × 45	4 plants	145 +	Late Nov +
Grower H	Kale Tuscan Cavolo Nero	Early Mar	Mid Apr	45 × 40	5.5 plants	70 +	Late Jun +
Grower H	Kale Tuscan Cavolo Nero	Early Apr	Mid May	45 × 40	5.5 plants	65 +	Late Jul +
Grower H	Kale Tuscan Cavolo Nero	Early May	Mid Jun	45 × 40	5.5 plants	65 +	Late Aug +
Grower I	Kale Tuscan Black Magic	Buy plants	Mid May	60 × 60	2.7 plants	120 +	Mid Sep +
Grower I	Kale Tuscan Black Magic	Buy plants	Late May	60 × 60	2.7 plants	110 +	Late Sep +
Grower I	Kale Tuscan Black Magic	Buy plants	Early Jun	60 × 60	2.7 plants	110 +	Early Oct +
Grower I	Kale Tuscan Black Magic	Buy plants	Late Jun	60 × 60	2.7 plants	120 +	Late Oct +
Grower K	Kale Tuscan Nero di Toscana	Mid Feb	Mid Apr	25 × 45	9 plants	100 +	Mid Jul +
Grower K	Kale Tuscan Nero di Toscana	Mid Mar	Mid May	25 × 45	9 plants	90 +	Mid Aug +
Grower K	Kale Tuscan Nero di Toscana	Mid May	Mid Jul	25 × 45	9 plants	110 +	Mid Nov +
Grower K	Kale Tuscan Nero di Toscana	Early Sep	Mid Oct	25 × 45	9 plants	150 +	Mid Mar +
Grower F	Kalette Kaleidoscope	Early Apr	Mid May	75 × 55	2.4 plants	160 +	Mid Oct+
Grower F	Kalette Garden Mix	Early May	Mid Jun	75 × 55	2.4 plants	180 +	Mid Dec +
Grower F	Kalette Garden Mix	Mid May	Early Jul	75 × 55	2.4 plants	190 +	Mid Jan +
Grower I	Kalette Garden Mix	-	Mid Apr	60 × 50	3.3 plants	170 +	Mid Oct +
Grower I	Kalette Garden Mix	-	Mid May	60 × 50	3.3 plants	160 +	Early Nov +
Grower I	Kalette Garden Mix	-	Mid Jun	60 × 50	3.3 plants	170 +	Early Dec +
Grower G	Kohlrabi Korist	Late Feb	Early Apr	55 × 15	12 plants	65 +	Late Jun +
Grower G	Kohlrabi Korist	Late Mar	Mid May	55 × 15	12 plants	60 +	Mid Jul +
Grower G	Kohlrabi Korist	Late Apr	Mid Jun	55 × 15	12 plants	60 +	Mid Aug +
Grower G	Kohlrabi Korist	Late May	Mid Jul	55 × 15	12 plants	65 +	Mid Sep +
Grower H	Kohlrabi Korist	Late Mar	Mid May	30 × 30	11 plants	60 +	Mid Jul +
Grower H	Kohlrabi Korist	Late Apr	Mid Jun	30 × 30	11 plants	65 +	Mid Aug +
Grower H	Kohlrabi Korist	Late May	Mid Jul	30 × 30	11 plants	75 +	Mid Sep +
Grower J	Kohlrabi Korist	Early Feb	Early Apr	38 × 30	13 plants	70 +	Mid Jun
Grower J	Kohlrabi Korist	Late Mar	Mid May	38 × 30	13 plants	60 +	Mid Jul
Grower J	Kohlrabi Korist	Mid May	Early Jul	38 × 30	13 plants	70 +	Early Sep
Grower J	Kohlrabi Korist	Early Jun	Late Jul	38 × 30	13 plants	80 +	Late Oct
Grower B	Romanesco Veronica	Buy plants	Mid May	75 × 45	3 plants	80 +	Early Aug +
Grower B	Romanesco Veronica	Buy plants	Late May	75 × 45	3 plants	85 +	Late Aug +
Grower B	Romanesco Veronica	Buy plants	Mid Jun	75 × 45	3 plants	90 +	Mid Sep +
Grower B	Romanesco Veronica	Buy plants	Late Jun	75 × 45	3 plants	95 +	Late Sep +
Grower B	Romanesco Veronica	Buy plants	Early Jul	75 × 45	3 plants	95 +	Early Oct +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower F	Romanesco Veronica	Mid Feb	Mid Apr	75 × 45	3 plants	90 +	Mid Jul
Grower F	Romanesco Veronica	Mid Mar	Early May	75 × 40	3.3 plants	80 +	Early Aug
Grower F	Romanesco Veronica	Mid Apr	Early Jun	76 × 40	3.3 plants	80 +	Late Aug +
Grower F	Romanesco Veronica	Mid May	Early Jul	75 × 45	3 plants	95 +	Late Sep +
Grower G	Romanesco Veronica	Late Feb	Mid Apr	55 × 45	4 plants	90 +	Mid Jul +
Grower G	Romanesco Veronica	Mid Mar	Early May	55 × 45	4 plants	90 +	Early Aug +
Grower G	Romanesco Veronica	Mid Apr	Late May	55 × 45	4 plants	85 +	Late Aug +
Grower G	Romanesco Veronica	Early May	Mid Jun	55 × 45	4 plants	85 +	Mid Sep +
Grower G	Romanesco Veronica	Late May	Early Jul	55 × 45	4 plants	85 +	Late Sep +
Grower G	Romanesco Veronica	Mid Jun	Late Jul	55 × 45	4 plants	90 +	Mid Oct +
Grower A	Sprouting broccoli Burgundy	Mid Mar	Mid May	75 × 40	3.3 plants	80 +	Mid Aug +
Grower A	Sprouting broccoli Burgundy	Mid Apr	Mid Jun	75 × 40	3.3 plants	90 +	Mid Sep +
Grower A	Sprouting broccoli Burgundy	Mid May	Mid Jul	75 × 40	3.3 plants	100 +	Late Oct +
Grower B	Sprouting broccoli Santee	Buy plants	Early Jun	75 × 90	1.5 plants	110 +	Early Oct +
Grower B	Sprouting broccoli Red Admiral	Buy plants	Early Jun	75 × 90	1.5 plants	130 +	Late Oct +
Grower B	Sprouting broccoli Red Fire	Buy plants	Early Jul	75 × 90	1.5 plants	140 +	Nov +
Grower B	Sprouting broccoli Claret	Buy plants	Early Jul	75 × 90	1.5 plants	225 +	Feb-Mar
Grower B	Sprouting broccoli Bonarda	Buy plants	Early Jul	75 × 90	1.5 plants	240 +	Apr +
Grower B	Sprouting broccoli Pozo	Buy plants	Early Jul	75 × 90	1.5 plants	270 +	Apr +
Grower B	Sprouting broccoli Cardinal	Buy plants	Early Jul	75 × 90	1.5 plants	300 +	Apr-May
Grower D	Sprouting broccoli Red Fire	Early May	Early Jul	70 × 60	2.3 plants	200 +	Late Dec +
Grower D	Sprouting broccoli Claret	Mid May	Mid Jul	70 × 60	2.3 plants	230 +	Late Jan +
Grower D	Sprouting broccoli Cardinal	Mid May	Mid Jul	70 × 60	2.3 plants	240 +	Late Feb +
Grower F	Sprouting broccoli Rudolph	Early Jun	Mid Jul	75 × 55	2.4 plants	110 +	Nov-Feb
Grower F	Sprouting broccoli Rioja	Early Jun	Mid Jul	75 × 55	2.4 plants	140 +	Jan-Mar
Grower F	Sprouting broccoli Mendocino	Early Jun	Late Jul	75 × 55	2.4 plants	200 +	Apr-May
Grower F	Sprouting broccoli Red Fire	Early Jun	Late Jul	75 × 55	2.4 plants	220 +	Apr-May
Grower F	Sprouting broccoli Claret	Early Jun	Late Jul	75 × 55	2.4 plants	240 +	Apr-May
Grower F	Sprouting broccoli Red Admiral	Early Jun	Late Jul	75 × 55	2.4 plants	240 +	Apr-May
Grower G	Sprouting broccoli Burgundy	Early May	Mid Jun	55 × 45	4 plants	80 +	Early Sep +
Grower G	Sprouting broccoli Burgundy	Mid May	Late Jun	55 × 45	4 plants	80 +	Late Sep +
Grower G	Sprouting broccoli Burgundy	Late May	Early Jul	55 × 45	4 plants	90 +	Early Oct +
Grower G	Sprouting broccoli Burgundy	Early Jun	Mid Jul	55 × 45	4 plants	90 +	Late Oct +
Grower I	Sprouting broccoli Burgundy	Mid Feb	Mid Apr	60 × 45	3.7 plants	90 +	Mid Jul +
Grower I	Sprouting broccoli Burgundy	Early Mar	Late Apr	60 × 45	3.7 plants	90 +	Early Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower I	Sprouting broccoli Burgundy	Mid Apr	Mid May	60 × 45	3.7 plants	85 +	Mid Aug +
Grower I	Sprouting broccoli Burgundy	Early May	Mid Jun	60 × 45	3.7 plants	80 +	Late Aug +
Grower I	Sprouting broccoli Burgundy	Late May	Mid Jul	60 × 45	3.7 plants	85 +	Late Sep +
Grower I	Sprouting broccoli Claret	Buy plants	Mid Jun	60 × 60	2.8 plants	220 +	Late Jan +
Grower I	Sprouting broccoli Bonarda	Buy plants	Mid Jun	60 × 60	2.8 plants	240 +	Mid Feb +
Grower I	Sprouting broccoli Cardinal	Buy plants	Mid Jun	60 × 60	2.8 plants	260 +	Early Mar +
Grower I	Sprouting broccoli Claret	Buy plants	Mid Jul	60 × 60	2.8 plants	240 +	Mid Apr +
Grower I	Sprouting broccoli Bonarda	Buy plants	Mid Jul	60 × 60	2.8 plants	260 +	Early Apr +
Grower I	Sprouting broccoli Cardinal	Buy plants	Mid Jul	60 × 60	2.8 plants	280 +	Early May +
Grower A	Swede Helenor	Early Apr	-	75 × 15	9 seeds	110 +	Late Jul +
Grower A	Swede Tweed	Late May	-	75 × 12	11 seeds	130 +	Mid Sep +
Grower A	Swede Magres	Late May	-	75 × 12	11 seeds	140 +	Late Sep +
Grower B	Swede Helenor	Mid Apr	-	40 × 18	14 seeds	110 +	Mid Aug +
Grower B	Swede Magres	Late May	-	40 × 18	14 seeds	120 +	Late Sep +
Grower E	Swede Helenor	Buy plants	Mid Apr	80 × 15	8.3 plants	90 +	Mid Jul +
Grower E	Swede Helenor	Mid Apr	-	80 × 12	10.5 seeds	95 +	Late Jul +
Grower E	Swede Tweed	Mid Apr	-	80 × 12	10.5 seeds	100 +	Early Aug +
Grower E	Swede Tweed	Late May	-	80 × 12	10.5 seeds	100 +	Oct +
Grower F	Swede Helenor	Mid May	-	75 × 12	11 seeds	80 +	Mid Aug +
Grower F	Swede Helenor	Mid Jun	-	76 × 12	11 seeds	90 +	Mid Sep +
Grower G	Swede Helenor	Late Apr	-	80 × 10	50 seeds	120 +	Late Jul +
Grower G	Swede Helenor	Late May	-	80 × 10	50 seeds	110 +	Mid Sep +
Grower G	Swede Magres	Late May	-	80 × 10	50 seeds	130 +	Early Oct +
Grower I	Swede Tweed	Buy plants	Late May	60 × 30	5.5 plants	80 +	Early Sep +
Grower I	Swede Tweed	Buy plants	Mid Jul	60 × 30	5.5 plants	95 +	Mid Oct +
Grower I	Swede Tweed	Late May	-	60 × 14	11 seeds	130 +	Early Nov +
Grower J	Swede Helenor	Early Apr	-	55 × 15	12 seeds	120 +	Early Jul +
Grower J	Swede Helenor	Mid May	-	55 × 15	12 seeds	110 +	Early Sep +
Grower K	Turnip Snowball	Late Mar	-	20 × 3	160 seeds	60	Early May +
Grower K	Turnip Snowball	Late Mar	-	20 × 3	160 seeds	75	Mid May +
Grower K	Turnip Snowball	Late Apr	-	20 × 3	160 seeds	65	Early Jul +
Grower K	Turnip Snowball	Late May	-	20 × 3	160 seeds	70	Mid Aug +
Grower K	Turnip Snowball	Late Jun	-	20 × 3	160 seeds	75	Mid Sep +
Grower K	Turnip Snowball	Late Jul	-	20 × 3	160 seeds	85	Late Oct +

Table 4 Cropping programmes for leafy/herb crops for the 11 MOPS project growers.

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower B	Basil British Basil	Mid Apr	Late May	45 × 20	11 plants	65 +	Late Jul +
Grower B	Basil Crimson King	Mid Apr	Late May	45 × 20	11 plants	70 +	Late Jul +
Grower B	Basil British Basil	Early May	Mid Jun	45 × 20	11 plants	70 +	Late Aug +
Grower B	Basil Crimson King	Early May	Mid Jun	45 × 20	11 plants	75 +	Late Aug +
Grower B	Basil British Basil	Late May	Early Jul	45 × 20	11 plants	80 +	Mid Sep +
Grower B	Basil Crimson King	Late May	Early Jul	45 × 20	11 plants	85 +	Mid Sep +
Grower F	Basil Sweet basil	Late May	Mid Jul	30 × 30	11 plants	40 +	Late Aug +
Grower H	Basil Bonazza	Early Apr	Late May	30 × 30	11 plants	45 +	Mid Jul +
Grower H	Basil Cinnamon	Early Apr	Late May	30 × 30	11 plants	40 +	Mid Jul +
Grower H	Basil Deep Purple	Early Apr	Late May	30 × 30	11 plants	40 +	Mid Jul +
Grower H	Basil Rubra	Early Apr	Late May	30 × 30	11 plants	40 +	Mid Jul +
Grower H	Basil Thai	Early Apr	Late May	30 × 30	11 plants	40 +	Mid Jul +
Grower H	Basil Bonazza	Early May	Mid Jun	30 × 30	11 plants	45 +	Aug +
Grower H	Basil Cinnamon	Early May	Mid Jun	30 × 30	11 plants	40 +	Aug +
Grower H	Basil Deep Purple	Early May	Mid Jun	30 × 30	11 plants	40 +	Aug +
Grower H	Basil Rubra	Early May	Mid Jun	30 × 30	11 plants	40 +	Aug +
Grower H	Basil Thai	Early May	Mid Jun	30 × 30	11 plants	40 +	Aug +
Grower J	Basil Sweet basil	Mid Apr	Late May	20 × 20	25 plants	50 +	Mid Jul +
Grower J	Basil Sweet basil	Mid May	Late Jun	20 × 20	25 plants	50 +	Mid Aug +
Grower A	Chard Rainbow	Buy blocks	Early Apr	40 × 20	12.5 plants	50 +	Mid May +
Grower A	Chard Rainbow	Buy plants	Mid May	40 × 20	12.5 plants	40 +	Early Jul +
Grower A	Chard Rainbow	Buy plants	Mid Jul	40 × 20	12.5 plants	50 +	Early Sep +
Grower A	Chard Rainbow	Buy plants	Mid Aug	40 × 20	12.5 plants	60 +	Mid Oct +
Grower A	Chard Rainbow	Buy plants	Mid Sep	40 × 20	12.5 plants	100 +	Jan +
Grower B	Chard Rainbow	Buy plants	Early Feb	40 × 15	16.5 plants	70 +	Mid Apr +
Grower B	Chard Rainbow	Buy plants	Mid Apr	40 × 15	16.5 plants	60 +	Mid Jun +
Grower B	Chard Rainbow	Buy plants	Mid Aug	40 × 15	16.5 plants	70 +	Late Oct +
Grower D	Chard Rainbow	Mid Feb	Late Mar	20 × 20	25 plants	60 +	May +
Grower D	Chard Rainbow	Early Apr	Mid May	20 × 20	25 plants	50 +	Jul +
Grower D	Chard Rainbow	Early Aug	Mid Sep	20 × 20	25 plants	50 +	Nov +
Grower F	Chard Rainbow	Early Mar	Mid Apr	30 × 15	22 cells	50 +	Early Jun +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower F	Chard Rainbow	Mid Apr	Early Jun	30 × 15	22 cells	50 +	Late Jul +
Grower F	Chard Rainbow	Early Jun	Mid Jul	30 × 15	22 cells	60 +	Mid Sep +
Grower F	Chard Rainbow	Early Jul	Mid Aug	30 × 15	22 cells	70 +	Late Oct +
Grower F	Chard Rainbow	Early Jul	Mid Aug	30 × 15	22 cells	70 +	Dec +
Grower H	Chard Rainbow	Mid Feb	Early Apr	20 × 20	25 plugs	50 +	Late May +
Grower H	Chard Rainbow	Early Jun	-	20 × 4	125 seeds	60 +	Early Aug +
Grower H	Chard Rainbow	Mid Aug	Late Sep	20 × 20	25 plants	80 +	Jan +
Grower J	Chard Bright Lights	Early Feb	Every 3-4 wks indoors	-	25-28 g seed	50 +	-
Grower J	Chard Bright Lights	Early Apr	Every 3-4 wks indoors	-	25-28 g seed	40 +	-
Grower J	Chard Bright Lights	Early Jun	Every 3-4 wks indoors	-	25-28 g seed	35 +	-
Grower J	Chard Bright Lights	Early Aug	Every 3-4 wks indoors	-	25-28 g seed	55 +	-
Grower K	Chard Rainbow	Late Jan	Mid Mar	12 × 12	70 cells/3-4 seeds	45 +	Early May +
Grower K	Chard Rainbow	Late Mar	Mid May	15 × 15	45 cells/3-4 seeds	50 +	Late Jun +
Grower K	Chard Rainbow	Late May	Mid Jul	15 × 15	45 cells/3-4 seeds	50 +	Early Sep +
Grower K	Chard Rainbow	Mid Aug	Late Sep	15 × 15	45 cells/3-4 seeds	80 +	Mid Dec +
Grower K	Chard Rainbow	Late Aug	Mid Oct	12 × 12	45 cells/3-4 seeds	100 +	Mid Jan +
Grower D	Chive Thick Leaf	Mid Mar	Mid May	20 × 20	25 plugs	90 +	Mid Aug +
Grower D	Chive Forescale	Mid Mar	Mid May	20 × 20	25 plugs	100 +	Late Aug +
Grower D	Chive Thick Leaf	Mid Mar	Mid Oct	20 × 20	25 plugs	150 +	Apr +
Grower D	Chive Forescale	Mid Mar	Mid Oct	20 × 20	25 plugs	150 +	Apr +
Grower J	Coriander Calibe	Mid Mar	Late May	20 × 20	25 plants	60 +	Late Jul +
Grower J	Coriander Calibe	Mid Apr	Late Jun	20 × 20	25 plants	65 +	Late Aug +
Grower J	Coriander Calibe	Mid May	Late Jul	20 × 20	25 plants	70 +	Late Sep +
Grower D	Corn salad Macholong	Mid Aug	Mid-late Sep	15 × 15	44 cells/4-6 seeds	40-50 +	Winter
Grower D	Corn salad Elan	Mid Aug	Mid-late Sep	15 × 15	44 cells/4-6 seeds	40-50 +	Winter
Grower D	Corn salad Verte de Cambrai	Mid Sep	Late Oct	15 × 15	44 cells/4-6 seeds	50-100 +	Winter
Grower D	Corn salad	Early Jan	Mid Feb	20 × 20	25 plants	60 +	Mid Apr
Grower D	Corn salad	Early Feb	Mid Mar	20 × 20	25 plants	40 +	Mid May
Grower J	Dill Delight	Mid Apr	Late May	20 × 20	25 plants	65 +	Mid Aug +
Grower H	Endive Wallone	Early May	Early Jun	20 × 20	25 plants	30-35	Early Jul
Grower H	Endive Wallone	Early Jun	Early Jul	20 × 20	25 plants	35 +	Mid Aug +
Grower K	Endive Wallone	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Mid Nov +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower K	Endive Tres Fine Maraichere	Early Aug	Mid Sep	20 × 20	25 plants	70 +	Mid Nov +
Grower K	Endive Wallone	Early Sep	Mid Oct	20 × 20	25 plants	90 +	Mid Jan +
Grower K	Endive Tres Fine Maraichere	Early Sep	Mid Oct	20 × 20	25 plants	90 +	Mid Jan +
Grower A	Lettuce Xem	Early Mar	Mid Apr (every 2-3 wks outdoors)	20 × 20	25 plugs	40 +	Late May +
Grower A	Lettuce Deronda	Early Mar	Mid Apr (every 2-3 wks outdoors)	20 × 20	25 plugs	40 +	Late May +
Grower A	Lettuce Oaking	Early Mar	Mid Apr (every 2-3 wks outdoors)	20 × 20	25 plugs	40 +	Late May +
Grower A	Lettuce Brighton	Mid Aug	Late Sep (every 2-3 wks outdoors)	30 × 30	11 plants	60 +	Late Nov +
Grower A	Lettuce Figaro	Mid Aug	Late Sep (every 2-3 wks outdoors)	30 × 30	11 plants	60 +	Late Nov +
Grower A	Lettuce Cerbiatta	Mid Aug	Late Sep (every 2-3 wks outdoors)	30 × 30	11 plants	60 +	Late Nov +
Grower A	Lettuce Winter Gem	Mid Aug	Late Sep (every 2-3 wks outdoors)	30 × 30	11 plants	60 +	Late Nov +
Grower A	Lettuce Ginko	Mid Aug	Late Sep (every 2-3 wks outdoors)	30 × 30	11 plants	60 +	Late Nov +
Grower A	Lettuce Brighton	Mid Sep	Mid Oct (every 2-3 wks outdoors)	30 × 30	11 plants	75 +	Dec +
Grower A	Lettuce Figaro	Mid Sep	Mid Oct (every 2-3 wks outdoors)	30 × 30	11 plants	75 +	Dec +
Grower A	Lettuce Cerbiatta	Mid Sep	Mid Oct (every 2-3 wks outdoors)	30 × 30	11 plants	75 +	Dec +
Grower A	Lettuce Winter Gem	Mid Sep	Mid Oct (every 2-3 wks outdoors)	30 × 30	11 plants	75 +	Dec +
Grower A	Lettuce Ginko	Mid Sep	Mid Oct (every 2-3 wks outdoors)	30 × 30	11 plants	75 +	Dec +
Grower B	Lettuce Xem	Buy plants	Mid Apr (sow early-mid Aug indoors)	30 × 20	16.5 plants	45 +	Mid Jun +
Grower B	Lettuce Xem	Buy plants	Early May (every 2 wks until late Jul)	30 × 20	16.5 plants	50 +	Late Jun
Grower B	Lettuce Brighton	Buy plants	Mid Jul	30 × 20	16.5 plants	55 +	Mid Sep +
Grower B	Lettuce Brighton	Buy plants	Early Aug	30 × 20	16.5 plants	65 +	Late Sep +
Grower B	Lettuce Winter Density	Buy plants	Mid Jul	30 × 20	16.5 plants	55 +	Mid Sep +
Grower B	Lettuce Winter Density	Buy plants	Early Aug	30 × 20	16.5 plants	65 +	Late Sep +
Grower B	Lettuce Arctic King	Buy plants	Mid Jul	30 × 20	16.5 plants	55 +	Mid Sep +
Grower B	Lettuce Arctic King	Buy plants	Early Aug	30 × 20	16.5 plants	65 +	Late Sep +
Grower B	Lettuce Brighton	Buy plants	Late Sep	30 × 20	16.5 plants	85 +	Mid-late Dec +
Grower B	Lettuce Winter Density	Buy plants	Late Sep	30 × 20	16.5 plants	85 +	Mid-late Dec +
Grower B	Lettuce Arctic King	Buy plants	Late Sep	30 × 20	16.5 plants	85 +	Mid-late Dec +
Grower D	Lettuce North Holland	Mid Aug	Mid-late Sep	15 × 15	44 cells/4-6 seeds	40-50 +	Winter
Grower D	Lettuce North Holland	Mid Sep	Late Oct	15 × 15	44 cells/4-6 seeds	50-100 +	Winter
Grower D	Lettuce Hawking	Mid Feb	Early Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	45 +	Mid May +
Grower D	Lettuce Xem	Mid Feb	Early Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	45 +	Mid May +
Grower D	Lettuce Hawking	Early Mar	Late Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Early Jun

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower D	Lettuce Xem	Early Mar	Late Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Early Jun
Grower D	Lettuce Hawking	Early Mar	Early May (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Mid Jun
Grower D	Lettuce Xem	Early Mar	Early May (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Mid Jun
Grower D	Lettuce Ezra	Early Mar	Early May (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Mid Jun
Grower D	Lettuce Ezatrix	Early Mar	Early May (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Mid Jun
Grower F	Lettuce Alezan	Early Aug	Mid Sep	20 × 20	25 plants	55 +	Mid Nov +
Grower F	Lettuce Alezan	Late Aug	Early Oct	25 × 25	16 plants	80 +	Dec +
Grower F	Lettuce Alezan	Mid Jan	Late Feb	25 × 25	16 plants	60 +	Mid Apr
Grower F	Lettuce Xem	Early Mar	Mid Apr (every 3 wks to early Sep outdr)	20 × 20	25 plugs	40 +	Late May +
Grower F	Lettuce Deronda	Early Mar	Mid Apr (every 3 wks to early Sep outdr)	20 × 20	25 plugs	40 +	Late May +
Grower F	Lettuce Oaking	Early Mar	Mid Apr (every 3 wks to early Sep outdr)	20 × 20	25 plugs	40 +	Late May +
Grower F	Lettuce Brighton	Early Aug	Mid Sep	20 × 20	25 plants	55 +	Mid Nov +
Grower F	Lettuce Ferega	Early Aug	Mid Sep	20 × 20	25 plants	55 +	Mid Nov +
Grower F	Lettuce Ginko	Early Aug	Mid Sep	20 × 20	25 plants	55 +	Mid Nov +
Grower F	Lettuce Brighton	Late Aug	Early Oct	25 × 25	16 plants	80 +	Dec +
Grower F	Lettuce Ferega	Late Aug	Early Oct	25 × 25	16 plants	80 +	Dec +
Grower F	Lettuce Ginko	Late Aug	Early Oct	25 × 25	16 plants	80 +	Dec +
Grower F	Lettuce Brighton	Mid Jan	Late Feb	25 × 25	16 plants	60 +	Mid Apr
Grower F	Lettuce Ferega	Mid Jan	Late Feb	25 × 25	16 plants	60 +	Mid Apr
Grower F	Lettuce Ginko	Mid Jan	Late Feb	25 × 25	16 plants	60 +	Mid Apr
Grower G	Lettuce Ferega	Late Apr	Early Jun	55 × 15	12 plants	50 +	Late Jul +
Grower G	Lettuce Kamalia	Late Apr	Early Jun	55 × 15	12 plants	50 +	Late Jul +
Grower G	Lettuce Ferega	Early May	Mid Jun	55 × 15	12 plants	50 +	Early Aug +
Grower G	Lettuce Kamalia	Early May	Mid Jun	55 × 15	12 plants	50 +	Early Aug +
Grower G	Lettuce Ferega	Mid Jun	Late Jul	55 × 15	12 plants	50 +	Mid Aug +
Grower G	Lettuce Kamalia	Mid Jun	Late Jul	55 × 15	12 plants	50 +	Mid Aug +
Grower G	Lettuce Ferega	Late Jun	Mid Aug	55 × 15	12 plants	55 +	Early Oct +
Grower G	Lettuce Kamalia	Late Jun	Mid Aug	55 × 15	12 plants	55 +	Early Oct +
Grower G	Lettuce Ferega	Mid Jul	Late Aug	55 × 15	12 plants	55 +	Late Oct +
Grower G	Lettuce Kamalia	Mid Jul	Late Aug	55 × 15	12 plants	55 +	Late Oct +
Grower H	Lettuce Alezan	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Mid Nov +
Grower H	Lettuce Alezan	Mid Aug	Late Sep	20 × 20	25 plants	80 +	Mid Dec +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower H	Lettuce Malis/Brighton	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Mid Nov +
Grower H	Lettuce Anizel/Ferega	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Mid Nov +
Grower H	Lettuce Magellan	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Mid Nov +
Grower H	Lettuce Lattughino Rosso	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Mid Nov +
Grower H	Lettuce Heathrow	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Mid Nov +
Grower H	Lettuce Malis/Brighton	Mid Aug	Late Sep	20 × 20	25 plants	80 +	Mid Dec +
Grower H	Lettuce Anizel/Ferega	Mid Aug	Late Sep	20 × 20	25 plants	80 +	Mid Dec +
Grower H	Lettuce Magellan	Mid Aug	Late Sep	20 × 20	25 plants	80 +	Mid Dec +
Grower H	Lettuce Lattughino Rosso	Mid Aug	Late Sep	20 × 20	25 plants	80 +	Mid Dec +
Grower H	Lettuce Heathrow	Mid Aug	Late Sep	20 × 20	25 plants	80 +	Mid Dec +
Grower H	Lettuce Xem	Early Feb	Early Apr	20 × 20	25 plants	45 +	Mid May +
Grower H	Lettuce Xem	Early Mar	Mid Apr	20 × 20	25 plants	40 +	Early Jun +
Grower H	Lettuce Xem	Early May	Mid Jun	20 × 20	25 plants	40 +	Mid Jul +
Grower H	Lettuce Xem	Early Jun	Early Jul	20 × 20	25 plants	45 +	Late Aug +
Grower H	Lettuce Piro	Early Feb	Early Apr	20 × 20	25 plants	30 +	Early May +
Grower H	Lettuce Cerbiatta	Early Feb	Early Apr	20 × 20	25 plants	30 +	Early May +
Grower H	Lettuce Saragossa	Early Feb	Early Apr	20 × 20	25 plants	30 +	Early May +
Grower H	Lettuce Cantarix	Early Feb	Early Apr	20 × 20	25 plants	30 +	Early May +
Grower H	Lettuce Red Salad Bowl	Early Feb	Early Apr	20 × 20	25 plants	30 +	Early May +
Grower H	Lettuce Piro	Late Feb	Mid Apr	20 × 20	25 plants	30 +	Mid May +
Grower H	Lettuce Cerbiatta	Late Feb	Mid Apr	20 × 20	25 plants	30 +	Mid May +
Grower H	Lettuce Saragossa	Late Feb	Mid Apr	20 × 20	25 plants	30 +	Mid May +
Grower H	Lettuce Cantarix	Late Feb	Mid Apr	20 × 20	25 plants	30 +	Mid May +
Grower H	Lettuce Red Salad Bowl	Late Feb	Mid Apr	20 × 20	25 plants	30 +	Mid May +
Grower H	Lettuce Piro	Early May	Early Jun	20 × 20	25 plants	25-30	Early Jul
Grower H	Lettuce Cerbiatta	Early May	Early Jun	20 × 20	25 plants	25-30	Early Jul
Grower H	Lettuce Saragossa	Early May	Early Jun	20 × 20	25 plants	25-30	Early Jul
Grower H	Lettuce Cantarix	Early May	Early Jun	20 × 20	25 plants	25-30	Early Jul
Grower H	Lettuce Red Salad Bowl	Early May	Early Jun	20 × 20	25 plants	25-30	Early Jul
Grower H	Lettuce Piro	Early Jun	Early Jul	20 × 20	25 plants	35 +	Mid Aug +
Grower H	Lettuce Cerbiatta	Early Jun	Early Jul	20 × 20	25 plants	35 +	Mid Aug +
Grower H	Lettuce Saragossa	Early Jun	Early Jul	20 × 20	25 plants	35 +	Mid Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower H	Lettuce Cantarix	Early Jun	Early Jul	20 × 20	25 plants	35 +	Mid Aug +
Grower H	Lettuce Red Salad Bowl	Early Jun	Early Jul	20 × 20	25 plants	35 +	Mid Aug +
Grower I	Lettuce Lea	Buy plants	Late Apr	30 × 30	11 plants	45 +	Mid Jun +
Grower I	Lettuce Stelix	Buy plants	Late Apr	30 × 30	11 plants	45 +	Mid Jun +
Grower I	Lettuce Olana	Buy plants	Late Apr	30 × 30	11 plants	45 +	Mid Jun +
Grower I	Lettuce Marcord	Buy plants	Late Apr	30 × 30	11 plants	45 +	Mid Jun +
Grower I	Lettuce Lea	Buy plants	Late May	30 × 30	11 plants	40 +	Mid Jul +
Grower I	Lettuce Stelix	Buy plants	Late May	30 × 30	11 plants	40 +	Mid Jul +
Grower I	Lettuce Marcord	Buy plants	Late May	30 × 30	11 plants	40 +	Mid Jul +
Grower I	Lettuce Lea	Buy plants	Late Jun	30 × 30	11 plants	45 +	Mid Aug +
Grower I	Lettuce Stelix	Buy plants	Late Jun	30 × 30	11 plants	45 +	Mid Aug +
Grower I	Lettuce Marcord	Buy plants	Late Jun	30 × 30	11 plants	45 +	Mid Aug +
Grower J	Lettuce Sky	Early Feb-mid Aug	Early Mar-late Oct (every 14 d)	30 × 30	11 plants	35-45	Mid Apr-late Nov
Grower J	Lettuce Brighton	Early Feb-mid Aug	Early Mar-late Oct (every 14 d)	30 × 30	11 plants	35-45	Mid Apr-late Nov
Grower K	Lettuce Hawking	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid May +
Grower K	Lettuce Xem	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid May +
Grower K	Lettuce Hawking	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun +
Grower K	Lettuce Xem	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun +
Grower K	Lettuce Salad Bowl	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun +
Grower K	Lettuce Hawking	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid May
Grower K	Lettuce Xem	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid May
Grower K	Lettuce Hawking	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun
Grower K	Lettuce Xem	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun
Grower K	Lettuce Salad Bowl	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun
Grower K	Lettuce Brighton	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Mid Nov +
Grower K	Lettuce Cerbiatta	Early Aug	Mid Sep	20 × 20	25 plants	70 +	Mid Nov +
Grower K	Lettuce Figaro	Early Aug	Mid Sep	20 × 20	25 plants	70 +	Mid Nov +
Grower K	Lettuce Brighton	Early Sep	Mid Oct	20 × 20	25 plants	90 +	Mid Jan +
Grower K	Lettuce Cerbiatta	Early Sep	Mid Oct	20 × 20	25 plants	90 +	Mid Jan +
Grower K	Lettuce Figaro	Early Sep	Mid Oct	20 × 20	25 plants	90 +	Mid Jan +
Grower K	Microgreen Red cabbage	Early Jan-late Dec	Repeat weekly sowing	-	1,500 + seeds	18-30	-
Grower K	Microgreen Red Lace	Early Jan-late Dec	Repeat weekly sowing	-	1,500 + seeds	18-30	-

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower K	Microgreen Micro kale	Early Jan-late Dec	Repeat weekly sowing	-	1,500 + seeds	18-30	-
Grower K	Microgreen Chickpea	Early Jan-late Dec	Repeat weekly sowing	-	1,500 + seeds	18-30	-
Grower K	Microgreen Red Lava	Early Jan-late Dec	Repeat weekly sowing	-	1,500 + seeds	18-30	-
Grower K	Microgreen Radish Sangria	Early Jan-late Dec	Repeat weekly sowing	-	1,500 + seeds	18-30	-
Grower K	Microgreen Green Frills	Early Jan-late Dec	Repeat weekly sowing	-	1,500 + seeds	18-30	-
Grower K	Microgreen Wild rocket	Early Jan-late Dec	Repeat weekly sowing	-	1,500 + seeds	18-30	-
Grower B	Mizuna Waido	Early Jan-early Sep	-	-	500-600 seeds	30-40	Early May-mid Sep +
Grower B	Mizuna Waido	Early Jan-early Sep	-	-	500-600 seeds	45 +	Early May-mid Sep +
Grower D	Mizuna	Mid Apr	Every 10-14 d to Aug, 10 d lte Aug-mid Sep indr	-	-	40-50	Late May
Grower D	Mizuna	Mid Aug	Mid-late Sep	15 × 15	44 cells/4-6 seeds	40-50 +	Winter
Grower D	Mizuna	Mid Sep	Late Oct	15 × 15	44 cells/4-6 seeds	50-100 +	Winter
Grower D	Mizuna Red mizuna	Mid Sep	Late Oct	15 × 15	44 cells/4-6 seeds	50-100 +	Winter
Grower D	Mizuna	Early Jan	Mid Feb	20 × 20	25 plants	60 +	Mid Apr
Grower D	Mizuna	Early Feb	Mid Mar	20 × 20	25 plants	40 +	Mid May
Grower F	Mizuna	Early Oct	Early Nov	15 × 15	44 cells	40 +	Mid Dec +
Grower F	Mizuna Green mizuna	Mid Apr	Every 7 d to early Sep, 3 × indr Sep-Oct	7.5 × 2.5	570 seeds	40 +	Mid May +
Grower F	Mizuna Red mizuna	Mid Apr	Every 7 d to early Sep, 3 × indr Sep-Oct	15 × 15	570 seeds	40 +	Mid May +
Grower F	Mizuna Green mizuna	Mid Mar	Mid Apr (every 7 d to ely Sep, 3 × indr Sep-Oct)	15 × 15	200 seeds	30-35 +	-
Grower F	Mizuna Red Knight	Mid Mar	Mid Apr (every 7 d to ely Sep, 3 × indr Sep-Oct)	15 × 15	200 seeds	30-35 +	-
Grower H	Mizuna	Late Mar	Every 2 wks late Mar-mid Aug	10 × 1.5	600 seeds	40 +	Early May +
Grower K	Mizuna	Late Jan	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	40-50 +	Mid Mar
Grower K	Mizuna	Late Jan	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	40-50 +	Mid Mar
Grower K	Mizuna	Late Feb	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	35-40 +	Mid Apr
Grower K	Mizuna	Late Feb	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	35-40 +	Mid Apr
Grower B	Mustard Red Frills	Early Jan-early Sep	-	-	500-600 seeds	30-40	Early May-mid Sep +
Grower B	Mustard Green Fire	Early Jan-early Sep	-	-	500-600 seeds	30-40	Early May-mid Sep +
Grower B	Mustard Red Frills	Early Sep	-	-	500-600 seeds	45 +	Early Oct +
Grower B	Mustard Green Fire	Early Sep	-	-	500-600 seeds	45 +	Early Oct +
Grower D	Mustard Purple Frills	Mid Apr	Every 10-14 d to Aug, 10 d lte Aug-mid Sep indr	-	-	40-50	Late May
Grower D	Mustard Scarlet Frills	Mid Apr	Every 10-14 d to Aug, 10 d lte Aug-mid Sep indr	-	-	40-50	Late May
Grower D	Mustard Purple Frills	Mid Aug	Mid-late Sep	15 × 15	44 cells/4-6 seeds	40-50 +	Winter
Grower D	Mustard Purple Frills	Mid Sep	Late Oct	15 × 15	44 cells/4-6 seeds	50-100 +	Winter

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower D	Mustard Red Dragon	Mid Sep	Late Oct	15 × 15	44 cells/4-6 seeds	50-100 +	Winter
Grower D	Mustard Purple Frills	Early Jan	Mid Feb	20 × 20	25 plants	60 +	Mid Apr
Grower D	Mustard Purple Frills	Early Feb	Mid Mar	20 × 20	25 plants	40 +	Mid May
Grower F	Mustard Red Knight	Early Oct	Early Nov	15 × 15	44 cells	40 +	Mid Dec +
Grower F	Mustard Red Frills	Early Oct	Early Nov	15 × 15	44 cells	40 +	Mid Dec +
Grower F	Mustard Pizzo	Early Oct	Early Nov	15 × 15	44 cells	40 +	Mid Dec +
Grower F	Mustard Green mustard	Mid Apr	Every 7 d to early Sep, 3 × indr Sep-Oct	15 × 15	570 seeds	40 +	Mid May +
Grower F	Mustard Red mustard	Mid Apr	Every 7 d to early Sep, 3 × indr Sep-Oct	15 × 15	570 seeds	40 +	Mid May +
Grower F	Mustard Red Frills	Mid Apr	Every 7 d to early Sep, 3 × indr Sep-Oct	15 × 15	570 seeds	40 +	Mid May +
Grower F	Mustard	Mid Mar	Mid Apr (every 7 d to ely Sep, 3 × indr Sep-Oct)	15 × 15	200 seeds	30-35 +	-
Grower F	Mustard Red Frills	Mid Mar	Mid Apr (every 7 d to ely Sep, 3 × indr Sep-Oct)	15 × 15	200 seeds	30-35 +	-
Grower F	Mustard Red Lion	Mid Mar	Mid Apr (every 7 d to ely Sep, 3 × indr Sep-Oct)	15 × 15	200 seeds	30-35 +	-
Grower F	Mustard Red Dragon	Mid Mar	Mid Apr (every 7 d to ely Sep, 3 × indr Sep-Oct)	15 × 15	200 seeds	30-35 +	-
Grower H	Mustard Purple Frills	Late Mar	Every 2 wks late Mar-mid Aug	10 × 1.5	600 seeds	40 +	Early May +
Grower H	Mustard Purple Streaks	Late Mar	Every 2 wks late Mar-mid Aug	10 × 1.5	600 seeds	40 +	Early May +
Grower H	Mustard Green in Snow	Late Mar	Every 2 wks late Mar-mid Aug	10 × 1.5	600 seeds	40 +	Early May +
Grower H	Mustard Red Dragon	Late Mar	Every 2 wks late Mar-mid Aug	10 × 1.5	600 seeds	40 +	Early May +
Grower H	Mustard Purple Frills	Mid Jul	Mid Aug	10 × 7	140 plg/6-8 seeds	30-35	Mid Sep +
Grower H	Mustard Purple Streaks	Mid Jul	Mid Aug	10 × 7	140 plg/6-8 seeds	30-35	Mid Sep +
Grower H	Mustard Red Dragon	Mid Jul	Mid Aug	10 × 7	140 plg/6-8 seeds	30-35	Mid Sep +
Grower H	Mustard Green Fire	Mid Jul	Mid Aug	10 × 7	140 plg/6-8 seeds	30-35	Mid Sep +
Grower H	Mustard Green in Snow	Mid Jul	Mid Aug	10 × 7	140 plg/6-8 seeds	30-35	Mid Sep +
Grower H	Mustard Purple Frills	Early Aug	Early Sep	10 × 7	140 plg/6-8 seeds	35-40	Mid Oct +
Grower H	Mustard Purple Streaks	Early Aug	Early Sep	10 × 7	140 plg/6-8 seeds	35-40	Mid Oct +
Grower H	Mustard Red Dragon	Early Aug	Early Sep	10 × 7	140 plg/6-8 seeds	35-40	Mid Oct +
Grower H	Mustard Green Fire	Early Aug	Early Sep	10 × 7	140 plg/6-8 seeds	35-40	Mid Oct +
Grower H	Mustard Green in Snow	Early Aug	Early Sep	10 × 7	140 plg/6-8 seeds	35-40	Mid Oct +
Grower H	Mustard Purple Frills	Early Aug	Mid Sep	10 × 7	140 plg/6-8 seeds	40-50	Mid Nov +
Grower H	Mustard Purple Streaks	Early Aug	Mid Sep	10 × 7	140 plg/6-8 seeds	40-50	Mid Nov +
Grower H	Mustard Red Dragon	Early Aug	Mid Sep	10 × 7	140 plg/6-8 seeds	40-50	Mid Nov +
Grower H	Mustard Green Fire	Early Aug	Mid Sep	10 × 7	140 plg/6-8 seeds	40-50	Mid Nov +
Grower H	Mustard Green in Snow	Early Aug	Mid Sep	10 × 7	140 plg/6-8 seeds	40-50	Mid Nov +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower K	Mustard Osaka	Late Jan	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	40-50 +	Mid Mar
Grower K	Mustard Purple Frills	Late Jan	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	40-50 +	Mid Mar
Grower K	Mustard Osaka	Late Feb	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	35-40 +	Mid Apr
Grower K	Mustard Purple Frills	Late Feb	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	35-40 +	Mid Apr
Grower B	Pak choi Bopak	Mid Feb	Late Mar	30 × 20	17 plants	50 +	Late May +
Grower B	Pak choi Bopak	Early Mar	Early Apr	30 × 20	17 plants	50 +	Early Jun +
Grower B	Pak choi Bopak	Mid Mar	Late Apr	30 × 20	17 plants	45 +	Mid Jun +
Grower B	Pak choi Bopak	Late Apr	Late May	30 × 20	17 plants	45 +	Mid Jul +
Grower B	Pak choi Bopak	Late May	Late Jun	30 × 20	17 plants	45 +	Mid Aug +
Grower B	Pak choi Yoshi	Mid Jun	Late Jul	30 × 20	17 plants	55 +	Late Sep +
Grower B	Pak choi Yoshi	Mid Jul	Late Aug	30 × 20	17 plants	65 +	Late Oct +
Grower D	Pak choi	Mid Apr	Every 10-14 d to Aug, 10 d lte Aug-mid Sep indr	-	-	40-50	Late May
Grower F	Pak choi Baraku	Early Oct	Early Nov	15 × 15	44 cells	40 +	Mid Dec +
Grower J	Pak choi Bopak	Early Mar	Early Apr	30 × 15	22 plants	50	Mid May +
Grower J	Pak choi Bopak	Mid Mar	Mid Apr	30 × 15	22 plants	50	Late May +
Grower J	Pak choi Bopak	Early Apr	Early May	30 × 15	22 plants	40	Early Jun +
Grower J	Pak choi Bopak	Mid Apr	Mid May	30 × 15	22 plants	40	Mid Jun +
Grower J	Pak choi Bopak	Early May	Early Jun	30 × 15	22 plants	40	Mid Jul +
Grower J	Pak choi Bopak	Mid May	Mid Jun	30 × 15	22 plants	40	Late Jul +
Grower J	Pak choi Bopak	Early Jun	Early Jul	30 × 15	22 plants	45	Mid Aug +
Grower J	Pak choi Bopak	Mid Jun	Mid Jul	30 × 15	22 plants	45	Early Sep +
Grower J	Pak choi Bopak	Early Jul	Early Aug	30 × 15	22 plants	50	Mid Sep +
Grower J	Pak choi Bopak	Mid Jul	Mid Aug	30 × 15	22 plants	50	Early Oct +
Grower J	Pak choi Bopak	Early Aug	Early Sep	30 × 15	22 plants	60	Mid Oct +
Grower J	Pak choi Bopak	Mid Aug	Mid Sep	30 × 15	22 plants	60	Nov +
Grower A	Parsley Krausa	Mid Feb	Mid Apr	30 × 20	17 plants	70 +	Early Jul +
Grower A	Parsley Krausa	Mid Mar	Late May	30 × 20	17 plants	65 +	Early Aug +
Grower A	Parsley Petra	Mid Apr	Early Jul	30 × 30	11 plants	120 +	Early Nov +
Grower B	Parsley Curly parsley	Buy plants	Late Apr	30 × 20	16.5 plants	70 +	Mid Jul +
Grower B	Parsley Italian Giant	Buy plants	Late Apr	30 × 20	16.5 plants	70 +	Mid Jul +
Grower E	Parsley Krausa	Buy plants	Mid Apr	35 × 22	13 plants	75 +	Early Jul +
Grower E	Parsley Krausa	Buy plants	Late Jun	35 × 22	13 plants	75 +	Early Sep +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower E	Parsley Krausa	Buy plants	Mid Jul	20 × 20	25 plants	120 +	Dec +
Grower J	Parsley Krausa	Mid Mar	Late May	20 × 20	25 plants	65 +	Late Jul +
Grower J	Parsley Krausa	Mid Apr	Late Jun	20 × 20	25 plants	75 +	Late Aug +
Grower J	Parsley Krausa	Mid May	Late Jul	20 × 20	25 plants	75 +	Late Sep +
Grower K	Parsley Italian Giant	Mid Jan	Early Apr	30 × 20	25 plants	60 +	Early Jun
Grower K	Parsley Italian Giant	Mid Feb	Early May	30 × 20	25 plants	50 +	Early Jul
Grower K	Parsley Italian Giant	Mid Mar	Early Jun	30 × 20	25 plants	50 +	Late Jul
Grower K	Parsley Italian Giant	Early May	Mid Jul	30 × 20	25 plants	60 +	Mid Sep
Grower K	Parsley Italian Giant	Early Jul	Mid Sep	30 × 20	25 plants	75 +	Mid Dec
Grower A	Rocket Montana/Uber	Buy plants	Late Mar	25 × 20	20 plants	40 +	Early May +
Grower A	Rocket Montana/Uber	Buy plants	Mid Apr	25 × 20	20 plants	40 +	Early Jun +
Grower A	Rocket Montana/Uber	Buy plants	Mid May	25 × 20	20 plants	35 +	Early Jun +
Grower A	Rocket Montana/Uber	Buy plants	Mid Jun	25 × 20	20 plants	35 +	Early Aug +
Grower A	Rocket Montana/Uber	Buy plants	Early Sep	25 × 20	20 plants	35 +	Late Oct +
Grower D	Rocket Salad rocket	Mid Apr	Every 10-14 d to Aug, 10 d lte Aug-mid Sep indr	-	-	40-50	Late May
Grower D	Rocket Salad rocket	Mid Aug	Mid-late Sep	15 × 15	44 cells/4-6 seeds	40-50 +	Winter
Grower D	Rocket Salad rocket	Mid Sep	Late Oct	15 × 15	44 cells/4-6 seeds	50-100 +	Winter
Grower F	Rocket Uber	Early Oct	Early Nov	15 × 15	44 cells	40 +	Mid Dec +
Grower F	Rocket Salad rocket	Early Oct	Early Nov	15 × 15	44 cells	40 +	Mid Dec +
Grower F	Rocket Uber	Mid Apr	Every 7 d to early Sep, 3 × indoors Sep-Oct	15 × 15	570 seeds	40 +	Mid May +
Grower F	Rocket Salad rocket	Mid Apr	Every 7 d to early Sep, 3 × indoors Sep-Oct	15 × 15	570 seeds	40 +	Mid May +
Grower F	Rocket Uber	Mid Mar	Mid Apr (every 7 d to ely Sep, 3 × indr Sep-Oct)	15 × 15	400 seeds	30-35 +	-
Grower F	Rocket Salad rocket	Mid Mar	Mid Apr (every 7 d to ely Sep, 3 × indr Sep-Oct)	15 × 15	200 seeds	30-35 +	-
Grower H	Rocket Letizia	Late Mar	Every 2 wks late Mar-mid Aug	10 × 1.5	600 seed	45 +	Early May +
Grower H	Rocket Letizia	Mid Jul	Mid Aug	10 × 7	140 plg/6-8 seeds	30-35	Mid Sep +
Grower H	Rocket Salad rocket	Mid Jul	Mid Aug	10 × 7	140 plg/6-8 seeds	30-35	Mid Sep +
Grower H	Rocket Letizia	Early Aug	Early Sep	10 × 7	140 plg/6-8 seeds	35-40	Mid Oct +
Grower H	Rocket Letizia	Early Aug	Mid Sep	10 × 7	140 plg/6-8 seeds	40-50	Mid Nov +
Grower K	Rocket Salad rocket	Late Jan	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	40-50 +	Mid Mar
Grower K	Rocket Salad rocket	Late Feb	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	35-40 +	Mid Apr
Grower J	Rosemary	Mid Mar	Late Jun	20 × 20	25 plants	70 +	Late Aug +
Grower J	Rosemary	Mid May	Late Aug	20 × 20	25 plants	70 +	Late Oct +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower F	Sage	Late Mar	Late May	30 × 30	11 plants	50 +	Mid Jul
Grower B	Salad leaves Red Devil	Early Jan-early Sep	-	-	500-600 seeds	30-40	Early May-mid Sep +
Grower B	Salad leaves Red Devil	Early Sep	-	-	500-600 seeds	45 +	Early Oct +
Grower D	Salad leaves Baby kale	Mid Apr	Every 10-14 d to Aug, 10 d lte Aug-mid Sep indr	-	-	40-50	Late May
Grower D	Salad leaves Vit	Mid Sep	Late Oct	15 × 15	44 cells/4-6 seeds	50-100 +	Winter
Grower H	Salad leaves Red sorrel	Late Mar	Every 2 wks late Mar-mid Aug	10 × 1.5	600 seed	45 +	Early May +
Grower H	Salad leaves Esher	Late Mar	Every 2 wks late Mar-mid Aug	10 × 1.5	600 seed	45 +	Early May +
Grower H	Salad leaves Sweet Intensity	Early Aug	Early Sep	10 × 7	140 plg/6-8 seeds	35-40	Mid Oct +
Grower H	Salad leaves Sweet Intensity	Early Aug	Mid Sep	10 × 7	140 plg/6-8 seeds	40-50	Mid Nov +
Grower H	Salad leaves Garter	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Mid Nov +
Grower H	Salad leaves Garter	Mid Aug	Late Sep	20 × 20	25 plants	80 +	Mid Dec +
Grower K	Salad leaves Naemenia	Late Jan	Every 2 wks to early Jun indoors, 3-4 × outdr	4 cm rw	600-800 seeds	40-50 +	Mid Mar
Grower K	Salad leaves Naemenia	Late Feb	Every 2 wks to early Jun indr, 3-4 × outdr	4 cm rw	600-800 seeds	35-40 +	Mid Apr
Grower A	Salanova Codex	Early Mar	Mid Apr (every 2-3 wks outdoors)	20 × 20	25 plugs	40 +	Late May +
Grower A	Salanova Barlach	Early Mar	Mid Apr (every 2-3 wks outdoors)	20 × 20	25 plugs	45 +	Early Jun +
Grower A	Salanova Extranet	Early Mar	Mid Apr (every 2-3 wks outdoors)	20 × 20	25 plugs	40 +	Late May +
Grower A	Salanova Behn	Early Mar	Mid Apr (every 2-3 wks outdoors)	20 × 20	25 plugs	40 +	Late May +
Grower A	Salanova Barlach	Mid Aug	Late Sep (every 2-3 wks outdoors)	30 × 30	11 plants	60 +	Late Nov +
Grower A	Salanova Barlach	Mid Sep	Mid Oct (every 2-3 wks outdoors)	30 × 30	11 plants	75 +	Dec +
Grower B	Salanova Expertise	Buy plants	Mid Apr (repeat sow early-mid Aug indoors)	30 × 20	16.5 plants	45 +	Mid Jun +
Grower B	Salanova Frostex	Buy plants	Mid Apr (repeat sow early-mid Aug indoors)	30 × 20	16.5 plants	45 +	Mid Jun +
Grower B	Salanova Barlach	Buy plants	Mid Apr (repeat sow early-mid Aug indoors)	30 × 20	16.5 plants	50 +	Mid Jun +
Grower B	Salanova Behn	Buy plants	Mid Apr (repeat sow early-mid Aug indoors)	30 × 20	16.5 plants	45 +	Mid Jun +
Grower B	Salanova Expertise	Buy plants	Early May (every 2 wks until late Jul)	30 × 20	16.5 plants	55 +	Late Jun
Grower B	Salanova Frostex	Buy plants	Early May (every 2 wks until late Jul)	30 × 20	16.5 plants	55 +	Late Jun
Grower B	Salanova Barlach	Buy plants	Early May (every 2 wks until late Jul)	30 × 20	16.5 plants	60 +	Late Jun
Grower B	Salanova Behn	Buy plants	Early May (every 2 wks until late Jul)	30 × 20	16.5 plants	50 +	Late Jun
Grower B	Salanova Barlach	Buy plants	Early Aug	30 × 20	16.5 plants	70 +	Early Oct +
Grower B	Salanova Barlach	Buy plants	Late Sep	30 × 20	16.5 plants	85 +	Mid-late Dec +
Grower D	Salanova Extranet	Mid Feb	Early Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	45 +	Mid May +
Grower D	Salanova Codex	Mid Feb	Early Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	45 +	Mid May +
Grower D	Salanova Extranet	Early Mar	Late Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Early Jun

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower D	Salanova Codex	Early Mar	Late Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Early Jun
Grower D	Salanova Barlach	Early Mar	Late Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Early Jun
Grower D	Salanova Behn	Early Mar	Late Apr (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Early Jun
Grower D	Salanova Extranet	Early Mar	Early May (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Mid Jun
Grower D	Salanova Codex	Early Mar	Early May (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Mid Jun
Grower D	Salanova Barlach	Early Mar	Early May (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Mid Jun
Grower D	Salanova Behn	Early Mar	Early May (every 5 wks early Mar-mid Jul)	20 × 20	25 plants	40 +	Mid Jun
Grower F	Salanova Codex	Early Mar	Mid Apr (every 3 wks to early Sep outdoors)	20 × 20	25 plugs	40 +	Late May +
Grower F	Salanova Barlach	Early Mar	Mid Apr (every 3 wks to early Sep outdoors)	20 × 20	25 plugs	45 +	Early Jun +
Grower F	Salanova Extranet	Early Mar	Mid Apr (every 3 wks to early Sep outdoors)	20 × 20	25 plugs	40 +	Late May +
Grower F	Salanova Behn	Early Mar	Mid Apr (every 3 wks to early Sep outdoors)	20 × 20	25 plugs	40 +	Late May +
Grower F	Salanova Barlach	Early Aug	Mid Sep	20 × 20	25 plants	60 +	Late Nov +
Grower F	Salanova Barlach	Late Aug	Early Oct	25 × 25	16 plants	80 +	Dec +
Grower F	Salanova Barlach	Mid Jan	Late Feb	25 × 25	16 plants	60 +	Mid Apr
Grower G	Salanova Barlach	Late Apr	Early Jun	55 × 15	12 plants	50 +	Late Jul +
Grower G	Salanova Barlach	Early May	Mid Jun	55 × 15	12 plants	50 +	Early Aug +
Grower G	Salanova Barlach	Mid Jun	Late Jul	55 × 15	12 plants	50 +	Mid Aug +
Grower G	Salanova Barlach	Late Jun	Mid Aug	55 × 15	12 plants	55 +	Early Oct +
Grower G	Salanova Barlach	Mid Jul	Late Aug	55 × 15	12 plants	55 +	Late Oct +
Grower H	Salanova Barlach	Early Aug	Mid Sep	20 × 20	25 plants	70 +	Mid Nov +
Grower H	Salanova Barlach	Mid Aug	Late Sep	20 × 20	25 plants	90 +	Late Dec +
Grower H	Salanova Barlach	Early Feb	Early Apr	20 × 20	25 plants	45 +	Mid May +
Grower H	Salanova Extranet	Early Feb	Early Apr	20 × 20	25 plants	45 +	Mid May +
Grower H	Salanova Telex	Early Feb	Early Apr	20 × 20	25 plants	45 +	Mid May +
Grower H	Salanova Behn	Early Feb	Early Apr	20 × 20	25 plants	45 +	Mid May +
Grower H	Salanova Octagon	Early Feb	Early Apr	20 × 20	25 plants	45 +	Mid May +
Grower H	Salanova Barlach	Early Mar	Mid Apr	20 × 20	25 plants	40 +	Early Jun +
Grower H	Salanova Extranet	Early Mar	Mid Apr	20 × 20	25 plants	40 +	Early Jun +
Grower H	Salanova Telex	Early Mar	Mid Apr	20 × 20	25 plants	40 +	Early Jun +
Grower H	Salanova Behn	Early Mar	Mid Apr	20 × 20	25 plants	40 +	Early Jun +
Grower H	Salanova Octagon	Early Mar	Mid Apr	20 × 20	25 plants	40 +	Early Jun +
Grower H	Salanova Barlach	Early May	Mid Jun	20 × 20	25 plants	35-40	Mid Jul +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower H	Salanova Extranet	Early May	Mid Jun	20 × 20	25 plants	40 +	Mid Jul +
Grower H	Salanova Telex	Early May	Mid Jun	20 × 20	25 plants	40 +	Mid Jul +
Grower H	Salanova Behn	Early May	Mid Jun	20 × 20	25 plants	40 +	Mid Jul +
Grower H	Salanova Octagon	Early May	Mid Jun	20 × 20	25 plants	40 +	Mid Jul +
Grower H	Salanova Barlach	Early Jun	Early Jul	20 × 20	25 plants	45 +	Late Aug +
Grower H	Salanova Extranet	Early Jun	Early Jul	20 × 20	25 plants	45 +	Late Aug +
Grower H	Salanova Telex	Early Jun	Early Jul	20 × 20	25 plants	45 +	Late Aug +
Grower H	Salanova Behn	Early Jun	Early Jul	20 × 20	25 plants	45 +	Late Aug +
Grower H	Salanova Octagon	Early Jun	Early Jul	20 × 20	25 plants	45 +	Late Aug +
Grower I	Salanova Barlach	Buy plants	Late Apr	30 × 30	11 plants	55 +	Late Jun +
Grower I	Salanova Barlach	Buy plants	Late May	30 × 30	11 plants	50 +	Mid Jul +
Grower I	Salanova Barlach	Buy plants	Late Jun	30 × 30	11 plants	50 +	Mid Aug +
Grower J	Salanova Barlach	Early Feb-mid Aug	Early Mar-late Oct (every 14 d)	30 × 30	11 plants	40-50	Late Apr-mid Dec
Grower K	Salanova Barlach	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	50 +	Late May +
Grower K	Salanova Codex	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid May +
Grower K	Salanova Behn	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid May +
Grower K	Salanova Barlach	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid Jun +
Grower K	Salanova Codex	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun +
Grower K	Salanova Behn	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun +
Grower K	Salanova Barlach	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	50 +	Late May
Grower K	Salanova Codex	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid May
Grower K	Salanova Behn	Mid Feb	Early Apr (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid May
Grower K	Salanova Barlach	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	45 +	Mid Jun
Grower K	Salanova Codex	Mid Mar	Early May (every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun
Grower K	Salanova Barlach	Early Aug	Mid Sep	20 × 20	25 plants	70 +	Late Nov +
Grower K	Salanova Barlach	Early Sep	Mid Oct	20 × 20	25 plants	100 +	Late Jan +
Grower A	Spinach Everglade	Buy blocks	Early Apr	40 × 20	12.5 plants	50 +	Mid May +
Grower A	Spinach Everglade	Buy blocks	Mid Apr	40 × 20	12.5 plants	50 +	Early Jun +
Grower A	Spinach Everglade	Buy plants	Mid May	40 × 20	12.5 plants	40 +	Late Jun +
Grower A	Spinach Everglade	Buy plants	Mid Jun	40 × 20	12.5 plants	40 +	Early Aug +
Grower A	Spinach Everglade	Buy plants	Mid Jul	40 × 20	12.5 plants	50 +	Early Sep +
Grower A	Spinach Everglade	Buy plants	Mid Aug	40 × 20	12.5 plants	60 +	Mid Oct +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower A	Spinach Everglade	Buy plants	Mid Sep	40 × 20	12.5 plants	100 +	Jan +
Grower B	Spinach Everglade	Buy plants	Early Feb	40 × 15	16.5 plants	70 +	Mid Apr +
Grower B	Spinach Everglade	Buy plants	Mid Apr	40 × 15	16.5 plants	60 +	Mid Jun +
Grower B	Spinach Everglade	Buy plants	Mid Aug	40 × 15	16.5 plants	70 +	Late Oct +
Grower B	Spinach Everglade	Early Apr	-	40 × 4	60 seeds	65 +	Early Jun +
Grower B	Spinach Everglade	Mid Apr	-	40 × 4	60 seeds	60 +	Late Jun +
Grower B	Spinach Everglade	Early May	-	40 × 4	60 seeds	55 +	Early Jul +
Grower B	Spinach Everglade	Late May	-	40 × 4	60 seeds	55 +	Late Jul +
Grower B	Spinach Everglade	Mid Jun	-	40 × 4	60 seeds	55 +	Mid Aug +
Grower B	Spinach Everglade	Late Jun	-	40 × 4	60 seeds	60 +	Early Sep +
Grower B	Spinach Everglade	Mid Jul	-	40 × 4	60 seeds	70 +	Late Sep +
Grower D	Spinach Arcadia	Direct sow	-	-	-	30-40	-
Grower D	Spinach Cherville	Direct sow	-	-	-	30-40	-
Grower D	Spinach Yukon	Direct sow	-	-	-	30-40	-
Grower D	Spinach Everglade	Early Feb	Late Mar	12 × 12	25 cells	50 +	Early May +
Grower D	Spinach Everglade	Early Mar	Mid Apr	12 × 12	25 cells	50 +	Early Jun +
Grower D	Spinach Erbette	Early May	Mid Jun	20 × 20	25 cells	50 +	Early Aug +
Grower D	Spinach Everglade	Early Jun	Mid Jul	20 × 20	25 cells	60 +	Mid Sep +
Grower D	Spinach Erbette	Early Jul	Mid Aug	20 × 20	25 cells	70 +	Late Oct +
Grower D	Spinach Everglade	Late Jul	Mid Sep	20 × 20	25 cells	70 +	Early Dec +
Grower F	Spinach Erbette	Early Mar	Mid Apr	30 × 15	22 plugs/4 seeds	45 +	Early Jun +
Grower F	Spinach Erbette	Early Apr	Mid May	30 × 15	22 plugs/4 seeds	40 +	Late Jun +
Grower F	Spinach Erbette	Early May	Mid Jun	30 × 15	22 plugs/4 seeds	40 +	Early Aug +
Grower F	Spinach Erbette	Early Jun	Mid Jul	30 × 15	22 plugs/4 seeds	45 +	Early Sep +
Grower F	Spinach Erbette	Early Jul	Mid Aug	30 × 15	22 plugs/4 seeds	55 +	Early Oct +
Grower F	Spinach Erbette	Mid Aug	Late Sep	20 × 20	25 plugs/4 seeds	70 +	Dec-Jan +
Grower F	Spinach Erbette	Mid Aug	Mid Oct	20 × 20	25 plugs/4 seeds	85 +	Jan-Feb +
Grower H	Spinach Erbette	Mid Feb	Early Apr	20 × 20	25 plugs	50 +	Late May +
Grower H	Spinach Erbette	Mid Mar	Late Apr	20 × 20	25 plugs	50 +	Mid Jun +
Grower H	Spinach Erbette	Mid Mar	Late Apr	20 × 20	25 plugs	60 +	Late Jun +
Grower H	Spinach Erbette	Early Apr	-	20 × 4	125 seeds	70 +	Mid Jun +
Grower H	Spinach Erbette	Early Jun	-	20 × 4	125 seeds	60 +	Early Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower H	Spinach Everglade	Early Jul	-	20 × 4	125 seeds	70 +	Mid Sep +
Grower H	Spinach Everglade	Mid Aug	Late Sep	20 × 20	25 plants	80 +	Jan +
Grower J	Spinach Renegade	Early Feb	Every 3-4 wks indoors	-	25-28 g seed	50	-
Grower J	Spinach Renegade	Early Mar	Every 3-4 wks indoors	-	25-28 g seed	45	-
Grower J	Spinach Renegade	Early Apr	Every 3-4 wks indoors	-	25-28 g seed	40	-
Grower J	Spinach Renegade	Early May	Every 3-4 wks indoors	-	25-28 g seed	35	-
Grower J	Spinach Renegade	Early Jun	Every 3-4 wks indoors	-	25-28 g seed	35	-
Grower J	Spinach Renegade	Early Jul	Every 3-4 wks indoors	-	25-28 g seed	40	-
Grower J	Perpetual Spinach	Aug	Every 3-4 wks indoors	-	10-12 g seed	55	-
Grower J	Perpetual Spinach	Sep	Every 3-4 wks indoors	-	10-12 g seed	60	-
Grower K	Spinach Erbette	Late Jan	Mid Mar	12 × 12	70 cells/3-4 seeds	45 +	Early May +
Grower K	Spinach Erbette	Late Feb	Mid Apr	15 × 15	45 cells/3-4 seeds	50 +	Late May +
Grower K	Spinach Erbette	Late Mar	Mid May	15 × 15	45 cells/3-4 seeds	50 +	Late Jun +
Grower K	Spinach Erbette	Late Apr	Mid Jun	15 × 15	45 cells/3-4 seeds	50 +	Early Aug +
Grower K	Spinach Erbette	Late May	Mid Jul	15 × 15	45 cells/3-4 seeds	50 +	Early Sep +
Grower K	Spinach Erbette	Late Jun	Late Aug	15 × 15	45 cells/3-4 seeds	65 +	Early Nov +
Grower K	Spinach Erbette	Mid Aug	Late Sep	15 × 15	45 cells/3-4 seeds	80 +	Mid Dec +
Grower K	Spinach Erbette	Late Aug	Mid Oct	12 × 12	45 cells/3-4 seeds	100 +	Mid Jan +
Grower H	Summer purslane	Early May	Mid May	15 × 15	45 × 6-8 seeds	40 +	Late May +
Grower H	Summer purslane	Mid May	Late May	15 × 15	45 × 6-8 seeds	40 +	Late Jun +
Grower H	Summer purslane	Mid Jun	Late Jun	15 × 15	45 × 6-8 seeds	40 +	Early Aug +
Grower H	Summer purslane	Early Jul	Late Jul	15 × 15	45 × 6-8 seeds	40 +	Early Sep +
Grower H	Summer purslane	Early Aug	Mid Aug	15 × 15	45 × 6-8 seeds	50 +	Late Sep +
Grower H	Summer purslane	Mid Aug	Late Aug	15 × 15	45 × 6-8 seeds	55 +	Early Oct +
Grower K	Summer purslane	Mid Mar	Early May (sow every 4 wks until early Aug)	20 × 20	25 plants	40 +	Mid Jun +
Grower K	Summer purslane	Mid Mar	Early May	20 × 20	25 plants	40 +	Mid Jun
Grower F	Thyme English winter	Late Mar	Mid Jun	30 × 30	11 plants	80 +	Early Sep +
Grower B	Winter purslane	Buy plants	Mid Jul	30 × 20	16.5 plants	90 +	Mid Oct +
Grower B	Winter purslane	Buy plants	Early Aug	30 × 20	16.5 plants	95 +	Mid Nov +
Grower D	Winter purslane	Mid Aug	Mid-late Sep	15 × 15	44 cells/4-6 seeds	40-50 +	Winter
Grower D	Winter purslane	Mid Sep	Late Oct	15 × 15	44 cells/4-6 seeds	50-100 +	Winter
Grower D	Winter purslane	Early Jan	Mid Feb	20 × 20	25 plants	60 +	Mid Apr

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower D	Winter purslane	Early Feb	Mid Mar	20 × 20	25 plants	40 +	Mid May
Grower F	Winter purslane	Early Oct	Early Nov	15 × 15	44 cells	50 +	Late Dec +
Grower H	Winter purslane	Mid Aug	Mid Sep	15 × 15	45 plg/8-10 seeds	60 +	Mid Nov +
Grower H	Winter purslane	Early Sep	Early Oct	15 × 15	45 plg/8-10 seeds	70 +	Late Nov +
Grower H	Winter purslane	Early Sep	Mid Oct	15 × 15	45 plg/8-10 seeds	90 +	Jan +
Grower K	Winter purslane	Early Sep	Mid Oct	20 × 20	25 plants	90 +	Mid Jan +
Grower K	Winter purslane	Early Aug	Mid Sep	20 × 20	25 plants	70 +	Mid Nov +

Table 5 Cropping programmes for root/tuber/bulb crops for the 11 MOPS project growers.

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower F	Artichoke Jerusalem Rema	-	Mid Apr	75 × 40	3.3 plants	180	Late Oct +
Grower F	Artichoke Jerusalem C9	-	Mid Apr	75 × 40	3.3 plants	170	Mid Oct +
Grower K	Artichoke Jerusalem Oregon	-	Early Apr	100 × 100	1 tuber	200 +	Mid Nov +
Grower K	Artichoke Jerusalem Red Fuseau	-	Early Apr	100 × 100	1 tuber	190 +	Mid Nov +
Grower A	Beetroot Pablo	Early Feb	Early Apr	40 × 15	16 modules	85 +	Late Jun +
Grower A	Beetroot Pablo	Early Apr	-	40 × 2.5	100 seeds	100 +	Mid Jul +
Grower A	Beetroot Pablo	Early May	-	40 × 2.5	100 seeds	90 +	Early Aug +
Grower A	Beetroot Pablo	Mid May	-	40 × 2.5	100 seeds	90 +	Mid Aug +
Grower A	Beetroot Pablo	Early Jun	-	40 × 3	80 seeds	95 +	Mid Sep +
Grower A	Beetroot Bettollo	Early Jun	-	40 × 3	80 seeds	100 +	Mid Sep +
Grower B	Beetroot Boro	Buy plants	Early Feb	40 × 12	21 plugs	90 +	Early May +
Grower B	Beetroot Boro	Mid Apr	-	40 × 3	83 seeds	95 +	Early Jul +
Grower B	Beetroot Boro	Early May	-	40 × 3	83 seeds	85 +	Mid Jul +
Grower B	Beetroot Boro	Mid Jun	-	40 × 3	83 seeds	90 +	Late Jul +
Grower D	Beetroot Bull's Blood	Mid Apr	Every 10-14 d to Aug, 10 d late Aug-mid Sep indoors	-	-	40-50	Late May
Grower E	Beetroot Boro	Buy plants	Mid Apr	80 × 15	12.5 cells	80 +	Mid Jul +
Grower E	Beetroot Boro	Mid Apr	-	80 × 2	62 seeds	120 +	Early Aug +
Grower E	Beetroot Boro	Mid May	-	80 × 1.5	83 seeds	110 +	Late Sep +
Grower E	Beetroot Boro	Mid Jun	-	80 × 2	62 seeds	120 +	Mid Oct +
Grower E	Beetroot Boro	Mid Jul	-	80 × 2.5	50 seeds	140 +	Mid Dec +
Grower E	Beetroot Boro	Buy plants	Mid Jul	35 × 15	12.5 cells	150 +	Dec +
Grower F	Beetroot Pablo	Mid Apr	-	75 × 2	66 seeds	90 +	Mid Jul +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower F	Beetroot Boro	Mid Apr	-	75 × 2	66 seeds	90 +	Mid Jul +
Grower F	Beetroot Boldor	Mid Apr	-	75 × 2	66 seeds	90 +	Mid Jul +
Grower F	Beetroot Avalanche	Mid Apr	-	75 × 2	66 seeds	100 +	Late Jul +
Grower F	Beetroot Pablo	Early May	-	75 × 2	66 seeds	80 +	Late Jul +
Grower F	Beetroot Boro	Early May	-	75 × 2	66 seeds	80 +	Late Jul +
Grower F	Beetroot Boldor	Early May	-	75 × 1	66 seeds	80 +	Late Jul +
Grower F	Beetroot Avalanche	Early May	-	75 × 1	66 seeds	90 +	Mid Jul +
Grower F	Beetroot Pablo	Mid Jun	-	75 × 1.5	66 seeds	100 +	Early Sep +
Grower G	Beetroot Boro	Early Apr	-	55 × 2	90 seeds	110 +	Late Jul +
Grower G	Beetroot Boro	Early May	-	55 × 2	90 seeds	95 +	Mid Aug +
Grower G	Beetroot Boro	Early Jun	-	55 × 2	90 seeds	100 +	Late Sep +
Grower G	Beetroot Bettollo	Early Jun	-	55 × 2	90 seeds	120 +	Mid Oct +
Grower H	Beetroot Boro	Early Apr	-	30 × 3	110 seeds	90 +	Early Jul +
Grower H	Beetroot Boro	Early May	-	30 × 3	110 seeds	90 +	Early Aug +
Grower H	Beetroot Boro	Early Jun	-	30 × 3	110 seeds	90 +	Early Sep +
Grower J	Beetroot Pablo	Early Apr	-	38 × 3	86 seeds	120 +	Early Jul +
Grower J	Beetroot Pablo	Late Apr	-	38 × 2.5	105 seeds	110 +	Early Aug +
Grower J	Beetroot Chioggia	Late Apr	-	38 × 2.5	105 seeds	115 +	Early Aug +
Grower J	Beetroot Pablo	Mid May	-	38 × 2.5	105 seeds	120 +	Early Sep +
Grower J	Beetroot Bettollo	Mid May	-	38 × 2.5	105 seeds	130 +	Early Sep +
Grower K	Beetroot Alvro Mono	Early Apr	-	30 × 4	83 seeds	95 +	Early Jul +
Grower K	Beetroot Golden	Early Apr	-	30 × 4	83 seeds	100 +	Early Jul +
Grower K	Beetroot Alvro Mono	Early May	-	30 × 4	83 seeds	90 +	Early Aug +
Grower K	Beetroot Golden	Early May	-	30 × 4	83 seeds	95 +	Early Aug +
Grower K	Beetroot Alvro Mono	Early Jun	-	30 × 4	83 seeds	110 +	Mid Sep +
Grower K	Beetroot Golden	Early Jun	-	30 × 4	83 seeds	110 +	Mid Sep +
Grower K	Beetroot Candy stripe	Early Jun	-	30 × 4	83 seeds	110 +	Mid Sep +
Grower A	Carrot Napoli	Early May	-	75 × 1.5	90 seeds	95 +	Early Aug +
Grower A	Carrot Miami	Early May	-	75 × 1.5	90 seeds	115 +	Late Aug +
Grower B	Carrot Napoli	Mid May	-	75 × 1.5	90 seeds	100 +	Mid Aug +
Grower B	Carrot Miami	Mid May	-	75 × 1.5	90 seeds	120 +	Mid Sep +
Grower E	Carrot Napoli	Early Apr	-	80 × 2	62 seeds	100 +	Mid Jul +
Grower E	Carrot Miami	Late May	-	80 × 1.2	104 seeds	120 +	Mid Sep +
Grower E	Carrot Nairobi	Late May	-	80 × 1.2	104 seeds	115 +	Mid Sep +
Grower E	Carrot Rainbow Mix	Late May	-	80 × 1.2	104 seeds	130 +	Late Sep +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower E	Carrot Miami	Mid Jun	-	80 × 1.2	104 seeds	140 +	Mid Oct +
Grower E	Carrot Nairobi	Mid Jun	-	80 × 1.2	104 seeds	130 +	Mid Oct +
Grower E	Carrot Norfolk	Mid Jun	-	80 × 1.5	83 seeds	130 +	Mid Oct +
Grower F	Carrot Sugarsnax	Mid Apr	-	7.5 × 1.5	90 seeds	80 +	Late Jun
Grower F	Carrot Mokum	Mid Apr	-	7.5 × 1.5	90 seeds	80 +	Late Jun
Grower F	Carrot Sugarsnax	Mid May	-	7.5 × 1.25	105 seeds	75 +	Early Aug +
Grower F	Carrot Mokum	Mid May	-	7.5 × 1.25	105 seeds	70 +	Early Aug +
Grower F	Carrot Rainbow Mix	Mid May	-	7.5 × 1.25	105 seeds	80 +	Early Aug +
Grower F	Carrot Sugarsnax	Mid Jun	-	7.5 × 1.25	105 seeds	80 +	Mid Sep +
Grower F	Carrot Mokum	Mid Jun	-	7.5 × 1.25	105 seeds	80 +	Mid Sep +
Grower F	Carrot Rainbow Mix	Mid Jun	-	7.5 × 1.25	105 seeds	90 +	Mid Sep +
Grower G	Carrot Mokum	Early Apr	-	80 × 1.75	72 seeds	110 +	Early Jul +
Grower G	Carrot Miami	Early Apr	-	80 × 1.75	72 seeds	125 +	Mid Jul +
Grower G	Carrot Mokum	Early May	-	80 × 1.25	100 seeds	100 +	Early Aug +
Grower G	Carrot Miami	Early May	-	80 × 1.25	100 seeds	120 +	Late Sep +
Grower G	Carrot Nairobi	Early May	-	80 × 1.25	100 seeds	115 +	Late Sep +
Grower G	Carrot Mokum	Late May	-	80 × 1.25	100 seeds	105 +	Early Sep +
Grower G	Carrot Miami	Late May	-	80 × 1.25	100 seeds	120 +	Mid Sep +
Grower G	Carrot Nairobi	Late May	-	80 × 1.25	100 seeds	120 +	Mid Sep +
Grower G	Carrot Norfolk	Late May	-	80 × 1.25	100 seeds	135 +	Late Sep +
Grower G	Carrot Rainbow	Late May	-	80 × 1.25	100 seeds	130 +	Late Sep +
Grower G	Carrot Mokum	Mid Jun	-	80 × 1.25	100 seeds	120 +	Mid Oct +
Grower H	Carrot Mokum	Mid Apr	-	30 × 3	110 seeds	75 +	Mid Jul +
Grower H	Carrot Napoli	Mid Apr	-	30 × 3	110 seeds	95 +	Late Jul +
Grower H	Carrot Mokum	Mid May	-	30 × 3	110 seeds	80 +	Mid Aug +
Grower H	Carrot Napoli	Mid May	-	30 × 3	110 seeds	90 +	Late Aug +
Grower H	Carrot Yellowstone	Mid May	-	30 × 3	110 seeds	90 +	Late Aug +
Grower J	Carrot Romance	Mid May	-	38 × 2	130 seeds	110 +	Early Sep +
Grower J	Carrot Romance	Late May	-	38 × 1.6	165 seeds	110 +	Late Sep +
Grower J	Carrot Nairobi	Late May	-	38 × 1.6	165 seeds	115 +	Early Oct +
Grower K	Carrot Mokum	Mid Feb	-	30 × 2.5	130 seeds	95 +	Mid May +
Grower K	Carrot Mokum	Mid Apr	-	30 × 2.5	130 seeds	90 +	Mid Jul +
Grower K	Carrot Yellowstone	Mid Apr	-	30 × 2.5	130 seeds	140 +	Late Aug +
Grower K	Carrot Purple Haze	Mid Apr	-	30 × 2.5	130 seeds	100 +	Late Jul +
Grower K	Carrot Miami	Late May	-	30 × 2	160 seeds	120 +	Late Sep +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower K	Carrot Yellowstone	Late May	-	30 × 2	160 seeds	130 +	Late Sep +
Grower K	Carrot Purple Haze	Late May	-	30 × 2	160 seeds	95 +	Late Aug +
Grower J	Celeriac Brilliant	Mid Mar	Late May	55 × 40	4 plants	150 +	Late Oct
Grower A	Fennel Rondo	Early Mar	Mid Apr	30 × 20	17 plants	85 +	Mid Jul +
Grower A	Fennel Rondo	Early Apr	Mid May	30 × 20	17 plants	75 +	Early Aug +
Grower A	Fennel Rondo	Early May	Mid Jun	30 × 20	17 plants	80 +	Late Aug +
Grower A	Fennel Rondo	Late May	Mid Jul	30 × 20	17 plants	90 +	Mid Oct +
Grower B	Fennel Rondo	Buy plants	Mid May	30 × 30	11 plants	90 +	Mid Aug +
Grower B	Fennel Rondo	Buy plants	Early Jun	30 × 30	11 plants	95 +	Early Sep +
Grower B	Fennel Rondo	Buy plants	Early Jul	30 × 30	11 plants	100 +	Mid Oct +
Grower G	Fennel Orion	Mid Apr	Late May	55 × 12	12 plants	70 +	Early Aug +
Grower G	Fennel Orion	Mid May	Late Jun	55 × 12	12 plants	80 +	Mid Sep +
Grower G	Fennel Orion	Mid Jun	Late Jul	55 × 12	12 plants	90 +	Late Oct +
Grower J	Fennel Rondo	Mid Mar	Mid May	38 × 20	13 plants	70 +	Late Jul +
Grower J	Fennel Rondo	Mid Apr	Mid Jun	38 × 20	13 plants	75 +	Early Sep +
Grower J	Fennel Rondo	Mid May	Early Jul	38 × 20	13 plants	80 +	Late Sep +
Grower J	Fennel Rondo	Mid Jun	Early Aug	38 × 20	13 plants	90 +	Nov +
Grower A	Garlic Messidrome	-	Oct-Nov	20 × 20	25 cloves	190 +	Mid May
Grower A	Garlic Vallelado	-	Nov	20 × 20	25 cloves	210 +	Early Jun
Grower D	Garlic Messidrome	-	Mid Nov	20 × 20	25 cloves	160 +	Late Apr +
Grower D	Garlic Vallelado	-	Mid Nov	20 × 20	25 cloves	170 +	Mid May +
Grower G	Garlic Vallelado	Mid Nov	-	55 × 10	18 cloves	160 +	Late May +
Grower G	Garlic Vallelado	-	Late Oct	55 × 10	18 cloves	160 +	Late May +
Grower G	Garlic Early Purple Wight	-	Late Oct	55 × 10	18 cloves	170 +	Early Jun +
Grower G	Garlic Elephant garlic	-	Late Oct	55 × 10	18 cloves	160 +	Late May +
Grower J	Garlic Music	-	Late Nov	38 × 12	12.8 cloves	180 +	Late May +
Grower J	Garlic Music	-	Mid Dec	38 × 12	12.8 cloves	180 +	Early Jun +
Grower J	Garlic Music	-	Early Jan	38 × 12	12.8 cloves	180 +	Late Jun +
Grower J	Garlic Music	-	Mid Jan	38 × 12	12.8 cloves	180 +	Mid Jul +
Grower J	Garlic Music	-	Early Feb	38 × 12	12.8 cloves	180 +	Late Jul +
Grower K	Garlic Vallelado	-	Early Nov	30 × 15	22 cloves	180 +	Mid Apr +
Grower K	Garlic Messidor	-	Early Nov	30 × 15	22 cloves	190 +	May +
Grower K	Garlic Vallelado	-	Early Nov	30 × 15	22 cloves	190 +	May +
Grower A	Leek Rally	Buy plants	Mid Apr	75 × 12	11 plants	85 +	Mid Jul +
Grower A	Leek Krypton	Buy plants	Mid Apr	75 × 10	13.3 plants	95 +	Early Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower A	Leek Krypton	Buy plants	Mid May	75 × 10	13.3 plants	85 +	Mid Aug +
Grower A	Leek Krypton	Buy plants	Mid Jun	75 × 10	13.3 plants	90 +	Mid Sep +
Grower A	Leek Pluston	Buy plants	Mid Jun	75 × 10	13.3 plants	110 +	Early Oct +
Grower A	Leek Pluston	Buy plants	Early Jul	75 × 10	13.3 plants	130 +	Mid Nov +
Grower A	Leek Triton	Buy plants	Early Jul	75 × 10	13.3 plants	180 +	Jan +
Grower B	Leek Krypton	Buy plants	Mid May	40 × 10	25 plants	90 +	Mid Aug +
Grower B	Leek Krypton	Buy plants	Early Jun	40 × 10	25 plants	90 +	Early Sep +
Grower B	Leek Pluston	Buy plants	Early Jun	40 × 10	25 plants	120 +	Early Oct +
Grower B	Leek Krypton	Buy plants	Mid Jun	40 × 10	25 plants	100 +	Late Sep +
Grower B	Leek Pluston	Buy plants	Mid Jun	40 × 10	25 plants	130 +	Mid Oct +
Grower B	Leek Triton	Buy plants	Late Jun	40 × 10	25 plants	180 +	Mid Feb +
Grower D	Leek Pluston	Buy plants	Early May	70 × 10	14 plants	120 +	Late Aug +
Grower D	Leek Pluston	Buy plants	Mid Jun	70 × 10	14 plants	130 +	Early Oct +
Grower D	Leek Vivaton	Buy plants	Mid Jun	70 × 10	14 plants	200 +	Jan +
Grower E	Leek Shafton	Buy plants	Early Apr	80 × 12	10.5 plants	90 +	Mid Jul +
Grower E	Leek Krypton	Buy plants	Early Apr	80 × 12	10.5 plants	100 +	Late Jul +
Grower E	Leek Krypton	Buy plants	Early May	80 × 10	12.5 plants	90 +	Early Aug +
Grower E	Leek Pluston	Buy plants	Early May	80 × 10	12.5 plants	120 +	Early Sep +
Grower E	Leek Pluston	Buy plants	Early Jun	80 × 10	12.5 plants	125 +	Early Oct +
Grower E	Leek Vivaton	Buy plants	Early Jun	80 × 10	12.5 plants	180 +	Early Jan +
Grower E	Leek Pluston	Buy plants	Early Jul	80 × 10	12.5 plants	190 +	Jan +
Grower E	Leek Triton	Buy plants	Early Jul	10 × 12	10.5 plants	230 +	Mar +
Grower F	Leek Krypton	Buy plants	Early May	75 × 10	13 plants	110 +	Mid Aug +
Grower F	Leek Pluston	Buy plants	Early May	75 × 10	13 plants	120 +	Late Aug +
Grower F	Leek Pluston	Buy plants	Early Jun	75 × 8	13 plants	120 +	Late Oct +
Grower F	Leek Aylton	Buy plants	Early Jun	75 × 8	13 plants	135 +	Mid Nov +
Grower F	Leek Pluston	Buy plants	Early Jul	75 × 10	13 plants	150 +	Mid Dec +
Grower F	Leek Triton	Buy plants	Early Jul	75 × 10	13 plants	220 +	Feb-Mar
Grower G	Leek Krypton	Early Apr	-	55 × 3	61 seeds	165 +	Mid Sep +
Grower G	Leek Pluston	Early Apr	-	55 × 4	45 seeds	190 +	Mid Oct +
Grower G	Leek Krypton	Buy plants	Mid Apr	55 × 10	18 plants	100 +	Late Jul +
Grower G	Leek Pluston	Buy plants	Mid Apr	55 × 10	18 plants	120 +	Late Aug +
Grower G	Leek Krypton	Buy plants	Mid Jun	55 × 10	18 plants	100 +	Late Sep +
Grower G	Leek Pluston	Buy plants	Mid Jun	55 × 10	18 plants	130 +	Mid Oct +
Grower H	Leek Chinook	Mid Mar	Early May	30 × 15	22 plants	95 +	Mid Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower H	Leek Chinook	Mid Apr	Late Jun	30 × 15	22 plants	105 +	Mid Oct +
Grower H	Leek Pluston	Mid Apr	Late Jun	30 × 15	22 plants	140 +	Dec +
Grower I	Leek Krypton	Buy plants	Early Jun	60 × 12	14 plants	115 +	Early Oct +
Grower I	Leek Pluston	Buy plants	Early Jun	60 × 12	14 plants	130 +	Mid Oct +
Grower I	Leek Pluston	Buy plants	Late Jun	60 × 12	14 plants	130 +	Mid Nov +
Grower I	Leek Triton	Buy plants	Late Jun	60 × 12	14 plants	150 +	Mid Nov-mid Feb
Grower I	Leek Skater	Buy plants	Late Jun	60 × 12	14 plants	150 +	Mid Nov +
Grower J	Leek Shafton	Buy plants	Early Apr	55 × 12	15 plants	125 +	Mid Aug +
Grower J	Leek Krypton	Buy plants	Early Apr	55 × 12	15 plants	130 +	Mid Aug +
Grower J	Leek Krypton	Buy plants	Late Apr	55 × 10	18 plants	120 +	Late Aug +
Grower J	Leek Krypton	Buy plants	Mid May	55 × 10	18 plants	120 +	Mid Sep +
Grower J	Leek Pluston	Buy plants	Mid May	55 × 10	18 plants	130 +	Late Sep +
Grower J	Leek Pluston	Buy plants	Early Jun	55 × 10	18 plants	150 +	Late Oct +
Grower J	Leek Pluston	Buy plants	Early Jul	55 × 12	15 plants	200 +	Mid Jan +
Grower J	Leek Vivaton	Buy plants	Early Jul	55 × 12	15 plants	240 +	Late Feb +
Grower J	Leek Triton	Buy plants	Early Jul	55 × 12	15 plants	260 +	Mid Mar
Grower K	Leek Krypton	Buy plants	Early May	30 × 20	17 plants	100 +	Mid Aug +
Grower K	Leek Krypton	Buy plants	Late May	30 × 20	17 plants	90 +	Early Sep +
Grower K	Leek Pluston	Buy plants	Late May	30 × 20	17 plants	120 +	Early Oct +
Grower K	Leek Pluston	Buy plants	Mid Jun	30 × 20	17 plants	140 +	Mid Nov +
Grower K	Leek Vivaton	Buy plants	Mid Jun	30 × 20	17 plants	190 +	Jan +
Grower K	Leek Bandit	Buy plants	Mid Jun	30 × 20	17 plants	200 +	Jan +
Grower A	Onion Hylander	Mid Feb	Mid Apr	40 × 15	16 cells × 5-6 seeds	100 +	Mid Aug +
Grower A	Onion Red Baron	Mid Feb	Mid Apr	40 × 15	16 cells × 5-6 seeds	120 +	Late Aug +
Grower A	Onion Redspark	Mid Feb	Mid Apr	40 × 15	16 cells	130 +	Early Sep +
Grower A	Onion Hercules	Sets	Early Apr	40 × 3	83 sets	100 +	Mid Jul +
Grower A	Onion Red Baron	Sets	Early Apr	40 × 3	83 sets	110 +	Late Jul +
Grower A	Onion Troy	Sets	Oct	40 × 3	83 sets	180 +	May +
Grower B	Onion Hylander	Buy plants	Mid Apr	40 × 20	12.5 plants	80 +	Early Jul +
Grower B	Onion Ross da Inverno sel Rubino	Buy plants	Early Apr	40 × 20	12.5 plants	75 +	Early Jul +
Grower D	Onion Hylander	Late Jan	Late Mar	20 × 20	25 plugs	120 +	Early Aug +
Grower D	Onion Red Baron	Late Jan	Late Mar	20 × 20	25 plugs	120 +	Early Aug +
Grower D	Onion Sturon	-	Late Mar	20 × 20	25 sets	90 +	Early Jul
Grower E	Onion Hercules	-	Early Apr	40 × 4	62 sets	100 +	Mid Jul +
Grower E	Onion Hylander	Buy plants	Mid Apr	40 × 15	17 plants	120 +	Mid Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower E	Onion Hystore	Buy plants	Mid Apr	40 × 15	17 plants	150 +	Mid Sep +
Grower E	Onion Red Baron	Buy plants	Mid Apr	40 × 15	17plants	140 +	Early Sep +
Grower F	Onion Hylander	Early Feb	Mid Apr	30 × 10	33 plugs	115 +	Mid Aug +
Grower F	Onion Red Baron	Early Feb	Mid Apr	30 × 10	33 plugs	120 +	Late Aug +
Grower F	Onion Stor B.C.	-	Early Apr	30 × 8	42 sets	85 +	Late Jun +
Grower G	Onion Hybing	Early Apr	-	-	72 seeds	150 +	Early Sep +
Grower G	Onion Redspark	Early Apr	-	-	72 seeds	170 +	Late Sep +
Grower G	Onion Forum	-	Early Apr	55 × 3	61 sets	120 +	Mid Aug +
Grower G	Onion Red Baron	-	Early Apr	55 × 3	61 sets	120 +	Mid Aug +
Grower H	Onion Sturon	-	Mid Mar	30 × 5	66 sets	100 +	Late Jun +
Grower H	Onion Kamal	-	Mid Mar	30 × 5	66 sets	100 +	Early Jul +
Grower J	Onion Hylander	Early Feb	Early Apr	38 × 15	17.5 plants	135 +	Mid Aug +
Grower J	Onion Red Baron	Early Feb	Early Apr	38 × 15	17.5 plants	140 +	Mid Aug +
Grower J	Onion Kosma	Early Feb	Early Apr	38 × 15	17.5 plants	140 +	Mid Aug +
Grower K	Onion Troy	-	Mid Sep	30 × 8	40 sets	200 +	Mid May
Grower K	Onion Troy	-	Mid Sep	30 × 10	33 sets	230 +	Mid Jun
Grower K	Onion Sturon	-	Late Mar	30 × 10	33 sets	130 +	Late Jul +
Grower K	Onion Santero	-	Late Mar	30 × 10	33 sets	115 +	Mid Jul +
Grower K	Onion Red Ray	-	Late Mar	30 × 10	33 sets	150 +	Mid Aug +
Grower K	Onion Red Baron	-	Late Mar	30 × 10	33 sets	150 +	Mid Aug +
Grower A	Parsnip Javelin	Early Apr	-	75 × 4	33 seeds	125 +	Mid Aug +
Grower A	Parsnip Javelin	Mid May	-	75 × 2.5	52 seeds	140 +	Oct +
Grower A	Parsnip Panorama	Mid May	-	75 × 2.5	52 seeds	150 +	Nov +
Grower B	Parsnip Javelin	Mid May	-	75 × 3	45 seeds	140 +	Early Oct +
Grower B	Parsnip Panorama	Mid May	-	75 × 3	45 seeds	130 +	Early Oct +
Grower E	Parsnip Picador	Mid Apr	-	80 × 3	41 seeds	140 +	Mid Sep +
Grower E	Parsnip Panorama	Mid Apr	-	80 × 2.5	50 seeds	150 +	Late Sep +
Grower E	Parsnip Panorama	Early Jun	-	80 × 2.5	50 seeds	160 +	Nov +
Grower G	Parsnip Picador	Early Apr	-	80 × 2.5	50 seeds	140 +	Mid Sep +
Grower G	Parsnip Panorama	Early Apr	-	80 × 2.5	50 seeds	160 +	Mid Sep +
Grower G	Parsnip Panorama	Late May	-	80 × 2.5	50 seeds	150 +	Late Oct +
Grower K	Parsnip Javelin	Late May	-	75 × 3	44 seeds	150 +	Late Oct +
Grower A	Potato Premier	-	Early Apr	75 × 35	3.8 tubers	85 +	Early Jul +
Grower A	Potato Premier	-	Early Apr	75 × 30	4.4 tubers	95 +	Mid Jul +
Grower A	Potato Orla	-	Mid Apr	75 × 30	4.4 tubers	100 +	Early Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower A	Potato Colleen	-	Mid Apr	75 × 30	4.4 tubers	115 +	Mid Aug +
Grower E	Potato Orla	-	Early Apr	80 × 32	3.9 tubers	100 +	Late Jul +
Grower E	Potato Connect	-	Mid Apr	80 × 30	4.1 tubers	130 +	Early Sep +
Grower E	Potato Setanta	-	Mid Apr	80 × 30	4.1 tubers	140 +	Late Sep +
Grower E	Potato Charlotte	-	Mid Apr	80 × 30	4.1 tubers	100 +	Late Jul +
Grower E	Potato Carolus	-	Mid Apr	80 × 30	4.1 tubers	140 +	Late Sep +
Grower F	Potato Charlotte	-	Early Apr	75 × 35	3.8 tubers	90 +	Early Jul +
Grower F	Potato Vitabella	-	Early Apr	75 × 30	4.4 tubers	95 +	Early Jul +
Grower F	Potato Charlotte	-	Late Apr	75 × 30	4.4 tubers	80 +	Early Aug +
Grower G	Potato Red Duke of York	-	Mid Apr	80 × 35	3.6 tubers	90 +	Mid Jul +
Grower G	Potato Orla	-	Mid Apr	80 × 35	3.6 tubers	90 +	Mid Jul +
Grower G	Potato Ambo	-	Mid Apr	80 × 30	4 tubers	120 +	Mid Aug +
Grower G	Potato Charlotte	-	Mid Apr	80 × 30	4 tubers	130 +	Late Aug +
Grower G	Potato Setanta	-	Mid Apr	80 × 30	4 tubers	160 +	Late Sep +
Grower G	Potato Arran Victory	-	Mid Apr	80 × 30	4 tubers	180 +	Late Oct +
Grower G	Potato Bambino	-	Mid Apr	80 × 30	4 tubers	130 +	Late Aug +
Grower H	Potato Vitabella	-	Mid Apr	60 × 40	4.1 tubers	75 +	Late Jun +
Grower H	Potato Colleen	-	Mid Apr	60 × 40	4.1 tubers	85 +	Mid Jul +
Grower H	Potato Charlotte	-	Mid Apr	60 × 30	5.5 tubers	95 +	Late Jul +
Grower H	Potato Cara	-	Mid Apr	60 × 30	5.5 tubers	100 +	Early Aug +
Grower H	Potato Connect	-	Mid Apr	60 × 30	5.5 tubers	100 +	Early Aug +
Grower H	Potato Carolus	-	Mid Apr	60 × 30	5.5 tubers	100 +	Early Aug +
Grower H	Potato Setanta	-	Mid Apr	60 × 30	5.5 tubers	120 +	Late Aug +
Grower J	Potato Orla	-	Mid Apr	90 × 30	3.7 tubers	130	Late Aug +
Grower J	Potato Orla	-	Late Apr	90 × 30	3.7 tubers	120	Mid Sep +
Grower J	Potato Setanta	-	Mid Apr	90 × 30	3.7 tubers	140	Late Sep +
Grower K	Potato Vitabella	-	Early Apr	75 × 35	3.8 tubers	95 +	Early Jul +
Grower K	Potato Orla	-	Early Apr	75 × 35	3.8 tubers	90 +	Early Jul +
Grower K	Potato Salad Blue	-	Early Apr	75 × 35	3.8 tubers	130 +	Mid Aug +
Grower K	Potato Connect	-	Late Apr	75 × 35	3.8 tubers	150 +	Mid Sep +
Grower K	Potato Sarpo Mira	-	Late Apr	75 × 35	3.8 tubers	150 +	Mid Sep +
Grower A	Scallion Parade	Late Jan	Early Apr	25 × 15	40 cells × 6-7 seeds	70 +	Mid May +
Grower A	Scallion Parade	Mid Feb	Late Apr	25 × 15	40 cells × 6-7 seeds	65 +	Late Jun +
Grower A	Scallion Performer	Mid Feb	Late Apr	25 × 15	40 cells × 6-7 seeds	70 +	Late Jun +
Grower A	Scallion Parade	Early Mar	Mid May	25 × 15	40 cells × 6-7 seeds	60 +	Mid Jul +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower A	Scallion Performer	Early Mar	Mid May	25 × 15	40 cells × 6-7 seeds	65 +	Mid Jul +
Grower A	Scallion Parade	Late Mar	Late May	25 × 15	40 cells × 6-7 seeds	60 +	Late Jul +
Grower A	Scallion Performer	Late Mar	Late May	25 × 15	40 cells × 6-7 seeds	65 +	Late Jul +
Grower A	Scallion Parade	Mid Apr	Mid Jun	25 × 15	40 cells × 6-7 seeds	60 +	Early Aug +
Grower A	Scallion Performer	Mid Apr	Mid Jun	25 × 15	40 cells × 6-7 seeds	65 +	Early Aug +
Grower A	Scallion Parade	Late Apr	Late Jun	25 × 15	40 cells × 6-7 seeds	60 +	Late Aug +
Grower A	Scallion Performer	Late Apr	Late Jun	25 × 15	40 cells × 6-7 seeds	65 +	Late Aug +
Grower A	Scallion Parade	Mid May	Mid Jul	25 × 15	40 cells × 6-7 seeds	60 +	Early Sep +
Grower A	Scallion Performer	Mid May	Mid Jul	25 × 15	40 cells × 6-7 seeds	65 +	Early Sep +
Grower D	Scallion Parade	Late Jan	Early Apr	15 × 15	45 cells × 8-9 seeds	50 +	Early Jun +
Grower D	Scallion Parade	Late Feb	Late Apr	15 × 15	45 cells × 8-9 seeds	50 +	Late Jun +
Grower D	Scallion Parade	Late Mar	Late May	15 × 15	45 cells × 8-9 seeds	45 +	Mid Jul +
Grower D	Scallion Parade	Mid May	Mid Jul	15 × 15	45 cells × 8-9 seeds	55 +	Early Aug +
Grower D	Scallion Parade	Late Jun	Late Aug	15 × 15	45 cells × 8-9 seeds	65 +	Early Nov +
Grower E	Scallion Parade	Buy plants	Early Apr	40 × 12	24 cells	65 +	Early Jun +
Grower E	Scallion Parade	Buy plants	Late Apr	40 × 12	24 cells	60 +	Late Jun +
Grower E	Scallion Parade	Buy plants	Mid May	40 × 12	24 cells	60 +	Mid Jul +
Grower E	Scallion Parade	Buy plants	Mid Jun	40 × 12	24 cells	65 +	Mid Aug +
Grower E	Scallion Parade	Buy plants	Early Jul	40 × 12	24 cells	70 +	Early Sep +
Grower E	Scallion Parade	Buy plants	Late Jul	40 × 12	24 cells	80 +	Mid Oct +
Grower E	Scallion Parade	Buy plants	Mid Aug	40 × 12	24 cells	80 +	Early Nov +
Grower F	Scallion Parade	Mid Feb	Late Apr	30 × 10	33 stations	65 +	Late Jun
Grower F	Scallion North Holland Blood Red	Mid Feb	Late Apr	30 × 10	33 stations	65 +	Late Jun
Grower F	Scallion Parade	Mid Mar	Late May	30 × 10	33 stations	60 +	Late Jul
Grower F	Scallion North Holland Blood Red	Mid Mar	Late May	30 × 10	33 stations	60 +	Late Jul
Grower F	Scallion Parade	Mid Apr	Late Jun	30 × 10	33 stations	65 +	Late Aug
Grower F	Scallion North Holland Blood Red	Mid Apr	Late Jun	30 × 10	33 stations	65 +	Late Aug
Grower F	Scallion Parade	Mid May	Late Jul	30 × 10	33 stations	70 +	Late Sep
Grower F	Scallion North Holland Blood Red	Mid May	Late Jul	30 × 10	33 stations	70 +	Late Sep
Grower G	Scallion Parade	Mid Feb	Mid Apr	55 × 12	15 plugs	65 +	Mid Jun +
Grower G	Scallion Parade	Mid Mar	Mid May	55 × 12	15 plugs	60 +	Mid Jul +
Grower G	Scallion Parade	Mid Apr	Mid Jun	55 × 12	15 plugs	60 +	Mid Aug +
Grower G	Scallion Parade	Mid May	Mid Jul	55 × 12	15 plugs	65 +	Mid Sep +
Grower G	Scallion Parade	Late May	Late Jul	55 × 12	15 plugs	70 +	Mid Oct +
Grower H	Scallion Parade	Early Feb	Early Apr	20 × 20	25 plugs × 7-8 seeds	40 +	Mid May +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower H	Scallion Parade	Early Feb	Mid Apr	20 × 20	25 plugs × 7-8 seeds	50 +	Lat May +
Grower H	Scallion Parade	Early Mar	Mid May	20 × 20	25 plugs × 7-8 seeds	50 +	Early Jul +
Grower H	Scallion Parade	Early Apr	Early Jun	20 × 20	25 plugs × 7-8 seeds	50 +	Mid Jul +
Grower H	Scallion Parade	Mid May	Early Jul	20 × 20	25 plugs × 7-8 seeds	50 +	Aug +
Grower H	Scallion Parade	Mid Jun	Late Jul	20 × 20	25 plugs × 7-8 seeds	60 +	Early Sep +
Grower H	Scallion Ramrod	Sep	-	20 × 2	250 seeds	200 +	Early Apr +
Grower J	Scallion Parade	Early Feb	Early Apr	38 × 12	22 plants	65 +	Mid Jun +
Grower J	Scallion Pearl	Early Feb	Early Apr	38 × 12	22 plants	70 +	Mid Jun +
Grower J	Scallion Parade	Early Mar	Early May	38 × 12	22 plants	65 +	Mid Jul +
Grower J	Scallion Pearl	Early Mar	Early May	38 × 12	22 plants	65 +	Mid Jul +
Grower J	Scallion Parade	Early Apr	Early Jun	38 × 12	22 plants	70 +	Mid Aug +
Grower J	Scallion Pearl	Early Apr	Early Jun	38 × 12	22 plants	70 +	Mid Aug +
Grower J	Scallion Parade	Early May	Early Jul	38 × 12	22 plants	80 +	Mid Sep +
Grower J	Scallion Pearl	Early May	Early Jul	38 × 12	22 plants	80 +	Mid Sep +
Grower K	Scallion Parade	Mid Feb	Late Apr	30 × 12	28 cells × 6-7 seeds	65 +	Early Jul
Grower K	Scallion Parade	Mid Feb	Late Apr	30 × 12	28 cells × 6-7 seeds	75 +	Mid Jul +
Grower K	Scallion Parade	Mid Mar	Late May	30 × 12	28 cells × 6-7 seeds	70 +	Early Aug +
Grower K	Scallion Parade	Mid May	Mid Jun	30 × 12	28 cells × 6-7 seeds	75 +	Late Aug +
Grower K	Scallion Parade	Early Jul	Early Sep	30 × 12	28 cells × 6-7 seeds	90 +	Early Dec +

Table 6 Cropping programmes for other crops for the 11 MOPS project growers.

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower D	Asparagus Gijnlim	Buy plants	Early Apr	180 × 40	1.4 plants	-	Early May-late Jun
Grower D	Asparagus Backlim	Buy plants	Early Apr	180 × 40	1.4 plants	-	Mid May-early Jul
Grower H	Aubergine Black Beauty	Early Mar	Early May	60 × 45	3.7 plants	65 +	Mid Jul +
Grower H	Aubergine Long Purple	Early Mar	Early May	60 × 45	3.7 plants	65 +	Mid Jul +
Grower H	Aubergine Leonidio	Early Mar	Early May	60 × 45	3.7 plants	65 +	Mid Jul +
Grower D	Bean broad Witkiem	Late Feb	-	70 × 20	7 plants	75 +	Mid May +
Grower D	Bean broad Witkiem	Mid Mar	-	70 × 20	7 plants	70 +	Early Jun +
Grower D	Bean broad Witkiem	Mid Apr	-	70 × 20	7 plants	70 +	Early Jul +
Grower D	Bean broad Witkiem	Mid Nov	-	70 × 20	7 plants	140 +	Mid Apr +
Grower K	Bean broad Hangdown Green	Early Jan	Early Mar	50 × 20	10 plants	90 +	Early Jun +
Grower K	Bean broad Hangdown Green	Early Mar	-	50 × 10	20 seeds	120 +	Early Jul +
Grower K	Bean broad Hangdown Green	Early Apr	-	50 × 10	20 seeds	95 +	Early Aug +
Grower K	Bean broad Aquadulce	Early Nov	-	50 × 10	20 seeds	180 +	Mid Apr +
Grower A	Bean climbing Cobra	Early May	Mid Jun	45 × 45	5 plants	60 +	Mid Aug
Grower B	Bean climbing Cobra	Buy plants	Early May	45 × 20	11 plants	60 +	Mid Jul +
Grower B	Bean climbing Cobra	Buy plants	Late May	45 × 20	11 plants	60 +	Late Jul +
Grower D	Bean climbing Cobra	Early Apr	Mid May	50 × 30	6.7 plants	50 +	Early Jul +
Grower D	Bean climbing Cobra	Mid Apr	Early Jun	50 × 30	6.7 plants	55 +	Early Aug +
Grower D	Bean climbing Cobra	Early May	Mid Jun	50 × 30	6.7 plants	55 +	Late Aug +
Grower F	Bean climbing Cobra	Early Apr	Mid May	70 × 30	4.8 plants	65 +	Late Jul
Grower F	Bean climbing Cobra	Early May	Mid Jun	70 × 30	4.8 plants	60 +	Mid Aug
Grower H	Bean climbing Borlotti	Early Apr	Mid May	45 × 20	11 plants	65 +	Mid Jul +
Grower H	Bean climbing Borlotti	Early May	Early Jun	45 × 20	11 plants	65 +	Early Aug +
Grower H	Bean climbing Cobra	Early Apr	Mid May	45 × 20	11 plants	60 +	Mid Jul +
Grower H	Bean climbing Cobra	Early May	Early Jun	45 × 20	11 plants	60 +	Early Aug +
Grower J	Bean climbing Cobra	Early Mar	Mid Apr	90 × 30	3.7 plants	75 +	Late Jun +
Grower J	Bean climbing Cobra	Early Apr	Mid May	90 × 30	3.7 plants	70 +	Late Jul +
Grower K	Bean climbing Cobra	Mid Mar	Mid May	65 × 20	6.6 plants	60 +	Mid Jul +
Grower K	Bean climbing Cobra	Mid Apr	Mid Jun	65 × 20	6.6 plants	60 +	Mid Aug +
Grower A	Bean climbing Cobra	Early Apr	Mid May	45 × 45	5 plants	65 +	Late Jul
Grower H	Bean dwarf Faraday	Early Apr	Mid May	45 × 20	22 plants	70 +	Late Jul +
Grower H	Bean dwarf Aiguillon	Early Apr	Mid May	45 × 20	22 plants	70 +	Late Jul +
Grower H	Bean dwarf Purple Teepee	Early Apr	Mid May	45 × 20	22 plants	70 +	Late Jul +
Grower H	Bean dwarf Faraday	Early May	Mid Jun	45 × 20	22 plants	70 +	Late Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower H	Bean dwarf Aiguillon	Early May	Mid Jun	45 × 20	22 plants	70 +	Late Aug +
Grower H	Bean dwarf Purple Teepee	Early May	Mid Jun	45 × 20	22 plants	70 +	Late Aug +
Grower G	Bean green Paulista	Mid Apr	-	55 × 10	18 plants	100 +	Early Aug +
Grower G	Bean green Paulista	Mid May	-	55 × 10	18 plants	90 +	Early Sep +
Grower A	Celery Frevo	Early Feb	Mid Apr	30 × 25	13 plants	90 +	Mid Jul +
Grower A	Celery Frevo	Mid Feb	Late Apr	30 × 25	13 plants	85 +	Late Jul +
Grower A	Celery Frevo	Mid Mar	Late May	30 × 25	13 plants	75 +	Mid Aug +
Grower A	Celery Frevo	Mid Apr	Late Jun	30 × 25	13 plants	80 +	Mid Sep +
Grower A	Celery Green Sleeves	Mid May	Late Jul	30 × 25	13 plants	95 +	Early Nov +
Grower A	Celery Green Sleeves	Mid May	Mid Aug	30 × 25	13 plants	105 +	Early Dec +
Grower B	Celery Jive	Buy plants	Mid Apr	30 × 30	11 plants	85 +	Early Jul +
Grower B	Celery Jive	Buy plants	Mid May	30 × 30	11 plants	90 +	Mid Aug +
Grower B	Celery Jive	Buy plants	Early Jun	30 × 30	11 plants	95 +	Mid Aug +
Grower B	Celery Green Sleeves	Buy plants	Mid Jun	30 × 30	11 plants	100 +	Mid Oct-late Dec
Grower B	Celery Green Sleeves	Buy plants	Mid Jul	30 × 30	11 plants	130 +	Mid-late Dec
Grower D	Celery Victoria	Mid Feb	Late Apr	30 × 30	11 plants	90 +	Late Jul +
Grower D	Celery Victoria	Mid Feb	Early May	30 × 30	11 plants	110 +	Early Aug +
Grower D	Celery Victoria	Mid Mar	Early Jun	30 × 30	11 plants	110 +	Late Aug +
Grower D	Celery Victoria	Mid Apr	Mid Jun	30 × 30	11 plants	120 +	Late Sep +
Grower D	Celery Victoria	Mid May	Early Jul	30 × 30	11 plants	120 +	Late Oct +
Grower D	Celery Victoria	Late May	Late Jul	30 × 30	11 plants	120 +	Dec +
Grower E	Celery Victoria	Buy plants	Late Apr	35 × 30	9.5 plants	90 +	Early Aug +
Grower E	Celery Victoria	Buy plants	Late May	35 × 30	9.5 plants	85 +	Late Aug +
Grower E	Celery Victoria	Buy plants	Late Jun	35 × 30	9.5 plants	95 +	Early Oct +
Grower E	Celery Victoria	Buy plants	Mid Jul	35 × 30	9.5 plants	110 +	Mid Nov +
Grower E	Celery Green Sleeves	Buy plants	Mid Jul	35 × 30	9.5 plants	120 +	Mid Nov +
Grower E	Celery Green Sleeves	Buy plants	Late Jul	30 × 25	16.6 plants	130 +	Mid-late Dec
Grower G	Celery Frevo	Early Mar	Mid May	55 × 20	9 plants	85 +	Early Aug +
Grower G	Celery Frevo	Early Apr	Mid Jun	55 × 20	9 plants	90 +	Early Sep +
Grower G	Celery Frevo	Early May	Mid Jul	55 × 20	9 plants	100 +	Mid Oct +
Grower G	Celery Frevo	Early May	Late Jul	55 × 20	9 plants	110 +	Nov +
Grower H	Celery Frevo	Mid Mar	Mid May	30 × 30	11 plants	70 +	Late Jul +
Grower H	Celery Frevo	Mid Mar	Mid May	30 × 30	11 plants	80 +	Early Aug +
Grower H	Celery Frevo	Mid Apr	Mid Jun	30 × 30	11 plants	70 +	Late Aug +
Grower H	Celery Frevo	Mid May	Mid Jul	30 × 30	11 plants	90 +	Mid Oct +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower H	Celery Green Sleeves	Mid May	Mid Jul	30 × 30	11 plants	100 +	Late Oct +
Grower J	Celery Tango	Late Jan	Mid Apr	38 × 30	8.8 plants	85 +	Mid Jul +
Grower J	Celery Tango	Early Mar	Mid May	38 × 30	8.8 plants	80 +	Mid Aug +
Grower J	Celery Tango	Early Apr	Mid Jun	38 × 30	8.8 plants	85 +	Mid Sep +
Grower J	Celery Green Sleeves	Early May	Mid Jul	38 × 30	8.8 plants	95 +	Mid Oct +
Grower J	Celery Green Sleeves	Late May	Early Aug	38 × 30	8.8 plants	100 +	Mid Nov +
Grower K	Celery Victoria	Late Jan	Mid Apr	30 × 25	13 plants	85 +	Mid Jul +
Grower K	Celery Victoria	Late Jan	Mid Apr	30 × 30	11 plants	95 +	Early Aug
Grower K	Celery Victoria	Mid Feb	Early May	30 × 30	11 plants	90 +	Mid Aug
Grower K	Celery Victoria	Mid Mar	Early Jun	30 × 30	11 plants	95 +	Mid Sep
Grower K	Celery Victoria	Mid Apr	Early Jul	30 × 30	11 plants	100 +	Early Oct
Grower K	Celery Victoria	Early May	Mid Jul	30 × 30	11 plants	110 +	Early Nov
Grower A	Courgette Dunja	Late Mar	Early May	100 × 100	1 plant	50 +	Mid Jun +
Grower A	Courgette Yellowfin	Late Mar	Early May	100 × 100	1 plant	50 +	Early Jul +
Grower A	Courgette Dunja	Late Apr	Late May	100 × 100	1 plant	45 +	Mid Jul +
Grower A	Courgette Yellowfin	Late Apr	Late May	100 × 100	1 plant	45 +	Mid Jul +
Grower B	Courgette Dunja	Buy plants	Mid May	100 × 100	1 plant	50 +	Early Jul +
Grower B	Courgette Dunja	Buy plants	Late May	100 × 100	1 plant	50 +	Late Jul +
Grower B	Courgette Yellowfin	Buy plants	Late May	100 × 100	1 plant	50 +	Late Jul +
Grower D	Courgette Dunja	Mid Apr	Mid May	100 × 100	1 plant	40 +	Late Jun +
Grower D	Courgette Cocozelle	Mid Apr	Mid May	100 × 100	1 plant	40 +	Late Jun +
Grower D	Courgette Goldy	Mid Apr	Mid May	100 × 100	1 plant	40 +	Late Jun +
Grower D	Courgette Dunja	Late Apr	Early Jun	100 × 100	1 plant	40 +	Mid Jul +
Grower D	Courgette Cocozelle	Late Apr	Early Jun	100 × 100	1 plant	40 +	Mid Jul +
Grower D	Courgette Goldy	Late Apr	Early Jun	100 × 100	1 plant	40 +	Mid Jul +
Grower F	Courgette Dunja	Early Apr	Mid May	100 × 100	1 plant	50 +	Early Jul +
Grower F	Courgette Cocozelle	Early Apr	Mid May	100 × 100	1 plant	50 +	Early Jul +
Grower F	Courgette Yellowfin	Early Apr	Mid May	100 × 100	1 plant	50 +	Early Jul +
Grower F	Courgette Floridor	Early Apr	Mid May	100 × 100	1 plant	50 +	Early Jul +
Grower F	Courgette Tatume	Early Apr	Mid May	100 × 100	1 plant	50 +	Early Jul +
Grower G	Courgette Dunja	Early Apr	Mid May	80 × 100	1.2 plants	55 +	Mid Jul +
Grower G	Courgette Yellowfin	Early Apr	Mid May	80 × 100	1.2 plants	55 +	Mid Jul +
Grower G	Courgette Dunja	Late Apr	Early Jun	80 × 100	1.2 plants	60 +	Early Aug +
Grower G	Courgette Yellowfin	Late Apr	Early Jun	80 × 100	1.2 plants	60 +	Early Aug +
Grower I	Courgette Dunja	Buy plants	Early May	90 × 90	1.2 plants	50 +	Early Jul +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower I	Courgette Dunja	Buy plants	Mid May	90 × 90	1.2 plants	50 +	Early Aug +
Grower I	Courgette Dunja	Buy plants	Early Jun	90 × 90	1.2 plants	50 +	Late Aug +
Grower I	Courgette Yellowfin	Buy plants	Early Jun	90 × 90	1.2 plants	55 +	Late Aug +
Grower J	Courgette Dunja	Mid Apr	Late May	100 × 100	1 plant	40 +	Mid Jul +
Grower K	Courgette Dunja	Mid Apr	Mid May	100 × 100	1 plant	55 +	Mid Jul +
Grower K	Courgette Yellowfin	Mid Apr	Mid May	100 × 100	1 plant	55 +	Mid Jul +
Grower K	Courgette Dunja	Mid May	Mid Jun	100 × 100	1 plant	55 +	Mid Aug
Grower K	Courgette Yellowfin	Mid May	Mid Jun	100 × 100	1 plant	55 +	Mid Aug
Grower A	Cucumber Kalunga	Late Mar	Mid May	45 × 45	7.5 plants	40 +	Late Jun +
Grower A	Cucumber Kalunga	Mid Apr	Early Jun	45 × 45	7.5 plants	35 +	Mid Jul +
Grower B	Cucumber Kalunga	Late Mar	Mid May	45 × 45	3 plants	50 +	Mid Jul +
Grower B	Cucumber Kalunga	Mid Apr	Early Jun	45 × 45	3 plants	50 +	Late Jul +
Grower B	Cucumber Passandra	Late Mar	Mid May	45 × 45	3 plants	45 +	Mid Jul +
Grower B	Cucumber Passandra	Mid Apr	Early Jun	45 × 45	3 plants	45 +	Late Jul +
Grower D	Cucumber Kalunga	Early Apr	Mid May	50 × 50	2 plants	40 +	Late Jun +
Grower D	Cucumber Kalunga	Late Apr	Mid Jun	50 × 50	2 plants	40 +	Late Jul +
Grower D	Cucumber Passandra	Early Apr	Mid May	50 × 50	2 plants	40 +	Late Jun +
Grower D	Cucumber Passandra	Late Apr	Mid Jun	50 × 50	2 plants	40 +	Late Jul +
Grower F	Cucumber Kalunga	Late Mar	Early May	40 × 40	6.2 plants	-	Mid Jul +
Grower F	Cucumber Kalunga	Mid Apr	Early Jun	40 × 40	6.2 plants	-	Early Aug +
Grower H	Cucumber Passandra	Mid Apr	Mid May	100 × 30	3.3 plants	40 +	Late Jun
Grower H	Cucumber Passandra	Mid May	Mid Jun	100 × 30	3.3 plants	40 +	Late Jul
Grower J	Cucumber Long European	Mid Mar	Mid May	60 × 45	3.7 plants	40 +	Early Jun +
Grower J	Cucumber Kalunga	Mid Mar	Mid May	60 × 45	3.7 plants	40 +	Early Jun +
Grower J	Cucumber Passandra	Mid Mar	Mid May	60 × 45	3.7 plants	35 +	Late Jun +
Grower K	Cucumber Marketmore	Late Mar	Mid May	45 × 45	5 plants	40 +	Late Jun +
Grower K	Cucumber Kalunga	Late Mar	Mid May	45 × 45	5 plants	40 +	Late Jun +
Grower K	Cucumber Styx	Late Mar	Mid May	45 × 45	5 plants	40 +	Late Jun +
Grower K	Cucumber Marketmore	Late Mar	Early Jun	45 × 45	5 plants	40 +	Late Jul +
Grower K	Cucumber Kalunga	Late Mar	Early Jun	45 × 45	5 plants	40 +	Late Jul +
Grower K	Cucumber Styx	Late Mar	Early Jun	45 × 45	5 plants	40 +	Late Jul +
Grower D	Pea Ambassador	Early Apr	-	70 × 3	47 seeds	120 +	Late Jul +
Grower D	Pea Ambassador	Early May	-	70 × 3	47 seeds	100 +	Early Sep +
Grower D	Pea Ambassador	Early Jun	-	70 × 3	47 seeds	100 +	Late Sep +
Grower G	Pea Ambassador	Late Apr	-	80 × 3	42 seeds	110 +	Mid Aug +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower G	Pea Ambassador	Late May	-	80 × 3	42 seeds	110 +	Mid Sep +
Grower H	Pea Nairobi	Late Feb	Mid Apr	Single 5 cm row	-	70 +	Late Jun +
Grower H	Pea Hurst Greenshaft	Late Feb	Mid Apr	Single 5 cm row	-	80 +	Early Jul +
Grower H	Pea Hurst Greenshaft	Late Mar	Early May	Single 5 cm row	-	70 +	Mid Jul +
Grower H	Pea Blauwschokker	Late Mar	Early May	Single 5 cm row	-	75 +	Mid Jul +
Grower K	Pea Ambassador	Mid Feb	-	100 × 5	20 seeds	120 +	Mid Jun +
Grower K	Pea Ambassador	Mid Mar	-	100 × 5	20 seeds	110 +	Mid Jul +
Grower K	Pea Ambassador	Mid Apr	-	100 × 5	20 seeds	100 +	Mid Aug +
Grower K	Pea Ambassador	Mid May	-	100 × 5	20 seeds	100 +	Mid Sep +
Grower D	Pepper Arwen	Early Mar	Mid May	60 × 60	1.7 plants	80 +	Early Aug +
Grower D	Pepper Ramiro	Early Mar	Mid May	60 × 60	1.7 plants	100 +	Late Aug +
Grower D	Pepper Buda	Early Mar	Mid May	60 × 60	1.7 plants	90 +	Mid Aug +
Grower H	Pepper Sprinter	Early Mar	Mid May	60 × 45	3.7 plants	50 +	Late Jul +
Grower H	Pepper Teseo	Early Mar	Mid May	60 × 45	3.7 plants	50 +	Late Jul +
Grower H	Pepper Xaro	Early Mar	Mid May	60 × 45	3.7 plants	50 +	Late Jul +
Grower H	Pepper Hungarian wax	Early Mar	Mid May	60 × 45	3.7 plants	50 +	Late Jul +
Grower H	Pepper Ring of Fire	Early Mar	Mid May	60 × 45	3.7 plants	50 +	Late Jul +
Grower H	Pepper Orbit	Early Mar	Mid May	60 × 45	3.7 plants	55 +	Late Jul +
Grower J	Pepper Habanero	Early Mar	Mid May	90 × 45	2.5 plants	65 +	Mid Jul +
Grower J	Pepper Ring of Fire	Early Mar	Mid May	90 × 45	2.5 plants	65 +	Mid Jul +
Grower J	Pepper Orbit	Early Mar	Mid May	90 × 45	2.5 plants	80 +	Late Jul +
Grower J	Pepper Sweet conical	Early Mar	Mid May	90 × 45	2.5 plants	80 +	Late Jul +
Grower J	Pepper Bendigo	Early Mar	Mid May	90 × 45	2.5 plants	80 +	Late Jul +
Grower J	Pepper Fiesta	Early Mar	Mid May	90 × 45	2.5 plants	80 +	Late Jul +
Grower A	Pumpkin/squash Crown Prince	Early Apr	Mid May	100 × 100	1 plant	120 +	Oct +
Grower A	Pumpkin/squash Knucklehead	Early Apr	Mid May	100 × 100	1 plant	120 +	Oct +
Grower A	Pumpkin/squash Marina di Chioggia	Early Apr	Mid May	100 × 100	1 plant	110 +	Late Sep +
Grower A	Pumpkin/squash Flynn	Early Apr	Mid May	100 × 100	1 plant	120 +	Oct +
Grower A	Pumpkin/squash Spyro	Early Apr	Mid May	100 × 100	1 plant	110 +	Late Sep +
Grower A	Pumpkin/squash Harvest Moon	Early Apr	Mid May	100 × 100	1 plant	110 +	Late Sep +
Grower B	Pumpkin/squash Uchiki Kuri	Buy plants	Mid May	100 × 100	1 plant	120 +	Mid Sep +
Grower B	Pumpkin/squash Crown Prince	Buy plants	Mid May	100 × 100	1 plant	130 +	Late Sep +
Grower B	Pumpkin/squash Autumn Crown	Buy plants	Mid May	100 × 100	1 plant	140 +	Mid Oct +
Grower D	Pumpkin/squash Harvest Moon	Mid Apr	Mid-late May	100 × 100	1 plant	110 +	Late Sep +
Grower D	Pumpkin/squash Flynn	Mid Apr	Mid-late May	100 × 100	1 plant	120 +	Early Oct +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower D	Pumpkin/squash Hokkaido	Mid Apr	Mid-late May	100 × 100	1 plant	120 +	Early Oct +
Grower D	Pumpkin/squash Knucklehead	Mid Apr	Mid-late May	100 × 100	1 plant	120 +	Early Oct +
Grower D	Pumpkin/squash Crown Prince	Mid Apr	Mid-late May	100 × 100	1 plant	120 +	Early Oct +
Grower D	Pumpkin/squash Marina di Chioggia	Mid Apr	Mid-late May	100 × 100	1 plant	110 +	Early Oct +
Grower F	Pumpkin/squash Crown Prince	Mid Apr	Late May	100 × 100	1 plant	120 +	Early Oct +
Grower F	Pumpkin/squash Buttercup	Mid Apr	Late May	100 × 100	2 plants	130 +	Mid Oct +
Grower F	Pumpkin/squash Uchiki Kuri	Mid Apr	Late May	100 × 100	1.5 plants	130 +	Mid Oct +
Grower F	Pumpkin/squash Hokkaido	Mid Apr	Late May	100 × 100	2 plants	130 +	Mid Oct +
Grower G	Pumpkin/squash Crown Prince	Mid Apr	Late May	80 × 100	1.2 plants	120 +	Early Oct +
Grower G	Pumpkin/squash Flynn	Mid Apr	Late May	80 × 100	1.2 plants	110 +	Late Sep +
Grower G	Pumpkin/squash Harvest Moon	Mid Apr	Late May	80 × 100	1.2 plants	110 +	Late Sep +
Grower G	Pumpkin/squash Knucklehead	Mid Apr	Late May	80 × 100	1.2 plants	120 +	Early Oct +
Grower G	Pumpkin/squash Amoro	Mid Apr	Late May	80 × 100	1.2 plants	110 +	Early Oct +
Grower H	Pumpkin/squash Black Beauty	Mid Apr	Mid May	100 × 100	1 plant	125 +	-
Grower H	Pumpkin/squash Jack be Little	Mid Apr	Mid May	100 × 100	1 plant	120 +	-
Grower H	Pumpkin/squash Buttercup	Mid Apr	Mid May	100 × 100	1 plant	125 +	-
Grower H	Pumpkin/squash Marina di Chioggia	Mid Apr	Mid May	100 × 100	1 plant	125 +	-
Grower H	Pumpkin/squash Chameleon	Mid Apr	Mid May	100 × 100	1 plant	120 +	-
Grower J	Pumpkin/squash Flynn	Mid Apr	Late May	100 × 100	1 plant	130 +	Mid Oct +
Grower J	Pumpkin/squash Orange Summer	Mid Apr	Late May	100 × 100	1 plant	130 +	Mid Oct +
Grower J	Pumpkin/squash Kaori Kuri	Mid Apr	Late May	100 × 100	1 plant	130 +	Mid Oct +
Grower J	Pumpkin/squash Harvest Moon	Mid Apr	Late May	100 × 100	1 plant	140 +	Late Oct +
Grower J	Pumpkin/squash Crown Prince	Mid Apr	Late May	100 × 100	1 plant	135 +	Mid Oct +
Grower J	Pumpkin/squash Early Butternut	Mid Apr	Late May	100 × 100	1 plant	150 +	Mid Oct +
Grower K	Pumpkin/squash Crown Prince	Mid Apr	Late May	120 × 100	0.85 plants	135 +	Early Oct +
Grower K	Pumpkin/squash Crown Prince	Late Apr	Mid Jun	120 × 100	0.85 plants	140 +	Late Oct +
Grower K	Pumpkin/squash Crown Prince	Mid Apr	Late May	120 × 100	0.85 plants	135 +	Early Oct
Grower K	Pumpkin/squash Crown Prince	Late Apr	Mid Jun	120 × 100	0.85 plants	140 +	Late Oct
Grower K	Pumpkin/squash Spyro	Mid Apr	Late May	120 × 100	0.85 plants	150 +	Late Oct
Grower D	Rhubarb Timperley Early	Own divides	Mid winter	100 × 100	1 plant	-	Early Apr +
Grower D	Rhubarb Reed's Early Superb	Own divides	Mid winter	100 × 100	1 plant	-	Late Apr +
Grower D	Rhubarb Victoria	Own divides	Mid winter	100 × 100	1 plant	-	May +
Grower D	Strawberry Honeoye	-	Late Mar	50 × 40	5 plants	95 +	Jun-Aug
Grower D	Strawberry Malling Centenary	-	Late Mar	50 × 40	5 plants	100 +	Jun-Aug
Grower D	Strawberry Symphony	-	Late Mar	50 × 40	5 plants	115 +	Jun-Aug

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower D	Strawberry Malwina	-	Late Mar	50 × 40	5 plants	120 +	Jun-Aug
Grower D	Strawberry Malling Allure	-	Late Mar	50 × 40	5 plants	130 +	Jun-Aug
Grower D	Strawberry Vibrant	-	Late Mar	50 × 40	5 plants	130 +	Jun-Aug
Grower D	Sweetcorn Earlibird	Mid Apr	Mid May	70 × 30	4.7 plants	110 +	Early Sep +
Grower D	Sweetcorn Swift	Mid Apr	Mid May	70 × 30	4.7 plants	120 +	Mid Sep +
Grower D	Sweetcorn Earlibird	Late Apr	Late May	70 × 30	4.7 plants	120 +	Late Sep +
Grower D	Sweetcorn Swift	Late Apr	Late May	70 × 30	4.7 plants	130 +	Early Oct +
Grower D	Sweetcorn Lark	Late Apr	Late May	70 × 30	4.7 plants	120 +	Early Oct +
Grower H	Sweetcorn Earlibird	Early May	Early Jun	45 × 30	7.5 plants	70 +	Early Aug +
Grower H	Sweetcorn True Platinum	Early May	Mid Jun	45 × 30	7.5 plants	75 +	Mid Aug +
Grower H	Sweetcorn Sweet Nugget	Early May	Mid Jun	45 × 30	7.5 plants	75 +	Mid Aug +
Grower H	Sweetcorn Sweet Nugget	Mid May	Mid Jun	45 × 30	7.5 plants	75 +	Early Sep +
Grower H	Sweetcorn True Platinum	Mid May	Mid Jun	45 × 30	7.5 plants	75 +	Early Sep +
Grower J	Sweetcorn Earlibird	Early May	Mid Jun	55 × 40	4.5 plants	70 +	Mid Aug +
Grower J	Sweetcorn Swift	Early May	Mid Jun	55 × 40	4.5 plants	75 +	Late Aug +
Grower J	Sweetcorn Earlibird	Mid May	Late Jun	55 × 40	4.5 plants	75 +	Mid Sep +
Grower J	Sweetcorn Swift	Mid May	Late Jun	55 × 40	4.5 plants	80 +	Late Sep +
Grower A	Tomato Sakura	Mid Feb	Mid May	45 × 45	5 plants	75 +	Mid Jul
Grower A	Tomato Sungold	Mid Feb	Mid May	45 × 45	5 plants	80 +	Late Jul
Grower A	Tomato Sunrise Blue	Mid Feb	Mid May	45 × 45	5 plants	80 +	Late Jul
Grower A	Tomato Bocati	Mid Feb	Mid May	45 × 45	5 plants	85 +	Late Jul
Grower A	Tomato Pink Bumble Bee	Mid Feb	Mid May	45 × 45	5 plants	80 +	Late Jul
Grower A	Tomato Roma	Mid Feb	Mid May	45 × 45	5 plants	80 +	Late Jul
Grower A	Tomato Miele	Mid Feb	Mid May	45 × 45	5 plants	80 +	Late Jul
Grower A	Tomato Violet	Mid Feb	Mid May	45 × 45	5 plants	80 +	Late Jul
Grower B	Tomato Sakura	Buy plants	Early May	45 × 45	3 plants	80 +	Late Jul +
Grower B	Tomato Sakura	Buy plants	Mid May	45 × 45	3 plants	75 +	Early Aug +
Grower D	Tomato Modus	Late Feb	Mid May	50 × 50	2 plants	75 +	Late Jul +
Grower D	Tomato Sakura	Mid Feb	Mid May	50 × 50	2 plants	75 +	Late Jul +
Grower D	Tomato Miele	Mid Feb	Mid May	50 × 50	2 plants	75 +	Late Jul +
Grower D	Tomato Sungold	Mid Feb	Mid May	50 × 50	2 plants	75 +	Late Jul +
Grower D	Tomato Indigo Rose	Mid Feb	Mid May	50 × 50	2 plants	75 +	Late Jul +
Grower D	Tomato Golden Sweet	Mid Feb	Mid May	50 × 50	2 plants	75 +	Late Jul +
Grower D	Tomato Indigo Rose	Mid Feb	Mid May	50 × 50	2 plants	75 +	Late Jul +
Grower F	Tomato Sakura	Late Feb	Mid May	70 × 55	4 plants	75 +	Mid Jul +

MOPS grower	Crop/cultivar/type	Sowing	Planting	Spacing (cm)	Plant density/m²	Days to maturity	Expected harvest
Grower F	Tomato Sungold	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Trilly	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Pink Bumble Bee	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Sunrise Bumblebee	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Lucky Tiger	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Black Cherry	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Bronze Torch	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Miele	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Atomic Grape	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Tiger cherry	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower F	Tomato Purple Bumble Bee	Late Feb	Mid May	70 × 55	4 plants	80 +	Late Jul +
Grower H	Tomato Sakura	Late Feb	Early Mar	100 × 40	2.5 plants	65 +	Early Jul +
Grower H	Tomato Sungold	Late Feb	Early Mar	100 × 40	2.5 plants	65 +	Early Jul +
Grower H	Tomato Roma	Late Feb	Early Mar	100 × 40	2.5 plants	65 +	Early Jul +
Grower H	Tomato Trilly	Late Feb	Early Mar	100 × 40	2.5 plants	65 +	Early Jul +
Grower H	Tomato Moneymaker	Late Feb	Early Mar	100 × 40	2.5 plants	65 +	Mid Jul +
Grower H	Tomato Mortage Lifter	Late Feb	Early Mar	100 × 40	2.5 plants	65 +	Mid Jul +
Grower H	Tomato Red Brandy Wine	Late Feb	Early Mar	100 × 40	2.5 plants	65 +	Early Jul +
Grower J	Tomato Cindel	Early Mar	Mid May	60 × 45	3.7 plants	75 +	Early Jul +
Grower J	Tomato Sakura	Early Mar	Mid May	60 × 45	3.7 plants	70 +	Late Jun +
Grower K	Tomato Martina	Early Mar	Mid May	65 × 50	2 plants	80 +	Late Jul
Grower K	Tomato Cindel	Early Mar	Mid May	65 × 50	2 plants	85 +	Late Jul
Grower K	Tomato Green Zebra	Early Mar	Mid May	65 × 50	2 plants	90 +	Early Aug
Grower K	Tomato Clementine	Early Mar	Mid May	65 × 50	2 plants	80 +	Late Jul
Grower K	Tomato Yellow Submarine	Early Mar	Mid May	65 × 50	2 plants	80 +	Late Jul
Grower K	Tomato Gardener's Delight	Early Mar	Mid May	65 × 50	2 plants	80 +	Late Jul
Grower K	Tomato Goldiana	Early Mar	Mid May	65 × 50	2 plants	80 +	Late Jul
Grower K	Tomato Black Cherry	Early Mar	Mid May	65 × 50	2 plants	85 +	Late Jul
Grower K	Tomato Velocity	Early Mar	Mid May	65 × 50	2 plants	90 +	Early Aug
Grower K	Tomato Berber Rose	Early Mar	Mid May	65 × 50	2 plants	85 +	Late Jul

1.3.3 Crop production and supply

1.3.3.1 Crops and production area

Crop production areas (ha) and a breakdown of crop types produced by the 11 MOPS project growers in the 2019/2020 and 2020/2021 growing seasons are displayed in Table 7 and Figure 13. The total crop production area for the group of project growers increased by 40% between 2019/2020 and 2020/2021. Nine of the project growers increased their area of land under production in 2020/2021 by 5-175% in comparison with the previous year. Field scale production represented 98-99% of land under production in both growing seasons and accounted for 40% of the increase in cropping area in 2020/2021 compared to the preceding season.

Overall, cropping area increased across each category of crop type between 2019-2020 and 2020/2021. Root/tuber/bulb cropping area increased by 48%; brassica crops by 17%; leafy/herb crops by 6%; and other minor/specialised crops by 199%. Crops of potatoes, carrots, beetroot and leeks were the main contributors to the cropping area for root/tuber/bulb crops. Broccoli, kale, swedes, cabbage, cauliflower and Brussels sprouts made the greatest cropping area contribution to brassica crops. Lettuces, spinach (true and perpetual), oriental leaves, chard, rocket, purslane (winter and summer) and parsley contributed most to the cropping area for leafy/herb crop types. Crops of courgettes, pumpkin/squash, celery, tomatoes, beans, sweetcorn and cucumbers were key contributing crops to the area of crops categorised as other crops.

Table 7 MOPS project growers crop production area (ha) categorised by number of growers for 2019/2020 and 2020/2021. Some production area data unavailable.

Production area	No. of MOPS growers 2019/2020	No. of MOPS growers 2020/2021
<0.5 ha	2	1
0.5-1 ha	2	3
1-3 ha	4	3
3-5 ha	1	1
5-10 ha	0	1
10-15 ha	1	1
30-60 ha	1	1

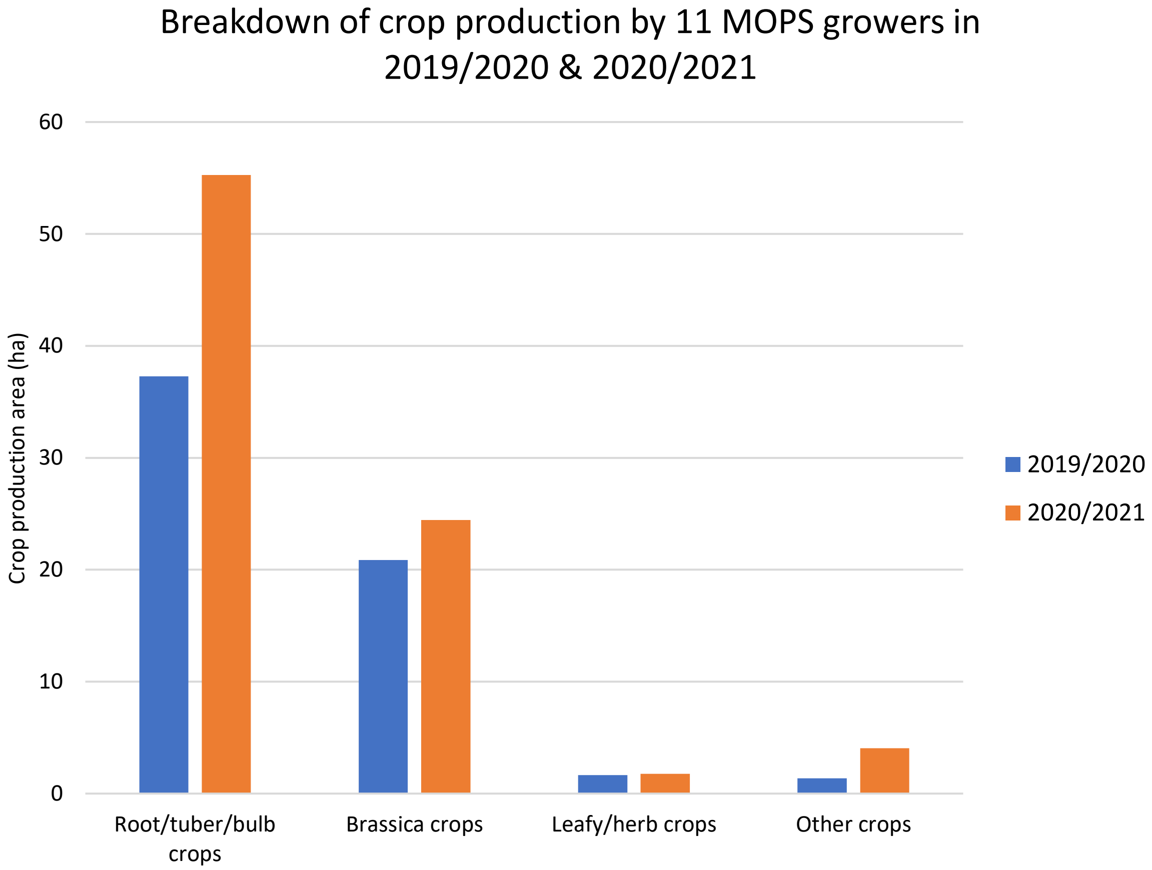

Figure 13 Crop types and production area (ha) for the 11 MOPS project growers for the 2019/2020 and 2020/2021 growing seasons. Some production area data unavailable.

1.3.3.2 Crop yields

Total yields for crops that were grown by the 11 MOPS project growers in the 2019/2020 and 2020/2021 growing seasons, associated with the cropping area and crop types displayed in Figure 13 and Table 7, are shown in Table 8 (root/tuber/bulb crops), Table 9 (brassica crops), Table 10 (leafy/herb crops and Table 11 (other crops).

Crops of potatoes, carrots, leeks, parsnips, beetroot, onions and scallions were key yielding root/tuber/bulb crops for the MOPS project growers (Table 8). Potatoes, carrots, leeks and onions had significant crop yield increases in 2020/2021 compared to 2019/2020 yields. Scallion and beetroot crop yields were lower in 2020/2021 than the previous season.

Kale, cauliflower, broccoli, cabbage, Brussels sprouts and swedes were the higher yielding brassica crops produced by the MOPS project growers (Table 9). Crop yields for cabbage, cauliflower and Brussels sprouts, in particular, had a greater increase in 2020/2021 in comparison with the previous season.

Mixed salad leaves, including lettuces and oriental leaves, along with spinach and chard were the higher yielding leafy/herb crops (Table 10). Of the crops categorised as other crops (Table 11), celery, tomatoes, courgettes, pumpkin/squash, cucumbers, sweetcorn and beans were the higher yielding for the MOPS project growers. Celery had a significant increase in yield in 2020/2021 in comparison with 2019/2020. Crop yields for courgettes, cucumbers, beans, pumpkin/squash and tomatoes were lower in 2020/2021 than the previous season.

Table 8 Total yields for root/tuber/bulb crops that were grown by the 11 MOPS project growers in the 2019/2020 and 2020/2021 growing seasons.

Root/tuber/bulb crops	2019/2020	2020/2021	Unit
Artichoke Jerusalem	335.00	774.50	kg
Beetroot	28,346.20	23,436.10	kg
	2,066	2,518	unit
Carrot	141,515.05	251,970.25	kg
	2,219	2,647	unit
Celeriac	2,391	3,883	unit
Fennel	1,383.00	1,614.00	kg
	–	2,650	unit
Garlic	640	447	unit
Leek	42,176.80	75,129.20	kg
Onion	7,173.60	14,994.30	kg
	1,737	3,370	unit
Parsnip	27,429.70	26,304.00	kg
Potato	603,874.85	1,330,515.00	kg
Scallion	10,405.55	3,116.60	kg

Table 9 Total yields for brassica crops that were grown by the 11 MOPS project growers in the 2019/2020 and 2020/2021 growing seasons.

Brassica crops	2019/2020	2020/2021	Unit
Broccoli	38,343.38	36,159.20	kg
Brussels sprout	8,593.15	11,051.40	kg
	321	146	unit
Cabbage	17,007.50	27,020.90	kg
	37,735	61,231	unit
Cauliflower	18,833	36,297	unit
kale	46,089.70	45,008.73	kg
Kalette	729.75	430.00	kg
Kohlrabi	763	509	unit
Purple sprouting broccoli	2,182.55	1,187.25	kg
Radish	1,119	–	unit
Romanesco	2,201	3,233	unit
Swede/Turnip	4,278.00	8,303.00	kg
	14,254	13,759	unit

Table 10 Total yields for leafy/herb crops that were grown by the 11 MOPS project growers in the 2019/2020 and 2020/2021 growing seasons.

Leafy/herb crops	2019/2020	2020/2021	Unit
Basil	–	13.50	kg
Chard	1,463.75	1,763.46	kg
Coriander	–	0.70	kg

Leafy/herb crops	2019/2020	2020/2021	Unit
Microgreens	41.58	14.48	kg
	460	96	unit
Parsley	215.40	231.52	kg
Pea shoots	29.19	7.95	kg
Sage	3.75	–	kg
Salad leaves	13,990.29	11,046.00	kg
	15,112	22,710	unit
Spinach	6,465.80	8,202.60	kg

Table 11 Total yields for other crops that were grown by the 11 MOPS project growers in the 2019/2020 and 2020/2021 growing seasons.

Other crops	2019/2020	2020/2021	Unit
Apple cooking	–	10.00	kg
Bean	2,212.90	1,221.00	kg
Celery	10,377	27,728	unit
Courgette	6,778.20	5,776.90	kg
	7,091	100	unit
Courgette flower	1,298	125	unit
Cucumber	991.60	161.20	kg
	11,401	7,046	unit
Pea	603.50	390.70	kg
Pepper	693.00	309.20	kg
	–	36	unit
Pumpkin/squash	2,615.50	534.60	kg
	1,082	672	unit
Raspberry	49.90	–	kg
Rhubarb	88	–	unit
Strawberries	–	111.45	kg
Sweetcorn	1,442	1,606	unit
Tomato	7,258.55	6,466.70	kg

1.3.4 Sales and routes to market

1.3.4.1 Sales own-grown crops

Figure 14 displays a breakdown of total sales of own-grown crops by the 11 MOPS project growers in the 2019/2020 and 2020/2021 growing seasons. The value of sales (€) for each crop are shown as percent (%) of total sales per crop per growing season listed largest to smallest. The total sales of all own-grown organic crops produced by the 11 MOPS project growers increased by +11% in 2020/2021 in comparison with the previous year. Own grown carrots, potatoes, leeks, onions, celery, cabbage, spinach, lettuce, Brussels sprouts, cauliflower, beetroot and kale saw the largest increase in sales value between 2019/2020 and 2020/2021. The sales value of scallions, broccoli, parsnips, mixed salad leaves, courgettes, cucumbers, sprouting broccoli, pumpkin/squash, tomatoes, rocket, peppers and beans decreased in 2020/2021 in comparison with sales the previous season.

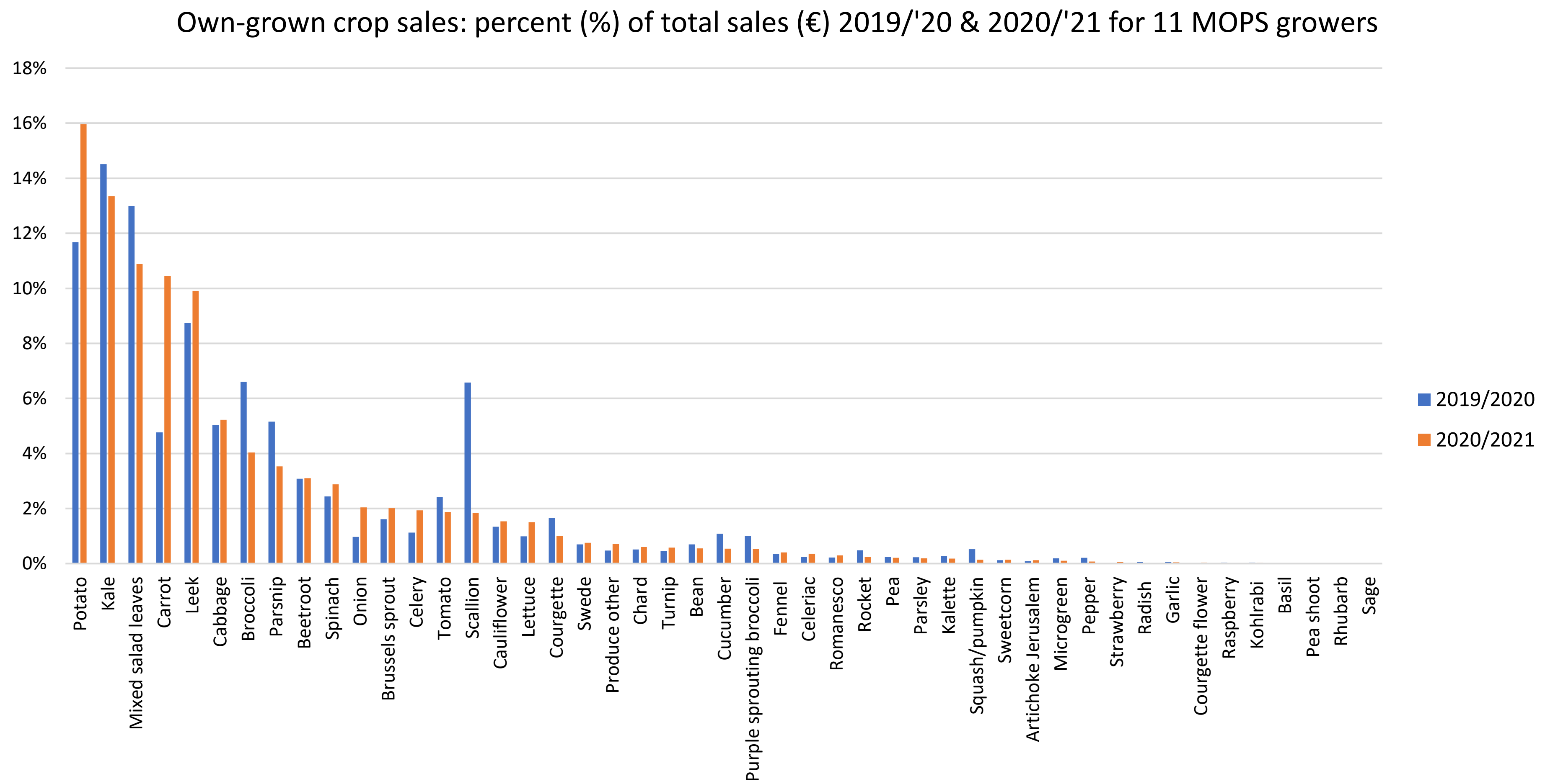

Figure 14 Sales of own-grown crops for the 2019/2020 and 2020/2021 growing seasons for the 11 MOPS project growers. Sales figures (€) displayed as percent (%) of total sales (€) for each year listed largest to smallest.

1.3.5 Trade by MOPS project growers

The increase in trade between the MOPS project growers and the contribution of individual MOPS growers to this trade is shown in Figure 15. Not all of the project farms purchased crops from the other growers in the project, instead they opted to supply produce.

Figure 16 shows a breakdown of horticultural fresh produce trade between the MOPS project growers in 2019/2020 and 2020/2021. The trade value (€) is shown as percent (%) of total trade listed largest to smallest. Trade of organic horticultural fresh produce between MOPS project growers increased by +62% year-over-year by the final year of the project.

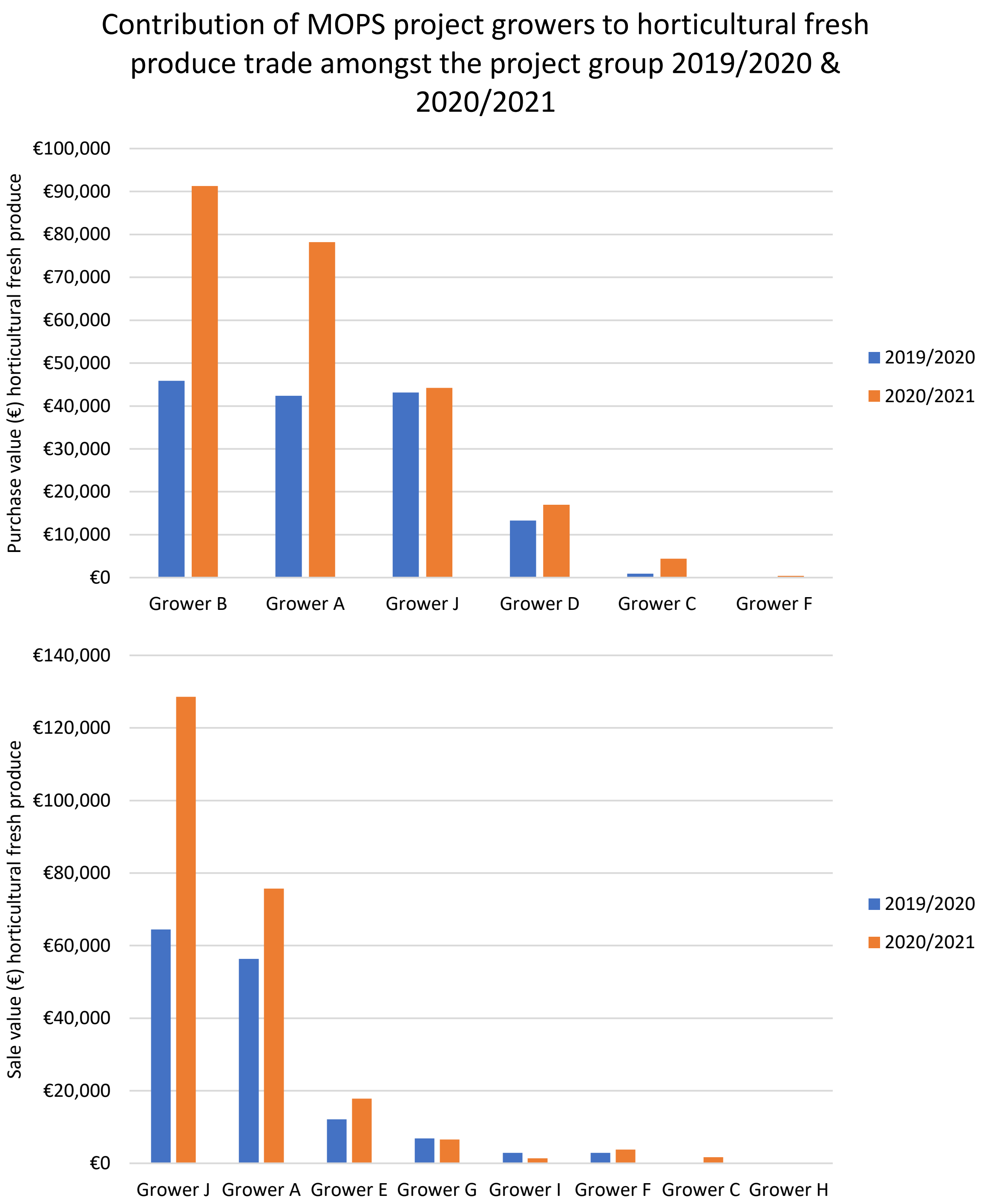

Figure 15 Trade of organic horticultural fresh produce between MOPS project growers and contribution of individual growers to the purchasing and selling in 2019/2020 and 2020/2021.

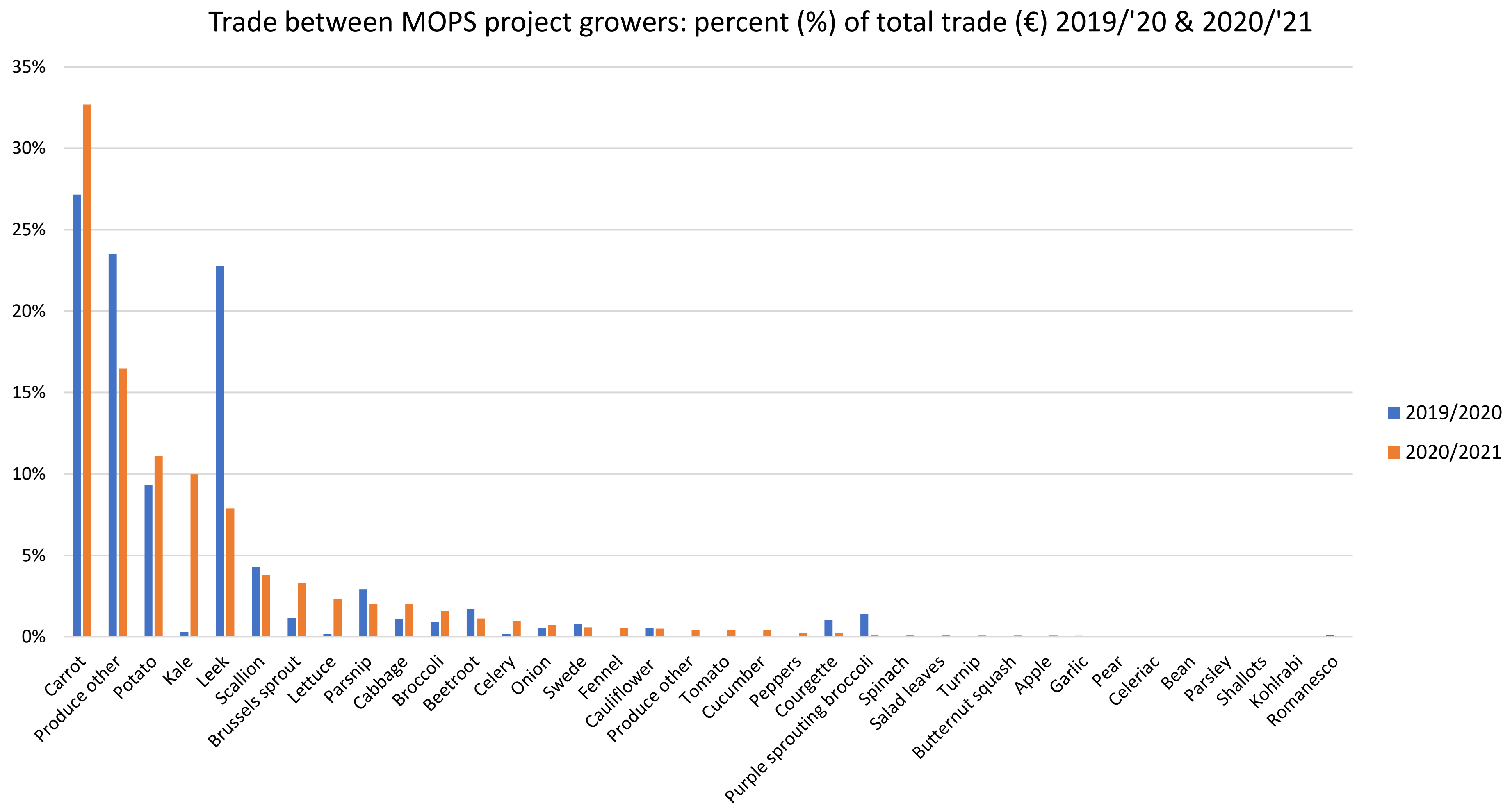

Figure 16 Trade of organic horticultural fresh produce between the MOPS project growers for the 2019/2020 and 2020/2021. Trade figures (€) displayed as percent (%) of total sales (€) for each year listed largest to smallest.

1.3.5.1 Other purchased Irish/Northern Irish and imported horticultural fresh produce

In addition to increased trade between the MOPS project growers, purchasing of additional Irish horticultural fresh produce from other Irish and Northern Irish organic growers and suppliers increased by +371% year-over-year by the final year of the project. The purchase of imported produce, with an overall greater value, increased by +119% compared to the previous year. Figure 17 shows a breakdown of the organic horticultural fresh produce purchases/imports that were made by the MOPS project growers over two years of the project, displayed as percentages of the total value (€) of purchases/imports in each year. Imported organic fresh produce represents non-Irish organic produce, while purchased Irish organic fresh produce is the combined value of purchases made between the MOPS project growers and produce purchased from other Irish/Northern Irish growers/suppliers outside the MOPS project. The value of purchases of both Irish and non-Irish imported produce increased year-over-year, with imported produce having a greater overall value. Significantly, in the final year of the MOPS project, the MOPS growers substituted 9% of non-Irish imported produce with Irish produce compared to the previous year.

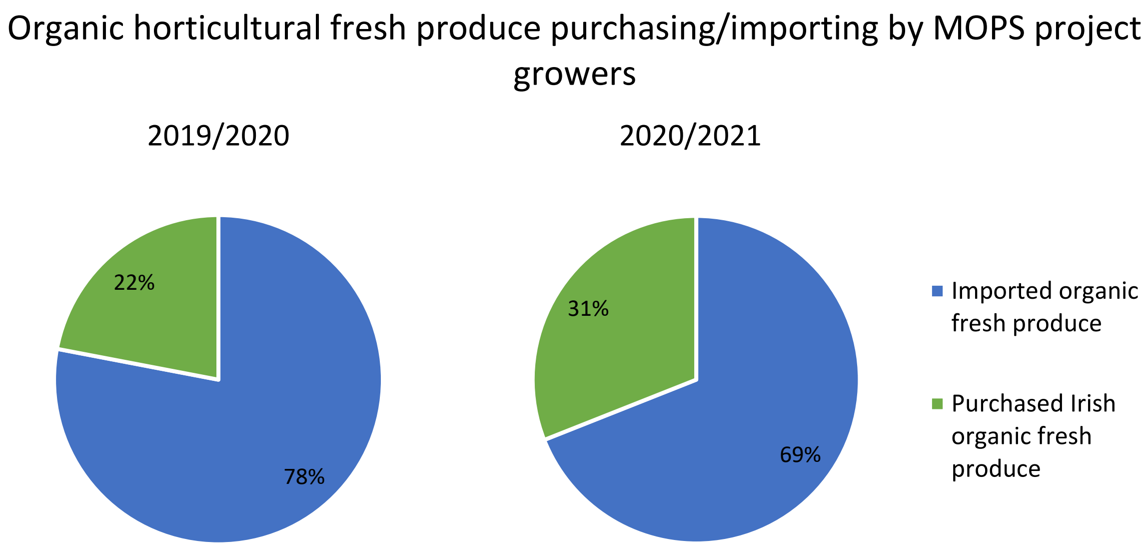

Figure 17 Breakdown of Irish purchased and non-Irish imported organic horticultural fresh produce (percent of total value € imports/purchases) by MOPS project growers in 2019/2020 and 2020/2021.

1.3.5.2 Total sales turnover

Figure 18 shows the total sales turnover, 2017 to 2020, for all organic horticultural fresh produce sales by the 11 MOPS project growers. Total sales turnover generated from sales of organic vegetables and fruit by the 11 growers increased +112% from €3.8 to €8.1 million between December 2017 and 2020. The highest single year growth was in the final year of the MOPS project where total sales turnover increased by +40% year-over-year.

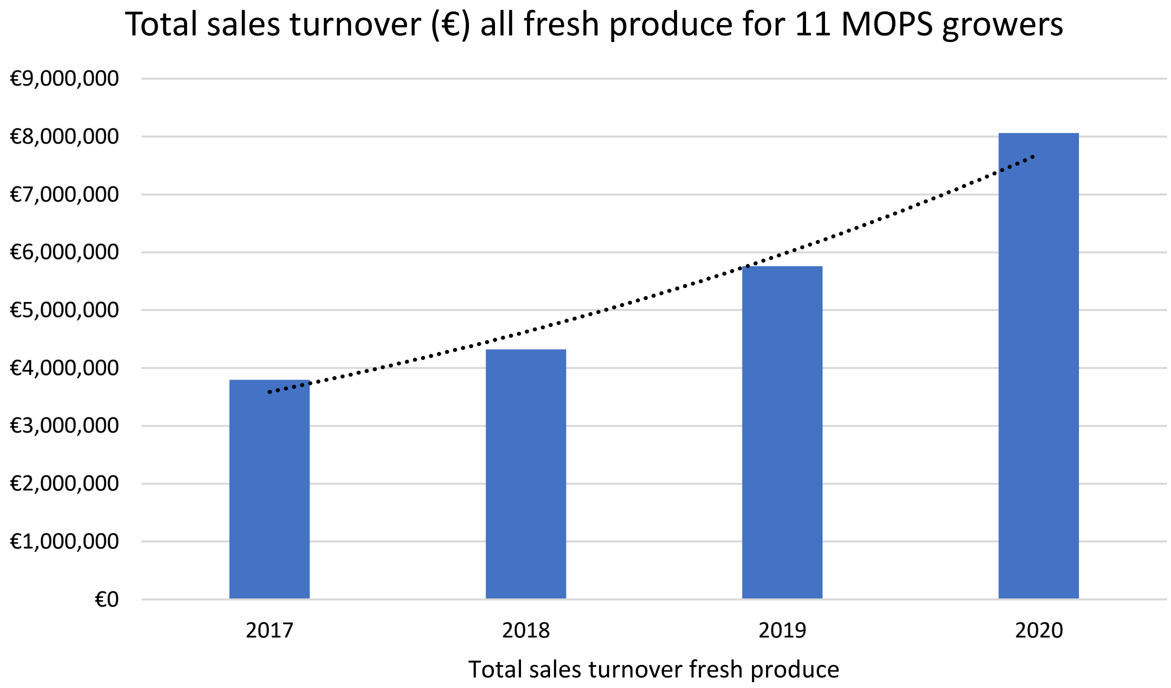

Figure 18 The total sales turnover (€) from organic horticultural fresh produce sales (2017-2020) for the 11 growers that participated in the MOPS project.

1.3.5.3 Market outlets

Figure 19 displays a breakdown of the market outlets that the 11 MOPS project growers sold organic horticultural fresh produce to in 2019/2020 and 2020/2021. The breakdown is based on total sales turnover figures (€) generated from sales to each market. Total sales turnover from produce sales to grocery retailers/supermarkets showed continued growth of +21% year-over-year. Direct-selling, particularly online box scheme/farm shop-based ordering, delivery and/or collection, grew significantly by +81%. Sales turnover generated from restaurant and shop sales dropped by -40% in comparison with the previous year.

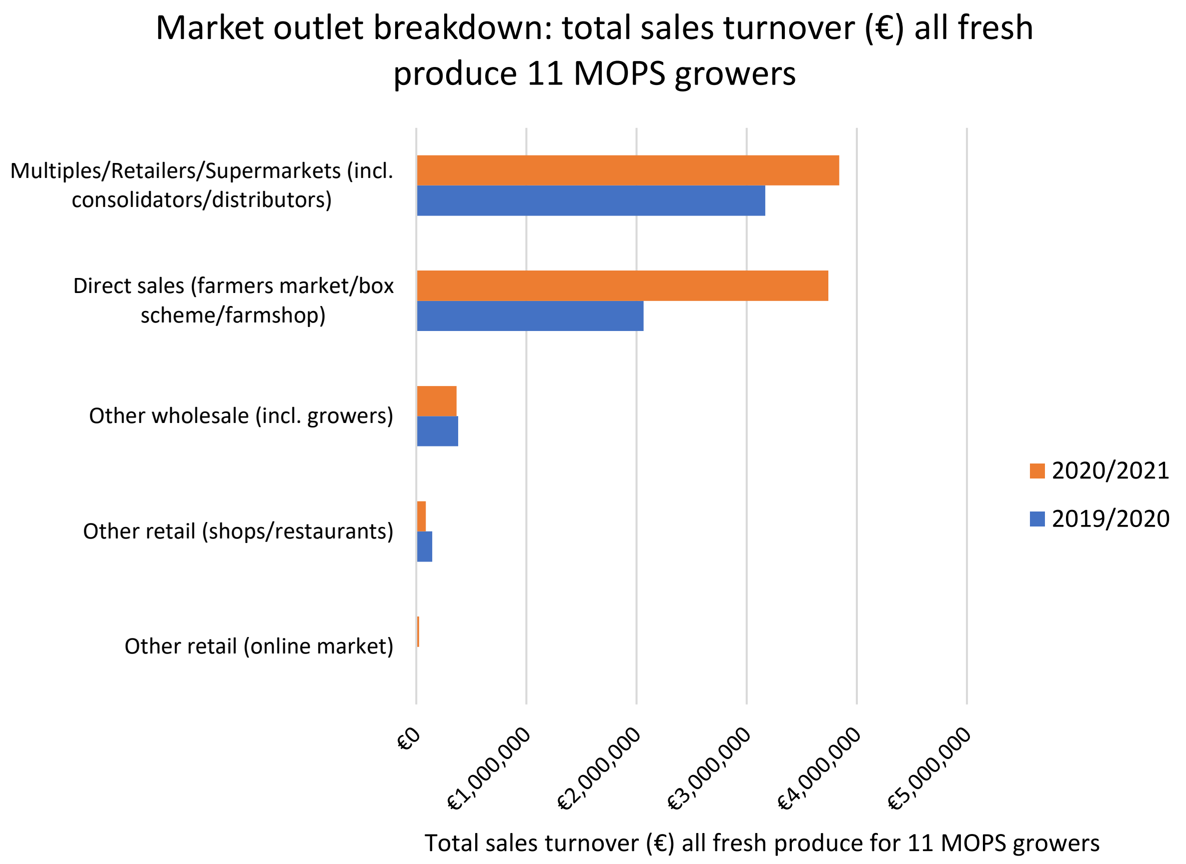

Figure 19 Breakdown of total sales turnover (€) from all horticultural fresh produce sales by market outlet for 2019/2020 and 2020/2021 for the 11 MOPS project growers.

1.4 Discussion

Sales of organic vegetables and fruit in Ireland have increased greatly in recent years. The supply of Irish grown organic horticultural fresh produce, however, falls significantly short of meeting current market demand. Scale and continuity of supply are some of the bigger challenges (and opportunities) in expanding the availability of Irish organic fruit and vegetables. Although importation of some organic horticulture produce is necessary to meet demand, particularly out of season, Ireland has the potential to produce more of its own organic fruit and vegetables to supply Irish consumers and to substitute imports.

The MOPS EIP project was funded as an innovative solution to increasing the supply of Irish-grown organic vegetables and fruit by optimising production and improving continuity of short supply chains through the collaborative crop planning and production of the 11 organic horticulture growers. Taking advantage of the differing geographical farm locations, their proximity to various commercial centres, existing grower expertise, routes to market and the range of growing systems available (field and protected), combined with the divergent characteristics of each farm, such as soil, weather and climate, afforded a wide-ranging choice of crops for better continuity of supply and season extension to satisfy the market demand. Results and insights from the project relating to this section of the MOPS project final report are discussed in the following paragraphs under headings that are based on the relevant project objectives and key performance indicators that were set out at the outset of the project.

1.4.1 Optimised crop programmes for collaborative production and trade and continuity of supply to meet increased market demand

Annual crop plans that were developed over the course of the MOPS project by the project growers and consultant agronomist, with the support of on-farm monitoring data and market research, resulted in successfully producing the optimised crop programmes that are presented in this report (Tables 3-6). The crop programmes guided each project grower to maximising their own production capacity and supply, whilst also facilitating greater market opportunities for the individual growers and the group of project growers through the collaborative production and trade amongst the group, which overall improved produce sales and supply consistency for the key markets being supplied, e.g., grocery retailers and direct sales, as shown in Figure 19 market outlets breakdown. The individual farm cropping plans were designed to correspond to and complement the output of the other project farms, thereby stimulating collaborative farm to farm supply chains and optimising production. Essential information and data collected from each farm on a regular basis, along with crop growing support from the project consultant agronomist, were key to establishing production capacity and identifying which producer was best suited for specific crops, what cultivars to use and when best to plant, sow and harvest for optimum quality and yields. Indeed, data and information gathered from on-farm monitoring fed directly into the cropping plans and, with guidance from the consultant agronomist, helped direct the growers in collaboratively achieving the objectives of the MOPS project.

Key agronomic information detailed in the crop plans (Tables 3-6) that assisted the growers during each growing season of the project, and that provided a record to improve crop planning and forecasting of production and market demand from year to year included: (1) the crops and varieties to be grown; (2) number of seeds and plants needed for a given amount of land, market demand and sales, availability of labour and costs of production; (3) planting density and spacings based on market specifications, equipment/machinery and harvesting; (4) dates for sowing seeds for transplanting and when to direct sow, plant and replant; (5) days to maturity; (6) and expected harvest dates. The crop plans were focused on optimising crop and variety selection for yield and quality, each farm's soil type and weather conditions, crop rotations, pest and disease resistance, continuity of supply during the growing season (with losses and waste minimised), and extending the harvesting of crops to supply the market for a longer period of time, which for some of the growers was the earliest date possible until the very end of the season or year-round production for others. Crop planning also concentrated on the planting of different crops and varieties at separate times, and the planting of multiple varieties of the same crop with different days to maturity at the same time to better spread harvesting. In addition, combining protected cropping, growing indoors in polytunnels and glasshouses and/or under cloches and row covers i.e., fleece, with transplanting/direct seeding of suitable crops and varieties was used in the crop plans to produce earlier crops in the spring and later crops in the autumn/winter. Growing certain varieties at appropriate times was a key planning consideration, not only for extended successive harvesting, but also to match the variety with the time of the growing season and weather. For example, some varieties were selected for crop plans due to being better suited to warmer months/weather conditions, whilst others grow best in cooler weather. During warm longer days in late spring/summer slower growing heat tolerant varieties were included in crop plans for planting. Whereas, in cooler short days in autumn/winter production faster growing cold tolerant varieties were planted. The agronomy related monitoring data collected from the project farms at the outset of the project (baseline in results section 1.3) and for its duration, including data on cropping, fertility and weather, played a key role in crop planning decisions. The regular farm visits to monitor progress, along with involving monthly collection of information and data, also included extensive sampling of soil, compost/other organic material inputs and crop leaf tissue, as well as review of weather conditions to help determine which crops performed well, where, and under what conditions. The climate monitoring records additionally assisted with better understanding incidence of crop pests and diseases during the growing season and decisions on management to minimise crop losses and waste.

The on-farm monitoring data that were collected for produce markets and trade, combined with the market knowledge and understanding of the growers themselves for their own markets and that of the consultant agronomist, along with marketing research by the MOPS project, presented in this report (section 2), and other market reports by Bord Bia (Bord Bia, 2020), for example, were additionally important to successfully producing the optimised crop plans. The farm monitoring data collected from the project growers about their produce sales, routes to markets, and other trade such as purchasing and selling between the group of project growers provided up-to-date data information on the implementation of the crop plans year to year. The market reports offered timely market information about current and future retail market demands and requirements for organic horticultural fresh produce, including the best selling organic horticultural fresh produce in Ireland, those with opportunity for growth with projected volumes, and produce that require better availability of volume and/or need to develop a supply. The reports also identified Irish grown produce that have good availability at present, produce that have potential for import substitution and crops that organic growers in Ireland find challenging to produce profitably due to competitive advantages of other producing countries. It is important to note that figures presented in the aforementioned market reports are largely grocery retailer based. Given the range of markets supplied by growers in the MOPS project (Figure 19), it is therefore not surprising that differences exist between the lists of produce in the market reports and the crops that make up the MOPS project cropping plans (Tables 3-6) and being produced (Tables 8-11) and sold (Figure 14), even though many of the most important selling crops for the MOPS project growers (e.g., potatoes, kale, carrots, leeks) are identified as best selling produce in the market reports.

The following Irish grown produce are listed as best sellers in the MOPS market report: carrots, broccoli, potatoes, spinach, brown onions, celery, courgettes, lettuce, cucumbers, rocket, vine and cherry tomatoes, and red onions. Produce that needs additional supply include: carrots, broccoli, potatoes, swedes, parsnips, cauliflower, cabbage, Brussels sprouts, pumpkins and lettuce. Produce that Bord Bia identify in their marketing report that need better availability of volume include potatoes, broccoli, carrots, cabbage, onions and cauliflower, whilst a supply needs to be developed for brown onions, broccoli, celery, cauliflower, cabbage and courgettes. Organic carrots and kale grown in Ireland have, at present, good availability of supply according to Bord Bia market research. Protected crops with opportunity for growth, but that are challenging for Irish growers to produce competitively, include cucumbers, garlic, tomatoes, spinach and peppers. Irish grown organic asparagus and beans are also noted as crops with opportunity for growth. In addition, a supply is needed for Irish organic fruit like apples, pears, strawberries, blueberries and raspberries. Key imported produce by retailers include potatoes, tomatoes, peppers, carrots, broccoli, onions, lettuce, cabbage, cauliflower, beans, garlic, turnips/swedes, leeks and kale. Organic fresh produce that are being imported by the MOPS project growers, such as apples, peppers, tomatoes, celery, broccoli, pears, onions, cucumbers, courgettes, garlic, cauliflower, blueberries, carrots, cabbage, lettuce, squash/pumpkins, fennel, potatoes, aubergines, leeks, asparagus, spinach and scallions, are similar to imported produce that are listed in Bord Bia market research.

Several noteworthy factors emerged from the MOPS project crop planning process that, in addition to those identified in the SWOT analysis results in this report (Table 1), influenced crop planning decisions on which crops to grow and in what volumes.

- Finalising the crop programmes was challenging due to the changes that occurred in the marketplace during the MOPS project. In particular, for the 2020/2021 season which changed dramatically due to the COVID-19 pandemic with produce sales to outlets such as restaurants suddenly dropping unexpectedly and direct sales like online box delivery increasing significantly.
- For growers with a diverse range of outlets, it was a challenge to agree programmes and volumes due to the range of produce needed at all times and fluctuations in volumes required, the time spent on deliveries to separate markets, different packaging and labelling requirements, and the high level of flexibility needed to achieve continuity of supply. Ability to pivot, however, was facilitated more seamlessly by having different routes to market. In this situation, crop programmes that were designed for certain outlet(s) were tailored and diverted to the new markets.
- Casual supply arrangements were difficult to plan for as the volumes required and market reliability varied. Outlets that consistently purchased larger volumes of produce on a regular basis greatly helped crop planning. Some growers supplying grocery retailers, for example, were able to finalise their crop plans as soon as commitments and precise details regarding weekly volumes, specifications and season of supply were received. This process of negotiation typically commences in the early winter period but may not conclude until the end of January.
- For some of the project growers, crop plans sometimes needed to be made without fully knowing at the point of planning where to market the produce due to sudden changes/loss of existing contracts.

1.4.2 Increased cropping area under production by the group of MOPS project growers

The total crop production area for the group of MOPS project growers, across each category of crop type, increased by 40% between 2019/2020 and 2020/2021. Nine of the project growers increased their area of land under production in 2020/2021 (Table 7). Growers producing crops at field scale, such as brassicas, carrots, and potatoes, accounted for a larger proportion of the total cropping area relative to protected indoor crops (Figure 13). Several factors were identified during the MOPS project that influenced land area under organic production, and that had a bearing on crop planning and scale of production of organic crops by the MOPS project growers.

- Availability of certified organic land and/or suitable land for converting to organic production.
- Availability of sufficient suitable land for growing horticultural crops, especially field scale crops. Carrots, for example, need to be harvested during difficult winter weather conditions, which greatly limits where they can be produced.

- Securing sufficient suitable land in close proximity to the packhouse. Growing on land that is a significant distance from the packhouse adds to labour management and logistics, especially with perishable crops.
- Ensuring that leased land is suitable. For example, free of perennial weeds and undesirable heavy metals/contaminants.
- Growers have difficulty committing to long term land leases (e.g., five to seven years) without securing long-term buying commitment from both retailers and their logistic partners in a timely fashion to enable them to plan their own purchasing of various inputs needed to produce the crops.
- Having sufficient land for expanding production whilst managing long term organic crop rotations to give land a period of rest, build soil fertility and avoid long term diseases like clubroot of Brassica crops and white rot of Alliums.

1.4.3 Production growth and increased sales of own-grown crops of organic horticultural fresh produce by the group of MOPS project growers

In the final year of the project, 2020/2021, total sales of all own-grown organic horticulture crops produced by the MOPS project growers increased by +11% in comparison with the previous year. The crops that contributed to this growth in sales are shown in Figure 14 and Tables 8-11. The crops with the greatest sales value for the group of MOPS project growers were potatoes, kale, mixed salad leaves, carrots, leeks, cabbage, broccoli, parsnips, beetroot, spinach, onions, Brussels sprouts, celery, tomatoes, scallions, cauliflower, lettuce, courgettes and swedes. During the MOPS project, a number of important factors were identified that influenced crop planning, production and availability of produce for sale. These factors link with the results of the SWOT analysis (Table 1) that was conducted on initial interview information collected from the MOPS project growers at the outset of the project that highlighted production challenges and opportunities.

- Larger scale production of crops such as potatoes or carrots for retailers/supermarkets require a considerable amount of commercial mechanisation.
- To produce top-quality crops, especially potatoes, carrots, leeks and broccoli, a reliable water supply close to the production fields is important.
- Securing staff with the necessary skills and durability continues to get very difficult and costly. Procuring skilled reliable motivated staff capable of managing various operations both on the farm and in the packhouse can be difficult as this may involve some long hours and weekend work on the farm, especially during periods of adverse weather conditions. Ensuring a uniform workload based on the total labour units available for sowing, planting, weeding, irrigation, harvesting and other maintenance schedules can be challenging. Investment in mechanisation can reduce dependency on labour as can crop and variety choice, e.g., harvesting headed lettuces rather than multi leaves and salads. The season of 2020/2021 during the COVID-19 pandemic proved to be extremely challenging, especially in relation to labour and accomplishing crop maintenance, lazy bed weeding, interrow cultivation and hand hoeing.
- Pressure on price from the larger retailers is limiting the production of some crops in the more difficult periods of the season. For example, carrots in the very early and late periods of the season are more costly to produce as they need to be protected from adverse weather conditions. Most of the larger retailers are not willing to pay for the extra costs involved.
- Continuous cost increases for inputs, including labour as mentioned above, nutrition, machinery, packaging, and other sundry supplies continues to be a big concern for growers.
- Failure to receive longer term commitments from retailers hinders intended investments in capital expenditure to improve efficiencies. Securing long term commitments from both retailers and their logistic partners in a timely fashion enables growers to plan their purchases of various inputs in a proper manner. It is very difficult for them to commit to long term land leases (five to seven years) whilst only receiving yearly agreements. Growers would ideally would need to

know before Christmas the intended produce required for the following year in order to secure timely deliveries of favoured seeds and plants and other sundry supplies. Brexit and the COVID-19 pandemic left some unique varieties of seed extremely difficult to source due to production shortages and disrupted transports deliveries.
- Securing reliable local markets to give the confidence to further increase production.
- Some growers aim to expand and simplify their markets, by producing a greater volume of produce for higher volume outlets and spending less time supplying smaller restaurants, for example, which are very time consuming.
- Producing weekly volumes of a range of crops to give sufficient income to cover costs and be able to invest in more efficient systems of growing and marketing.
- Increasing the fertility of soils to a level suitable for producing the range of crops to be grown to quality standards.
- Managing pests and diseases that impact crop quality. Reducing weed pressure using good rotation, crop mulches and good crop husbandry.

1.4.3.1 Surplus production and waste

There are strong business, environmental and social incentives for reducing food surplus and waste that align with the principles of organic production and EU policy on sustainable food systems. One of the objectives and KPIs of the MOPS project was reducing surplus produce and waste across the group of project growers. The growers were questioned during the project planning meetings and farm visits about how much surplus produce and food waste they have, how they measure waste, what are the main causes, and what happens to the waste. In developing the optimised crop plans, the project growers and consultant agronomist, were therefore cognisant of addressing known and potential causes of produce surpluses, losses and waste. Implementation of the crop plans and collaborative trade amongst the group provided a market for produce that may otherwise not have been marketed. The main sources of waste identified were pre-harvest conditions, e.g., frosty weather and waterlogged soil, and agronomic practices that influenced quality, losses and waste on-farm and later in the supply chain such as variety choice, pest, disease and fertility management. Poor harvesting and handling and/or lack of post-harvest processing and storage were also identified as contributory to waste. The following are other findings from the MOSP project that can serve to inform future work.

- Surplus, loss and waste levels and how they were measured was observed to be variable between the different farms, across different growing seasons, and for the range of markets that the growers were supplying e.g., grocery retailers and/or direct selling.
- Factors elsewhere in the supply chain greatly influence on-farm surplus and waste that the growers cannot address on their own. For example, customer specifications, especially for the growers that supply grocery retailers, and more generally, changes in supply and demand dynamics. A collaborative effort therefore is needed between growers and their customers and across whole supply chains to address surplus and waste. Some of the project growers combined supplying retailers and direct selling to give themselves a secondary market with more relaxed specifications. Short supply chains, therefore, offer options for re-distribution of produce that was destined for grocery retailers that would otherwise be waste due to specifications. Collaborative production and trade amongst the MOPS project growers supplying different markets provided greater market opportunities for the project growers.
- For growers of organic vegetables and fruit, quantifying food waste and loss is challenging as production is very heterogeneous and so waste levels vary. Several of the project growers measure waste in more detail than others. Some do not measure waste. There was no standard approach to measurement. Overall, the growers found it challenging to provide accurate estimates for waste especially beyond field losses where better estimates were provided e.g., for the amount of crop/discards/losses due to weather, pest and disease damage, not harvesting,

that was ploughed in. Many of the growers with a packhouse have systems in place for measuring and quantifying waste, particularly for their quality control and packing operations.
- Waste levels were reduced considerably for some crops during the project due to better quality linked to improved handling and harvesting techniques and understanding of days to maturing for the crops/varieties.
- Quality was enhanced on a number of the farms who achieved Bord Bia Quality Assurance Scheme certification.
- Where waste was unavoidable every effort was made by the MOPS project growers to divert to extract maximum value from the waste through animal feed, anaerobic digestion, soil fertility building, composting, land application.
- Further work is needed to improve existing waste measurement and management procedures and there is scope to develop new systems for the sector that includes practical vegetable/fruit production specific guides and templates to help measurements and benchmarking of waste. This would provide growers with better understanding and data as to the size and cause of waste, find opportunities to reduce waste and to identify market outlets and alternative opportunities.

1.4.4 Increased trade amongst the MOPS project growers

Trade (purchasing and selling) of organic horticultural fresh produce between MOPS project growers (Figure 15) increased by +62% year-over-year by the final year of the project. Not all of the project farms purchased organic fresh produce from the other growers in the project, instead they opted to supply produce. These findings highlight the potential and opportunities that exist in taking a collaborative approach to supply, and show that the MOPS project achieved the key project objectives of greater trade through grower collaboration.

1.4.4.1 MOPS project WhatsApp Messenger trading platform

The MOPS project provided an innovative platform for trade and supply amongst the group of growers through the use of WhatsApp Messenger (Figure 2). Key to this collaboration was ongoing discussion and open dialogue amongst the growers relating to crop production techniques, equipment/machinery and crop planning along with markets and supply needs, while all the time respecting the commercial confidentiality wishes of each individual farm business. When market opportunities opened to a grower(s), or a grower(s) could produce a crop in greater volume or more efficiently, or grow a particular type of crop(s), then dialogue and trade within the group was very evident. As was the case during times of surplus produce and indeed supply shortages on occasion. Several of the growers additionally carried out group purchasing of certain inputs, like plants and seeds. WhatsApp was an ideal tool to facilitate collaboration and discussion on production and trade. The benefits of WhatsApp as a platform included: cost effective (free) and easy to use; mobile and can work anywhere at any time; and flexible, quick response time to market demands.

1.4.5 Increased purchasing and importing of organic produce from other growers and suppliers to supply demand from Irish consumers

To meet the growing demand for organic produce in Ireland, the growers not only continued selling their own-grown crops and trading produce with the other project farms, some also increased purchasing Irish and imported organic produce to supply the market. In addition to increased trade between the MOPS project growers, purchasing of additional Irish horticultural fresh produce from other Irish and Northern Irish organic growers and suppliers increased by +371% year-over-year by the final year of the project. The purchase of imported produce, with an overall greater value, increased by +119% compared to the previous year. Imported organic fresh produce represents non-Irish organic produce, while purchased Irish organic fresh produce is the combined value of purchases made between the MOPS project growers and produce purchased from other Irish/Northern Irish growers/suppliers outside the MOPS project. The value of purchases of both

Irish and non-Irish imported produce increased year-over-year, with imported produce having a greater overall value. Significantly, in the final year of the MOPS project, the MOPS growers substituted 9% of non-Irish imported produce with Irish produce compared to the previous year (Figure 17).

Reducing levels of imported organic produce was an objective of the MOPS project. Whilst overall importing of produce did not decrease during the project, the finding that growers utilised short supply chains to replace some imports during the last year of the project is important. Also, increased production of Irish grown crops by the MOPS growers, and increased trade between the group of project growers, undoubtedly demonstrates the potential that exists for reducing the need to import produce through collective efforts, especially substituting imported produce that is suitable for Irish production. Nevertheless, with demand outpacing supply at present in Ireland, importation of some organic horticulture produce will be necessary to meet demand from Irish consumers, particularly out of season. DAFM and Bord Bia have previously established that approximately 70% of organic horticultural produce is imported (DAFM, 2019). Results from the MOPS project show similar levels of importation of organic horticultural fresh produce (Figure 17). Despite increased land area under organic horticulture, the level of imported organic produce will remain high to supply the continued parallel growth in consumer demand. Notwithstanding that importing of certain organic fresh produce also enables year-round supply especially for out-of-season crops, the production cost advantages in other countries for some crops, and modern Irish consumer preferences and eating trends, substituting imported produce with Irish grown crops offers a considerable opportunity for Irish growers. The MOPS project growers, for example, optimised the output of their own-grown crops, and as demand increased, purchase of imported organic vegetables and other Irish grown organic produce correspondingly increased to supply the rise in market demand. In the last year of the project, the growers increased purchasing of organic produce from other growers and suppliers in Ireland, in support of short supply chains, and substituted some imports compared to the previous year, within the overall year-over-year greater increase in value of imported fresh produce, needed to meet higher market demand levels.

1.4.6 Increased total sales turnover for the group of MOPS project growers and market dynamics

Total sales turnover generated from sales of organic fresh produce by the 11 growers that participated in the MOPS project increased +112% from €3.8 to €8.1 million between December 2017 and 2020 (Figure 18). This not only demonstrates the increase in demand for organic horticultural fresh produce in Ireland, but also confirms what may be achieved by taking a collaborative supply approach. By supplying one another with crops, be it surplus or contract grown, the project group have helped to supply market demand, secure sales and overall improve continuity of supply of organic produce. The highest single year growth was in the final financial year of the MOPS project where total sales turnover increased by +40% year-over-year.

Total sales turnover from produce sales to retailers showed continued growth of +21% year-over-year (Figure 19). Direct-selling, particularly online box scheme/farm shop-based ordering, delivery and/or collection, grew significantly by +81%. Sales turnover generated from restaurant and shop sales dropped by -40% compared to the previous year. Changes in consumer food purchasing during the COVID-19 pandemic, which coincided with the latter stages of the MOPS project, especially on-line ordering, home-delivery and dining out behaviour, undoubtedly influenced sales patterns during this period but the overall trend of increased total sales turnover experienced by the MOPS project growers over a sustained period, along with the findings of the MOPS market report, emphasises the increased market demand that exists for more organic fresh produce.

1.4.7 Enhancing capacity: innovative record keeping and farm information/data management knowledge sharing from the MOPS project

One of the innovative approaches employed in the MOPS project for record keeping and processing the range of data collected from different sources during the monitoring of the 11 project farms was the use of Farmplan GateKeeper farm management software. Advancements in technology usage and agri-digitalisation are taking place in Irish farming as part of EU policy and through private investment (Teagasc, 2016; DAFM, 2020). Technology is being used to improve, simplify and make farm business processes and tasks more integrated and efficient. Farm record keeping is evolving from basic systems to more sophisticated technology-based farm information management systems, like GateKeeper software, that integrate: field operations; workforce, machinery and inventory management; compliance, traceability and quality assurance; along with budgeting, finance and other farm enterprise administration. Some key benefits of farm management software systems for farm businesses are:

- eases the demands of handling large amounts of separate information and paperwork.
- supports more efficient operation decisions, assists with resource management across the farm, and organises costs associated with production that impact profitability.
- real-time source of information/data that can also be used retrospectively and predictively e.g., possible to do quick multi-year analysis and generate reports using automated data processing functions.
- can be a closed system for the farm business or an open collaborative system to link information related to the farm practices with other stakeholders in the supply chain e.g., farm advisors, compliance and traceability.
- improves marketing planning and forecasting with better management of information.

The adoption of new technology and management systems by Irish farmers has traditionally been slow (Teagasc, 2016). Some factors identified during the MOPS project that influenced grower adoption of GateKeeper farm management software are listed below. It is important to note that grower adoption and use of GateKeeper farm management software was beyond the scope of the MOPS project objectives, particularly given the short project timescale relative to addressing the complexity of factors that influence farmer transition to technology-based record keeping systems. In general, noted over the course of the project, many of the MOPS project growers are using technology as part of their businesses for record keeping, either GateKeeper or similar software packages like Field Margin and Muddy Boots, automating on-farm operations (e.g., GPS equipment), accounting software, workforce management software, logistics software, sales transactions systems and marketing (e.g., QR code).

- attitude to using technology.
- awareness/perception of potential benefits.
- cost/initial investment and affordability for farmers, especially small-scale not able to see the profitability potential.
- farmers engulfed in day-to-day tasks find it challenging to dedicate time needed.
- suitability and/or appropriateness for scale of operations/complexity of farm enterprises/farmer needs and resources. System/app. can be missing features/too specific and/or have a difficult/complex interface for user with too much information/information overload.
- skills/ability levels on-farm. Skills can be lacking/insufficient on-farm that are necessary to use information and the system/app.
- step-wise adoption with training, support and follow-up needed to overcome perceived difficulties especially the initial perception that the software interface is too complex with many features.

- continuity of use beyond set up. Information and data entry and set up is time consuming, particularly at the initial stages and where a wide range of crops are grown and/or a large number of inputs and products are used. The simpler the farm business/operations the easier the software is to use.
- more opportunities needed for growers to share experiences of using GateKeeper i.e., peer-to-peer learning. A grower champion, already proficient in using farm management software, may help other growers with the adoption process.
- data availability and farm records that are inconsistent/incompatible/poor quality/many different data sources e.g., unstructured book/diary/some spreadsheets. Excellent record keeping is needed for software to operate accurately from operations to financial/cost records to crop yields etc.
- UK software has some features and terminology that are not applicable to Ireland, which can be off-putting.
- confidentiality/privacy concerns regarding use/sharing of data between farmers and other stakeholders including competitors competing for markets. Needs organisational links and collaboration. Data security concerns.
- infrastructure lacking e.g., access to internet connection in rural areas.
- other stakeholders in the supply chain paper based.

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2 Market report

Summary

For the year 2020, the sales volume of organic vegetable in packs or units through the Irish multiple retailers has been estimated at 34,922,009 which converts to approximately 23,032 tons. Best-selling organic vegetables are onions, potatoes and carrots.

For the five years up until 2020 there was steady growth of up to 20% every year in the volume of organic vegetables sold through Irish multiple retailers, and this increased further during 2020 with the onset of the pandemic. An increase in scratch cooking saw an increase of up to 25% growth for organic vegetables during 2020. This growth is set to continue at a rate of 10% - 20% during 2021.

Further segmentation of Irish organic products in terms of value positions and wider use of environmentally friendly packaging will drive further growth in consumer demand. Increased marketing efforts on a national level by organic growers, retailers and trade stakeholders to raise awareness of the health and environmental benefits of organic vegetables, and the superior taste of the products, is required to further increase demand.

Throughout the research multiple retail buyers demonstrated a high level of support for Irish organic vegetable growers and are keen to further support the sector as they see the potential for increased growth. However, they and other trade stakeholders including consolidators and foodservice operators recognise that there are several challenges to the sector, notably in terms of a fragmented market, with a high number of small growers producing several crops in small quantities, and a relatively low number of large growers growing a higher volume of a limited number of crops. Increased scale and a higher level of expertise are necessary to support the commercial success of Irish organic growers, while at the same time they recognise the 2nd tier market for those small volume growers focussing on the direct to consumer route to market. The Irish climate and seasonality pose challenges for consistent year round supply of Irish grown organic vegetables which could be addressed by increased availability of cold storage. The formation of a producer group is a solution to addressing the need for an increased level of commercialisation of organic vegetable growers being called for by several trade buyers.

Two markets recognised for potential largely untapped growth, are foodservice and value added organic sectors, whereby growers could investigate diversifying to produce packaged food or supplying organic vegetables to manufacturers of these products.

This report concludes with several recommendations for the organic vegetable sector summarised into 4 main pillars: organic vegetable growers, organic vegetable trade buyers, organic vegetable consumers and branding, packaging and labelling.

The EU has set 2030 as a target for 25% of agricultural land to be organic. Ireland has a long way to go to achieve this, but the research conducted for this report suggests the climate is right among trade buyers and consumers to move this agenda along faster.

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2.1 Introduction

James Burke & Associates (JB&A) were appointed by Maximizing Organic Production Systems CLG (MOPS) to carry out industry liaison research to feed into the MOPS project. The goal of this project is to mainly focus on growth opportunities for the Irish organic vegetable sector and identify what it needs to do to capitalise on these, as well as encouraging non-organic Irish vegetable growers to enter the organic market.

JB&A were specifically requested to carry out sector research and analysis of the organic vegetable market through interviews with industry experts and a desk top study of other jurisdictions followed by dissemination of findings to the project group. Further, the research project was tasked to explore smaller niche markets for produce that does not go to the multiple retailers. As part of this research, JB&A were asked to undertake to review the level of demand for organic vegetables and to establish any deficit in supply for Irish produced organic vegetables and also to identify the potential that exists for the organic horticulture sector.

2.2 Methodology

The following methodology was used for the two areas of focus:

2.2.1 Stakeholders Interviewed

Interviews were conducted with the following representatives of the multiple retail, specialist retail, food service, distribution, and consolidator sectors. Interviews were conducted over Q4 2020 and Q1 2021:

- SuperValu
- Aldi
- Tesco
- Lidl
- Dunnes Stores
- Donnybrook Fair
- Total Produce
- Leo Dunne
- Meade Potatoes
- Country Crest
- Begley’s
- Press Up Hospitality
- Gather & Gather
- Ballymaguire Foods
- Bord Bia

2.2.2 Reports Reviewed

The following reports were reviewed as part of the research:

- Bord Bia - Fresh Produce Study, July 2020
- Bord Bia - Assessing the Growth Opportunities for Irish Horticulture, Feb 2020
- Ireland Organic Market Overview - Kantar for Bord Bia 52 weeks to 6 Sept 2020
- Irish Organic Vegetable Data - Kantar for Bord Bia 52 weeks to 21 Feb 2021
- Bord Bia - Attitudes towards Organic Food, September 2020
- Bord Bia - The Packaging Challenges in the Food Industry, January 2020
- BOLW Market Report of the German Organic Food Industry, March 2021
- More Value Positions In The Organic Market, Organic Denmark, Dec 2020

- Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions On An Action Plan For The Development Of Organic Production, March 2021
- UK Mintel GNPD - Vegetable Organic Products Analysis, April 2021
- Mintel GNPD - Vegetable Organic Products, March 2021
- Passport Euromonitor - Organic Packaged Food in the UK, Jan 2021
- Mintel - Organic food & drink in post Covid-19 Europe Insight report, May 2020
- Mintel - organic veg may be too expensive for its key audience Insight, June 2020
- Bord Bia - Foodservice Market Insights, November 2020
- Bord Bia - Rebuilding Foodservice - Learnings from Elsewhere Webinar, March 2021
- Euromonitor - Organic Packaged Food in Ireland, Jan 2021

2.3 Irish and International Research

This section contains a summary of the desk research carried out on the reports set out in the methodology section above:

2.3.1 Organics and The Irish Consumer

17% of Irish consumers surveyed said that they tend to select organic when available, with pre-family (23%) and empty nesters (22%) being the most likely demographic groups to purchase organic. Older shoppers are driven by appearance and seasonality (Bord Bia, July 2020).

25% of Irish consumers have purchased more organic food since 2019 – the biggest cohort are in Dublin aged 25-34. 67% would chose locally produced Irish food over organic food, which is a challenge for organic food. 62% buy organic food weekly or monthly – under 24's being the biggest cohort. Reasons for buying organic food in order of preference (main reason) are:

- Better for your health – 36% (biggest cohort 16 – 24 year olds)
- Better for the environment – 25%
- Taste better – 21%

47% of Irish consumers would pay more for organic food with the biggest cohort under 35 year olds and middle class, but 10% price premium is the maximum Irish consumers would be willing to pay, and mostly for health reasons (Bord Bia, September 2020).

2.3.2 Organics and Irishness

21% of consumers select fresh produce based on whether it is Irish (Bord Bia, July 2020). 83% of Irish consumers think supermarkets should provide more Irish sourced fruit and vegetables where possible (Bord Bia, Feb 2020). There is a commitment from foodservice suppliers to source Irish produce, but support does not seem to be as developed as the retail sector.

2.3.3 Organic Vegetable Value Positions

More value positions are seen as one of the paths to growth in the organic vegetable market meaning that there should be more than one retail offering per product category to suit different consumer needs (Organic Denmark, December 2020). A more tiered product quality approach will ensure continued development of the organic vegetable market and meet the demands of consumers.

The best opportunities for creating more organic value positions arise when one or more of the following factors are in play:

- The share of organic products is high
- There are clear taste differences in the products

- Packaging differences are clear
- There is collaboration in the value chain e.g., work with different flavours, varieties, fair trade, climate and sustainability
- Different degrees of convenience are brought into play e.g., a greater degree of sorting, cleaning, chopping and mixing within vegetables or with a greater degree of processing and packaging sizes to suit different consumption situations and household sizes.

The grading system used by Organic Denmark is “Good, Better, Best”, which in Denmark is available with carrots and several other varieties of organic vegetables e.g. beetroot and mushrooms. As well as having 3 value positions of unprocessed organic carrots, further processing of organic carrots adds value to the product category through product offerings of snack carrots, shredded carrots, mixed root vegetables and soup mixes.

Following the pandemic and the potential for an economic crisis, consumers are expected to go for “value for money” positions which is not the same as “cheapest possible.”

According to Mintel in its Insight report “Organic veg may be too expensive for its key audience” (Mintel June 2020) the affordability of organic vegetables is going to be a key driver of demand for its largest audience, which from both Irish and US research is seen as Gen Z (b 1995+) as younger consumers show greater interest in organic than older ones. 36% of Gen Zs in the US look for vegetables that are organic. 52% of them say that organic foods are worth the higher price. However, as with Ireland, Mintel’s US research found that Gen Z is likely to be among the most affected by COVID-19-related financial hardship due to them suffering from the highest incidence of job losses, reducing their ability to purchase costlier organic products. Recommendations to address this issue for both the Gen Z and 25 – 34 year old organic vegetable cohorts include:

- **Help make organic feel affordable:** Reach Gen Zs on social media with discounts, coupons and other means for Gen Zs to feel they can afford to buy organic food. Smaller, less expensive options can make one-off purchases more accessible
- **Demonstrate value through organic’s attributes:** Help Gen Zs connect organic attributes with their ethical values to create a lasting relationship. While Gen Z does show increased interest in organics compared to other generations, a majority of this generation does not prioritize organics and must be convinced why organic matters

In its May 2020 Insight report “Organic food & drink in post Covid-19 Europe” Mintel made several recommendations for organic farmers to address consumer needs post COVID:

- **Demonstrate value:** Consumers will need facts and guidance to choose organic food over conventional. Measurable commitments to support farmers and specific clean label claims are ways brands can communicate the total value of their products beyond price
- **Re-position around preventive health:** As a result of COVID 19 consumers will demand food that helps protect their health in the short and long terms. Organic food brands can leverage consumers' strong belief that organic food is "cleaner" safer and healthier than conventional products

Strengthen sustainability credentials: Organic brands should foster the connection between healthy soil and healthy food as the pandemic will reinforce the connection consumers make between the health of the planet and the health of the people

The same report also noted that post COVID 19, local food is a threat for organic brands. In France, Germany, Italy and Spain, three-quarters of consumers are more interested in locally produced products rather than organic ones – during COVID 19 buying local food was seen as an effective way to support national economies. Organic brands should be more transparent and detailed about their commitments to national agriculture and local farmers.

2.3.4 Organics and EU Policy

The EU has set itself a 25% organic target share by 2030 with its Farm to Fork Strategy. The European Green Deal is at the centre of the commission's policy agenda. Its prime objective is a sustainable, climate-neutral Europe by 2050, acting as a vehicle for investment and growth. The Green Deal emphasizes that it is 'key' to manage the transition towards a more sustainable food system, in particular strengthening the farmer's efforts to tackle climate change, protect the environment and preserve biodiversity'. The farming community has an essential role to play in the achievement of these objectives. Organic farmers are the pioneers of the sustainable agriculture of the future.

In the EU, the area under organic farming has increased by almost 66% in the last 10 years - from 8.3 million hectares in 2009 to 13.8 million hectares in 2019. It currently accounts for 8.5% of the EU's total 'utilised agricultural area'. This increase in area has been matched by a substantial increase in retail sales. These have doubled in value in the last 10 years, from approximately EUR 18 billion in 2010 to more than EUR 41 billion in 2019 (Communication From The Commission To The European Parliament, March 2021).

- In its Farm to Fork Strategy and the Biodiversity Strategy, the Commission has defined the objective of "at least 25% of the EU's agricultural land under organic farming by 2030. Even if we continue doing just what we are doing, the share of organic agriculture should reach between 15% and 18% of agricultural land by 2030"
- The action plan aims to encourage a marked increase of the share of organic farming in the EU, through encouraging farmers to convert to organic farming, and to expand the accessibility of organic food to close the gap between a business-as-usual growth curve and the "extra effort" necessary to reach a 25% target by 2030
- Details of the action plan include:
    - By integrating organic products into school meals, public institutions and workplace canteens through public procurement, into the hospitality sector through incentives and visibility, into supermarkets through promotion campaigns, and into everyday home cooking, more organic food will become accessible to more European citizens
    - Tackle the accessibility and affordability of organic food to help increase access to organic food for low-income families e.g., vouchers
    - Support farmers in converting to organic production, by boosting education and training opportunities, by supporting the market for organic products and in parallel identifying relevant incentives
- Facilitators identified in the report:
    - Each member state is to develop as soon as possible its own national strategy on organic farming, drawing on a comprehensive analysis of the sector and with related actions, incentives, clear deadlines and national objectives
    - The commission will monitor the progress of member states towards their national targets, providing the commission and member states with the opportunity to discuss the implementation of the proposed actions, and providing guidance on necessary and relevant adjustments
    - Boost overall demand for organic products
    - 30% of the budget for research and innovation actions in the field of agriculture, forestry and rural areas will be dedicated to topics specific to or relevant for the organic sector to include changing farmers and consumers behaviours, increased crop yields, genetic biodiversity and alternatives to contentious products
    - Increase awareness of the benefits of organic products and consumer trust in the EU Organic logo
    - Short organic supply chains e.g., the creation of "bio districts" within each EU country

2.3.5 Organics in Denmark

According to Organic Denmark, the Danish consumers are the most pro-organic consumers in the world. In fact, Denmark has the world's highest organic share and the most well-developed organic market. More than half of Danes – 52.5% – buy organic food every single week. Organic vegetables have a market share of 25.4% with carrots at 45.2%, onions at 25.7%, tomatoes at 24.5% and potatoes a 16.2% market share. In terms of value added products, organic ready meals have a 21.5% share of the market. The lack of pesticides is a major motivation for buying organic products in Denmark. (Organic Denmark, Dec 2020).

2.3.6 Organics in Germany

10.2% of Germany's agricultural land was managed by organic farmers in 2020, while a 5.3% increase in land area created a further 209,866 acres of organic land. Over the last five years, 3,351 farms (+26%) moved over to organic food production. In 2020, Germans bought 22% more organic food and beverages than in 2019. The organic segment grew at about twice the rate of the food market as a whole. The organic share of the food market rose sharply to a preliminary figure of 6.4% and the organic food trade saw a turnover increase of 16.4% from both regular and new customers during the coronavirus crisis. (BOLW Market Report of the German Organic Food Industry, March 2021).

German customers bought organic products at all points of sale, with the greatest upswing in "other places of retail" e.g., health food stores and farm shops, online retailers (incl. delivery services) and weekly markets. By 2020, a surge in products from new organic farms met a COVID-19 related surge in demand in shops. Market growth has offered producers considerably more opportunities, especially when they work with the community of organic associations to tailor their production to meet demand from food producers and the retail trade.

For Germany to meet the EU's 25% organic target by 2030 target the following needs to be met:

- New organic legislation in Brussels, in Berlin, and in the German states needs to be both sensible and viable
- More organic research and development
- Increase sales of domestic organic products

2.3.7 Organics in the UK

According to the "UK Mintel GNPD Vegetable Organic Products Analysis, April 2021" report, the sales of organic fruit and vegetables in the UK increased by 100% for the 12 months Q2 2002 to Q1 2021. At the same time, organic packaged food is seeing strong growth across all sectors in the UK. This is reflected in the UK Retail volume sales of organic packaged food increasing by 5% during 2020 to 320,000 tonnes. Retail Value Sales increased by 9% to £1.3bn (Mintel GNPD Vegetable Organic Products, March 2021).

Interest in quality organic ingredients is supported by COVID-19 health concerns as UK consumers are looking to stay healthy and are paying more attention to the ingredients in their food. There is a fear that the interest of new consumers in organic products could slow down with COVID-19 and tightened wallets, although demand is likely to remain strong among consumers who were buyers before the pandemic.

In terms of recovery and opportunities, economic recovery and growing health concerns are expected to further drive sales of UK organic vegetables. Consumers are likely to further embrace the health and wellness trend and continuing to work partially from home is expected to have a major impact on the development of organic products.

Examples of new brands of organic value added products containing organic vegetables include:

- Vegetarian planet organic grown to go pots
    - Broccoli corn bread pot
    - Super greens salad bowl
    - Red pepper hummus & harissa veg sandwich
- Organic vegetable snacks
    - Honeyrose organic kale & spiced nut toast
    - Little Freddie organic sweetcorn & carrot super seed tubes
    - Doughlicious lite bites carrot cake organic ready-to-eat cookie dough
    - Organic food bar’s active greens bar
- Organic vegetable meals
    - Clive's Mexican chilli pie
    - Clive's nut roast
    - Oil & vinegar veggie pasta
    - La Famiglia rana organic spinach, ricotta & burrata fresh ravioli
- Organic baby food is the highest selling category in terms of packaged food containing organic vegetables and has seen a 13.6% increase in value from 2019 – 2020. Organic ready meals, also a heavy user of organic vegetables, has seen a 6.8% increase in value. Organic soup has seen a 9% increase in value.
- Forecast growth in terms of value 2020 – 2025:
    - Organic baby food +7.6%
    - Organic ready meals +6.7%
    - Organic soups +12.9%
    - Store based retailing accounts for 91.6% of organic packaged food in the UK

2.4 Retail Buyers and Consolidators

The following is a summary of the research carried out through interviews with retailer buyers, consolidators and distributors of Irish organic vegetables:

2.4.1 Buyer Sentiment Positive

Throughout the interview process stakeholders expressed positive sentiment to the Irish organic vegetable sector, a belief that significant growth could be achieved and a willingness to work with the sector. Interview quotes…

- It is a shame that the range is predominantly imported – multiple retail buyer
- There are massive opportunities here – multiple retail buyer
- Carrots selling 15,000 units of an imported product would automatically jump to 18,000 units once the source is from domestic farmers. There is a customer trust factor with Irish produce – multiple retail buyer
- We are willing to work with the Irish organic veg sector – multiple retail buyer
- This is a viable category. It produces a higher margin – multiple retail buyer

2.4.2 Steady Organic Vegetable Growth

It also emerged from interviews that up until 2020 there was a steady growth of up to 20% every year in the volume of organic vegetables sold through the multiple retailers, and this increased further during 2020 with the onset of the pandemic. This has been attributed to more consumers buying into the perceived health benefits of organic vegetables and the increased scratch cooking by consumers at home. The growth rate since the pandemic began in Q1 2020 was strengthened further with some retailers noting a 25% increase in sales volume. Organic Root vegetables, potatoes and salad vegetables saw the largest increases.

The research further identified that some retailers noted that 2021 will be a difficult year to predict the level of growth in, as 2020 saw such an increase in the demand for organic produce, and that any future growth rate is coming off of a very high base. There was a general consensus that the medium-term outlook for organic vegetable growth is good, and several trade buyers described organic veg as an “opportunity category”. Interview quotes…

- “6 years ago, organic veg started to grow, since then growth has been +18% or +16% consistently year on year” – Multiple Retail Buyer
- “COVID scratch cooking has helped organics as it moved the product at a faster pace” – multiple retail buyer
- “There is no doubt there is an organic veg opportunity” – multiple retail buyer
- “There is lots of growth in this category currently” – multiple retail buyer
- “There is huge hunger there from customers for Irish organic veg. Doubling the Irish organic veg market is possible” – multiple retail buyer

2.4.3 Availability of Organic Vegetables

Interviewees generally agreed that progress has been made in the last 10 years to establish a wider range and coverage across the organic vegetable category, which is here to stay and will become more important. The organic vegetable category has gone from a small share of the fruit & vegetable sector to now having a more credible presence.

2.4.4 Organic Growth Rates

Organic vegetables metrics are all positive and the category is growing. Stakeholders interviewed acknowledged that organic vegetables have a faster growth rate ahead of the total vegetable category, which has a growth rate of 9% year on year, driven by increase in volume per trip.

2.4.5 Key Buyer Frustrations – Scale & Size

The key frustrations expressed by trade buyers centred around the scale of Irish organic veg farming which often results in stop/start supply. Consolidators and retailers found this uncertainty of supply the key challenge for the sector. Interview quotes…

- “There is a large number of small volume growers so this is difficult to build into having a core range of organic vegetables as they need consistent product across all stores” – multiple retail buyer
- “One grower who is growing seven crops, but not growing enough of any one crop is not good enough for me. They need to grow more of less range. We can absolutely do with more cabbage, we can't get enough organic cabbage and have a shortfall” – multiple retail buyer
- “Smaller organic growers cannot survive due to the ordering process, fill rates, paperwork, invoicing, and the listing process is simply too much for them. They don't have a clue how to talk to retailers. When we dealt directly with growers, final costs were not accurate from the farmers as they hadn't taken everything into account” – multiple retail buyer

2.4.6 Imports

Due to the Irish climate, seasonality, the limited number of growers and lack of storage facilities, Irish organic vegetables are only available for part of the year. For example, Irish organic tomatoes are available for approx. 22 weeks of the year, Irish organic potatoes for 3 – 4 months of the year and Irish organic brown onions for 2 months of the year. When consolidators cannot source organic vegetables from Irish growers, they then look to imports in order to guarantee year round availability to their customers in retail and foodservice.

One retailer noted that when organic or conventional vegetables are clearly labelled (SELs and packs) as Irish, sales volume increased by 100%. There is a trust factor in Irish products and if clearly labelled as Irish (SELs and packs) then customers will buy it. Increased sales and Irishness have a very strong correlation. Interviewees were upbeat about their ability to sell more Irish organic veg if available, with some interviewees expressing a real wish for the Irish sector to fill the gaps. Interview quotes…

- “The decision on the pick between Irish and Imported is largely driven by the Consolidators who only import when Irish products are not available (primarily due to the Irish climate and seasonality, they say)”
- “It is a shame that the range is predominantly imported” – multiple retail buyer
- “Organic onions sold through the multiples are 99% imported” – consolidator
- “There are more opportunities now with the UK not exporting as much” – consolidator
- “33% is currently domestic product. It could be 50/50” – consolidator

2.4.7 The Use of Consolidators by Multiple Retailers

Most of the retail buyers rely almost solely on sourcing from consolidators. Consolidators are required for the smaller organic growers as it is not feasible for several growers to approach Multiple retailers directly. One retailer stated that they cannot deal with six growers for just one variety. Retailers want consolidators to deal with smaller growers and for the consolidator do the quality checks, labelling and grading etc., and to manage the listing process. Another retailer who uses a mix of growers and consolidators would prefer to deal directly with the growers. For commercial and consistency reasons the buyer needs to work through a consolidator but still likes to have links to the grower, as this helps them to sell more to customers i.e. customers like the organic grower back stories. Interview quote…

- “This arrangement works well between (the consolidator) and smaller suppliers as (the consolidator) arranges the logistics and supply chain so using one consolidator simplifies the sourcing process as we are then only dealing with one consolidator. It is more challenging to deal with individual growers.” – multiple retail buyer

2.4.8 Buyer Suggested Solutions

Buyer and consolidators interviewed in some instances made proactive suggestions which they felt would help the sector thrive. These centred around wanting greater engagement from growers with buyers, building a personality around the sector and forming a producer group or similar. There were some wishes for larger conventional growers to grow organic too, or even for larger international organic growers to commence farming in Ireland. More extensive recommendations are contained on pages 26 – 28. Interview quotes…

- “Farmer engagement needs to improve. There is nobody currently talking to me” – multiple retail buyer
- “Come out more, knock on the doors more, get help from Bord Bia to get themselves out there. Look at the likes of Keoghs - you know who they are and what you get. I don't know these organic people; I only know the consolidators” – multiple retail buyer
- “There is room for a producer group” – consolidator
- “Form a producer group - Each farmer to grow a narrower range, but larger quantities of each product” – multiple retail buyer
- “The farmers need to form a co-op. If there was a producer group, we would deal with them” – multiple retail buyer
- “A key action that could be taken by the Irish organic veg sector is for a large company or conglomerate to set up an organic farm and show that it can be done” – multiple retail buyer

2.4.9 Sustainable Packaging

Organic customers are more aware of the environment and concerned with the damage that is being done to the planet. Therefore, packaging format is an important aspect for organic customers. Sustainable, recyclable, or compostable packaging came up in stakeholder interviews often and is becoming important. This is being used by some retailers to enhance the consumer proposition for organic vegetables.

One retailer described how 2 years ago they moved to an eco-friendly solution for organic vegetables, got rid of the packaging and started to sell vegetables loose. Customers initially bought into the idea. However, the retailer stated that, even pre-pandemic, the customer stopped/reduced buying loose vegetables. Organic customers want less packaging and want it to be eco-friendly but still want it to be packed, was the retailer's conclusion. A lot of organics are sold in environmentally friendly packs which are recyclable or compostable, however, despite the eco credentials of these packs, the look of "plastic" puts organic vegetable customers off according to some retailers.

Some organic apple growers are using packaging made from grass which has the cardboard look and feel that organic customers are seeking. Bags do help with shelf life e.g., carrots packed in bags last a week in the fridge but only a day or two if stored loose. Stakeholders flagged the dilemma of how to get the message across that the bag is compostable or recyclable is the challenge.

2.4.10 Demand for, and Availability of Organic Vegetables

There is current high demand from Irish consumers, and stakeholders interviewed suggested the plant-based consumer will soon want pesticide free products too, which will potentially lead more customers to the organic vegetable category.

Those interviewed put forward a range of suggested supports for new organic entrants via schemes such as freeing up farmland and encouraging organic conversion via the Organic Farming Scheme, new supplier programs and advisory support could stimulate more organic production etc. Retailers interviewed do not think there is sufficient land available for organic vegetables at present.

2.5 Foodservice Operators and Value-Added Organic Food

The research and interviews also looked at the foodservice sector and valued added organic food.

2.5.1 The Irish Foodservice Sector

Following eight years of consecutive growth, the Irish foodservice market fell by 47% in 2020. Covid-19 related lockdowns and 'stay at home' mandates resulted in a €4bn drop in consumer spending and a market that is now worth €4.5bn at the beginning of 2021. The Sales of Fruit & Vegetables in the Irish foodservice sector fell by 41% during 2020. (Bord Bia Irish Foodservice Market Insights 2020).

Global eating behaviours are shifting. Demand for health and immunity boosting foods is expected to increase by 54% and healthy foods & beverages 35% in the post-COVID era. (Bord Bia - Rebuilding Foodservice - Learnings from Elsewhere Webinar, March 2021). This could present as an opportunity to organic vegetables.

Although there has been a fall in focus on sustainability in the foodservice sector during COVID-19, this is expected to bounce back in 2021, starting with packaging and moving onto the products, and the effect of food on the planet by 2023. (Bord Bia - Rebuilding Foodservice - Learnings from Elsewhere Webinar, March 2021) This further signals other opportunities for Irish organic veg within the sector.

2021 Foodservice sales expectations are 18 – 22% above 2020 levels for Europe as a whole. (Bord Bia - Rebuilding Foodservice - Learnings from Elsewhere Webinar, March 2021).

On a worst case scenario, the foodservice channels which are likely to sell the most organic vegetables have been amongst the worst hit. The full service restaurant channel has fallen by 56% during 2020 and is expected to grow by 6% above this during 2021. Business & industry catering (workplace canteens) has fallen by 64% during 2020 and is expected to increase by 17% above this during 2021. (Bord Bia Irish Foodservice Market Insights 2020).

2.5.2 Feedback on Organic Vegetables from Foodservice Operators

Organic sourcing is playing an increasing role in the foodservice operators own sustainability and corporate responsibility policies, particularly with corporate catering companies. This is driven by the foodservice operators themselves rather than demands from their customers according to foodservice stakeholders interviewed. Interview quotes…

“Our Company is the main driving move to organic rather than client companies or end consumers. This is something as a company our company feels it should do” – Food Service Operator

“The Company is always looking for organic purchases, they are very interested in buying as much organic as possible as they have developed a whole green project for sustainability” – Foodservice operator

Foodservice operators indicated they like to have direct links with growers and farmers as it assists them to tell the farm to fork story of their suppliers, to their trade customers, and the end diner. Chefs also feel more connected to food if they know the people and stories behind them. They like to visit the farmers and see where the crops are grown. However, for practical invoicing, paperwork and logistical purposes they often source the vegetables via consolidators and distributors, thus breaking the link with the grower. Interview quotes…

“Our distributor buys a lot of organic products from the farms and provides the wheels, the admin and the logistics to get the F&V to us. However, I like to meet the farmer also” – Foodservice operator.

Stakeholders interviewed suggested some diners are increasingly looking for organic or local produce. The diners want to know if the vegetables are really organic and really better for the environment. There is a lack of education amongst diners regarding organic vegetables. The challenge is to firstly encourage diners to eat seasonal and local, and then organic.

Some foodservice operators are putting organic vegetables on the menus more recently.

Organic vegetables are more expensive than conventional and foodservice operators need to be able to justify that extra cost by being clever about how organic features on their menus. Stakeholders suggested one way they are doing this is by building a connection between local organic farmers and growers to the products. The first step is to get chefs to link with growers, and then diners.

Diner demand for organic vegetables tends to be more prevalent in high end, premium, well branded full service restaurants. Organic potatoes, root vegetables and salad vegetables e.g., leaves, tomatoes and onions, are the most in demand.

One of the drivers of demand for organic vegetables amongst premium restaurants is taste. Interview quotes…

“Organic Vegetables 100% taste better and this is the main driving force to buying organic vegetables. Also, the company is conscious of sustainability and supporting organic growers” – Foodservice operator.

2.5.3 Research on the demand for Organic Vegetables from the Irish Foodservice sector

Demand from workplace catering for organic vegetables is pulling through the supply chain. Higher end restaurants and independents are willing to make the effort. The public sector has an opportunity to lead by example, as is evidenced in other countries. Foodservice operators identified there is customer demand for Irish origin in some key products which command a price premium e.g., Tomatoes, but getting consistent supply was challenging.

Foodservice is often a second choice to supply, for growers after retailers, but there are some opportunities if growers are willing to work in partnership directly with foodservice operators. Some foodservice operators are willing to commit to flat prices across the season which could enable longer term planning.

There is a commitment from some foodservice operators to source Irish produce, but support does not seem to be as developed as with the retail sector (Bord Bia Assessing the Growth Opportunities for Irish Horticulture Feb 2020).

2.5.4 Irish Organic Value-Added Products

Organic packaged food recorded strong growth in 2020 as many wealthier Irish consumers sought to provide their families with the best quality, most natural food which is free of traces of pesticide or artificial fertiliser. The strong association of organic packaged food with health and wellness supported growth in 2020, especially given the renewed emphasis on living a healthy lifestyle and with a natural diet during the pandemic. The category recorded an 8% retail value growth to reach EUR161m in 2020, while retail volume sales increase by 6% to 42,700 tonnes. However, despite this strong performance, organic packaged food continued to struggle with a number of significant challenges, which limited its appeal to better-off shoppers – largely its high selling prices and high costs of acquiring certification and processing. Price was an important factor for manufacturers striving to stay afloat during the lockdown periods as some consumers limited their spending during the health crisis to the most vital products and were much more conscious about price (Euromonitor Organic Packaged Food In Ireland, Jan 2021).

Compared to the UK and Danish markets surveyed, the availability of packaged value-added Organic Vegetable Products e.g., Ready Meals and Soups using organic vegetables as an ingredient, frozen and mixed organic vegetables, is low in Ireland. Pre-COVID, manufacturers of these products interviewed stated they did have some enquiries from customers to supply products containing organic vegetables, but that interest appears to have waned. Interview quotes…

“Organic is not on any of our customers agenda. Elements such as provenance 'Irish' are to the fore.” – Packaged food manufacturer

Examples of Irish produced organic value added packaged products include Just Food, based in Cork, who supply organic soup to the retail sector.

2.6 Key Challenges

From the interviews conducted and desk research undertaken the following have been identified as the challenges facing the Irish organic vegetable sector:

- **Climate and Seasonality:** A number of examples were given where climate and seasonality working against the sector. Ireland’s climate is only suitable for 3 – 4 months per year for organic potatoes to be available. There is potential for growth with 75 – 80% of organic potatoes coming from the UK, France, Italy and some from Israel. During certain times of the year organic onions come from Egypt or New Zealand for 6 weeks a year due to the lack of growing conditions elsewhere. In some instances, improved storage was suggested as a way to extend availably of Irish crops.

- **Lack of Organic Land and Expertise:** The availability of organic land is less than required and expertise to grow organic vegetables is limited to a core group of growers. There is a limited amount of Irish farmland that is certified as organic.
- **Structure of the Irish Organic Market:** The market consists of a highly fragmented producer base, resulting in relatively small crop sizes.
- **Disease:** The wet, rain, damp and disease associated with Ireland's climate make it difficult to grow disease free organic vegetables, particularly potatoes.
- **Challenges with Yield:** Organic vegetables are not as high yielding as conventional crops which compounds yield for the available organic land.
- **Shortage of farm labour:** Organic growing is more labour intensive than conventional (due to the need to weed etc). The wider agriculture sector is struggling with a labour shortage in parallel, which is further exaggerated in the organic sector. Some growers in the organic sector are investing in greater mechanisation.
- **Lack of storage facilities:** Only a handful of organic growers and consolidators have cold storage facilities to extend the shelf life of organic vegetables. Having cold storage can increase availability by 8 – 9 months giving year-round supply for some crops like organic potatoes.
- **Meeting Organic Rules:** Several retail buyers and consolidators have observed that Organic specifications from the multiple retailer's private label are difficult to meet and the Irish Organic rules are deemed to be too complicated for growers.
- **Lack of Growers:** Attracting younger people and new talent into the wider horticulture sector is a challenge and is paralleled in the organic vegetable sector.
- **Low Margin for Growers:** The margins for growers supplying the retail sector are perceived to be too low and organic vegetable growers claim to be able to make more profit selling directly to the consumer. Some organic growers therefore prefer to stay small, and keep control of their markets by selling directly through box schemes, at markets etc. Some also state they could have half the size of operations and make twice the money from conventional vegetables.
- **Costs of Growing Organic:** The cost of growing organic is greater than conventional product, but many growers feel the premium required to cover costs is not achievable in the market.
- **Small Share of a Small Population in Ireland:** There is a small cohort of the population who buy organic vegetables and there has been a slow, slow steady rise which peaked during the pandemic. The organic share still however remains small, and the overall population lacks the density of other countries resulting in a limited market size.
- **Limited Awareness of Irish Organic Vegetables and Associated Benefits:** There is a need to increase consumer knowledge and awareness of the benefits and advantages of organic vegetables.
- **Continuity of Year-Round Supply:** Growing multiple crops on smaller farms leads to continuity challenges.
- **Lack of Scale:** Scale was repeatedly called out by interviewees as a major challenge for the sector.
- **Pricing Sensitivity – Volume Driven by Price:** Some retailers have used price promotions with organic vegetables bringing them under the price of conventional vegetables. This has created an artificial market for some organic produce because as soon as the price reverts to the normal 20% premium above conventional vegetables, those price sensitive consumers fall away.
- **Waste and Shorter Shelf Life:** Organic vegetables tend to have a shorter shelf life than conventional due to the lack of pesticides. Organic vegetables can be more difficult to grow but often consumers and trade customers expect the same quality as conventional products. As a result, this can result in rejections from customers as they see imperfections. Waste tends to occur at store level if some organic vegetables are not store in refrigerated units.
- **Threat of Imports:** All multiple retailers have access to internationally sourced organic vegetables. The lack of commitment to Irish grown vegetables by some buyers leads to grower insecurity and imperfect crop planning.

2.7 Trade Suggested Solutions

Stakeholder suggestions revolved around the following:

- Grants for investment in machinery, poly-tunnels and cold storage facilities: In line with the Dept. of Agriculture grants for converting to organic. "The Irish organic industry needs mechanisation" – multiple retail buyer
    - In the UK, significant grants were given to grow organic produce, improve mechanisation and storage.
    - A minority of growers are already growing under polytunnels but more crops could be grown for longer this way. This needs scale.
- Grow on a small scale initially then once feasible focus on scaling up: Buyers interviewed advised that Irish growers should experiment on a smaller scale, to see if and how the organic vegetable crop grows and sells. Not every line will suit and be commercially viable. Then focus on scale.
- Focus on crops that the growers have experience of growing conventionally: This would make for a logical transition to first organic crops
- Consumer education about imperfections yet health benefits of organic vegetables: There is a need for education of the end consumer that there will be imperfections with organic veg appearance, but the product will be perfect.
- Encourage a greater use of sustainable packaging: This will encourage conventional vegetable consumers to switch to organic.
- Narrow down the range grown to be more commercial: While it is acknowledged by interviewees that it is good to see that the smaller organic vegetable growers are growing a variety of organic vegetables, there is also concern that too much diversity resulting in breaks in supply. Some organic growers will be more focussed in directly selling via box schemes and markets, and therefore will ned to continue with mixed planting schemes.
- Form a Producer Grower Group: Multiple buyers suggested on several occasions that producers interested in supplying supermarkets should come together to form a producer group or similar.

2.8 Best sellers and Gaps in Range

Stakeholders interviewed identified both best sellers of organic vegetables and gaps which Irish growers might potentially fill:

2.8.1 Organic Vegetable Best sellers

The best sellers according to retailers and consolidators across the board are stated below in order of volume:

- Carrots
- Broccoli
- Potatoes
- Spinach
- Brown onions
- Celery
- Courgettes
- Lettuce
- Cucumber
- Rocket
- Vine tomatoes
- Cherry tomatoes
- Red onions
- Mushrooms

2.8.2 Gaps in Range of Organic Vegetables

- Additional supplies of carrots, broccoli, potatoes, swedes, and parsnips
- Cauliflower and Cabbage – there is current poor availability of both
- Sprouts – seasonally
- Pumpkins – seasonally
- Lettuce

2.8.3 Growth opportunities

There were suggestions from respondents that Brexit could yield new opportunities as UK sourced crops become more difficult to source because of disrupted supply chains. It was also suggested there will be more demand for transplanted and propagated plants for crops that can be grown indoors e.g., polytunnels, and outdoor from seeds e.g. celery and onions.

2.9 Volume Research

Stakeholders who were interviewed were asked to provide data which would be kept anonymous and merged with others to identify the sales volume of organic vegetables in Ireland. 5 datasets were received and were combined with other data to extrapolate volumes by product. The datasets received included both Irish grown imported vegetables and imported vegetables with no distinction between the two.

2.9.1 Methodology

- All interviewees were asked to supply their volume sales of organic vegetables broken down by kg, units or packs for the 12 months to year end 2020. 5 interviewees supplied this data for the majority but not for all organic vegetables
- As a guide, a review of sales volume data for the 52 weeks to 06 09 20 and 21 02 21 for all Irish retailers was reviewed
- Data was calculated for each organic vegetable on the basis of both pack sizes and tonnage based on the assumptions below

2.9.2 Assumptions

- The focus of the research was for the sales volume of the 5 Irish multiple retailers
- Where data was not submitted from a multiple retailer, an estimate of their volume sales was made using the market share for that multiple retailer as stated by Kantar for the 52 weeks to 6 Sept 2020, having been assured by both retailers and consolidators that this market share is still relevant, and extrapolating this data based on the sales volume from the 3 multiple retailers who did supply their data
- The sales volume data for symbol groups and other retailers was stripped out from the Kantar sales volume and market share data before extrapolation took place
- The sales volume given by the 3 multiple retailers and the resultant extrapolation of the sales data for the remaining two multiple retailers was cross checked against the volume of organic vegetables supplied to all 5 retailers by the consolidators who supplied their data.
- The total sales volume reached for each organic vegetable was cross checked with data from Kantar for the 52 weeks to 21 02 21
- As the multiple retailers supplied their data as a mix of units, pack sizes and kg, store audits and online shopping databases were used to determine an average weight for each organic vegetable / pack size to determine the tonnage, and where the tonnage was provided, this facilitated an estimate of the sales volume in terms of pack sizes
- On cross checking the total volume of each vegetable in terms of pack sizes and tonnage, estimates had to be made as to whether the data provided by Kantar was denominated in either tonnage or pack sizes for each organic vegetable

2.9.3 Total Organic Vegetables Sales Volumes in Irish Multiple Retailers for 2020

Multiple retailers sales volumes of organic vegetables for the year 2020 in terms of packs and tonnage are estimated below using the above methodology and assumptions as follows:

- **Total sales volume of organic vegetable in packs or units: 34,922,009 approx.**
- **Total sales volume of organic vegetables in tonnage: 23,032 approx.**

2.9.4 Sales volumes of specific Organic Vegetables in Irish Multiples Retailers for 2020

The approximate 2020 sales volume of main and less mainstream organic vegetables sold by Irish multiple retailers is set out in the table below in terms of both units or packs and tonnage. The assumption on the average weight of pack or unit size is also stated. This list does not include all organic vegetables included in the total volumes above.

Volume of Specific Organic Vegetables sold in Irish Multiple Retailers 2020				
		Average weight		
Product	Units or packs	Units or Packs (Kg)	Total Kg	Tonnage
Swede	70,676	0.6	42,406	42.41
Kale	286,149	0.2	57,230	57.23
Broccoli	2,572,302	0.4	1,028,921	1,028.92
Potatoes	3,888,199	2	7,776,398	7,776.40
Carrots	4,387,976	0.75	3,290,982	3,290.98
Leeks	355,331	0.4	142,132	142.13
Cabbage	103,149	0.5	51,574	51.57
Brown Onions	4,902,730	0.75	3,677,048	3,677.05
Celery	2,075,254	0.3	622,576	622.58
Beetroot	356,225	0.5	178,112	178.11
Cauliflower	212,983	1	212,983	212.98
Tomatoes	2,479,917	0.25	619,979	619.98
Courgettes	922,074	0.5	461,037	461.04
Spinach	1,241,567	0.2	248,313	248.31
Parsnip	127,277	0.5	63,639	63.64
Squash	257,323	1	257,323	257.32
Mixed Leaves	109,490	0.1	10,949	10.95

The best-selling organic vegetable is brown onions followed closely by carrots and potatoes. This is in line with data identified in the course of international research.

2.10 Forecast Volume

The majority of retailers and consolidators interviewed predicted double digit growth across the Organic Vegetable Sector for 2021, although cautioned that this was off the very high base of pandemic-driven growth in 2020.

2.10.1 Projected Sales Volume For Main and less Mainstream Organic Vegetables For 2021 (units or packs) sold in Irish Multiple Retailers

Taking the volume estimates in terms of average sized packs for the data above, estimates were created for the growth of the following vegetables on a worst case, medium case and best-case scenario of 10%, 15% and 20% respectively:

Projected Volume For Main Organic Vegetables For 2021 (units or packs) sold in Irish Multiple Retailers				
Product	**Worst case**	**Medium Case**	**Best case**	
	10%	**15%**	**20%**	
Swede	77,744	81,277	84,811	
Kale	314,763	329,071	343,378	
Broccoli	2,829,532	2,958,147	3,086,762	
Potatoes	4,277,019	4,471,429	4,665,839	
Carrots	4,826,774	5,046,173	5,265,572	
Leeks	390,864	408,630	426,397	
Cabbage	113,464	118,621	123,778	
Onions	5,393,003	5,638,140	5,883,276	
Celery	2,282,780	2,386,542	2,490,305	
Beetroot	391,847	409,658	427,470	

Projected Volume For Less Mainstream Organic Vegetables For 2021 (units or packs) sold in Irish Multiple Retaile				
	Worst case	**Medium Case**	**Best case**	
	10%	**15%**	**20%**	
Cauliflower	234,281	244,930	255,580	
Tomatoes	2,727,909	2,851,905	2,975,901	
Courgettes	1,014,282	1,060,386	1,106,489	
Spinach	1,365,724	1,427,802	1,489,880	
Parsnip	140,005	146,369	152,733	
Squash	283,055	295,921	308,787	
Mixed Leaves	120,439	125,914	131,388	

2.11 Recommendations

Taking all of the research, interview feedback and industry knowledge onboard, the authors of the report have identified the following recommendations summarised under 4 main pillars: Organic vegetable growers, organic vegetable trade buyers, organic vegetable consumers and branding, packaging and labelling:

2.11.1 Recommendations Effecting Organic Vegetable Growers

- The Development of a twin strategy approach for different stakeholders
    - Large scale growers targeting multiple retailers
    - Micro growers targeting local and direct selling

  Both groups have totally different needs and objectives and will needed to be guided by different strategies and advice.
- Strategically some growers will need support to decide “who am I”. The debate will centre on whether to remain supplying consumers direct, or to scale up and supply large market channels.
- Maximise awareness of, and the availability of grants for investment in machinery, poly-tunnels and storage facilities to encourage better automation and storage to help improve capacity building and efficiencies.
- Attract more conventional growers to convert some land and bring their growing “know-how and volume attitude” to the organic vegetable sector.
- Explore the need for an organic “technical showcase farm”, or a number of showcase farms that would become best in class for certain crops. These farms would be used as knowledge transfer hubs.
- Arrange more potential organic vegetable grower educational trips to countries of best practice e.g., Germany or Denmark.
- Ramp up the lean upskilling for larger growers.
- Get the larger scale growers to operate as one by forming a producer group.

- Organic growers should reach out to foodservice operators and engage with them to develop a supply partnership either directly or via distributors and consolidators and promote the positives or organic produce.
- Use this report as a catalyst for an industry briefing, but only for those interested in scale.
- Work with both trade buyers to carry out consumer research to segment organic vegetables into different value positions. This way organic vegetables with slight imperfections could still be sold in a retail setting as a value range, the top-quality organic vegetables sold as a premium range and more processing e.g., snack, chopped, mixed varieties of organic vegetables could generate higher value.

2.11.2 Recommendations Effecting Organic Vegetable Trade Buyers

- The organic industry to develop a 3-year road map with the 5 multiple retailers and consolidators – the "window for dialogue is open" as multiple retailers are all keen to support the growth of the organic vegetable category, and further support Irish organic vegetable growers. Retailer buy in will be crucial.
- Build the image of Irish organic vegetables to trade and consumers.
    - Grower responsibility to be active promoting the organic sector through active social media and PR. Continuity of messaging will be vital.
    - Organise a wider organic industry campaign focussed on telling the Irish organic vegetable provenance stories and calling out the sector USPs.
    - The objective of the campaign is to prevent the industry becoming faceless, and ensuring the consumer understands more about the Irish organic veg industry and the USPs of the crops grown.
- Explore positioning organic vegetables more strategically in a retail setting (where not in place already) e.g., merchandised with conventional vegetables giving consumers the choice of vegetables, as well as being prominently displayed in specific organic sections in larger retail settings.
- Increase the amount of point-of-sale material in the vegetable sections highlighting Irish organic vegetables and their USPs.
- Organic growers should be encouraged to visit stores and engage with potential organic vegetable consumers (meet the grower events) to highlight the differences between organic and conventional vegetables and the environmental and other benefits.
- Retailers should explore the role of sustainable packaging for own label organic vegetables where not already in place.
- Retailers should be encouraged to look at "non price" promotion of Irish organic vegetables with the aim of enhancing the consumers understanding of the category and range.
- Consolidators and distributors should consider engagement between organic vegetable growers and their retail and foodservice trade customers i.e., ensure the buyer immerses in the back story and understands the personalities behind each product.

2.11.3 Organic Vegetable Consumers

- Embark on a consumer education programme via social media and advertising in order to highlight the health benefits of organic vegetables, the growing methods, lack of chemicals and pesticides etc and the positive effect this has on the land and the environment.
- The marketing of organic vegetables should target consumer interest in "safeguarding" and reposition organic food around preventive health i.e., organic food is cleaner, safer and healthier.
- Plant based consumers should be targeted by organic vegetable marketing campaigns as they are seen as being potential organic vegetable consumers in the future.

- Encourage organic growers and retailers to work collaboratively on developing different organic value propositions, particularly in the retail sector, to suit different consumer values, household numbers and budgets.
- As recommended by the EU, a nationwide social media and advertising campaign should be implemented to highlight the health and environmental benefits of organic vegetables and stories of the organic vegetable growers themselves.
- Younger organic vegetable consumers should be targeted with social media giveaways (promotions, vouchers etc) for organic vegetables and smaller pack sizes to increase the affordability of organic vegetables.

2.11.4 Branding, Packaging and Labelling

- Branding on organic vegetables, including on an own label product, needs to better tell the story of the farmers and growers to make the connection with the consumer and raising a sense of value for money.
- Sustainable packaging needs to be to the forefront of the Irish vegetable sector, with care taken to choose pack options which convey best the eco credentials.
- Labelling and point of sale material on organic vegetables needs to highlight when organic vegetables are in season in Ireland and the product is Irish grown in the retail setting.
- Foodservice operators should be encouraged to highlight organic vegetables on menu when used and particularly highlight the origin if they are Irish.
- Irish organic growers should be encouraged to explore developing value-added products e.g. farm to fork soups and ready meals and see food ingredients as a 3rd route to market for their products alongside retail and foodservice.

3 Climate and weather monitoring

Abstract

This monitoring effort was undertaken to provide data in delayed mode in order to potentially provide insight into growing patterns that might have been influenced by seasonal variability in environmental conditions, specifically soil and air temperature.

Research grade quality soil temperature and air temperature/relative humidity sensors were deployed at all the growing sites covered by the MOPS project. Where covered growing areas were in use the air sensors were placed both inside and outside. Data were downloaded at regular project monitor visits and collated centrally where various summary data were produced, e.g., daily averages. Time series plots were provided at regular intervals as feedback to project meetings and for general interest.

Coupled to phenological observation, seasonal monitoring of even a relatively straight forward time series data such as temperature serves to inform on seasonal patterns and rates of change of succession between seasons.

This report serves to present the data and outline the methodologies employed in its collection. The sensor data were output using the manufacturers software with further processing undertaken using the python open source programming language, all code and the raw and processed (*.csv) data files are included as part of the report.

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3.1 Introduction

3.1.1 Data collection sites

The MOPS project included a level of environmental monitoring in its operation. This was intended to provide background context, but also serve as a demonstration to promote the usefulness of these data in horticultural production systems. Figure 1a shows the general locations of the MOPS project farms/monitoring sites, with Figure 1b displaying the locations of the synoptic Met Éireann weather stations where data are freely and openly available for public consumption. Table 1 provides further details on the locations of the MOPS project farms/monitoring sites and Met Éireann weather stations.

(a) (b)

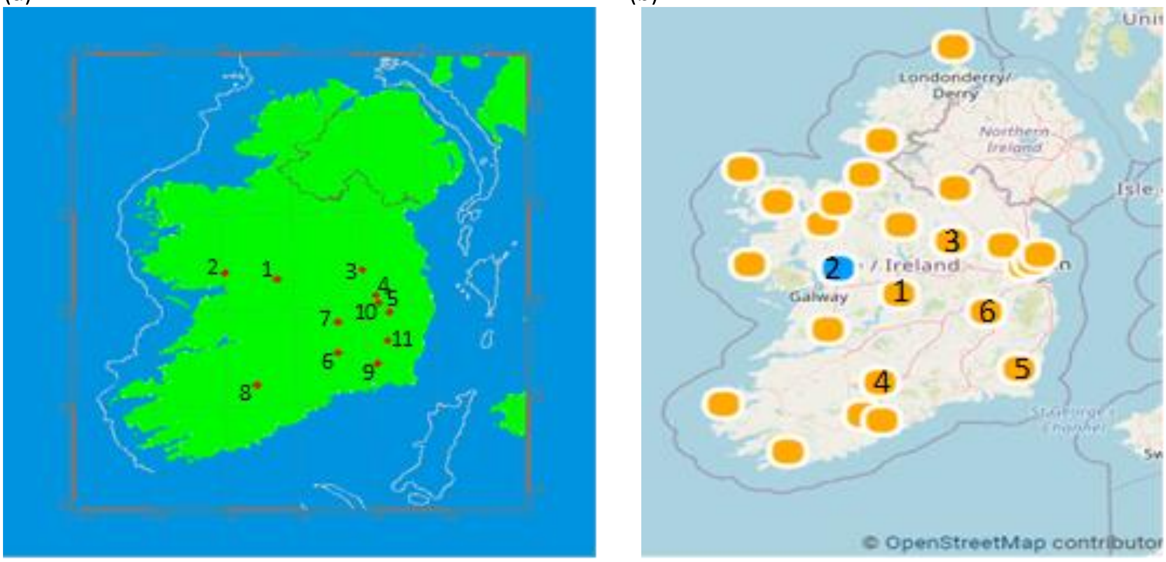


Figure 1a Location of MOPS project farms/monitoring sites and 1b Met Éireann synoptic weather stations. See Table 1 for site names.

Table 1 Growing site locations and National weather monitoring services available from Met Éireann.

Site	MOPS project farm/monitoring site	Latitude, longitude	Adjacent Met Éireann monitoring station (https://www.met.ie/climate/available-data/monthly-data)	
1	Beechlawn Farm	53.318238, -8.224681	2	Athenry
2	Green Earth Organics Farm	53.390563, -8.976953	2	Athenry
3	Nurney Farm	53.388107, -6.990220	3	Mullingar
4	Moyleabbey Farm	53.042783, -6.791531	6	Oak Park
9	Knockroe Farm	52.413760, -6.858238	5	Johnstown Castle
6	Riverside Farm	52.533990, -7.399630	4	Moore Park
7	Shalom Farm	52.858196, -7.382717	6	Oak Park
8	Kilbrack Farm	52.220673, -8.554540	4	Moore Park
11	Gorse Farm	52.646510, -6.699050	6	Oak Park
10	Ballysax Farm	53.121350, -6.825900	6	Oak Park
5	Ballinroan Farm	52.941700, -6.643290	6	Oak Park

3.1.2 2.1 The Irish climate

The dominant influence on Ireland's climate is the Atlantic Ocean. Consequently, Ireland does not suffer from the extremes of temperature experienced by many other countries at similar latitude. The warm North Atlantic Drift has a marked influence on sea temperatures. This maritime influence is strongest near the Atlantic coasts and decreases with distance inland. The hills and mountains, many of which are near the coasts, provide shelter from strong winds and from the direct oceanic influence. Winters tend to be cool and windy, while summers, when the depression track is further north and depressions less deep, are mostly mild and less windy.

The polar front is a feature of the atmospheric circulation which plays an important part in determining Irish weather. It's a zone of transition between warm, moist air (sometimes of tropical origin) moving northwards and colder, denser, drier air (usually of polar origin) which is moving southwards. The flow of air between the equator and the pole is complicated and indirect.

The air masses separated by the polar front are sometimes considerably modified on their paths from their respective source regions. In the North Atlantic the polar front can often be traced on weather maps as a continuous line over thousands of kilometres. In winter, it usually extends north eastwards from the east coast of the United States, in summer it is less well-defined and can be difficult to locate. Disturbances on the front (waves), sometimes amplify and deepen to form the large scale depressions of the middle latitudes.

These depressions often move north eastwards across the North Atlantic and pass to the northwest of Ireland. Ahead of the depression centres, warm moist air is swept northwards while behind them colder, drier air is swept southwards. This gives the sequence of cloudy, humid weather with rain, followed by brighter, colder weather with showers so typical of the Irish climate (Met Éireann, 2021).

3.2 Materials and Methods

3.2.1 Instrumentation

Quotes were sought for various options and cost effective professional grade sensors were obtained from Tempcon Instrumentation Ltd (Table 2). These are long endurance self logging instruments with a universal fitment optical RS232 interface for set up and download.

Table 2. Sensors deployed and general specifications.

Supplier: Tempcon Instrumentation Ltd, Ford Lane Business Park, Ford, West Sussex, BN18 0UZ, UK, Tel: +44 (0)1243 558270, www.tempcon.co.uk		
(a) Soil temperature		Operation range: *-20° to 70°C (-4° to 158°F) in air; maximum sustained temperature of 30°C (86°F) in water* Accuracy: ±0.21°C from 0° to 50°C (±0.38°F from 32° to 122°F) Resolution: 0.02°C at 25°C (0.04°F at 77°F) Stability (drift): 0.1°C (0.18°F) per year
(b) Air temperature and relative humidity		Operation Range 0 to 100% RH, -40° to 70°C (-40° to 158°F). Exposure to conditions below -20°C (-4°F)
(c) PC Interface		USB interface reader with adapters for a range of sensors. Optical communication.

3.2.1.1 Instrument configuration and set up

The instruments were installed in the various locations as shown in Figure 2, and field data staff were equipped with operating procedures and interface hardware. A certain amount of disassembly out of the radiation shields (to avoid the temperature effects of direct sunlight and resultant errors) was required for data download, but this was kept to a practical minimum.

(a)

Air temperature and relative humidity sensors were installed in a covered growing area. The instrument housings (designed to monitor shade values) were attached to a convenient mounting point on an area where air could circulate freely.

Air temperature and relative humidity installed at an open field site. The instrument housings (designed to monitor shade values) were attached approximately 24 inches above ground to a fence post.

(b)

The soil temperature monitors were buried at 10cm depth adjacent to the air temperature (plus RH) sensor mounting post. Care was taken such that the outside monitors were not located where the ground could become saturated with standing water.

Figure 2. Methods of deployment for (a) air temperature and relative humidity sensors and (b) soil temperature sensors.

3.2.1.2 Sensor deployed locations

The sensors were deployed at the various sites as indicated in Table 3.

Table 3. Deployed sensor monitoring sites/locations.

Instrument serial number	Location	Monitoring started	Monitoring ended
Soil temperature monitoring sites × 11 sensors			
20403934	Knockroe House	09/02/18 14:13:56	10/29/20 10:13:56
20417228	Gorse Farm	12/11/18 17:08:35	12/01/20 13:08:35
20403938	Nurney House	07/24/18 19:50:57	06/16/20 08:50:57
20403937	Shalom House	08/26/18 09:23:47	11/10/20 15:23:47
20403935	Ballysax	07/26/18 21:04:28	01/25/21 13:04:28
20403930	Kilbrack	08/26/18 09:22:01	02/26/21 15:22:01
20403932	Moyleabbey	07/26/18 21:01:54	11/03/20 10:01:54
20403936	Caherlea	09/02/18 14:13:12	03/11/21 12:13:12
20403929	Ballinroan	7/17/18 19:27:37	1/25/21 09:27:37
20403928	Beechlawn	07/31/18 20:45:32	03/03/21 10:45:32
20403933	Riverside Farm	09/02/18 14:10:26	03/16/21 14:10:26
Temperature and relative humidity monitoring outside (co-located with soil temperature) × 11 sensors			
20420783	Riverside Farm	08/26/18 09:19:14	03/16/21 13:19:14
20444616	Knockroe House	09/02/18 13:46:49	10/29/20 09:46:49
20420784	Gorse Farm	12/11/18 17:12:17	12/01/20 13:12:17
20420776	Nurney House	07/24/18 19:52:48	06/16/20 07:52:48
20420771	Shalom House	08/26/18 09:20:39	11/10/20 15:20:39
20420773	Kilbrack	08/26/18 09:29:10	12/16/20 11:29:10
20420777	Moyleabbey	07/26/18 20:12:19	11/03/20 08:12:19
20425802	Caherlea	09/02/18 13:54:18	03/11/21 11:54:18
20420785	Ballinroan	07/26/18 20:22:12	01/25/21 08:22:12
20420786	Beechlawn	07/26/18 20:11:23	03/03/21 10:11:23
20444617	Ballysax	02/10/19 17:28:07	01/25/21 11:28:07
Temperature and relative humidity monitoring under cover (e.g., In a greenhouse) × 10 sensors			
20420775	Nurney House	07/24/18 20:07:39	06/16/20 09:07:39
20420770	Moyleabbey	07/26/18 20:12:19	11/03/20 08:12:19
20420767	Beechlawn	07/31/18 20:37:33	03/03/21 10:37:33
20420784	Gorse Farm	12/11/18 17:12:17	12/01/20 13:12:17
20420766	Caherlea	07/24/18 19:52:48	01/12/21 03:52:48
(replaced by) 20534520		11/30/20 15:34:31	03/11/21 11:34:31
20425803	Kilbrack	09/02/18 13:51:29	12/16/20 09:51:29
20420781	Shalom House	08/17/18 17:45:19	11/10/20 13:45:19
20420772	Riverside Farm	08/26/18 09:12:56	03/16/21 15:12:56

3.2.2 Data collection

3.2.2.1 Periodic data downloading regime

The MOPS project farms were widely geographically distributed so downloading data was undertaken contemporaneously with the farm visits by project staff. The battery life of the sensors was 5 years at the monitoring frequency chosen (every 4 hours), so downloading was simplified by the operators downloading the entire file each time and then emailing it in to a nominated email address for onward processing. Two software suites were used (Table 4): firstly 'Hoboware' which is the manufacturers software for set up and download with display functionality and, secondly Python, where scripts were developed for batch processing, data manipulation and creation of reports. The scripts are included in Appendix 2 section 8.

Table 4. Softwqre used for instrument / data management.

Instrument Manufacturers software  www.tempcon.co.uk	Highly developed interface and processing software. Used for download and intial display.
www.python.org	Command line programming language used as a development environment to read in data files, re-format and process for collation and reporting.

3.2.2.2 3.3.2 Data File formats

The files were processed as single complete records from each monitor as follows, with header formats described in Table 5:

Level 1 – Raw files downloaded from the instruments

Level 2 – Files exported from HOBOware (not archived as easily recreated)

Level 3 – Files processed through python.

Table 5 Level 3 file header structures.

(a) Soil temperature (ST)
Line no, mm,dd,yyy,hh,mm,s,sdy,decsdy,temp,end of day flag,Avg Daily temp,time increment,line no,spare,spare,spare,time increment,spare
(b) Soil temperature and relative humidity (TRF), both in field and under cover (TRFH)
Line no, mm,dd,yyy,hh,mm,s,sdy,decsdy,temp,end of day flag,Abg Daily temp,time increment,line no,spare,spare,spare,time increment,spare,,RH avg daily, RH Dailly,spare

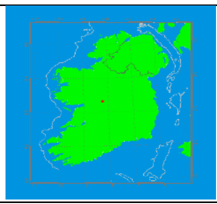
3.3 Results

The results for each monitoring site are provided in Appendix 2 section 8, which consist of the raw and processed data files and a summary report. A sample report is discussed in this section relating to data collection and display of various parameters for Beechlawn Farm.

Through consultation, a number of standard fields were added to the files during processing. In the case of soil temperature, this was the daily average value. In the case of open field temperature, the value of interest was the average and minimum daily values. In the case of covered growing areas, average daily air temperatures together with maximum and minimum relative humidity were and added to the data files using the python scripts.

Summary reports were provided for review at regular points throughout the project to coincide with project meetings to enable participants to consider the data and feedback. Charts provided followed the theme of the annual cycle so correspond with seasonal succession. Feedback was incorporated into the approach taken and any data requests were serviced.

3.3.1 Example summary reports

Beechlawn Farm Data summary		
Soil temperature sensor 20403928	Outside temperature and relative humidity sensor 20420786	Covered area temperature and humidity sensor 20420767

Timeline

In order to facilitate the processing of the timeline for some of the graphics presented below which are based on decimal synchronous day of the year (SDY), where January 1st is day 1.0 and December 31st is day 365.0 (account is taken for leap years, in the case of MOPS this was 2020).

The table below shows the day of the year and corresponding actual dates. The data files produced retain the date also broken out into mm,dd,yyyy,hh,mm,ss.

Data summaries for the duration of the project (3 years) are formatted for presentation here in two ways, (1) as time series plots generated by the instrument manufacturers software (Onset Hoboware v 3.7.21), and (2) as year on year summary plots using Python (v 3.7.6) where the data is plotted against decimal SDY.

SDY CHART - NORMAL YEAR

JAN		FEB		MAR		APR		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC	
	SDY		SDY		SDY		SDY		SDY		SDY		SDY		SDY		SDY		SDY		SDY		SDY
1	1	1	32	1	60	1	91	1	121	1	152	1	182	1	213	1	244	1	274	1	305	1	335
2	2	2	33	2	61	2	92	2	122	2	153	2	183	2	214	2	245	2	275	2	306	2	336
3	3	3	34	3	62	3	93	3	123	3	154	3	184	3	215	3	246	3	276	3	307	3	337
4	4	4	35	4	63	4	94	4	124	4	155	4	185	4	216	4	247	4	277	4	308	4	338
5	5	5	36	5	64	5	95	5	125	5	156	5	186	5	217	5	248	5	278	5	309	5	339
6	6	6	37	6	65	6	96	6	126	6	157	6	187	6	218	6	249	6	279	6	310	6	340
7	7	7	38	7	66	7	97	7	127	7	158	7	188	7	219	7	250	7	280	7	311	7	341
8	8	8	39	8	67	8	98	8	128	8	159	8	189	8	220	8	251	8	281	8	312	8	342
9	9	9	40	9	68	9	99	9	129	9	160	9	190	9	221	9	252	9	282	9	313	9	343
10	10	10	41	10	69	10	100	10	130	10	161	10	191	10	222	10	253	10	283	10	314	10	344
11	11	11	42	11	70	11	101	11	131	11	162	11	192	11	223	11	254	11	284	11	315	11	345
12	12	12	43	12	71	12	102	12	132	12	163	12	193	12	224	12	255	12	285	12	316	12	346
13	13	13	44	13	72	13	103	13	133	13	164	13	194	13	225	13	256	13	286	13	317	13	347
14	14	14	45	14	73	14	104	14	134	14	165	14	195	14	226	14	257	14	287	14	318	14	348
15	15	15	46	15	74	15	105	15	135	15	166	15	196	15	227	15	258	15	288	15	319	15	349
16	16	16	47	16	75	16	106	16	136	16	167	16	197	16	228	16	259	16	289	16	320	16	350
17	17	17	48	17	76	17	107	17	137	17	168	17	198	17	229	17	260	17	290	17	321	17	351
18	18	18	49	18	77	18	108	18	138	18	169	18	199	18	230	18	261	18	291	18	322	18	352
19	19	19	50	19	78	19	109	19	139	19	170	19	200	19	231	19	262	19	292	19	323	19	353
20	20	20	51	20	79	20	110	20	140	20	171	20	201	20	232	20	263	20	293	20	324	20	354
21	21	21	52	21	80	21	111	21	141	21	172	21	202	21	233	21	264	21	294	21	325	21	355
22	22	22	53	22	81	22	112	22	142	22	173	22	203	22	234	22	265	22	295	22	326	22	356
23	23	23	54	23	82	23	113	23	143	23	174	23	204	23	235	23	266	23	296	23	327	23	357
24	24	24	55	24	83	24	114	24	144	24	175	24	205	24	236	24	267	24	297	24	328	24	358
25	25	25	56	25	84	25	115	25	145	25	176	25	206	25	237	25	268	25	298	25	329	25	359
26	26	26	57	26	85	26	116	26	146	26	177	26	207	26	238	26	269	26	299	26	330	26	360
27	27	27	58	27	86	27	117	27	147	27	178	27	208	27	239	27	270	27	300	27	331	27	361
28	28	28	59	28	87	28	118	28	148	28	179	28	209	28	240	28	271	28	301	28	332	28	362
29	29			29	88	29	119	29	149	29	180	29	210	29	241	29	272	29	302	29	333	29	363
30	30			30	89	30	120	30	150	30	181	30	211	30	242	30	273	30	303	30	334	30	364
31	31			31	90			31	151			31	212	31	243			31	304			31	365

SDY CHART - LEAP YEAR

JAN	SDY	FEB	SDY	MAR	SDY	APR	SDY	MAY	SDY	JUNE	SDY	JULY	SDY	AUG	SDY	SEPT	SDY	OCT	SDY	NOV	SDY	DEC	SDY
1	1	1	32	1	61	1	92	1	122	1	153	1	183	1	214	1	245	1	275	1	306	1	336
2	2	2	33	2	62	2	93	2	123	2	154	2	184	2	215	2	246	2	276	2	307	2	337
3	3	3	34	3	63	3	94	3	124	3	155	3	185	3	216	3	247	3	277	3	308	3	338
4	4	4	35	4	64	4	95	4	125	4	156	4	186	4	217	4	248	4	278	4	309	4	339
5	5	5	36	5	65	5	96	5	126	5	157	5	187	5	218	5	249	5	279	5	310	5	340
6	6	6	37	6	66	6	97	6	127	6	158	6	188	6	219	6	250	6	280	6	311	6	341
7	7	7	38	7	67	7	98	7	128	7	159	7	189	7	220	7	251	7	281	7	312	7	342
8	8	8	39	8	68	8	99	8	129	8	160	8	190	8	221	8	252	8	282	8	313	8	343
9	9	9	40	9	69	9	100	9	130	9	161	9	191	9	222	9	253	9	283	9	314	9	344
10	10	10	41	10	70	10	101	10	131	10	162	10	192	10	223	10	254	10	284	10	315	10	345
11	11	11	42	11	71	11	102	11	132	11	163	11	193	11	224	11	255	11	285	11	316	11	346
12	12	12	43	12	72	12	103	12	133	12	164	12	194	12	225	12	256	12	286	12	317	12	347
13	13	13	44	13	73	13	104	13	134	13	165	13	195	13	226	13	257	13	287	13	318	13	348
14	14	14	45	14	74	14	105	14	135	14	166	14	196	14	227	14	258	14	288	14	319	14	349
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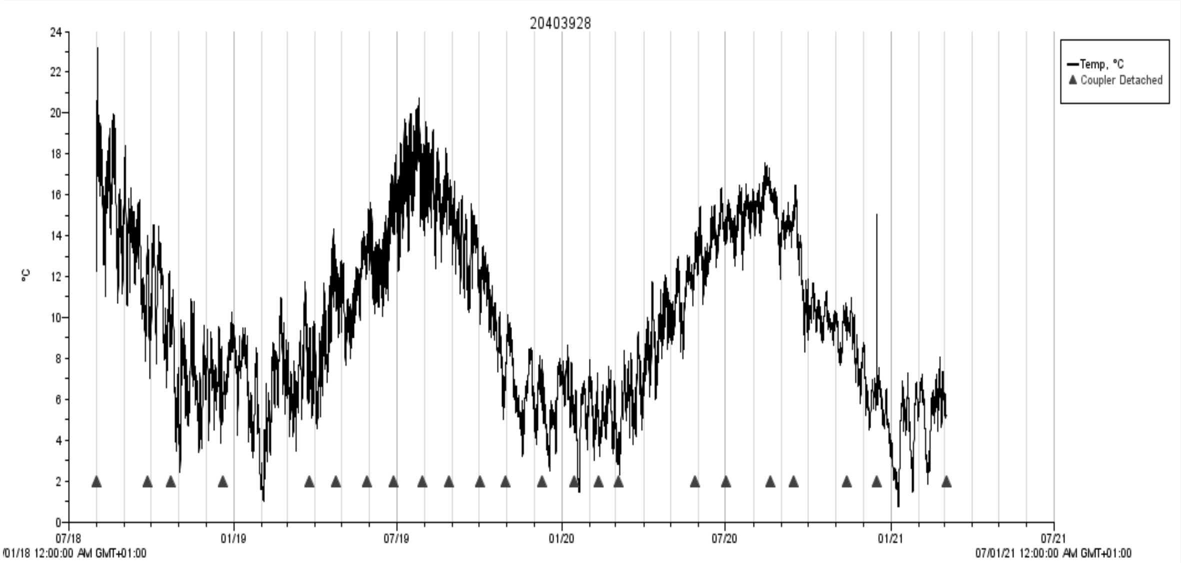
18	18	18	49	18	78	18	109	18	139	18	170	18	200	18	231	18	262	18	292	18	323	18	353
19	19	19	50	19	79	19	110	19	140	19	171	19	201	19	232	19	263	19	293	19	324	19	354
20	20	20	51	20	80	20	111	20	141	20	172	20	202	20	233	20	264	20	294	20	325	20	355
21	21	21	52	21	81	21	112	21	142	21	173	21	203	21	234	21	265	21	295	21	326	21	356
22	22	22	53	22	82	22	113	22	143	22	174	22	204	22	235	22	266	22	296	22	327	22	357
23	23	23	54	23	83	23	114	23	144	23	175	23	205	23	236	23	267	23	297	23	328	23	358
24	24	24	55	24	84	24	115	24	145	24	176	24	206	24	237	24	268	24	298	24	329	24	359
25	25	25	56	25	85	25	116	25	146	25	177	25	207	25	238	25	269	25	299	25	330	25	360
26	26	26	57	26	86	26	117	26	147	26	178	26	208	26	239	26	270	26	300	26	331	26	361
27	27	27	58	27	87	27	118	27	148	27	179	27	209	27	240	27	271	27	301	27	332	27	362
28	28	28	59	28	88	28	119	28	149	28	180	28	210	28	241	28	272	28	302	28	333	28	363
29	29	29	60	29	89	29	120	29	150	29	181	29	211	29	242	29	273	29	303	29	334	29	364
30	30			30	90	30	121	30	151	30	182	30	212	30	243	30	274	30	304	30	335	30	365
31	31			31	91			31	152			31	213	31	243			31	305			31	366

1. Soil temperature sensor 20403928

(a)



1. Soil temperature sensor 20403928
(b)

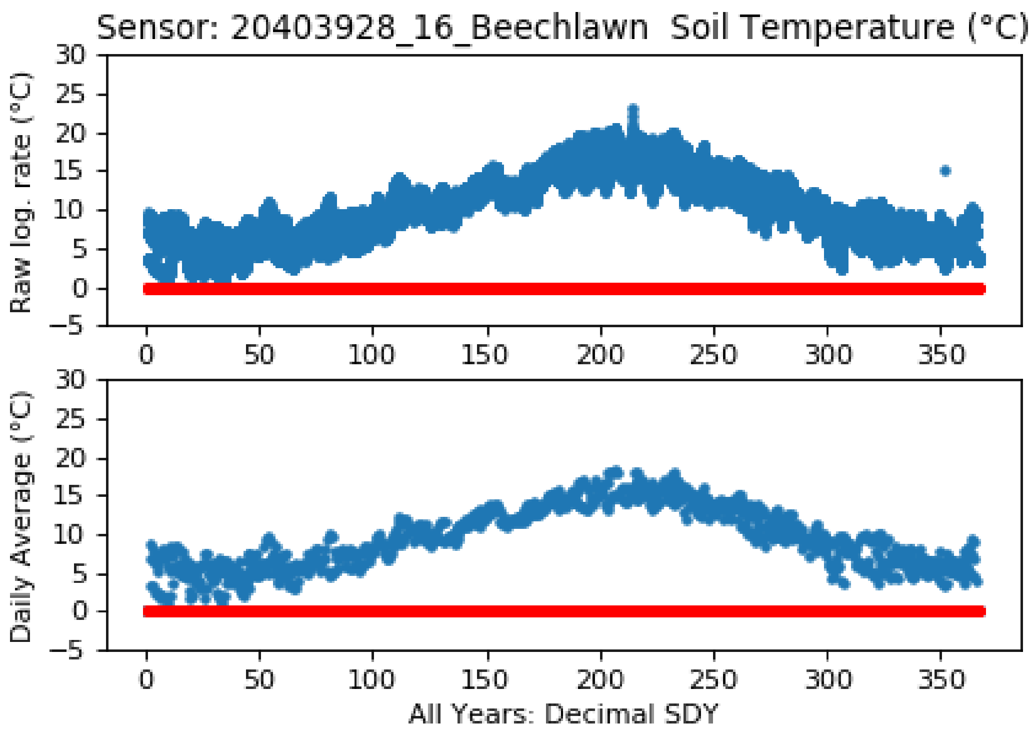
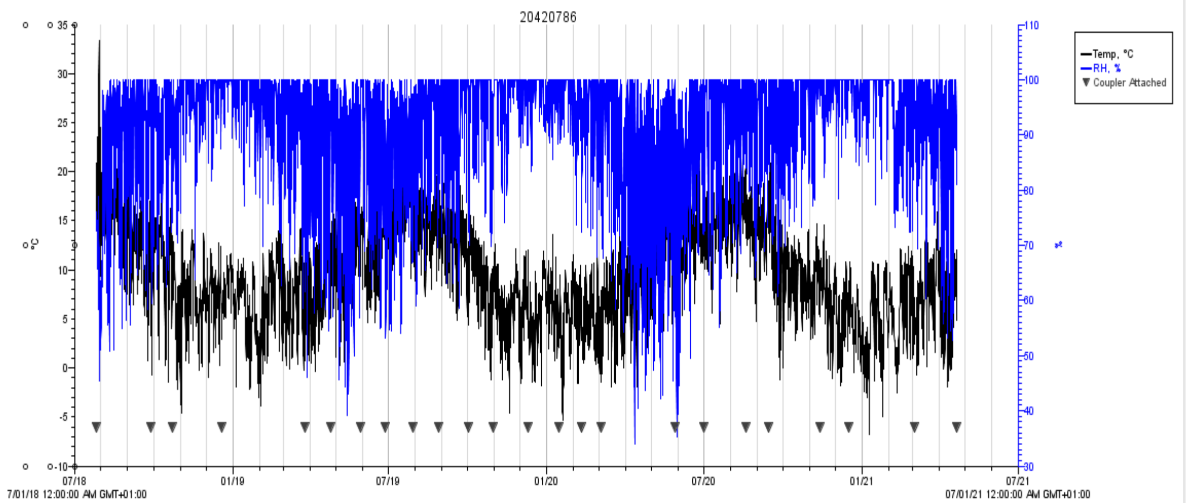


Figure 3 (a) Soil temperature time series data summary for the duration of the project, also shown (arrow heads) are the intervals when the sites were visited for data download (b) soil temperature time series overlaid year on year (upper plot) and average soil temperature data summary since the monitoring began (Lower plot). The 0°C line is in red.

2. Outside temperature and relative humidity sensor 20420786
(a)



2. Outside temperature and relative humidity sensor 20420786

(b)

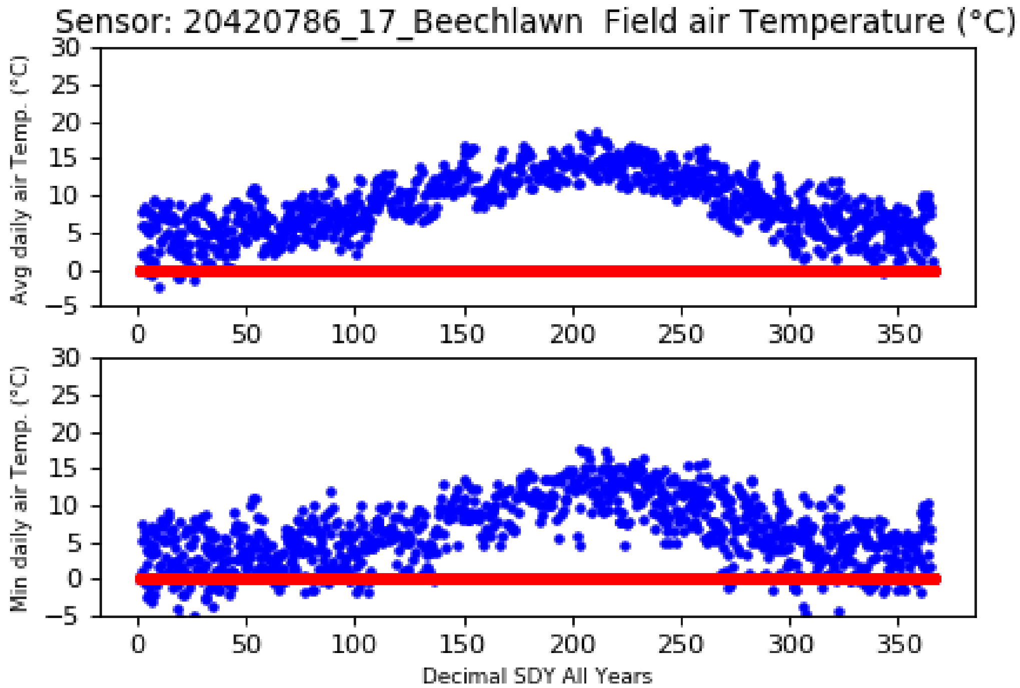
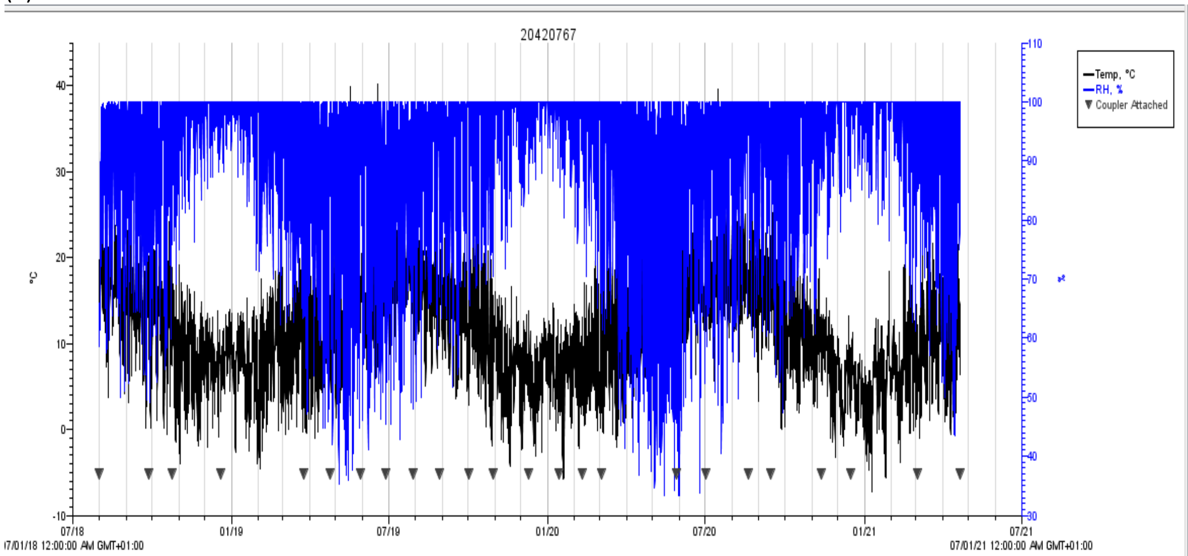


Figure 4 (a). Open field air and relative himidity time series data summary for the duration of the project, also shown are the intervals when the sites were visited for data download (arrow heads). (b) Average daily air temperature data overlaid year on year (upper plot) and minimum air tempearture data summary since the monitoring began (Lower plot). It can be seen where air temperature dips below 0°C (red line).

3. Covered area temperature and humidity sensor 20420767

(a)



3. Covered area temperature and humidity sensor 20420767
(b)

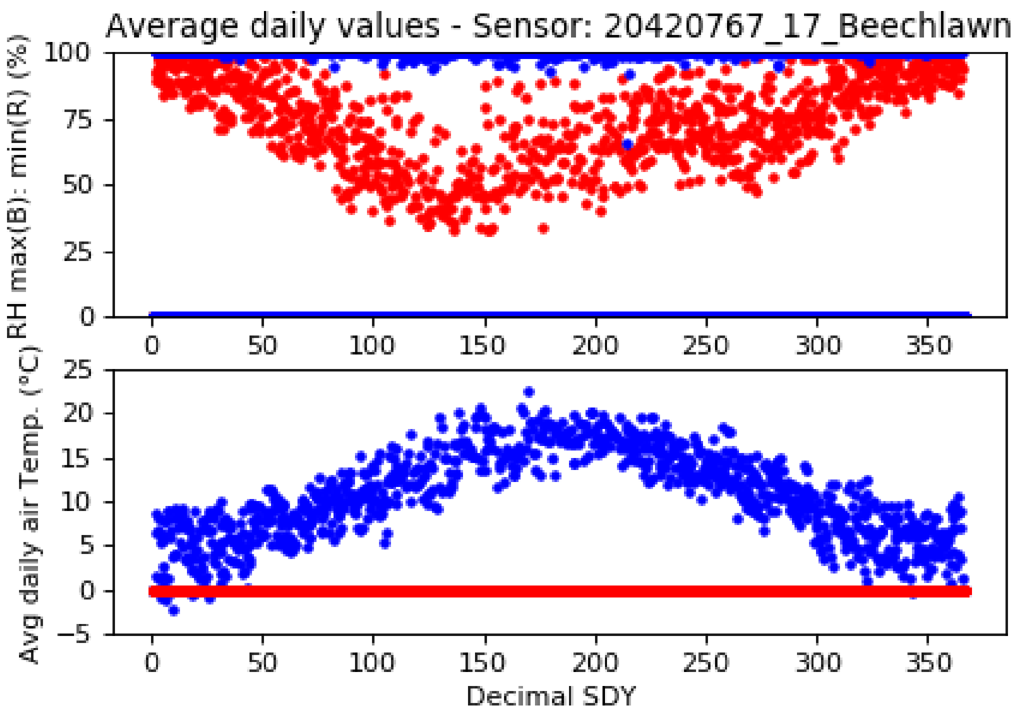
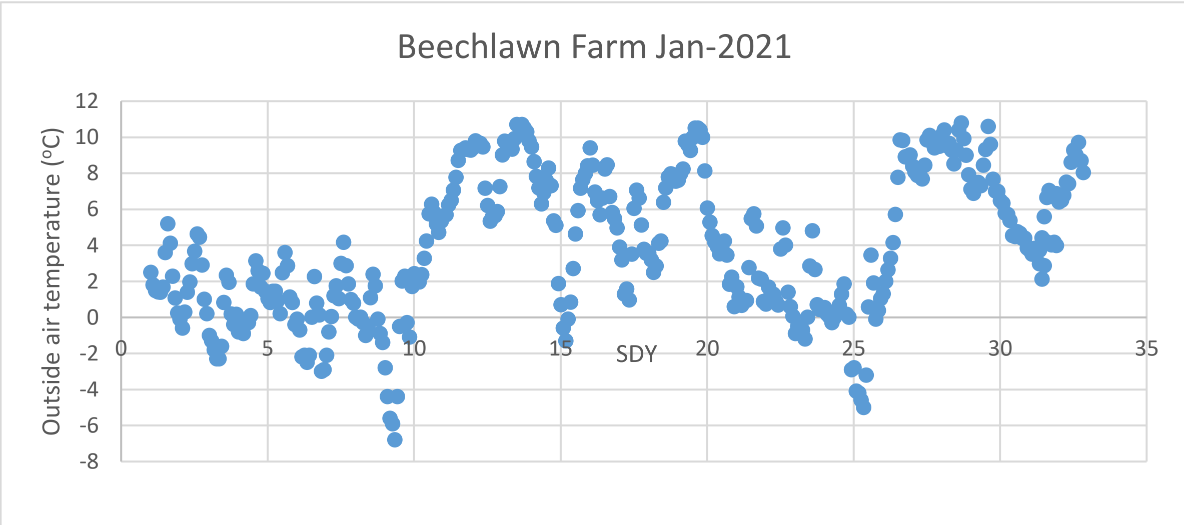


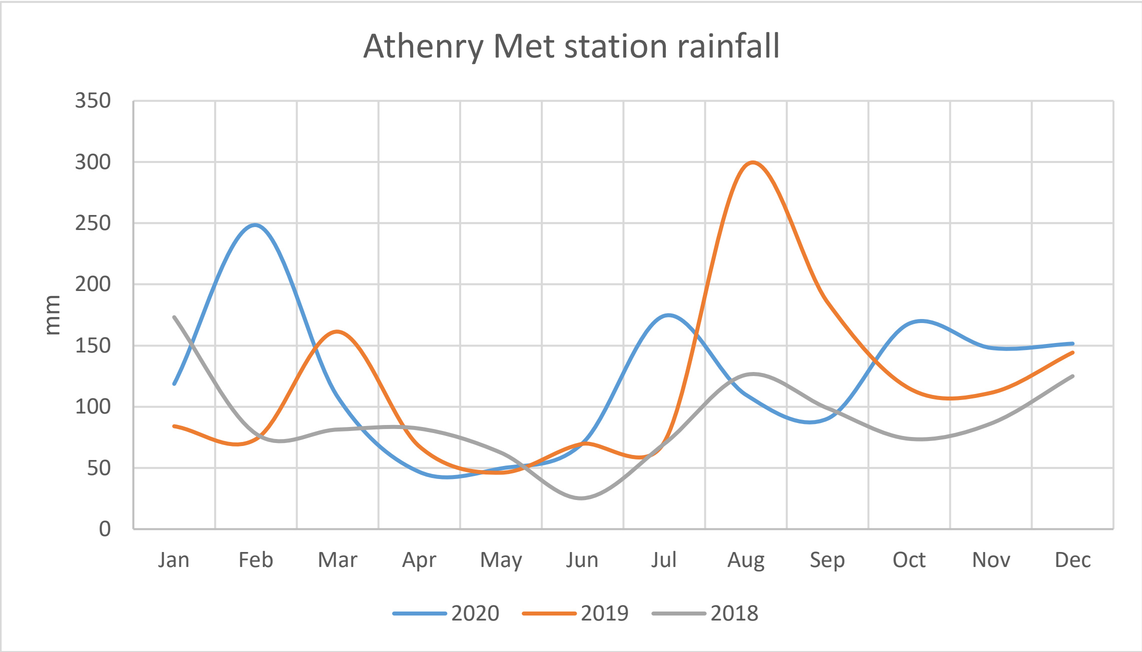
Figure 5 (a) Under cover air temperature and relative humidty time series data since observations started where the farms had indor gorowing areas, also shown are the intervals when the sites were visited for data download, (b) Minimum and maximum raltive humidity observed during the period of observation (upper plot) and average daily air temperature observed (lower plot). The 0°C line is in red.

(a)



Lowest daily air temperatures recorded in the month of January 2021.

(b)



Total annual rainfall on all farms for the periods 2020, 2019 and 2018 (data taken from www.met.ie).

Figure 6. Sample data made available by the growing team.

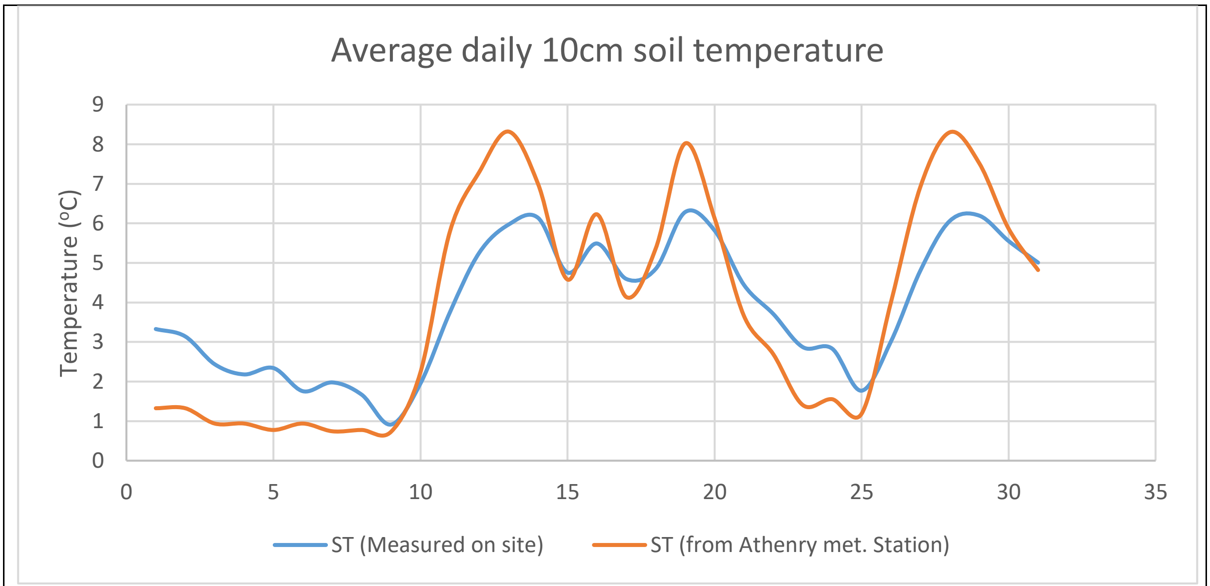


Figure 7. Comparison of local (Beechlawn Farm) measured soil temperature and soil temperature measured at a nearby weather station during January 2021 (data from www.met.ie).

3.4 Discussion, conclusions and future work

The objective of the MOP project relating to monitoring climate/weather on the project farms was met, with data of a known quality collected at the various locations with a high rate of data return. As well as a cost effective option, the sensors chosen proved to be robust and straight forward to use, with operatives quickly becoming familiar with their operation. Processes put in place for the rolling batch data analysis and data management proved effective.

Following on from a discussion at a project horticultural team meeting (02/02/2021) various data were considered of interest: (i) Lowest daily air temperatures recorded on all farms in the period from the 8th-30th of May 2020 both indoor and outdoor; (ii) Lowest daily air temperatures recorded on all farms, in a period from Mid- end November 2020; (iii) Lowest daily air temperatures recorded on all farms in the month of January 2021, both indoors and outdoors; and (iv) Total annual rainfall on all farms for the periods 2018-2019; 2019-2020; 2020-2021.

These data were readily recovered from the data files and were reported back to the group for consideration, albeit after the fact, e.g., items (iii) and (iv) are illustrated in Figure 6 for Beechlawn Farm.

The exercise whereby data were being collected locally was considered worthwhile to obtain an insight with time into local conditions. However, with a proliferation of synoptic weather stations distributed within Ireland a short period of data were collated to indicate how effective this exercise could be compared, say, to relying solely on the Met Éireann network.

Data displayed in Figure 7 show a time series comparison of daily soil temperature averages for January 2021 at Beechlawn Farm and the Athenry Met Station. There are two immediately apparent aspects to these data where the general temporal pattern can be seen to coincide, but the values vary significantly in terms of magnitude (R^2 = 2.63). This would indicate that there is value in augmenting the national network with local observation.

It was noted the relative humidity in the growing areas varies very significantly, typically with a seasonal pattern to the observational as would be expected in a temperate maritime climate. It could be the case that in some instances growing spaces could be optimised if real time data were to be used as part of a control system regulating ventilation.

The devices deployed are available with enhanced functionality such as wireless data availability and real time display. It would be cost effective to include this kind of functionality where it would add useful a useful record and monitoring tool to growers.

3.5 References

Met Éireann, 2021. *Climate of Ireland.* [Online] Available at: https://www.met.ie/climate/climate-of-ireland [Accessed 12 July 2021].

4 Green manure field trials

The role of short-term green manures in organic vegetable production in Ireland

4.1 Introduction

"Green manures" are crops specifically sown to be incorporated into the soil to improve soil structure and fertility by increasing the organic matter content of the soil. They can also serve a myriad of other purposes, such as soil surface protection to prevent crusting ("cover crops"), interception of soil nutrients, particularly nitrate, to reduce leaching losses ("catch crops"), and suppression of weeds, but all will be grouped here under the heading of "green manures".

4.1.1 Types of green manure

There are three main types of green manure: long-term green manure, short-term summer green manures and short-term winter green manures. Long-term green manures are grown for at least one year before incorporation, with the principal aims of increasing the nitrogen content and improving the structure of the soil. They were widely used in conventional agriculture before the advent of chemical fertilisers but are still important on organic farms, being particularly appropriate during the initial conversion period to organic production or to increase soil fertility and are of particular value on stockless organic farms. Long-term green manures are currently by far the most widely used green manures.

Short-term green manures, on the other hand are relatively recent innovations, designed to be grown for 2-4 months (summer green manures) or 6-8 months (winter green manures) between two successive cash crops, to make protective use of the land, rather than leave it fallow, with the risks that that entails.

4.1.2 Effects of green manures

4.1.2.1 Increased soil organic matter

All green manures contribute organic matter to the soil, as the incorporated plants (both tops and roots) decompose. This provides a reservoir of nutrients, increases the water-holding capacity, especially of light soils, improves the drainage of heavy soils, reduces soil crusting, and encourages earthworms and beneficial fungi and bacteria in the soil. Plants with high biomass, e.g., white mustard, fodder radish, buckwheat, grazing rye, oats, phacelia, are particularly effective at supplying organic matter.

4.1.2.2 Increased soil nitrogen (N)

Soil N can be increased by including N-fixers, N-lifters, or catch crops in the green manures. N-fixers are legumes, like the clovers, vetch, lucerne, and medicks, which host specific bacteria in their roots, which can convert atmospheric N into forms plants can use, at rates of 200 kg N per ha or higher (e.g., red clover), although long-term green manures (at least one year) are needed for clovers, etc.to perform optimally. The bacteria for most clovers will be present in any Irish soil, apart from very acid soils, but not those for lucerne and sweet clover, for which the soil will need to be inoculated each year with commercial inoculum. Short-term green manures containing fast-growing annual legumes, such as crimson, Egyptian or Persian clovers, can provide a boost to soil N but need to be growing at temperatures of at least 8°C for at least 12 weeks to achieve significant N fixation, e.g., short-term summer green manure/April to August. N-lifters are green manure plants with very long/extensive root systems, such as grazing rye, buckwheat, or Westerwolds ryegrass, which can take up N from deep in the soil horizon and deposit it, following green manure incorporation, in the upper horizons, where crops can access it. Finally, in terms of green manure crops to improve the soil N balance, are fast-growing annual plants, e.g., grazing rye, mustard, phacelia, in short-term green manures, which can take up any nitrate released from soil reserves in bare ground as the soil warms up, and which would otherwise be leached away by rainfall.

The N in all three of these types of N-beneficial green manures will be released when the green manure is incorporated. A legume-only green manure will release N almost immediately, making it suitable for growing N-hungry brassica or potato crops, whereas a grass/legume green manure, e.g., ryegrass/clovers, will release the N later in the season, being more suitable for organic cereals

4.1.2.3 Increased soil mineral content.

Plants with long root systems can also "lift" minerals like calcium, phosphorus, potassium from deep in the soil horizon where they are not usually available to the cash crops. Buckwheat is capable of attracting phosphorus to its roots, making this difficult-to-access macronutrient more available to subsequent cash crops.

4.1.2.4 Improved soil structure

Green manure plants with long and/or extensive root systems (e.g., rye, phacelia, buckwheat) improve soil structure by increasing aeration, and providing organic matter throughout the soil profile, as the roots decompose, whereas green manure plants with taproots, e.g., chicory, break up compacted soils and "pans" in longer-term green manures. On clay soils, the action of heavy rain on bare soil causes separation of the finer particles into a thin layer at the surface, which dries to form a crust which impedes the penetration of water and the emergence of crop seedlings. To prevent this, an annual cover crop green manure, such as mustard or phacelia, quickly forms a protective layer of leaves over the soil surface, while increases in near-surface soil organic matter content after green manure incorporation will also reduce the risk of soil surface crusting.

4.1.2.5 Improved pest, weed, disease management

Green manures can reduce weed populations in several ways. Fast-growing leafy green manure plants, such as mustard, phacelia, grazing rye, oats, vetch and buckwheat will suppress annual weeds by competing with them for light and other resources – by preventing weed flowering, the weed seed bank will be depleted. Prostrate-growing weeds, like chickweed, however, can survive under tall green manures such as buckwheat. As they decompose after incorporation, many green manure plants, particularly clovers, vetch and rye (not ryegrass, as much of the literature states), release allelopathic chemicals which prevent seed germination. This can help suppress weeds but can also inhibit germination of direct-drilled cash crops, so a longer delay after incorporation is recommended before small-seeded cash crops are direct drilled.

The presence of a short-term green manure crop can result in increased biodiversity, potentially resulting in increases in beneficial insects Although it is not advisable to allow green manures to flower, as decomposition after incorporation is slower and there is a risk of green manure seeds entering the seed bank, green manures with simple flowers, like mustard and phacelia, attract beneficial insects such as hoverflies, the larvae of which eat aphids and caterpillars.

A side-effect of green manures is that they can act as break crops against soil-borne pests and diseases, as long as plants unrelated to the intended cash crops are used. Buckwheat and phacelia are particularly valuable as they belong to plant families which contain no cash crops.

4.1.3 Single-species or mixed-species green manures?

Single-species green manures are usually restricted to fast-growing high-biomass short-term summer green manures, e.g., mustard or phacelia.

Because no one green manure plant can achieve all the beneficial effects possible (e.g., source of soil organic matter, improved soil structure, weed control, pest management), mixtures are often used, e.g., long-term green manures are commonly grass/clover mixes, combining the high biomass and deep rooting (to improve soil structure) of the grasses with the nitrogen-fixing ability of the clover.

In addition to the use together of individual green manures, each with different characteristics, complementarity is often selected, e.g., in summer or winter green manures using vetch as a N-fixing plant, better performance was achieved when the sprawling vetch was combined with a vertical green manure plant, such as rye (winter or summer green manures) or buckwheat (summer), over which the vetch could scramble.

In wild plant ecology or crop agronomy, it is recognised that the greater the species diversity in a plant population, the more stable and the higher yielding the population would generally be. A single-species green manure could fail completely, whereas some members of a mixed-species green manure would survive and would thrive as they had more space should one member species die out. In a crop population, the greatest competition for resources such as light, water and nutrients occurs between plants of the same species as they grow to the same height, root to the same level, etc. Compared to single-species “monocultures”, mixed-species intercrops often yield better (“intercropping advantage”), partly because they compete less with neighbouring plants. A long-term perennial ryegrass/red clover ley grown as a green manure intercrop would yield better than either red clover or ryegrass monocultures, with the N-fixing red clover being able to fix N, whereas the taller and deeper-rooted ryegrass would be able to access light, water and minerals better than the clover.

4.1.4 Green manures and modern-day organic farming systems

Short- or long-term green manures involve extra expense (green manure seed, particularly expensive if organic; diesel for ground preparation, sowing and green manure incorporation) and workload (site preparation, green manure topping, incorporation) which may give growers second thoughts as to the value of green manures. But, carried out properly, with selection of appropriate green manures, sowing dates and management regimes, green manures can provide long- and short-term benefits which exceed any immediate expenses.

Long-term green manures take land for cash crops out of production, but the benefits in terms of increased production in the next 2–3 crops over the medium term (largely, as N production. In addition, other beneficial effects of green manures (organic matter, soil structure, weed and pest control) should also be taken into account.

Short-term green manures tend to exploit soil which is already unproductive, between successive crops, meaning no loss of production, although sowing a winter legume-containing green manure in September, to maximise growth and N-fixing potential, may necessitate digging-in the last few plants of the vegetable cash crop. For organic vegetable enterprises, an additional restriction is caused by the dominance of brassicas among the cash crops, which prevents the use of brassicas as green manure crops, preventing the use of some of the widely used green manure crops, such as mustard and fodder radish.

4.1.5 Aims of research

The aim of this study was to carry out a multi-annual investigation of the effects of green manures (summer and winter) on organic vegetable production in Ireland. The “gold standard” for research studies on aspects of field crop agronomy is the use of multi-annual field trials, i.e., repeating the same field trials in the same site over at least two years, ideally over at least two different sites (i.e., multi-site trials). The MOPS green manure trials are being run on one field (at different sites) in Co. Wexford over three years. The reasoning behind the use of multi-annual trials is that, to be of value to growers, the effects being studied (e.g., the incorporation of summer or winter green manures on cash crop yield in the MOPS trials) need to be robust enough to be expressed despite changes in growing conditions, as would arise from year to year, e.g., hot, dry summer 2018.

This included the effects on yield and quality, soil properties (including nutrient and organic matter content), and biodiversity, including diseases, pest and weeds and beneficial organisms, as well as cost-benefit analysis of the effects of green manures on cash crops. No Irish-based research had been published on this topic to date, so the experiments were carried out over a 3-year period (2018-2021) in the same field on a mixed organic farm at Enniscorthy, Co. Wexford. The restrictions associated with the COVID-19 pandemic limited some of the planned studies.

4.2 Materials and methods

4.2.1 Trial site

The trials were carried out over three years (June 2018 - August 2021) on the organic mixed farm of Des Thorpe at Lacken, Enniscorthy, Co. Wexford (52°23’59.5”N 6°52’21.4”W). The soil on the site, which had been under grass for silage for a number of years, was sampled (to a depth of 20 cm) on 20 June 2018, using a W-shaped sampling strategy, with 25 samples taken which were pooled and determined to be a sandy loam, pH 5.9. Soil samples were taken twice in 2018: once before the summer green manure plots were sown and once two weeks after the summer green manures had been incorporated.

The 3000–4000 m^2 site for each trial was moved within the same field each year and had headlands (consisting of hawthorn, ash, sycamore, elder, brambles, ferns and tussocky grasses) to the S, W and N boundaries, with grassland to the E (Fig. 1).

Figure 1 MOPS green manure trial site showing four different short-term summer green manures 8 weeks after sowing. Tall, flowering green manure, e.g. bottom left, is buckwheat/phacelia.

The site was marked out in as 64 x (9 m x 7 m) plots, 32 for summer and 32 for winter green manures. The plots consisted of four different summer green manures (Table 1), with four replicate plots of each. The 32 individual 9 m x 7 m plots (four green manures, including the control, and two cash crops, with four replicates of each [green manure x cash crop] combination) were arranged in a completely randomised block design (summer green manure trial 2018) or a Latin Square design (other trials). The plots were ploughed and harrowed, seeded with a tractor-mounted Hatzenbichler seeder, and rolled. After 12 weeks growth, the vegetation in the individual green manure plots (including the control plots) were mulched with a tractor-mounted Rinieri mulcher, leaving a 0.5 m wide strip along the 9 m length as a refuge for beneficial insects, and incorporated into the soil. For the 32 summer green manure plots, three weeks after green manure incorporation, 16 plots were subsequently planted with winter cabbage (cv. Duncan; 28 plants per row, 60 cm inter-row spacing) as the cash crop and 16 with onion (cv. Element; 15 cm intra-row spacing, 60 cm inter-row spacing) as the cash crop. The cabbage plants were transplanted by hand and the onion plants were transplanted using a Checchi and Magli transplanter on 15/09/2018.

A similar design was used for the 4000 m^2 trial area containing the 32 winter green manure plots (Table 1), with transplants of broccoli and red oakleaf lettuce being hand planted as the two cash crops.

Table 1 Composition of the green manure seed mixes (Fruit Hill Farms, Bantry, Co. Cork)

Green manure	Composition	Ratio	Seeding rate (kg/ha)
	Control*	-	-
	Buckwheat/phacelia	60: 40	32
	Rye/phacelia	60: 40	67
Summer	Persian clover/Egyptian clover/Westerwold’s ryegrass	30: 30: 40	28.5
	Control*	-	-
	Vetch/crimson clover/Westerwold’s ryegrass (Landsberger)	30: 30: 40	65
	Rye/vetch	60: 40	160
Winter	Squarrose clover/crimson clover/vetch/Japanese oats/wild rye (Wild Atlantic Mix)	10: 10: 30: 20: 30	100

*In the control plots, the plots were ploughed, harrowed and rolled but no seed was sown, with weeds from the seed bank allowed to germinate and grow

4.2.2 Weed cover and green manure establishment

Total weed and % establishment of the individual green manure species cover were determined visually on three dates, using templates of 5, 10, 20, 30, 40, 50, 60, 70 and 80% cover on clear plastic as guides, with the mean value of six estimates taken from each plot. The number of dock plants per plot was also counted.

4.2.3 Crop development stage of summer green manure cash crops

The number of leaves on 30 plants from three randomly selected rows of either onion or cabbage was counted several times prior to harvesting in each plot, as a measure of plant development.

4.2.4 Ground beetle abundance

A pitfall trap consisting of one 500 ml plastic container (120 mm in diameter, containing 150 ml 40% ethanol) was dug into the soil in the centre of each plot, so that the top of the container was level with the soil (Fig. 2). Two days later, the contents of each trap was recovered, identified according to species and the number of individuals of each species was counted.

Figure 2 Pitfall traps.

4.2.5 Invertebrate diversity in green manure refuge

Pitfall traps were set up in 0.5 m-wide refuge strips after summer and winter green manure incorporation and in cash crop plots and ground beetle numbers were counted. Biodiversity was monitored in the refuge strips at intervals, using sweep nets (figure-of-eight sweeps) over 9-m distances in a 30-s period per plot, and the identity and numbers of beneficial predatory invertebrates (hoverflies, ladybirds, lacewings) was recorded.

4.2.6 Nutrient analyses

Pooled soil samples taken before and after summer green manure incorporation in 2018 (Section 2.1) were sent for nutrient analysis by Yara (Grimsby, UK). A sample of lettuce plants from each replicate plot was taken at harvest time, ten weeks after winter green manure incorporation in 2021, and analysed by Yara (Grimsby, UK).

4.2.7 Community Level Physiological Profiling (CLPP)

The CLPP tests in this experiment were carried out using BIOLOG Ecoplates^{TM} purchased from Biolog, Inc. (Hayward, CA, USA). Tetrazolium violet, a redox dye, is used to detect the utilisation of a variety of sole carbon sources by bacteria present in environmental samples. Each Ecoplate^{TM} contains ninety- six wells, divided into three replicate sets of thirty-one different carbon sources and one control well per set. These carbon sources include amines (e.g., phenylethylamine), amino acids (e.g., arginine and phenylamine), carbohydrates (e.g., lactose and xylose), carboxylic acids (e.g., galacturonic acid) and polymers (e.g., glycogen). All vessels along with micropipette tips were autoclaved. A subsample (10 g) was taken from each of the thirty-two soil samples. A 1:5000 dilution (by serial dilution) in Ringer's solution was set up for each of the 32 soil samples and a 150-µl aliquot was pipetted into each of the thirty-one BIOLOG Ecoplates wells per replicate. Each Ecoplate was individually wrapped in tinfoil and incubated in the dark at 25°C for seven days before optical density (OD; 590 nm) readings were recorded using a spectrophotometer microplate reader.

OD results were corrected by subtracting the OD value for the water blank from each replicate. OD results were used to calculate diversity indices: average well colour development (AWCD), richness (R) and Shannon index (H). The indices are calculated as follows:

$AWCD = \sum OD \div 31$

$R = \# \; OD > 0.25$

$H = -\sum p \; (\ln p)$

where p is the ratio of the activity on each substrate (OD) to the sum of activities on all substrates (OD). For richness (R), 0.25 was used as a threshold for a positive response. AWCD, richness and the Shannon index were analysed by ANOVA. Relationships among different samples on the basis of corrected OD values were determined by Principal Component Analysis (PCA) and Cluster Analysis (CA) using Multivariate Statistical Package (MVSP; Kovach Computing Services, www.kovcomp.com).

4.2.8 Pot trials to assess allelopathy of incorporated winter green manures

Soil was collected 14 days from trial plots after incorporation of each of the four green manures, placed into replicate 4" pots and transplants of red oakleaf lettuce, green oakleaf lettuce, butterhead lettuce, cabbage, spring onion and broad beans were transplanted Six weeks later, the fresh weight of the seedlings was weighed and recorded.

4.2.9 Statistical analysis

The distribution of each variable was assessed. For variables approximating to a normal distribution, parametric analysis of variance was used with Tukey's pairwise multiple comparison test. Where the variable distribution did not approximate to a normal distribution, non-parametric Kruskal-Wallis analysis was used.

4.3 Results

4.3.1 Site characteristics

The historically hot, dry conditions in June/July 2018 following seeding of the summer green manures necessitated irrigation using a tractor-mounted sprayer and a slurry tanker, but acceptable levels of green manure establishment were achieved from the three green manure mixes after four weeks. The restrictions imposed by COVID-19 regulations prevented field staff accessing the trial sites after March, with the result that some parameters could be measured only in the first year (2018-9) or the last summer (2021) of the trials.

4.3.2 Soil nutrient analyses (2018)

The original soil nutrient levels are presented in Table 2. Granular fertilisers were subsequently applied on 15/09/2018 by hand to raise the levels of K (sulphate of potash, 5 kg/plot) and P (rock phosphate, 5 kg/plot) to Index 2. Nutrient analysis was carried out in summer 2018 on the summer green manure plots representing the four different green manure treatments, including the non-planted controls, two weeks after incorporation of the green manure but before planting of the cash crops. Compared to the analysis of soil samples taken from the trial site before the green manures were sown ("Previous analysis"), all green manures (including the non-planted control, where weeds were allowed to grow) exhibited higher soil nutrient concentrations than in the pre-planting soil, with the exception of potassium which decreased in all the test plots (Table 3), particularly the control plots. Because potassium is not incorporated into organic matter and is highly soluble, a possible cause of the decrease in concentration could have been the irrigation carried out during the dry conditions of summer 2018.

The general trend was that, as predicted, the control plots exhibited among the lowest nutrient levels, although with respect to both nitrogen and magnesium there was no marked difference between any of the treatment plots.

Table 2 Soil analysis of original trial site.

Element	Concentration	Index
Phosphorus	0.6 ppm	1
Potassium	40 ppm	1
Magnesium	135 ppm	4
Calcium	1024 ppm	-
Manganese	117 ppm	-
Boron	0.89 ppm	-
Copper	4.9 ppm	-
Molybdenum	<0.01 ppm	-
Iron	554 ppm	-
Zinc	2.5 ppm	-
Sulphur	2.0 ppm	-
Sodium	25 ppm	-
CEC	8.9 meq/100 g	-
Organic matter (LOI)	4.4 %	-
Organic C	2.6 %	-
Total N	2314 mg/kg	-

Table 3 Effect of summer green manure incorporation on soil nutrient analysis.

Nutrient	Previous analysis	Control	Buckwheat/phacelia	Rye/phacelia	Clover/ryegrass
Total nitrogen (ppm)	2314	2980	3016	2694	2894
Phosphorus (ppm)	600	719	709	947	841
Potassium (ppm)	4000	2830	3206	3766	3242
Calcium (ppm)	1024	1628	2201	2338	1957
Magnesium (ppm)	1350	1995	1898	2053	2020
Organic matter (%)	1.63	1.65	2.02	1.93	1.78
Water (%)	-	18.1	18.0	17.1	18.2

The most successful of the green manures was the rye/phacelia green manure which exhibited the highest concentrations of phosphorus, potassium, calcium and magnesium, due presumably to the very long root system of rye which could harvest nutrients from deep in the soil profile; this green manure also exhibited the lowest total nitrogen (Table 3). Each of the three green manures (but not the control plots) exhibited higher soil OM content than did the soil before incorporation, with buckwheat/phacelia being the most effective followed by rye/phacelia.

Unexpectedly, the N-fixing clover/ryegrass green manure did not show any increased soil N, the reportedly P-scavenging buckwheat did not accumulate more phosphorus and the high biomass of the buckwheat/phacelia green manure did not increase the soil % water content, which would be expected from the effect of increased organic matter on water-holding capacity. The delayed start to the MOPS project meant that the green manures grew for only two months which could have resulted in the limited performances of the clover/ryegrass and buckwheat/phacelia green manures in increasing soil N and P, respectively.

Interestingly, the grower (D. Thorpe, personal communication) reported that, following incorporation of summer or winter green manures into the plots, the soil texture was markedly improved, with the soil in the green manure plots being more friable and easier to work than that in the control plots.

4.3.3 Plant nutrient analysis

The effect of winter green manures on nutrient accumulation was tested by measuring the nutrient content in the cash crop leaves. Here, lettuce plants were sampled at harvest time, ten weeks after green manure incorporation. In this case, all three winter green manures (which each contained N-fixing legumes, clovers or vetch) resulted in significant increases in N content (Table 4).

Table 4 Effect of winter green manures on macronutrient contents (%) in leaves of red oakleaf lettuce. Any two samples within a row with a common letter are not significantly different.

Nutrient	Wild Atlantic Mix	Vetch/Rye	Landsberger Mix	Control
N	4.95 b	4.90 b	5.03 b	4.55 a
P	0.35 a	0.41 a	0.40 a	0.35 a
K	5.35 c	4.57 a	5.15 bc	4.90 b
Mg	0.60 a	0.56 a	0.53 a	0.63 a
Ca	0.90 a	0.81 a	0.82 a	0.91 a

4.3.4 Green manure plant establishment (2018)

The green manures on the south half of the site grew markedly better than those in the north half. Overall, when the % cover by the green manures was estimated on 11/09/2018, the buckwheat/phacelia green manure achieved the highest ground cover, followed by the rye/phacelia and the clover/ ryegrass green manure (Fig. 3). The dominant crop in the green manures differed between the S and N parts of the trial site. In the rye/phacelia mixture, rye (58%) outperformed phacelia (22%) in the low-growth site, but phacelia (42%) outperformed the rye (28%) in the high-growth rate site. In the clover/ryegrass mix, the Egyptian clover (30%) outperformed the Persian clover (20%) under the high growth conditions, whereas the opposite occurred under the low-growth rate site (4% and 24%, respectively). Buckwheat outperformed the phacelia in both the low- (68 and 20%, respectively) and the high-growth rate sites (92 and 5%, respectively).

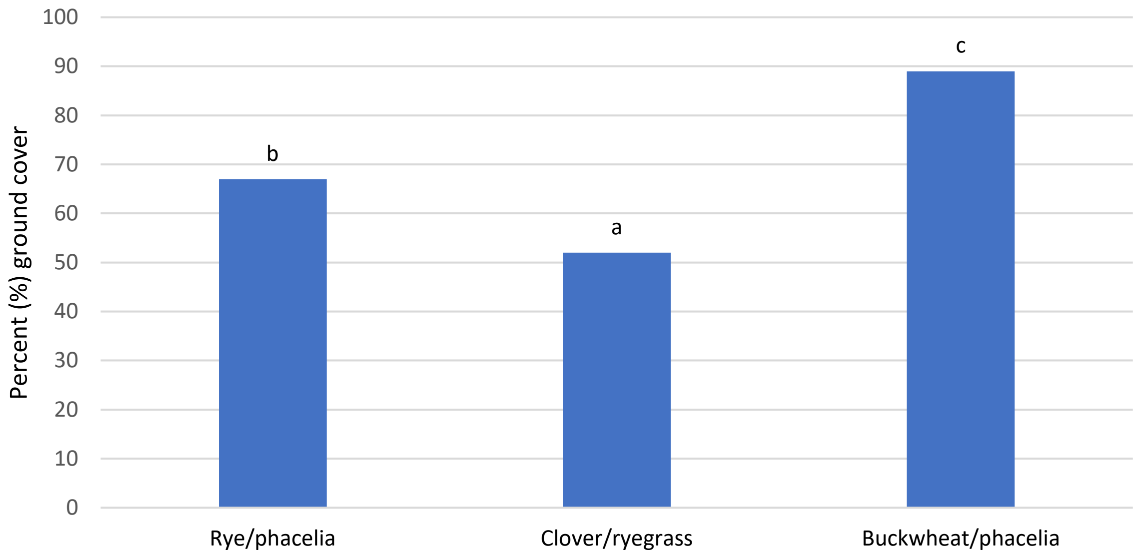


Figure 3 Percentage ground cover of the three summer green manure crops after 2 months in 2018. Any two samples with a common letter are not significantly different (P>0.05).

On 06/02/2019, there was a significant difference in soil area covered by the three winter green manures, with the Wild Atlantic mix having a significantly higher coverage than rye/vetch (due largely to the oats component of the former mix), which in turn was significantly higher than that of the Landsberger mix. By the second assessment on 27/02/2019, the differences had decreased, due to rapid growth of the Landsberger mix, the % cover of which was no longer significantly different from that of rye/vetch (Table 6), and the same trend, of rapidly increasing cover by the Landsberger green manure, was apparent at 20/03/2019, an observation supported by the percentage establishment values on 21/05/2019, where no significant difference in establishment between the three winter green manures was determined (Table 5) These results suggest that Landsberger mix requires an earlier autumn sowing date, whereas the Wild Atlantic mix is suitable for later-than-usual sowing of a winter green manure.

Table 5 Winter green manure establishment in 2019 (percentage soil cover). Any two samples within a row with a common letter are not significantly different.

Date	Landsberger mix	Rye/vetch	Wild Atlantic mix
06/02/2019	23 c	40 b	66 a
27/02/2019	40 b	52 b	71 a
21/05/2019	71 a	70 a	81 a

4.3.5 Weed management (2018-2020)

The main weed species in the trial site were the annuals corn spurrey, fumitory and charlock (Fig. 4) (from the seed bank) and the perennials dock and perennial ryegrass.

Corn spurrey **Fumitory** **Charlock**

Figure 4 Major annual weed species in trial site.

All three summer green manures achieved significant reductions in annual weed populations, compared to the control plot at 11/09/2018, with the buckwheat/phacelia mix resulting in the lowest weed cover (Fig. 5), with a significant negative relationship between green manure % cover and percentage weed cover (r=0.878, P<001). The green manures caused significant reductions in the population sizes of the annual weeds but had no significant effect on % cover of the perennial weeds.

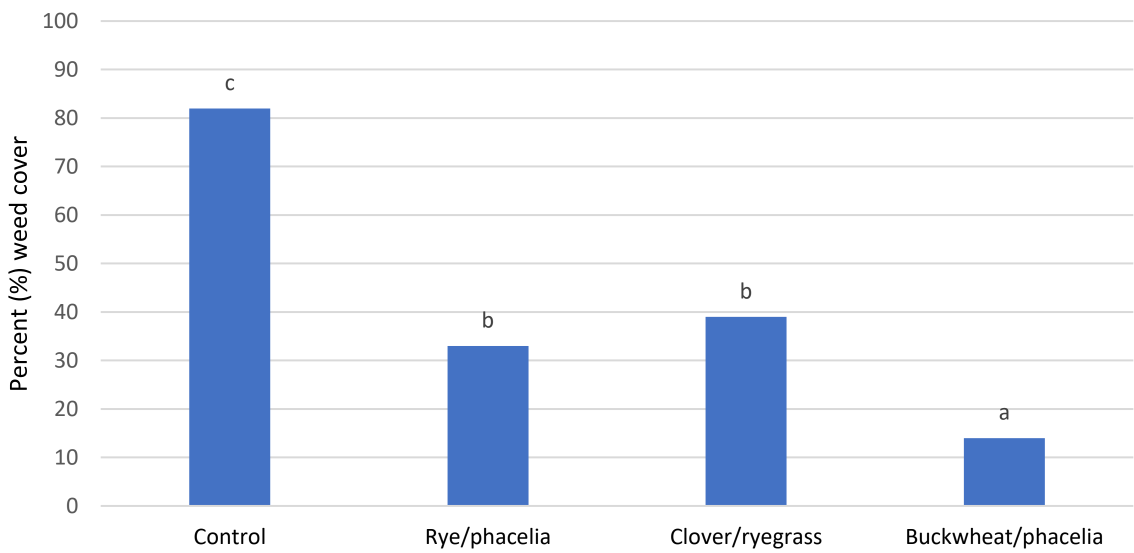


Figure 5 Percentage weed cover in the summer green manure plots after 2 months in 2018. Any two samples with a common letter are not significantly different (P>0.05).

After incorporation of each of the three summer green manures and transplantation of the onion and cabbage cash crops in October 2018, weed cover was determined on 27 February 2019. Annual weed cover was significantly lower in each of the green manure plots than in the control plots (Table 6), with the buckwheat/phacelia green manure being the most effective, reducing the annual weed density by almost 40% compared with the control. When the dock population *(Rumex* spp.) was assessed, it was observed that both the buckwheat/phacelia and the rye/phacelia green manures resulted in significant decreases in the dock population compared with the control plots (Table 7).

Table 6 Effect of incorporated summer green manures on weed cover. Any two samples within a row with a common letter were not significantly different.

	Clover/ryegrass	Rye/phacelia	Buckwheat/phacelia	Control
Total weed cover (% area)	30 b	34 b	27 b	46 a
Number of dock plants per plot	16 a	3 b	8 b	17 a

Possible explanations for this weed control include competition for light (and other resources) during the green manure phase, where the tall plants of the buckwheat/phacelia green manure reduced the number of annual weeds which flowered, reducing the soil seed bank, and allelopathic effects (particularly pre-emergence effects on weed seed germination) of decomposing green manure, an effect where rye is known to be particularly effective. The summer green manure plots were mechanically weeded on 27/02/2019, and then hand-weeded on 20/03/2019 to allow cash crop development.

Low annual weed seed germination at assessment on 27/02/2019 meant that there were no significant differences in weed cover between the four winter green manure treatments. On the other hand, the number of dock plants per plot was significantly affected by the composition of the green manure treatment when scored on 21/05 (Table 7), with both the Wild Atlantic mix and the rye/vetch mix supporting significantly fewer dock plants than in the control plots. Rye, a component common to both of these green manures, is known to release allelopathic chemicals from its roots, which can interfere with the growth of neighbouring plants; decomposing rye plants are reported to be highly active allelopathically.

Table 7 Effect of winter green manure treatments on the frequency of dock (*Rumex* sp.) plants (mean number per plot) (21/05/2019). Any two samples within a row with a common letter are not significantly different.

Landsberger mix	Rye/vetch	Wild Atlantic mix	Control
16.0 ab	5.8 b	6.8 b	22.3 a

4.3.6 Beneficial insect abundance (2018-2020)

To estimate the density of invertebrates in the different trial plots, 300 ml pitfall traps, each containing 30% ethanol, were set up in each trial plot and the insects trapped were collected 48 h later. The main beneficial insects trapped were the common ground beetles (Fig. 6), which feeds on pest species such as slugs and insect larvae. The number of ground beetles in the different summer green manures in 2018 was not associated with the green manure % cover, as the buckwheat/phacelia mix, producing the highest % green manure cover, harboured the fewest ground beetles, fewer even than the control plots (Fig. 7). Phacelia is usually regarded as a green manure which supports high populations of beneficial insects.

Figure 6 Common ground beetle.

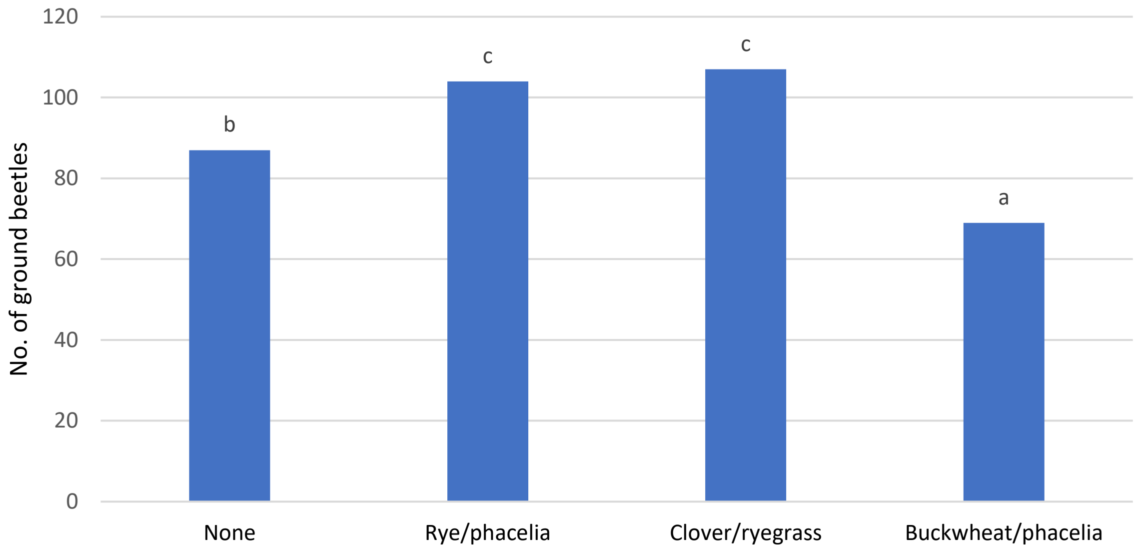


Figure 7 Number of ground beetles trapped in summer green manure crops after 2 months growth (2018). Any two samples with a common letter are not significantly different (P>0.05).

The numbers of ground beetles present in the summer green manure plots in 2019 were consistent with the 2018 data again higher than in the control plots, with a negative relationship between green manure height and ground beetle density, the tall buckwheat/phacelia plots supporting similar numbers to the control plots, and the short clover/ryegrass plots supporting the highest frequency (Fig. 8).

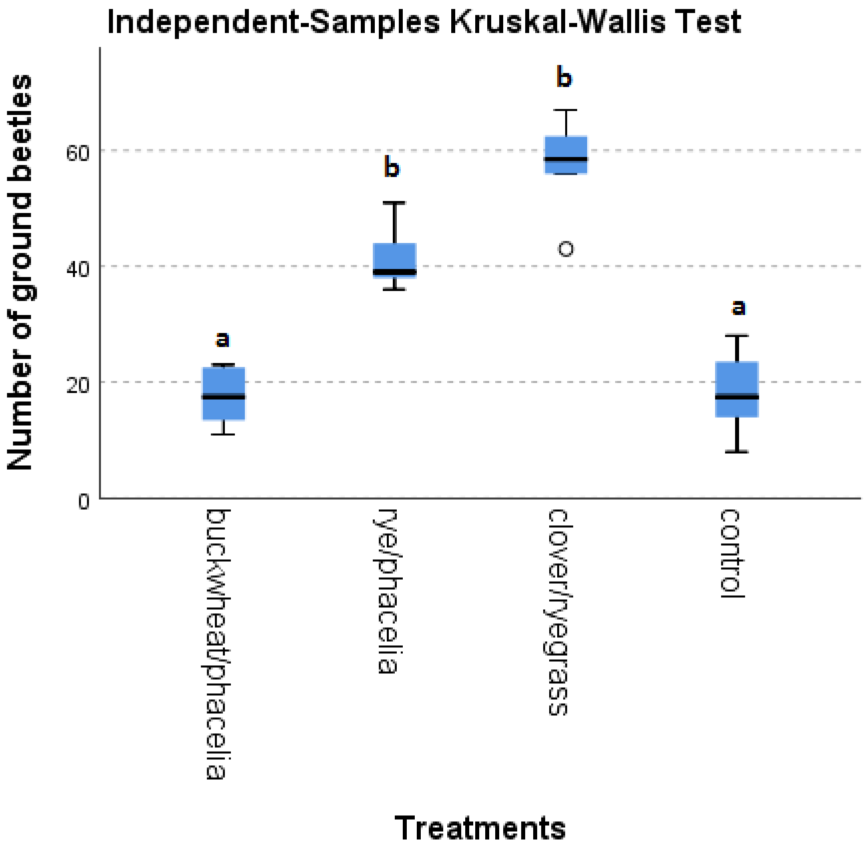


Figure 8 Numbers of ground beetles in summer green manure and control plots in 2019. Any two samples with a shared letter are not significantly different (P>0.05).

The only species caught in the deadfall traps in the winter green manure plots were the beneficial common ground beetles and two specimens of *Deroceras reticulatum* (grey field slug). The numbers of ground beetles collected per plot on 21/05 from the winter green manure plots were similar to the numbers collected from the summer green manure plot, though the average weight of each beetle was only 21% that of the value from those in the summer green manure, indicating that these were juveniles. In both the summer and winter green manures, a 30-cm wide strip of the green manure crop was left unincorporated to provide a refuge for beneficial insects, from which they could colonise the cash crop; this strip around each plot formed a corridor ("beetle bank") for ground beetle migration from the adjoining headland into the trial plots.

The highest frequency of ground beetles was obtained from the Landsberger mix, which was significantly higher than the frequency in either the Wild Atlantic mix or the control, which, in turn, attracted significantly more ground beetles than did the rye/vetch green manure (Table 8). This finding mirrors that from the summer green manure, in that low-growing green manure plants supported a greater frequency of ground beetles than did tall green manure plants such as in the rye/vetch and Wild Atlantic mix winter green manures or the buckwheat/phacelia summer green manure.

Table 8 Numbers of ground beetles in winter green manures in 2018. Any two samples within a row with a common letter are not significantly different.

Landsberger mix	**Rye/vetch**	**Wild Atlantic mix**	**Control**
125 a	70 c	92 b	95 b

When pitfall traps were set up in the refuge strips and cash crop plots after summer green manure incorporation, the numbers of ground beetles in the refuge/cash crop were 197/38 (ryegrass/clover), 156/40 (rye/phacelia), 139/61 (buckwheat/phacelia) and 1/9 (control), respectively, with all plants being removed from the control refuge. These results highlight the beneficial role of the refuge strips (which would be more widely spaced in reality).

The refuge strips also attracted large numbers of flying beneficial insects, with sweep net sampling identifying hoverflies, ladybirds and lacewings (in that order), with the density of hoverflies increasing when the refuge strips were allowed to flower.

4.3.7 Soil bacterial diversity (2018-2020)

Soil samples collected from each plot and from the horizon of the undisturbed neighbouring grassland ("original") were assessed for the quantity and diversity of bacteria, using Community-Level Physiological Profiling, with BIOLOG plates. Each 96-well BIOLOG plate contains three replicates each of wells containing one of 31 different C sources (and control). Suspensions of soil from the different plots were pipetted into each well; after incubation, the development of colour in a well indicates the presence of bacteria in that soil sample which can use the C source in that particular well (Fig. 9). The average intensity of colour (AWCD) over the plate reflects the density of bacteria in the soil (Fig. 9), while Principal Component Analysis (Fig. 11) of the results reflects the functional diversity of the bacteria in each soil sample.

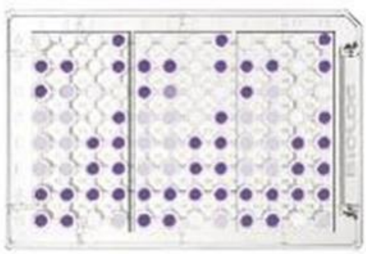


Figure 9 A developed BIOLOG Ecoplate: the deeper the colour in a particular well, the more bacteria in the soil could use the particular C source in that well.

Soil samples were collected from each green manure plot before the green manures were incorporated into the soil. There were clear differences in the total number of bacteria from the different green manures, but the main difference was with respect to the density of pseudomonads, a group of largely beneficial soil bacteria, associated with valuable traits such as pathogen biocontrol and nutrient (e.g., iron) acquisition. All three green manures contained significantly higher densities of pseudomonads than did the control and original plots, with the clover/ryegrass green manure plot containing by far the highest density of pseudomonads (Fig. 10). Note that the y-axis (vertical axis) of Fig. 10 is log bacterial density (colony-forming units, cfus, per g soil), so that a difference of 1 on the y-axis represents a 10-fold difference in bacterial density. These effects probably reflect the effect of root exudates from the different plants in each plot. The density of plants in the green manure plots was greater than that in the control plot. The green manure supporting the lowest bacterial density was buckwheat/phacelia (9×10^6), species from plant families (Polygonaceae and Boraginaceae) not commonly found in grassland. The clover/ryegrass mix supported the highest bacterial density (7×10^8), more than 100 x the density in the control plots; legumes, such as the clovers, are known to produce high concentrations of root exudates, largely to encourage N-fixing bacteria to home in on the host plant roots.

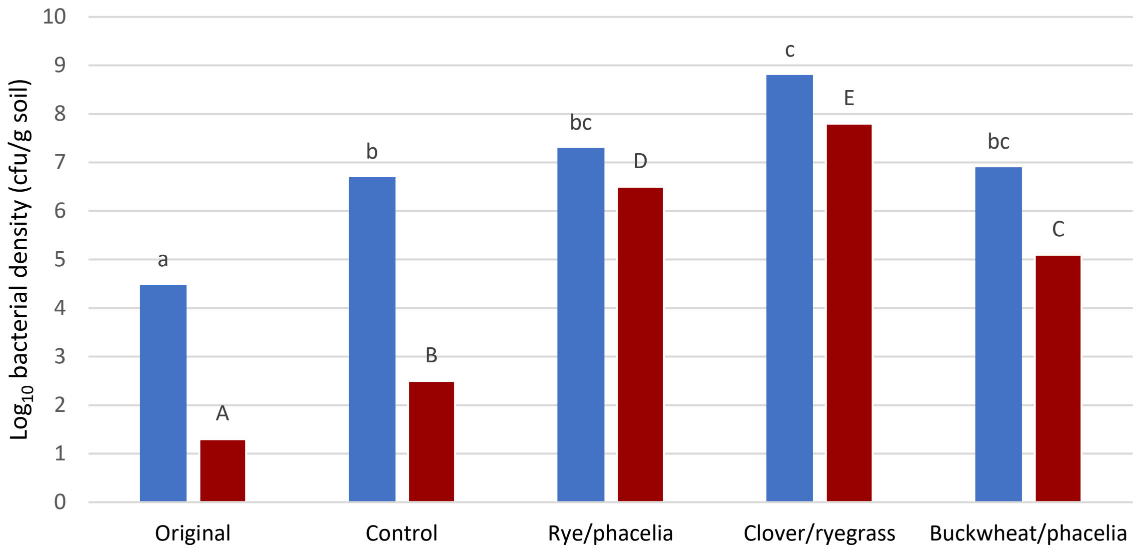


Figure 10 Effect of different soil sources on log total bacterial density (cfu/g soil; blue) and log total pseudomonad density (cfu/g soil; orange) in summer green manures in 2018. Any two samples with a common lower- or uppercase letter were not significantly different (P>0.05).

Functional diversity analysis on the soil samples revealed that the bacteria from the three green manure plots were markedly different from those in the control and original samples. The diversity of the bacteria in the control, original and buckwheat/phacelia plots were similar to one another (data not shown), whereas the phacelia/rye and, in particular, the clover/ryegrass plots gave quite distinct diversity signatures, reflecting the results from the bacterial densities (Fig. 10).

The 2019 trial expanded on the 2018 trial, under the different summer green manures; the samples were frozen until being analysed in 2020. The bacteria in the different soil samples were analysed for the numbers of bacteria (AWCD) and the number of different types of bacteria (Richness, Shannon Index). CLPP uses AWCD, richness (R) and the Shannon index (H) to analyse soil functional biodiversity and activity. A profile of the functional biodiversity within the system is what is observed (as opposed to the species biodiversity level) because the meta-analysis of this high dimensional datasets is much more efficiently portrayed. Where AWCD is a measure of what the SMC activity is, i.e., how it feeds upon the various carbon sources across each well, Richness is then a measure of how many species there are within the community and the Shannon index take the richness and species distribution, i.e., evenness, into account. The Shannon index is widely used in ecological studies, and it is considered that the higher the H value, the more diverse the SMC.

In the 2018 trial, the clover/ryegrass green manure supported the highest bacterial population. In the 2019 trial, again the clover/ryegrass supported the largest population, but the buckwheat/phacelia green manure supported the most diverse population, as measured by richness (Table 9).

A second evaluation was then carried out in 2019, four weeks after incorporation of the green manures; this is the first such published analysis as to whether the effects of green manures were maintained after the green manures were dug in. Incorporation resulted in an increase in the size of the soil bacterial population (presumably as a result of increased organic matter) in all plots (including the control plots, which contained weeds) bar the clover/ryegrass green manure plot, which exhibited a significant decrease in the size of the soil bacterial population (Table 9). This unusual behaviour of the clover/ryegrass plot may be because legumes, such as clovers, attract N-fixing bacteria – following incorporation, production of these chemical signals would fade away, resulting in elimination of the N-fixing bacteria. After incorporation, the green manures had little significant effect on the numbers and diversity of the soil bacterial population, although the buckwheat/phacelia green manure had the greatest beneficial effect.

Table 9 Effect of green manures (before and after incorporation) on soil bacterial population numbers (AWCD) and diversity (Richness, Shannon Index) from BIOLOG-Ecoplates. AWCD: average well colour development; - incorporation = before incorporation; + incorporation = after incorporation. For a given parameter, any two samples with a shared letter are not significantly different (P>0.05).

Parameter	**Incorporation**	**Buckwheat/ phacelia**	**Rye/ phacelia**	**Clover/ ryegrass**	**Control**
AWCD	-	0.92bc	0.71b	1.03c	0.58a
	+	1.15d	1.03c	0.86bc	1.11c
Richness	-	25b	20a	22a	21a
	+	30c	27bc	24b	27bc
Shannon index	-	1.36ab	1.26a	1.30a	1.28a
	+	1.42b	1.38b	1.35ab	1.36ab

Principal Component Analysis (PCA) was then carried out to compare the functions of the different bacterial populations under the different green manures and before/after incorporation. Despite the apparent similarities under the different green manures after incorporation (Table 9), PCA revealed that differences remained in the ability of the bacterial populations under different green manures to metabolise different organic compounds in the soil.

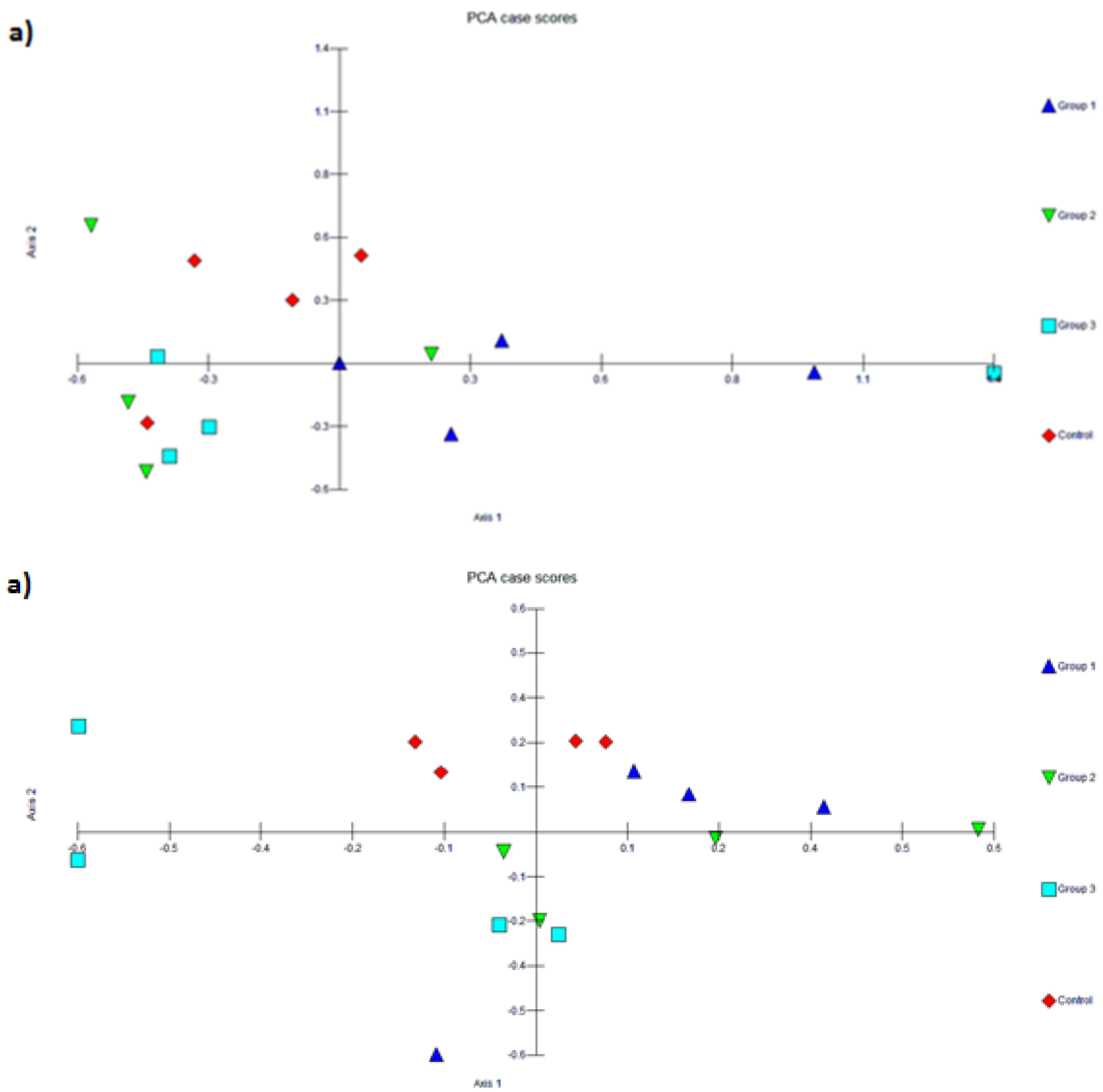


Figure 11 Principal Component Analysis of BIOLOG-Ecoplate data from the different summer green manure plots before (upper) and after incorporation (lower graph). Red: control; dark blue: buckwheat/phacelia; green: rye/phacelia; light blue: clover/ryegrass.

The four examples of each green manure in Fig. 11 represent the four replicate plots. Although the replicates of the same green manure are scattered, trends are visible. Before incorporation (Fig. 11a), the dark blue symbols (buckwheat/phacelia) were widely separated from the red symbols (control), showing that the greater diversity in the green manure supported bacterial populations with different functions from the control plots. After incorporation (Fig. 11b), the differences were smaller but were retained, with the scatter of the buckwheat/phacelia green manure plots still being different from that of the control, with the distribution of the light blue symbols (clover/ryegrass) now being quite different from that of the control. These results indicate that, after incorporation, any effects of the green manure on soil bacteria were due to the functions rather than the numbers of the bacteria.

4.3.8 Cash crop performance: development, yield and cost-benefit analysis (2018-2021)

The onion and cabbage plants were transplanted into the plots after summer green manure incorporation. Some pigeon damage occurred on the cabbage plants, which were netted in November 2018. No herbivory damage was observed on the onion plants, although some wind damage was observed. No significant difference in cash crop plant survival between the different green manure plots was detected in either the onion or cabbage plots.

Plant development of both onion and cabbage was measured as leaf number. For both crops in 2019, the number of leaves in the buckwheat/phacelia plots was significantly greater than that in the control plants (Table 10). The stage of development was largely reflected in the mean cabbage head fresh weight harvested on 21/05/2019, although only the yield of cabbage planted after buckwheat/phacelia green manure was significantly greater (by 13.6%) than that of the control (Table 11).

Table 10 Effect of incorporated summer green manures on crop plant development (2019). Any two samples within a row with a common letter were not significantly different.

Leaf number per plant	Clover/ryegrass	Buckwheat/phacelia	Rye/phacelia	Control
Cabbage	6.61c	7.93 a	7.20 b	7.02 bc
Onion	2.89 ab	3. 05 a	2.73 b	2.58 b

Table 11 Effect of incorporated summer green manures on mean cabbage head fresh weight (g) (2019). Any two samples within a row with a common letter were not significantly different.

Clover/ryegrass	Buckwheat/phacelia	Rye/phacelia	Control
59.6 ab	64.1 a	60.9 ab	56.4 b

The onion crops after each of the summer green manures were significantly heavier than in the control plots (Fig. 12).

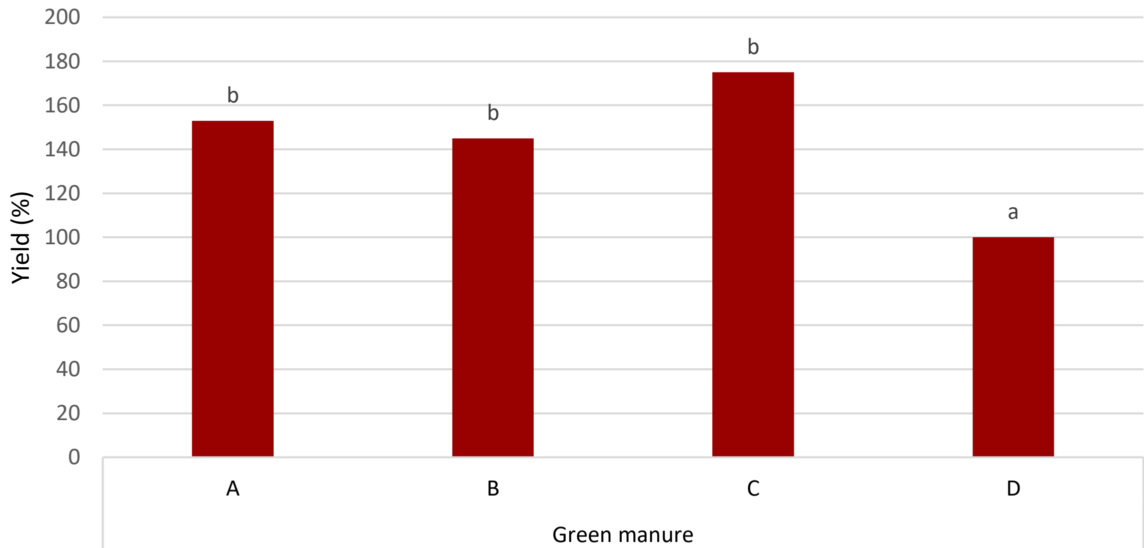


Figure 12 Effect of summer green manure incorporation on onion yield, as % of control (D). A: rye/phacelia; B: buckwheat/phacelia; C: clover/ryegrass; D: control. Any two bars with a common lowercase letter are not significantly different.

Crop development was also scored in the different plots in early March 2020. The results were similar to those from the 2019 study, with all green manures being associated with more rapid development of both cash crops, onion and cabbage (Table 12). For onion, the only significant effects of the green manures on onion development were the stimulatory effects of rye/phacelia and buckwheat/phacelia green manures, whereas all three green manures increased cabbage development.

Table 12 Effects of incorporated summer green manures on crop development (leaf number/plant) of onion and cabbage cash crops in 2020. Any two samples within a row with a shared letter are not significantly different (P>0.05), using the Tukey test.

	Rye/phacelia	Buckwheat/phacelia	Clover/ryegrass	Control
Onion	2.43b	2.33b	2.12a	2.10a
Cabbage	7.23b	7.40c	7.36c	6.85a

In Years 1 (2018–2019) and 2 (2019–2020), the pointed cabbage (cv. Duncan F_1) was planted after summer green manure incorporation. The yields were similar between the three years (Table 13), with the yield of the control plots (no green manures sown) being the lowest in all years, but with different green manures giving the highest cabbage yields: buckwheat/phacelia gave the highest cabbage yield in 2019, compared with clover/ryegrass which gave the highest yield in 2020 and 2021 (Table 13).

Table 13 Effects of summer green manures on yield of pointed cabbage in 2019–2021. Any two treatments within a year with a common letter are not significantly different.

Green manure	Yield/plant (2019) (%)*	Yield/plant (2020) (%)*	Yield/plant (2021) (%)*
Rye/phacelia	108 ab	104 ab	110b
Buckwheat/phacelia	114 b	110 b	120c
Clover/ryegrass	106 ab	126 c	123c
Control	100 a	100 a	100a

*Yield expressed as % of control

For the winter green manures, both cash crops (broccoli and oakleaf lettuce) developed faster in the winter green manure plots than in the control plots.

Within the acceptable size and quality range, the mean weight of the lettuce heads over two harvests in each of the three winter green manure plots was significantly heavier than that of the control, with the exception of green manure C (rye/vetch), where the heads were significantly smaller than those of the controls (Fig. 13).

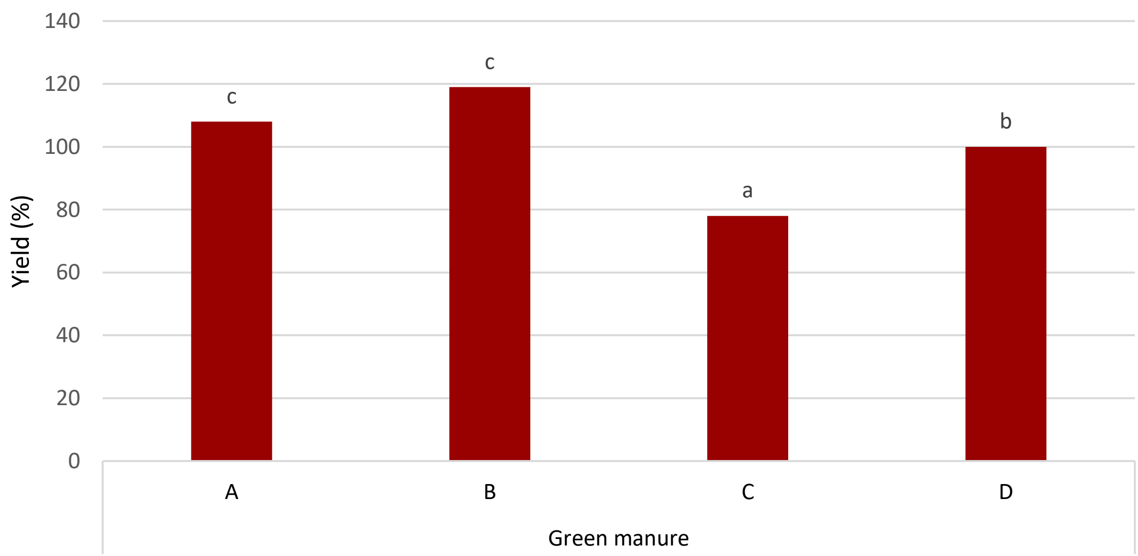


Figure 13 Effect of winter green manure incorporation on red oakleaf lettuce yield in 2019, as % of control (D). A: vetch/clover/ryegrass; B: clover/oats/rye; C: rye/vetch; D: control. Any two bars with a common lowercase letter are not significantly different.

Subsequent pot testing of soil samples from the different plots showed that the soil into which the rye/vetch green manure had been incorporated inhibited lettuce from direct sowing or transplants, with directly sown plants being particularly badly affected. Grazing rye is known to have inhibitory ("allelopathic") effects on small-seeded crops, but this is the first report of an inhibitory effect on transplants, although, of the various crops tested in the pot trial, lettuce was the only sensitive crop. The absence in the field trial of an inhibitory effect on lettuce from the Wild Atlantic mix, which also contained rye, suggested that the lower rate of rye (30% as opposed to 60% in the rye/vetch green manure), or the different rye population (wild rye as opposed to grazing rye in the rye/vetch mix) may have avoided the inhibitory effect.

Lettuce showed inhibition, relative to the control, when planted after the rye/vetch winter green manure (60% grazing rye) but not after the Wild Atlantic winter green manure (30% grazing rye), indicating that the effect was concentration dependent. Furthermore, earlier studies had shown that rye-based green manures were effective at controlling perennial weeds such as docks, suggesting an allelopathic effect, in which plants like rye produce chemicals (from living roots or as they decompose) which inhibit the germination or growth of other plants; rye is known to produce allelochemicals when decomposing.

The reason for this effect was investigated in growth room experiments, using soil collected from incorporated winter green manure plots. Of six crops tested, transplants of only lettuce (green or red oakleaf, butterhead) showed growth inhibition (relative to the transplants in control soil), with only the rye/vetch green manure proving inhibitory (Table 14). As a consequence, particular care needs to be taken when using high percentage rye (30–60%) as a component of a green manure, to avoid planting lettuce as the subsequent cash crop.

Table 14 Fresh weight of six-week-old plants (as % of control (no green manure)) growing in soil containing incorporated winter green manures.

Transplant	Wild Atlantic	Rye/vetch	Landsberger
Red oakleaf lettuce	122	78	118
Green oakleaf lettuce	126	73	130
Butterhead lettuce	119	69	128
Cabbage	126	127	120
Spring onion	117	120	131
Broad bean	124	132	134

Positive effects were also observed with broccoli, except that all three green manures resulted in significant increases in both numbers of heads of acceptable quality and average broccoli head size (Fig. 14), with average head weights of 392 g (control), 530 g (vetch/clover/ryegrass), 563 g (clover/oats/rye), and 528 g (rye/vetch), with no evidence of an inhibitory effect of the rye/vetch green manure on the broccoli cash crop.

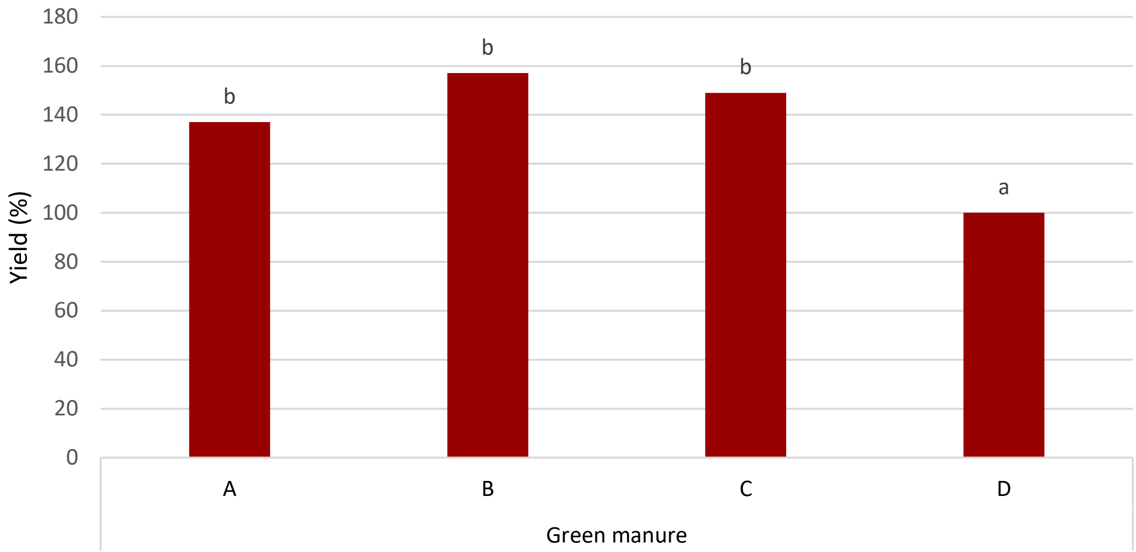


Figure 14 Effect of winter green manure incorporation on broccoli yield in 2019, as % of control (D). A: vetch/clover/ryegrass; B: clover/oats/rye; C: rye/vetch; D: control. Any two bars with a common lowercase letter are not significantly different.

Of the nine [green manure × cash crop] combinations, eight resulted in a statistically significant increase in yield compared to the corresponding control, while one (the oakleaf lettuce crop grown after the rye/vetch winter green manure) exhibited a significantly lower yield than the control.

The yields of the broccoli and red oakleaf lettuce cash crops were broadly similar in 2020 to those in 2019, although the effects in 2019 were more extreme than those in 2020 (Tables 15 and 16). The broccoli yields after each green manure incorporation in 2019 were at least 30% higher than the control, whereas, in 2020, the highest broccoli yield increase was 28% (Table 15). In both years, the green manure which resulted in the highest increase in broccoli was the clover/oats/rye green manure. In 2019, the second-highest increase in broccoli yield was achieved from the rye/vetch green manure, but, in 2020, this green manure did not result in a significant increase in broccoli yield (Table 15).

Table 15 Effects of winter green manures on yield of broccoli in 2019 and 2020. Any two treatments within a year with a common letter are not significantly different.

Treatment	Green manure	Yield/plant (2019) (%)*	Yield/plant (2020) (%)*
A	Vetch/clover/ryegrass	133 b	116 bc
B	Clover/oats/rye	154 c	128 c
C	Rye/vetch	148 bc	105 ab
D	Control	100 a	100 a

*Yield expressed as % of control

In 2018-2019, the clover/oats/rye and vetch/clover/ryegrass green manures caused a significant increase in lettuce yield (though lower increases than in broccoli yield), whereas the rye/vetch green manure causing a significant decrease in lettuce yield. Subsequent studies showed that the inhibitory effect was caused by an inhibitory (“allelopathic”) effect of the 60% rye composition of the green manure on the lettuce, though not by the 30% rye composition in the clover/oats/rye green manure. In 2019, a period of 14 days was allowed between green manure incorporation and transplanting of the cash crops; because this short period could have exacerbated the effect of the rye/vetch green manure on the lettuce yield, the period was extended to 23 days in each of 2020 and 2021. In 2020 and 2021, instead of a 20% inhibition of lettuce yield, the rye/vetch green manure resulted in the highest promotion of lettuce yield (Table 16). There was clear evidence of green manure-specific effects on cash crop yield in 2020 and 2021, with rye/vetch green manure causing the lowest yield-stimulation of broccoli but the greatest stimulation of lettuce yield, after extending the delay between green manure incorporation and cash crop transplantation.

Table 16 Effects of winter green manures on yield of red oakleaf lettuce in 2019–2020. Any two treatments within a year with a common letter are not significantly different.

Green manure	Yield/plant (2019) (%)*	Yield/plant (2020) (%)*	Yield/plant (2021) (%)*
Vetch/clover/ryegrass	107 c	109 b	120 b
Clover/oats/rye	118 d	104 a	116 b
Rye/vetch	80 a	122 c	124 b
Control	100	100 a	100 a

*Yield expressed as % of control. Green manure crops were incorporated into the soil 14 days (2019), 23 days (2020) or 23 days (2021) before red oakleaf lettuce seedlings were transplanted

Although green manures caused marked increases in yields of most of the green manure/cash crop combinations in both years, showing that the effects of green manures were robust, the effects in 2019 were larger than in 2020. Part of this difference could have been due to differences in the characteristics of the growing seasons with, for example, summer 2019 being hotter and drier than in 2020. Interestingly, establishment of the summer and winter green manures in 2018–2019 (larger effects on cash crops) was greater than in 2019–2020. For example, the buckwheat plants in the buckwheat/phacelia summer green manures at incorporation time were approximately twice the height in 2018–2019 (32–37 cm) (Fig. 1) than in 2019–2020 (15–19 cm)

The cost-benefit analysis of the use of green manures in 2018-2019 took into account extra costs associated with the use of green manures, namely site preparation (labour, diesel), purchase of green manure seed, sowing green manure seed (labour, diesel), mulching and incorporation of the green manure (labour and diesel). These additional costs were subtracted from any extra income from the cash crop harvest relative to that from the control plots (Fig. 15–17).

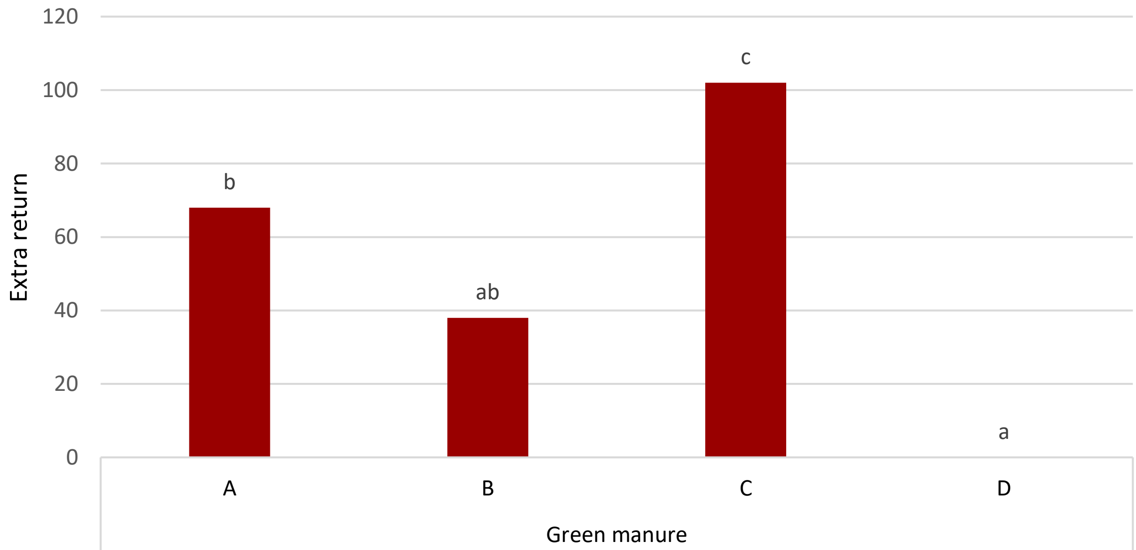


Figure 15 Net additional income (€/500 m2) from onions grown after summer green manure in 2019, with control (D) being zero. A: rye/phacelia; B: buckwheat/phacelia; C: clover/ryegrass; D: control. Any two bars with a common lowercase letter are not significantly different.

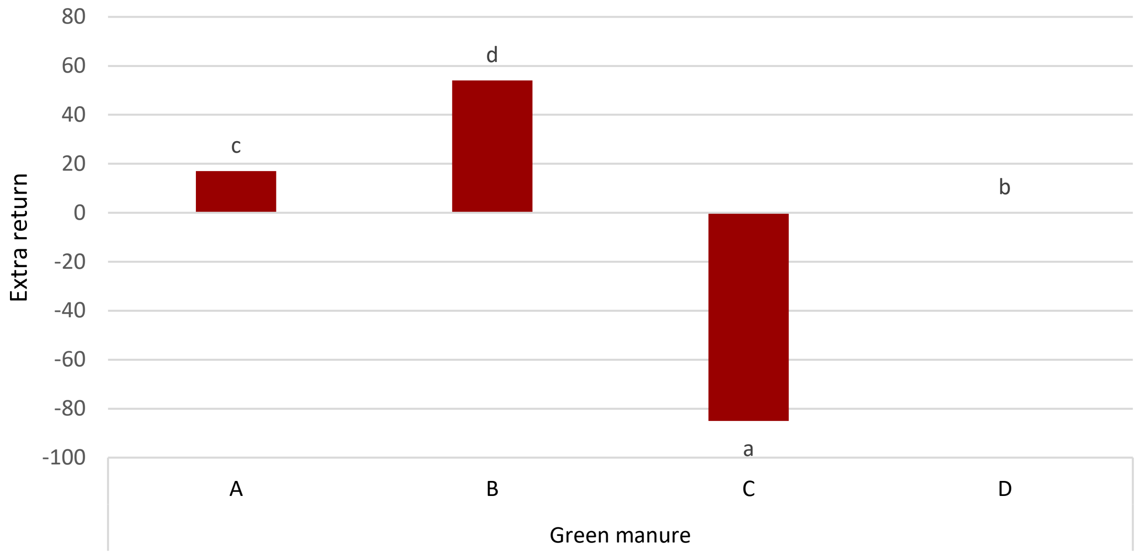


Figure 16 Net additional income (€/500 m2) from red oakleaf lettuce grown after winter green manure in 2019, with control (D) being zero. A: rye/phacelia; B: buckwheat/phacelia; C: clover/ryegrass; D: control. Any two bars with a common lowercase letter are not significantly different.

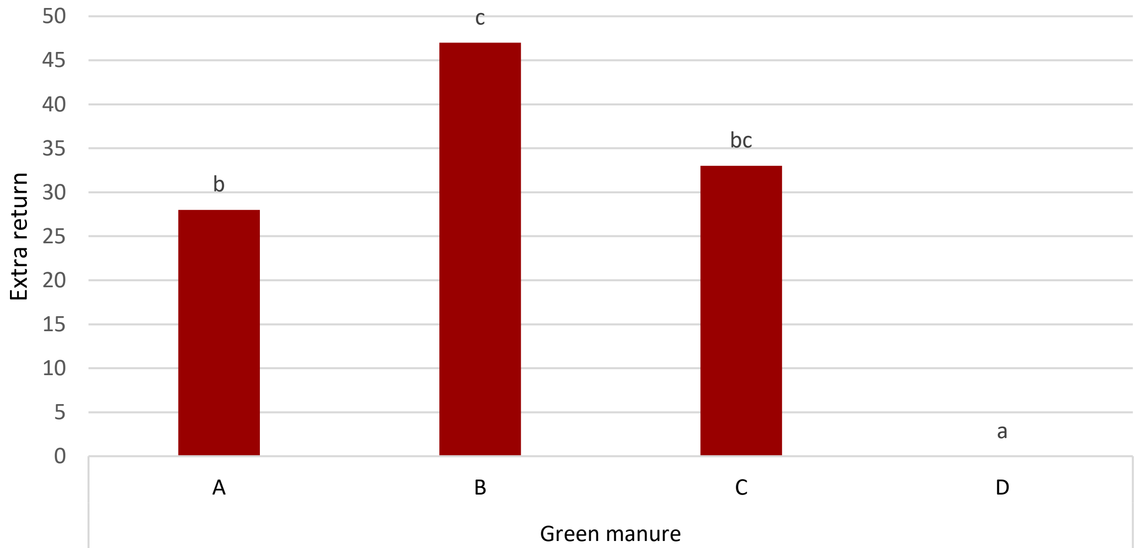


Figure 17 Net additional income (€/500 m2) from broccoli grown after winter green manure in 2019, with control (D) being zero. A: rye/phacelia; B: buckwheat/phacelia; C: clover/ryegrass; D: control. Any two bars with a common lowercase letter are not significantly different.

The cost-benefit analyses showed that all cash crops bar the lettuce crop after the rye/vetch winter green manure in 2019 resulted in a significant increase in returns over and above the costs associated with setting up the green manures (Figs. 15–17). Of the nine green manure-cash crop combinations evaluated in 2019, eight produced significantly higher yields than in the control and higher cost-benefit analysis (after subtraction of additional costs) than the control, with extra profits in the range €38–106 per 500 m^2 (onion), €16–53 (lettuce) and €28–46 (broccoli). The only exception was for the lettuce-rye/vetch winter green manure combination, where the yield was 23% lower and returns were €86 per 500 m^2 lower than in the control. This inhibitory effect was replaced by a marked increase in lettuce yield (Table 16) and a significant increase in net return (€61/500 m^2 in 2020 and €67/500 m^2 in 2021, compared with the control plots) from the lettuce crops after winter green manures when the period between green manure incorporation and lettuce transplanting was increased from 14 days (in 2019) to 23 days (in 2020 and 2021).

To our knowledge, this is the first report of a cost-benefit analysis, demonstrating increased net returns from green manures under Irish conditions. No single effect was associated with the increased yield or net return, rather a number of effects such as improved nutrient availability, weed control, pest control, altered soil bacterial population, accelerated crop development and improved soil structure.

4.4 Summary

In the summer green manures:

- Biomass: buckwheat/phacelia>rye/phacelia>clover/ryegrass>control
- Annual weed control: buckwheat/phacelia>rye/phacelia>clover/ryegrass>control
- Perennial weed control: rye/phacelia∼buckwheat/phacelia>clover/ryegrass>control
- Beneficial insects: clover/ryegrass>rye/phacelia>control>buckwheat/phacelia
- Soil bacterial diversity: clover/ryegrass>rye/phacelia>control>buckwheat/phacelia
- Soil nutrient levels: rye/phacelia>buckwheat/phacelia∼clover/ryegrass>control
- Soil organic carbon: buckwheat/phacelia>rye/phacelia>clover/ryegrass∼control
- Cash crop development: buckwheat/phacelia>rye/phacelia∼clover/ryegrass>controlOnion yield: clover/ryegrass>rye/phacelia>buckwheat/phacelia>control

In the winter green manures:

- Biomass: Wild Atlantic mix*>rye/vetch>Landsberger**>control
- Perennial weed control: rye/vetch> Wild Atlantic>Landsberger>control
- Beneficial insects: Landsberger>Wild Atlantic∼control>rye/vetch
- Soil nutrient levels: Landsberger∼Wild Atlantic∼rye/vetch>control
- Soil organic carbon: Wild Atlantic> rye/vetch>Landsberger>control
- Broccoli yield: Wild Atlantic>rye/vetch>Landsberger>control
- Lettuce yield: Wild Atlantic>Landsberger>control>rye/vetch

*Wild Atlantic mix = oats/rye/vetch/clovers

**Landsberger = ryegrass/clovers

>= significantly greater; ∼ = not significantly different

4.5 Conclusions

Overall, these short-term green manures (two months for summer green manure, six months for winter green manure) have achieved consistent beneficial effects over the three years of the study, associated with better weed control, more beneficial insects, more and greater functional diversity of soil bacteria, greater soil organic matter content and earlier-developing cash crops than in the control.

Although no single factor was identified as the cause of the increased yield, the consistent improvement over the three years of the trial despite major differences in weather e.g., rainfall (April to September) values of 210 mm (2018), 360 mm (2019), 250 mm (2020) and 300 mm (2021), shows that the effect is robust. Cost-benefit analysis showed that extra financial returns were achieved for growing short-term green manures.

Overall, the results indicated that the use of short-term brassica-free green manures was beneficial (in terms of crop performance and biodiversity) under Irish conditions. The non-incorporation of a 0.5 m-wide strip of the green manure (“refuge”) increased biodiversity throughout the growing season and provided a corridor for ground beetle movement from the headlands (data not shown). The strip could be topped to prevent flowering or allowed to flower, further increasing beneficial biodiversity, such as hoverflies. The early development of all cash crops in response to green manure incorporation opens up the possibility of using green manures on part of the cropping space to spread the harvest period for a crop.

This is the first study of the use of short-term green manures in organic vegetable growing in Ireland and more research is needed, testing different green manures, cash crops and sites around the country. Though multi-species green manures have benefits, a potential problem involves the problems of producing seedbed conditions suitable for both large- and small-seeded green manures (e.g., rye/phacelia). These preliminary results, however, are promising and suggest that short-term green manures can readily and profitably be incorporated into Irish organic vegetable production.

5 Technical note

Using organic materials in organic agriculture and horticulture production in Ireland

Maximising Organic Production Systems European Innovation Partnership Project June 2018-2021

Maximising Organic Production Systems (MOPS) is a European Innovation Partnership (EIP) project that is co-funded by the Department of Agriculture, Food and the Marine and the European Commission. This technical note has been produced as part of the MOPS EIP project and provides information on using organic materials in organic agriculture and horticulture production in Ireland. Sample analysis results included in this technical note are from samples of organic materials that were collected from participant MOPS project growers.

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Disclaimer

5.1 Introduction

Managing the fertility, physical condition and biological health of soil is a key principle of organic production [17, 20]. Soil management practices, in line with organic standards, that promote soil health and fertility include: crop rotations; return of organic matter to the soil e.g. crop residues; use of cover crops and catch crops for nitrogen fixation and nutrient retention; effective use of manures/composts; using supplementary nutrients where needed; maintenance of soil drainage and pH; soil cultivation techniques that maintain soil structure; and use of assessment, sampling and nutrient analysis to guide soil nutrient management decisions, e.g. manure applications, and for correcting pH and lime deficiencies to ensure the availability of soil nutrients.

This technical note provides information on:

- the main types of organic materials, including green manures, that are used in organic horticultural crop production in Ireland (Figure 1)
- sampling organic materials and interpreting the laboratory analysis report
- relevant legislation, regulations, standards and guidelines

Figure 1 Organic horticultural crop production by growers participating in the MOPS EIP project.

Organic materials such as livestock manures, composts, anaerobic digestate, organic fertilisers, soil conditioners/amendments and green manures are valuable sources of soil nutrients and organic matter for soil fertility management. Some of the ways in which organic materials influence soil properties, plant growth and the environment are summarised in Figure 2 [2].

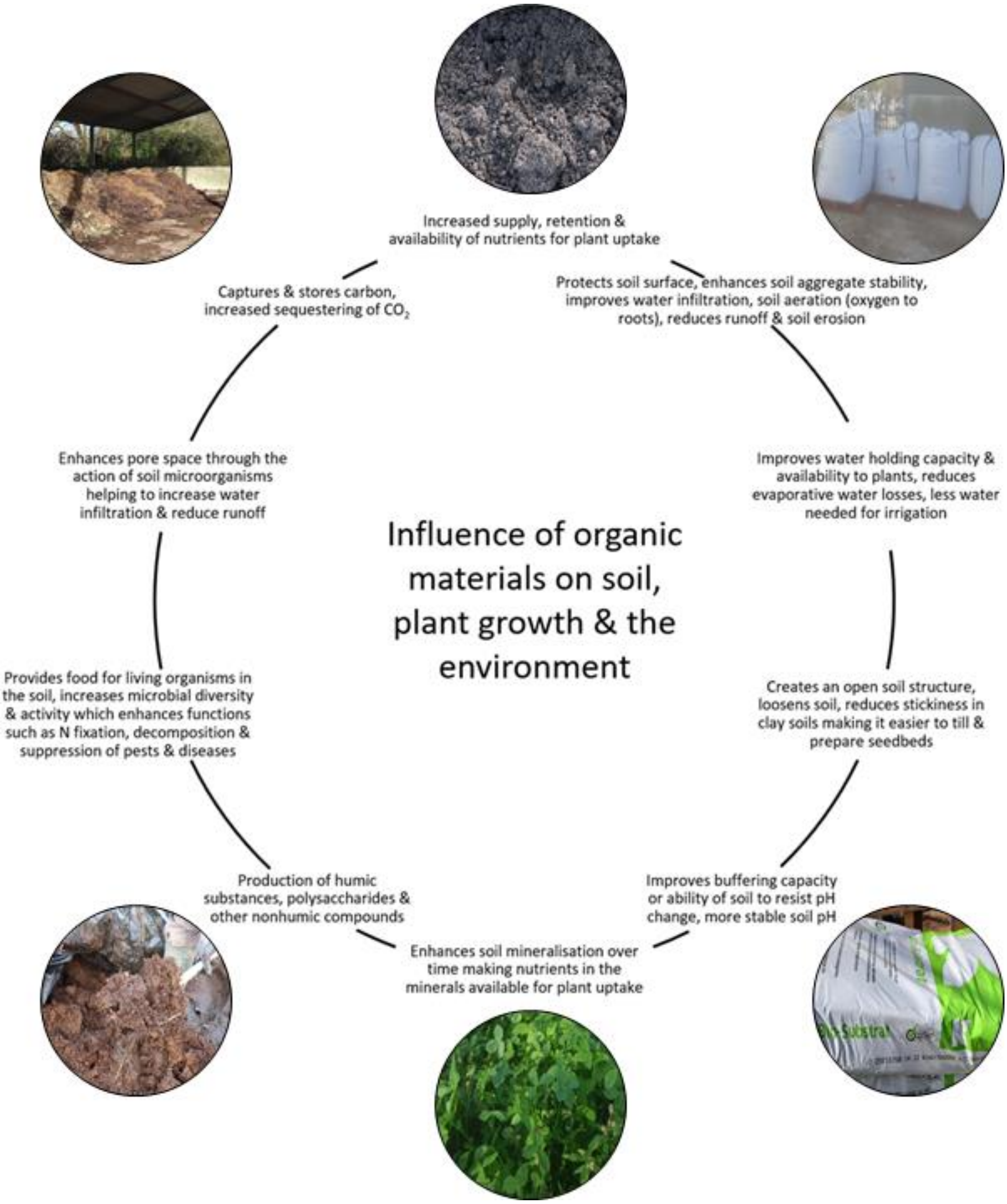


Figure 2 Important ways in which organic materials influence soil properties, plant growth and the environment.

The principles, rules and requirements for using organic materials in organic production are set out in EU and national legislation, and the Organic Food and Farming Standards. Organic materials can be a source of environmental and pathogenic contamination if not handled, stored and applied properly. It is important to ensure that their use complies with national and EU legislation and the Organic Food and Farming Standards in Ireland.

5.2 Relevant legislation, regulations, standards and guidelines

- Water Framework Directive [11, 13]
- Nitrates Directive [7]
- Animal by-products regulations [4, 10, 19]
- Fertilising products regulations [9, 21]
- Organic farming and production regulations [3, 5, 8, 20]
- Organic Food and Farming Standards in Ireland [17]
- Good practice codes and guidelines for handling, storage and application [12, 14, 15]
- Quality assurance schemes

See section 5.11 Additional information and references in this technical note for links to further details on the above legislation, regulations, standards and guidelines.

Note: the new organic Regulation (EU) 218/848[20] repealing Regulation (EC) No 834/2007[8] which sets out the principles and rules concerning organic production was due to be fully applicable from 1st January 2021, along with implementing regulations. At the time of compiling this technical note, this date was postponed until 1st January 2022.

5.3 Sampling organic materials for nutrient analysis

5.3.1 Sample collection: solid manure

- Take at least 10 subsamples of about 1 kg each as described below
- Place on a clean, dry tray or sheet
- Break up any lumps and thoroughly mix the sample
- Take a representative sample of around 500 g for analysis
- Samples should be dispatched in plastic bags, expel excess air from the bag before sealing
- Label samples clearly, providing information as per the laboratory analysis request/order form

5.3.2 Sample collection: manure heaps

- Provided the manure is dry and safe to walk on, identify at least 10 locations which appear to be representative of the heap
- After clearing away any weathered material with a spade or fork, either 1) dig a hole approximately 0.5 metres deep and take a 1 kg sample from each point, or 2) use a soil auger to obtain subsamples from at least 50 cm into the heap
- Alternatively, take subsamples from the face of the heap at various stages during spreading

5.3.3 Sample collection: liquid manure

- Collect at least five subsamples of two litres each and pour into a large container
- Thoroughly mix the bulked sample
- Samples should be dispatched in a clean, screw topped, plastic 250 ml container
- Leave 2-3 cm of airspace to allow the sample to be shaken in the laboratory
- Label samples clearly, providing information as per the laboratory analysis request/order form
- Dispatch the sample to the laboratory ASAP

Reproduced from Advice Sheet 24: Analysis of Manures, Slurries and Dirty Waters [18] with permission from NRM Laboratories.

5.4 Interpretation of nutrient analysis results and calculations

The following notes are intended to provide some guidelines for interpreting and understanding laboratory analysis results.

5.4.1 The analytical report

Basic laboratory analysis for organic materials consists of the following tests: dry matter (DM), nutrients, organic matter (OM), pH and carbon-to-nitrogen ratio (C:N ratio). Depending on requirements, additional tests are offered by laboratories for parameters such as electrical conductivity (EC), cation exchange capacity (CEC), bulk density, heavy metals/potentially toxic elements, pesticides and pathogens.

The laboratory analysis report for organic materials will typically comprise the analytical results and a summary of the fertiliser value in kg/t for solids and kg/m^3 for liquids/slurries. It is important to be aware that analytical reports may differ in the way the results are expressed:

- on a dry weight (DW), 100 % dry matter (DM) or fresh weight (FW) basis
- units of parts per million (ppm), g/kg, mg/kg, g/100 g, %, g/l, mg/l, kg/t, kg/m^3
- total nutrients or available (extractable) nutrients
- as nutrient element (N, P, K, Ca, Mg, S) or nutrient oxide (P_2O_5, K_2O, CaO, MgO, SO_3)

Conversion of the laboratory analysis results is sometimes required. If in doubt about how to interpret the results of the analysis, seek help from the laboratory, or an experienced and/or suitably qualified person.

5.4.2 Conversion calculations for nutrients

Nutrient content results in laboratory analysis reports may be expressed in oxidised form or elemental form. For example, P_2O_5 and K_2O rather than P and K. Similarly, the nutrient content of fertilisers [21] and nutrient recommendations may be expressed as either nutrient oxide or nutrient element. Table 1 provides conversion factors for converting nutrient oxide to nutrient element and vice versa.

Table 1 Conversion factors for converting nutrient oxide and nutrient element [1, 21].

Nutrient oxide to element	Nutrient element to oxide
P_2O_5 × 0.436 = P	P × 2.292 = P_2O_5
K_2O × 0.83 = K	K × 1.205 = K_2O
CaO × 0.715 = Ca	Ca × 1.399 = CaO
MgO × 0.603 = Mg	Mg × 1.658 = MgO
SO_3 × 0.40 = S	S × 2.50 = SO_3
Na_2O × 0.742 = Na	Na × 1.348 = Na_2O

5.4.3 Example conversion calculations for nutrients

An example of conversion calculations for nutrients is shown in Table 2 where nutrient oxides, reported in laboratory analysis results for cattle dungstead manure, are converted to nutrient elemental form using conversion factors from Table 1.

Table 2 Converting nutrient oxides to nutrient elements for cattle dungstead manure analysis results using conversion factors from Table 1.

Parameter	kg/t FW	Parameter	Converted kg/t FW
Total Nitrogen (N)	6.49	Total Nitrogen (N)	6.49
Ammonium Nitrogen (NH_4^+)	0.53	Ammonium Nitrogen (NH_4^+)	0.53
Nitrate Nitrogen (NO_3^-)	0.2	Nitrate Nitrogen (NO_3^-)	0.2
Phosphorus (P_2O_5)	4.04	Phosphorus (P)	1.77
Potassium (K_2O)	8.84	Potassium (K)	7.34
Calcium (CaO)	9.92	Calcium (Ca)	7.09
Magnesium (MgO)	2.82	Magnesium (Mg)	1.7
Sulphur (SO_3)	2.83	Sulphur (S)	1.13
Zinc (Zn)	0.05	Zinc (Zn)	0.05
Copper (Cu)	0.01	Copper (Cu)	0.01
Dry Matter	315	Dry Matter	315
pH	8.5	pH	8.5
C:N ratio	12.4	C:N ratio	12.4

5.4.4 Conversion calculations for solid and liquid manures

Tables 3 and 4 provide conversion calculations for solid manures where dry matter is expressed as a percentage or gram per kilogram, respectively. Table 5 shows conversion calculations for liquid manures.

Table 3 Converting solid manures (DM expressed as %).

To convert mg/kg nutrient in DM to kg/t FW:	$\frac{\text{mg/kg nutrient}}{1{,}000} \times \frac{\%\ \text{DM}}{100}$
To convert g/kg nutrient in DM to kg/t FW:	g/kg nutrient × $\frac{\%\ \text{DM}}{100}$
To convert g/100 g nutrient in DM to kg/t FW:	g/100 g nutrient × $\frac{\%\ \text{DM}}{10}$
To convert % nutrient in DM to kg/t FW:	% nutrient × $\frac{\%\ \text{DM}}{10}$

Table 4 Converting solid manures (DM expressed as g/kg).

To convert mg/kg nutrient in DM to kg/t FW:	$\frac{\text{mg/kg nutrient}}{1{,}000} \times \frac{\text{g/kg DM}}{1{,}000}$
To convert g/kg nutrient in DM to kg/t FW:	g/kg nutrient × $\frac{\text{g/kg DM}}{1{,}000}$
To convert g/100 g nutrient in DM to kg/t FW:	g/100 g nutrient × $\frac{\text{g/kg DM}}{100}$
To convert % nutrient in DM to kg/t FW:	% nutrient × $\frac{\text{g/kg DM}}{100}$

Table 5 Converting liquid manures.

To convert mg/l nutrient to kg/m^3:	$\frac{\text{mg/l nutrient}}{1{,}000}$
To convert g/l nutrient to kg/ m^3:	g/l nutrient (no change)

Reproduced from the Nutrient Management Guide (RB209) [1] with permission from the Agriculture and Horticulture Development Board (AHDB).

5.4.5 Example conversion calculations for solid manures

The seed compost in Table 6 has a total nitrogen (N) content of 12,742 mg/kg.

To convert mg/kg nutrient in DM to kg/t FW: $\frac{\text{mg/kg nutrient}}{1{,}000} \times \frac{\text{\% DM}}{100}$

$\frac{12{,}742 \text{ mg/kg total N}}{1{,}000} \times \frac{33.3 \text{ \% DM}}{100}$ = 4.24 kg total N/t FW

Table 6 Converting mg/kg, reported in laboratory analysis results for seed compost tested, to kg/t FW.

Parameter	Unit	Lab analysis results	Converted to kg/t FW
Nitrogen (N) Total	mg/kg	12,742	4.24
Phosphorus (P) Total	mg/kg	777	0.26
Potassium (K) Total	mg/kg	2,566	0.85
Calcium (Ca) Total	mg/kg	17,242	5.74
Magnesium (Mg) Total	mg/kg	2,777	0.92
Sulphur (S) Total	mg/kg	2,034	0.68
Iron (Fe) Total	mg/kg	3,938	1.31
Manganese (Mn) Total	mg/kg	160	0.05
Boron (B) Total	mg/kg	10.9	0.004
Zinc (Zn) Total	mg/kg	65.6	0.02
Copper (Cu) Total	mg/kg	26.2	0.01
Molybdenum (Mo) Total	mg/kg	6.59	0.002
Sodium (Na) Total	mg/kg	431	0.14
Dry Matter	%	33.3	333
pH		6.2	

5.4.6 Example conversion calculations: how much nitrogen, phosphorus and potassium is in a bag?

Commercial fertiliser product labels provide information on percentage nutrient content, which may be expressed in elemental form (e.g., P and K) or oxidised form (e.g., P_2O_5 and K_2O) or both elemental and oxidised forms. The organic fertiliser products in Figure 3 contain 25 kg of 9-9-0 and 25 kg of 13 %, 1.2 % and 3 % granular fertiliser, respectively. Each product will supply the following amounts of N, P and K:

Fertiliser analysis	Conversion to percent element**	kg of element in 25 kg bag
9-9-0* fertiliser		
9 % N	No conversion = 9 %	0.09 × 25 kg = 2.25 kg of N
9 % P_2O_5	9 % × 0.436 = 3.924 %	0.03924 × 25 kg = 0.981 kg of P
0 % K_2O	0 % × 0.83 = 0 %	0 × 25 kg = 0 kg of K
13-1.2-3 fertiliser		
13 % N	No conversion = 13 %	0.13 × 25 kg = 3.25 kg of N
1.2 % P_2O_5	1.2 × 0.436 = 0.524	0.00524 × 25 kg = 0.131 kg of P
3 % K_2O	3 × 0.83 = 2.49	0.0249 × 25 kg = 0.623 kg of K

*Analysis parameters confirmed with manufacturer (personal communication)

**See conversion factors in Table 1

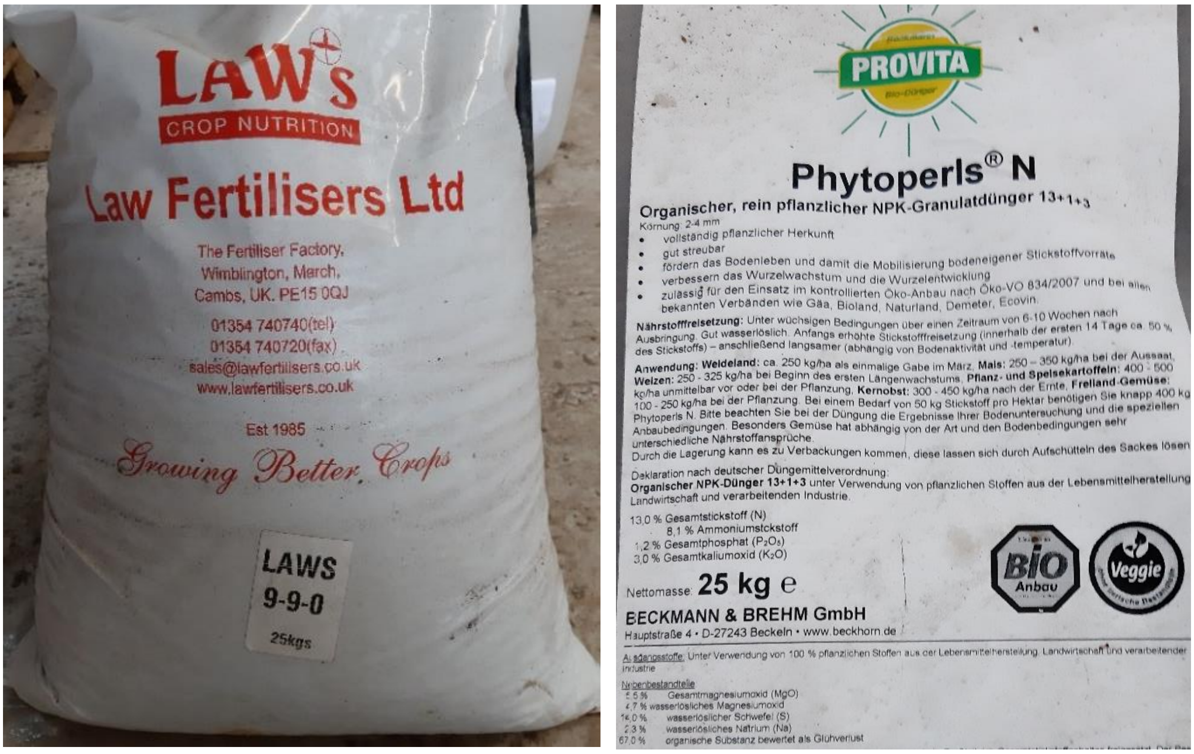


Figure 3 Example of labels on fertiliser bags. Left, the three number code 9-9-0 stands for percentage N, P_2O_5 and K_2O. Right, stated as 13.0 % N, 1.2 % P_2O_5 and 3.0 % K_2O.

5.4.7 Example laboratory analysis results and using organic materials

Table 7 provides example laboratory analysis results (total quantities of nutrients) for a sample of farmyard manure and calculated amounts of nutrients applied at an equivalent total nitrogen application of 170 kg N/ha. Important: this calculated application rate is for the sample of farmyard manure analysed and does not account for factors such as soil type and nutrient status, availability of nutrients from total quantities, previous cropping and manure application history nor the nutrient requirements of the crop and for crop yields.

Irish nutrient legislation sets out standard values for the total N and P content of animal manures and spent mushroom compost (Table 8), and for the percentage availability of nutrients of the total nutrient content of each type of fertiliser. Whether using standard values or analysis results, in addition to identifying soil and crop nutrient requirements (e.g. Index System https://www.teagasc.ie/crops/soil--soil-fertility/soil-analysis/soil-index-system/), standard values must be used for compliance with regulations when calculating availability of the nutrients and application rate. Important: the total amount of livestock manure, as defined in Directive 91/676/EEC [7] and set out in regulations [3, 5, 8, 20] and the standards [17] for organic production, shall not exceed 170 kg of nitrogen per year/hectare of agricultural area used.

Table 7 For information only. Example farmyard manure (cattle) analysis results and amount of nutrients applied at an equivalent total nitrogen application of 170 kg N/ha.

Parameter	**Unit**	**Analysis result**	**Kg/t fresh weight**	**Amount applied in application of 170 kg N/ha**	**Unit**
Molybdenum (Mo) Total	mg/kg	4.1	0.001	0.03	kg Mo
Sodium (Na) Total	mg/kg	3585	0.61	22.37	kg Na
Nitrogen (N) Total	mg/kg	27245	4.66	170	kg N
Potassium (K) Total	mg/kg	45551	7.79	284.22	kg K
Dry Matter	%	17.1	171	6239.68	kg DM
Copper (Cu) Total	mg/kg	17.7	0.003	0.11	kg Cu
Zinc (Zn) Total	mg/kg	132.7	0.02	0.83	kg Zn
Calcium (Ca) Total	mg/kg	17594	3.01	109.78	kg Ca
Magnesium (Mg) Total	mg/kg	3791	0.65	23.65	kg Mg
Manganese (Mn) Total	mg/kg	467	0.08	2.91	kg Mn
Boron (B) Total	mg/kg	16	0.003	0.10	kg B
Iron (Fe) Total	mg/kg	4578	0.78	28.57	kg Fe
Sulphur (S) Total	mg/kg	3790	0.65	23.65	kg S
Phosphorus (P) Total	mg/kg	5843	1.00	36.46	kg P
pH		7.6			
Application rate equivalent to total nitrogen application of 170 kg N/ha				**36.49**	**t/ha**

5.5 Livestock manures

Livestock manure is a mixture of animal excreta and bedding material that is a valuable source of nutrients and organic matter. Table 8 provides the amount of nutrients in livestock manures as specified in Irish Nutrient Legislation and the Organic Food and Farming Standards.

Table 8 Irish Nutrient Legislation S.I. No. 605 of 2017. Amount of nutrients in 1 m^3 of slurry and in 1 tonne of organic fertilisers other than slurry [11].

Livestock type	Unit	Nitrogen (N) Total	Phosphorus (P) Total
Cattle	Kg/m^3	5	0.8
Pig	Kg/m^3	4.2	0.8
Sheep	Kg/m^3	10.2	1.5
Poultry (30 % Dry Matter)	Kg/m^3	13.7	2.9
Poultry manure broilers/deep litter	kg/t	11	6
Poultry manure layers (55 % Dry Matter)	kg/t	23	5.5
Poultry manure turkeys	kg/t	28	13.8
Dungstead manure cattle	kg/t	3.5	0.9
Farmyard manure	kg/t	4.5	1.2
Spent mushroom compost	kg/t	8	1.5
Dairy processing residues and other products not listed above	Total nitrogen and total phosphorus content per tonne based on certified analysis shall be provided by the supplier		

The amount of nitrogen and phosphorus specified in the above table is deemed to be the amount contained in that manure or substance unless otherwise specified in a certificate issued by a competent authority in accordance with S.I. No. 605 of 2017

The composition of livestock manures can vary significantly from standard values due to factors such as type of livestock, diet/feeding, bedding and manure handling practices. Tables 9 and 10 show analysis results for samples of cattle dungstead/farmyard manure and poultry manure. The most accurate way to manage nutrients is by analysing representative samples.

Table 9 Nutrient content of cattle dungstead manure. Analysis results from 13 samples.

	kg/t FW		
Parameter	**Mean**	**Minimum**	**Maximum**
Total Nitrogen (N)	7.63	4.00	17.90
Ammonium Nitrogen (NH_4^+)	0.90	0.32	2.29
Nitrate Nitrogen (NO_3^-)	0.26	0.01	1.19
Phosphorus (P)	1.53	0.71	2.58
Potassium (K)	9.42	3.73	37.03
Calcium (Ca)	8.09	1.81	19.02
Magnesium (Mg)	1.59	0.48	3.38
Sulphur (S)	1.15	0.26	2.13
Iron (Fe)	2.07	0.78	4.92
Manganese (Mn)	0.20	0.08	0.30
Boron (B)	0.01	0.003	0.01
Zinc (Zn)	0.05	0.01	0.17
Copper (Cu)	0.01	0.003	0.04
Molybdenum (Mo)	0.001	0.0004	0.002
Sodium (Na)	1.25	0.54	2.45
Dry Matter (DM)	287.45	146.70	505.70
pH	8.57	7.00	9.90
C:N ratio	14.60	12.40	16.80

Table 10 Nutrient content of poultry manure. Analysis results from three samples.

Parameter		**kg/t FW**	
Total Nitrogen (N)	11.47	11.73	6.13
Ammonium Nitrogen (NH_4^+)	-	5.72	-
Nitrate Nitrogen (NO_3^-)	-	3.06	-
Phosphorus (P)	11.15	12.7	7.01
Potassium (K)	8.17	18.25	9.43
Calcium (Ca)	10.56	92.09	12.82
Magnesium (Mg)	4.93	5.15	3.56
Sulphur (S)	2.24	3.65	1.60
Iron (Fe)	0.99	-	11.73
Manganese (Mn)	0.39	-	1.45
Boron (B)	0.02	-	0.01
Zinc (Zn)	0.31	0.23	0.19
Copper (Cu)	0.05	0.05	0.03
Molybdenum (Mo)	0.003	-	0.002
Sodium (Na)	1.75	-	1.56
Dry Matter	295	460	487
pH	-	7.4	-
C:N ratio	-	7.5	-

5.6 Compost

Organic materials other than livestock manures (e.g., compost, anaerobic digestate, organic fertilisers, soil conditioners/amendments) can be particularly useful when livestock manures are unavailable or in short supply e.g., specialised stockless organic horticultural production.

Compost is made from the controlled biological decomposition with oxygen of biodegradable materials. The resulting material is stable, sanitised, humus-like, rich in organic matter and free from odours. Table 11 provides nutrient analysis results for samples of some professional composts that are allowed in organic production. In Ireland, the National Standard I.S. 441:2011 describes the quality requirements for producing compost. The UK specification for quality compost production is PAS 100:2018. Producers of compost using quality protocols should be able to provide a typical analysis of their product. Figures 4, 5 and 6 are examples of producer composition analysis results for a number of certified organic composts.

Table 11 Nutrient content of professional composts. Analysis results from one sample of peat-free seed compost, two samples of peat-based seed compost and one sample of peat-free compost.

	Kg/t FW			
Parameter	**Seed compost (peat-free)**	**Seed compost (peat-based)**		**Compost (peat-free)**
Total Nitrogen (N)	3.93	4.24	4.28	10.16
Ammonium Nitrogen (NH_4^+)	-	-	-	0.73
Nitrate Nitrogen (NO_3^-)	-	-	-	0.01
Phosphorus (P)	0.34	0.26	0.29	1.68
Potassium (K)	2.02	0.85	1.06	5.59
Calcium (Ca)	3.53	5.74	63.99	26.82
Magnesium (Mg)	0.63	0.92	0.88	2.2
Sulphur (S)	0.39	0.68	0.62	1.17
Iron (Fe)	3.28	1.31	1.45	-
Manganese (Mn)	0.07	0.05	0.05	-
Boron (B)	0.01	0.004	0.004	-
Zinc (Zn)	0.02	0.02	0.02	0.14
Copper (Cu)	0.01	0.01	0.01	0.03
Molybdenum (Mo)	0.001	0.002	0.002	-
Sodium (Na)	0.33	0.14	0.17	-
Dry Matter	353	333	376	647.2
pH	6.3	6.2	6.9	8.3

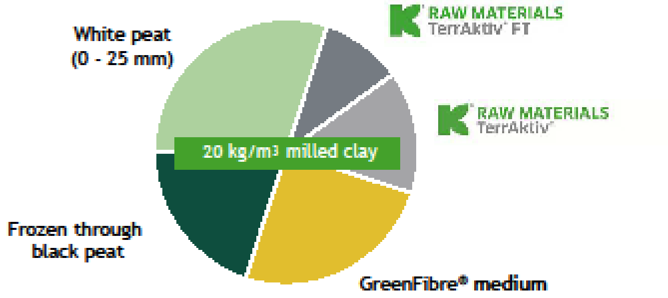
SUBSTRATES
Easy Growing

we make it grow

Bio Potting Substrate

Composition: **Rec. 840**

Approved by ECOCERT INPUTS



Structure:
medium (0 - 25 mm)

Chemical Data:
(according to VDLUFA)

pH-value (H_2O, v/v 1:2.5):	6.0
Salt level (g/l, v/v 1:3.6):	1.0 - 1.2

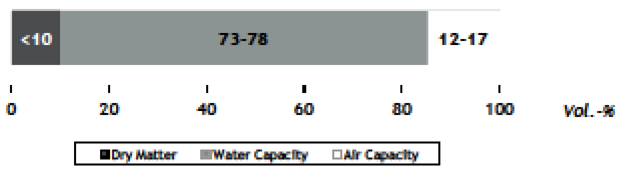
Fertiliser	kg/m³
Horn shaves	4.0
+ extra trace element fertiliser	

Nutrients Added:
Source: TerrAktiv FT, TerrAktiv, horn shaves

Nitrogen (mg N/l):	400 - 500
Mineralised N (mg N/l)*	80 - 120
Phosphorus (mg P_2O_5/l):	250 - 450
Potassium (mg K_2O/l):	350 - 700
Magnesium (mg Mg/l):	100 - 200

* available on delivery

Physical Data:
(according to EN 13 041)



Pot Size:	Additional Comments:	Plants:
< 13 cm	All substrate components comply with the regulation (EC) No 834/2007 and its detailed rules for implementation (EC) No 889/2008, appendix I, approved by Ecocert®. TerrAktiv® green compost is from in-house production. During composting there are two treatments with biodynamic preparations.	Ornamental plants Shrubs Pot plants

The carbon footprint for this product is available on request. Send us an e-mail including order and recipe number to pcf@klasmann-deilmann.com. Find out more at www.klasmann-deilmann.com/sustainability.

Variation limits according guidelines of the quality assurance association Growing Media for Plant cultivation RAL.
All product information which we provide has been prepared by us to our best knowledge and belief. Our information documents therefore make no claim to completeness and correctness. In particular, we reserve the right to make changes. All application and usage recommendations from us must be understood as non-binding guidelines and must be adjusted to meet local circumstances and code of practice. Please note additional information on the delivery note.

www.klasmann-deilmann.com 01/2019

Figure 4 Example of producer compost analysis results.

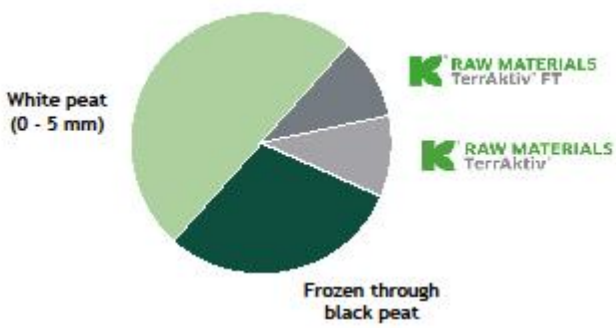
SUBSTRATES
Easy Growing

we make it grow

Bio Tray Substrate

Composition:	20% peat reduced	Rec. 062

Approved by ECOCERT INPUTS



Structure:
extra fine (0 - 5 mm)

Chemical Data:
(according to VDLUFA)

pH-value (H_2O, v/v 1:2.5):	6.0
Salt level (g/l, v/v 1:3.6):	0.7 - 1.3

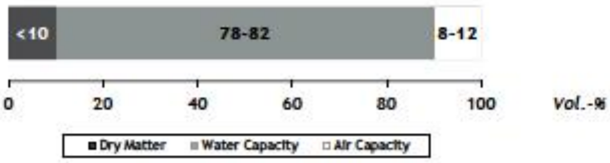
Fertiliser	kg/m³
Horn shaves	2.0
+ extra trace element fertiliser	

Nutrients Added:
Source: TerrAktiv, TerrAktiv FT, horn shaves

Nitrogen (mg N/l):	300 - 400
Mineralised N (mg N/l)*	50 - 80
Phosphorus (mg P_2O_5/l):	200 - 300
Potassium (mg K_2O/l):	300 - 500
Magnesium (mg Mg/l):	100 - 200

* available on delivery

Physical Data:
(according to EN 13 041)



Trays:	Additional Comments:	Plants:
	All substrate components comply with the regulation (EC) No 834/2007 and its detailed rules for implementation (EC) No 889/2008, appendix I, approved by Ecocert®. TerrAktiv® green compost is from in-house production. During composting there are two treatments with biodynamic preparations. TerrAktiv® FT is a fermented wood fibre especially produced for organic cultivation.	Pot herbs Vegetable young plants

The carbon footprint for this product is available on request. Send us an e-mail including order and recipe number to pcf@klasmann-deilmann.com. Find out more at www.klasmann-deilmann.com/sustainability.

Variation limits according guidelines of the quality assurance association Growing Media for Plant cultivation RAL.
All product information which we provide has been prepared by us to our best knowledge and belief. Our information documents therefore make no claim to completeness and correctness. In particular, we reserve the right to make changes. All application and usage recommendations from us must be understood as non-binding guidelines and must be adjusted to meet local circumstances and code of practice. Please note additional information on the delivery note.

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Figure 5 Example of producer compost analysis results.

enrich

Enrich Compost Enrich Compost is Manufactured to the Irish Standards I.S. 441	
Range of Use	Soil amendment to enhance and improve the physical chemical and biological of nutrient deficient soils prior to planting to creating optimum conditions for plant growth. Must be mixed with soil before use. Not suitable for ericaceous plants.
Material	100% Peat-free compost.
Purity	Sustainable free from physical containments, viable weed seeds and pathogens.
Size Distribution	95% pass through 15mm screen. 90% pass through 10mm screen.
Conductivity	<3500 µS/cm
Total Nutrient Values	Enrich Avg.
Total Nitrogen	1 – 2.5 %w/w
Total Phosphorous	1,500 – 4,000 mg/kg
Total Potassium	6,000 – 15,000 mg/kg
Total Magnesium	3,000 – 5,500 mg/kg
Total Calcium	3 – 6 %w/w
Organic Matter (LOI)	30 – 60 %w/w
pH Value	6.5-8.5
Carbon : Nitrogen Ratio	<20 : 1
Bulk Density	350 – 700 g/L

HEALTHY SOIL HEALTHY PLANTS HEALTHY PEOPLE

Enrich Environmental Limited
Larch Hill, Kilcock, Co. Meath
Ireland, W23 W9DN.

T: +353 1 610 3672
E: info@enrich.ie
W: www.enrich.ie

Figure 6 Example of producer compost analysis results.

5.7 Anaerobic digestate

Anaerobic digestate is one of the products of anaerobic digestion, which is the controlled biological decomposition without oxygen of biodegradable materials such as vegetable/plant matter and materials of animal origin like livestock manures. Digestate is available as whole (slurry) or separated into liquid and fibre.

In Ireland, animal by-product anaerobic digestate applied to land as an organic fertiliser/soil improver is strictly controlled by EU and national legislation and the organic standards. The UK specification for quality anaerobic digestate production is PAS 110:2014. Producers of digestate to quality protocols should be able to provide a typical analysis of their product.

5.7.1 Using digestate for organic production in Ireland

- DAFM compliance: if you keep animals permanently or temporarily/have a herd number you have to register as an end user of animal by-product digestate with DAFM and follow the conditions in the end user document CN17 (https://www.gov.ie/en/publication/8c7cd-conditions-for-abp-processing-operations/). Complete the end user registration form with the digestate producer who will then send the completed registration form to DAFM. If you do not keep animals, you do not have to register as an end user of animal by-product digestate. The digestate producers must be approved by DAFM. Further information at https://www.agriculture.gov.ie/agri-foodindustry/animalbyproducts/.
- Organic certification: the digestate must comply with the organic standards [17]/Regulation (EC) 889/2008[5] and amending Regulation (EU) 2019/2164[3], which provide a list of the types of digestate that are allowed in organic production. It is a requirement to maintain documentary evidence of reasons for use, source, quantity, status, storage arrangements and declaration from the supplier that the digestate is produced in accordance with compositional requirements. This includes an organic certificate from the digestate producer or if this is not available details of the source of the materials in the digestate and up-to-date laboratory analysis results for the batch of digestate to be used. Contact your organic (control) certification body if you have any questions.
- Check for any further responsibilities you may have under quality assurance schemes and/or retailer product safety and quality specifications.

Table 12 shows the analysis results for three separate digestate samples. Two samples of whole digestate and a sample of separated fibre digestate.

Table 12 Nutrient content of anaerobic digestate. Analysis results from two samples of whole digestate and one sample of separated fibre digestate.

Parameter	kg/m³ FW Whole (slurry) digestate	kg/t FW Whole digestate	kg/t FW Separated fibre digestate
Total Nitrogen (N)	10.05	25.01	7.02
Ammonium Nitrogen (NH_4^+)	8.75	1.79	2.30
Nitrate Nitrogen (NO_3^-)	0.02	-	-
Phosphorus (P)	1.45	23.44	2.23
Potassium (K)	4.94	21.36	4.88
Calcium (Ca)	2.02	-	-
Magnesium (Mg)	0.52	7.45	0.84
Sulphur (S)	0.83	7.48	1.80
Zinc (Zn)	0.044	0.224	0.093
Copper (Cu)	0.013	0.039	0.021
Dry Matter	79.9	890	315
pH	8.9	6.9	8.6

5.8 Waste-derived materials

Table 13 provides nutrient content information for some waste-derived organic materials, two samples of spent mushroom compost and one sample of corn husk.

Table 13 Nutrient content of waste-derived spent mushroom compost and corn husk. Analysis results from two samples of spent mushroom compost and one sample of corn husk.

	Kg/t FW		
Parameter	**Spent mushroom compost**		**Corn husk**
Total Nitrogen (N)	8.44	5.31	8.37
Ammonium Nitrogen (NH_4^+)	1.71	-	0.59
Nitrate Nitrogen (NO_3^-)	0.01	-	<0.1
Phosphorus (P)	1.98	2.03	1.01
Potassium (K)	12.06	5.49	5.6
Calcium (Ca)	32.65	20.58	4.89
Magnesium (Mg)	2.2	1.17	1.01
Sulphur (S)	12.12	2.27	0.72
Iron (Fe)	1.1	-	-
Manganese (Mn)	0.09	-	-
Boron (B)	0.01	-	-
Zinc (Zn)	0.1	0.05	0.03
Copper (Cu)	0.02	0.01	<0.01
Molybdenum (Mo)	0.001	-	-
Sodium (Na)	2.54	-	-
Dry Matter	360.7	299	558
pH	6.5	-	6.3

5.9 Organic fertiliser

Table 14 provides nutrient content results for four samples of professional granular/pelleted organic fertiliser. Only fertilisers and soil conditioners that have been authorised for use in organic production can be used, and only to the extent necessary. Mineral nitrogen fertilisers are not permitted.

Table 14 Nutrient content of professional granular/pelleted organic fertiliser. Analysis results from four samples.

Parameter	**% nutrient in organic fertiliser DM basis***			
Total Nitrogen (N)	7.15	5.38	8.00	13.1
Ammonium Nitrogen (NH_4^+)	1.65	0.82	1.36	9.36
Nitrate Nitrogen (NO_3^-)	0.31	0.03	0.08	0.03
Phosphorus (P)	1.69	1.001	6.30	0.69
Potassium (K)	1.27	1.93	0.94	2.09
Calcium (Ca)	1.11	0.87	13.17	1.04
Magnesium (Mg)	0.59	0.65	0.39	0.47
Sulphur (S)	0.74	0.72	0.68	15.00
Zinc (Zn)	0.01	0.01	0.01	<0.01
Copper (Cu)	0.001	0.001	<0.01	<0.01
Dry Matter	91.3	90.1	95.6	98.9
pH	5.9	6.0	6.1	2.6
C:N ratio	-	6.9	3.7	1.3

*Manufacturer fertiliser nutrient content specification: percentage N 9-13%

5.10 Green manures

"Green manures" are crops specifically sown to be incorporated into the soil to improve soil structure, organic matter and fertility. They also serve a myriad of other purposes including: soil surface protection ("cover crops"); interception of soil nutrients, particularly nitrate, to reduce leaching losses ("catch crops"); and weed suppression.

5.10.1 Types of green manure

There are three main types of green manure:

- long-term green manures (grown at least one year before incorporation)
- short-term summer green manures (grown for 2-4 months)
- short-term winter green manures (grown for 6-8 months)

Long-term green manures are grown with the principal aims of increasing the nitrogen content and improving the structure of the soil, so are particularly appropriate during the initial conversion period to organic production or to increase soil fertility, of particular value on stockless organic farms. Short-term green manures (summer/winter), on the other hand are designed to be grown between two cash crops, to make use of the land, rather than leave it fallow.

5.10.2 Effects of green manures

5.10.2.1 Increased soil organic matter

All green manures contribute organic matter to the soil, as the incorporated plants (both tops and roots) decompose. This provides a reservoir of nutrients, increases the water-holding capacity, especially of light soils, improves the drainage of heavy soils, reduces soil crusting, and encourages earthworms and beneficial fungi and bacteria in the soil. Plants with high biomass, e.g., white mustard, fodder radish, buckwheat, grazing rye, oats, phacelia, are particularly effective at supplying organic matter.

5.10.2.2 Increased soil nitrogen (N)

Soil N can be increased by including N-fixers, N-lifters, or catch crops in the green manures. N-fixers are legumes, like the clovers, vetch, lucerne, and medicks, which host specific bacteria in their roots that can convert atmospheric N into forms plants can use, at rates of 200 kg N per ha or higher (e.g., red clover), although long-term green manures (at least one year) are needed for clovers, etc.to perform optimally. The bacteria for clovers etc. will be present in any Irish soil, apart from very acid soils, but not for lucerne and sweet clover, which will need to be inoculated each year with commercial inoculum. Short-term green manures containing fast-growing annual legumes, such as crimson, Egyptian and Persian clovers, can provide a boost to soil N but need to be growing at temperatures of at least 8oC for at least 12 weeks to achieve significant N fixation, e.g., short-term summer green manure/April to August. Short-term winter N-lifters are green manure plants with very long/extensive root systems, such as grazing rye, buckwheat, Westerwolds ryegrass that can take up N from deep in the soil horizon and deposit it in the upper reaches where crops can access it, following green manure incorporation. Finally, catch crops are fast-growing annual plants, e.g., grazing rye, mustard, phacelia, in short-term green manures that can mop up any nitrate released from soil reserves as the soil warms up that would otherwise be leached away by rainfall in bare ground. The N in all three of these green manures will be released when the green manure is incorporated. A legume-only green manure will release N almost immediately, making it suitable for growing N-hungry brassica crops, whereas a grass/legume green manure, e.g., ryegrass/clovers, will release the N later in the season, suitable for organic cereals.

5.10.2.3 Increased soil mineral content

Plants with long root systems can also "lift" minerals like calcium, phosphorus, potassium from deep in the soil horizon where they are not usually available to the cash crops. Buckwheat is capable of attracting phosphorus to its roots, making this difficult-to-access macronutrient more available to subsequent cash crops.

5.10.2.4 Improved soil structure

Green manure plants with long and/or extensive root systems (e.g., rye, phacelia, buckwheat) improve soil structure by increasing aeration, providing organic matter throughout the soil profile, as the roots decompose. Whereas green manure plants with taproots, e.g., chicory, can break up compacted soils and "pans" in longer-term green manures. Increases in near-surface soil organic matter after green manure incorporation will also reduce the risk of soil surface crusting. On clay soils, heavy rain on bare soil causes separation of the finer particles into a thin layer at the surface, which dries to form a crust that can impede penetration of water and seedlings. To prevent this, an annual cover crop green manure, such as mustard or phacelia, can form a protective layer of leaves over the soil surface. In MOPS green manure trials research (Figure 7), soil into which short-term manures had been incorporated was noticeably more friable and easy-to-work.

Figure 7 MOPS green manure trial site showing four different short-term summer green manures eight weeks after sowing. Foreground left, the tall, flowering green manure is buckwheat/phacelia.

5.10.2.5 Increased pest, weed, disease management

Green manures can reduce weed populations in several ways. Fast-growing leafy green manure plants, such as mustard, phacelia, grazing rye, oats, vetch and buckwheat will suppress annual weeds by competing with them for light and other resources – by preventing weed flowering, the weed seed bank will be depleted. Prostrate-growing weeds, like chickweed, however, can survive under tall green manures such as buckwheat. As they decompose after incorporation, many green manure plants, particularly clovers, vetch and rye (not ryegrass, as many books state), release allelopathic chemicals which prevent seed germination. This can help suppress weeds but can also inhibit germination of direct-drilled cash crops, so a longer delay after incorporation is recommended before small-seeded cash crops are direct drilled.

MOPS green manure trials showed that a rye-based green manure is also effective against perennial weeds, like docks, both before and after incorporation (Figure 8), but proved inhibitory to lettuce transplants after incorporation.

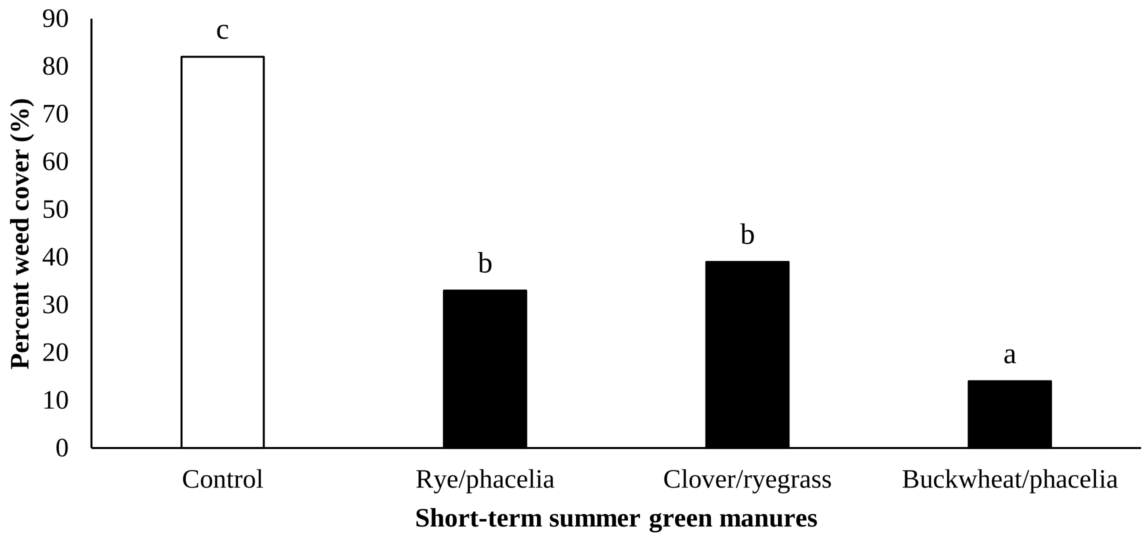

Figure 8 Effect of short-term summer green manures on percentage (%) weed cover ("control" means no green manure sown). Any two samples with a common letter are not significantly different.

The presence of a short-term summer green manure resulted in significant increases in beneficial insects like slug-devouring ground beetles in MOPS green manure trials, though low-growing green manures, such as ryegrass/clover supported larger populations than did tall green manures, such as buckwheat/phacelia. Vetch is particularly good at encouraging ground beetle populations. Although it is not advisable to allow green manures to flower, as there is a risk of seeds being released to cause problems, green manures with simple flowers, like mustard and phacelia, attract beneficial insects such as hoverflies, the larvae of which eat aphids and caterpillars. To retain these populations after the incorporation phase, a 0.5 m wide strip was retained during the incorporation stage as a "beetle bank". Short-term summer green manures resulted in significantly higher bacterial populations in the soil, both before and after incorporation. Clover-based green manures were best before incorporation, but others like phacelia, buckwheat and rye green manure were more effective after incorporation.

A side-effect of green manures is that they can act as break crops against soil-borne diseases, as long as plants unrelated to the intended cash crops are used. Buckwheat and phacelia are particularly valuable as they belong to plant families which contain no cash crops. On the other hand, mustard and fodder radish are brassicas, so should not be used as green manures before an intended brassica cash crop.

5.10.3 Single-species or mixed-species green manures?

Single-species green manures are usually restricted to fast-growing high-biomass short-term summer green manures, e.g., mustard, phacelia.

Because no one green manure plant can achieve all the beneficial effects possible (e.g., soil organic matter, soil structure, weed control, pest management), mixtures are often used. For example, long-term green manures are commonly grass/clover mixes, combining the high biomass and deep rooting (to improve soil structure) of the grasses with the nitrogen-fixing ability of the clover. In addition to the use together of individual green manures, each with different characteristics, complementarity was often selected. For example, in summer or winter green manures using vetch as a N-fixing plant, better performance was achieved when the sprawling vetch was combined with a vertical green manure plant, such as rye (winter, summer) or buckwheat (summer), over which the vetch could scramble.

In wild plant ecology or crop agronomy, it is recognised that the greater the species variation in a plant population, the more stable and the higher yielding the population would generally be. A single-species green manure could fail completely, whereas some members of a mixed-species green manure would survive and would thrive as they had more space if one member species had died out. In a crop population, the greatest competition for resources such as light, water and nutrients occur between plants of the same species as they grow to the same height, root to the same level, etc. Compared to single-species "monocultures", mixed-species intercrops often yield better ("intercropping advantage") because they compete less with neighbouring plants. A long-term perennial ryegrass/red clover ley grown as a green manure intercrop would yield better than either red clover or ryegrass monoculture, with the N-fixing red clover being able to access N better than the ryegrass, whereas the taller and deeper-rooted ryegrass would be able to access light, water and minerals better than the clover.

5.10.4 Growing green manures

5.10.4.1 Selecting the green manure species

The first step is to select the species make-up of the appropriate green manure, taking account of your goals for the green manure i.e., long-term/short-term, summer/winter, sowing date (see Table 15). Where possible, obtain information from Irish sources, as they should be relevant to Irish conditions. Take soil samples and soil structure assessments including measuring soil organic matter. Consider testing soil before and after growing the green manure crops.

Table 15 Overview of the main green manure species.

Plant	N effect[1]	Weed effect[2]	Sowing date	Sowing rate (kg/ha)	Green manure type[3]	Comments
Alsike clover	NF	WS (late)	March-May, or August	15-25	LT	Short-lived perennial, frost tolerant. Slow establishment, lower biomass but better than other clovers on wet, heavy, more acid soils.
Crimson clover	NF	WS	March-May, or August	15-30	STS, STW	Annual, but can overwinter from autumn sowing. High biomass; do not top too low. Grows on wide range of soils. As with most clovers, dislikes acid soils.
Egyptian clover	NF		Late March/early April, late August	15-30	STS	Annual, frost sensitive. Upright habit, not very weed suppressive. Best on heavy, not too acid soils.
Persian clover	NF	WS (early)	April-May, or August	10-20	STS	Annual, high biomass. Less woody than others, decomposes quickly. Tolerates poorly drained, heavy, alkaline soils.
Red clover	NF		March-May, or August	15-25	LT	Herbaceous perennial, erect habit, topped at 30 cm. Deep roots, improves soil structure.
Sweet clover	NF		March-May, or August	15-30	STS, STW	Biennial, erect habit (not good weed suppression).

Plant	N effect[1]	Weed effect[2]	Sowing date	Sowing rate (kg/ha)	Green manure type[3]	Comments
						High biomass. Tap root, breaks "pans".
Lucerne	NF		March-May, or August	20-30	LT	Herbaceous perennial. Needs alkaline soil (> pH 6.3). Slow to establish, slow to suppress weeds.
Vetch	NF	WS, WA	March to October	80-100	STS, STW	Annual. Frost tolerant. Can be sown later than clovers. Not good on very acid soils. Best sown with a support plant, e.g., rye. Excellent weed suppression and allelopathy – delay cash crop sowing after incorporation. Not topped.
Buckwheat	NH, NL	WS	After April, May (frost sensitive)	50-85	STS	Annual. Increases soil P availability. Deep roots – improves soil structure. Good weed suppression. No topping. Grows well on poor, acid soils. In different family from all cash crops. Expensive seed.
Chicory	NL	WS (late)	March-May or August-September	15-25	LT	Medium-term perennial. Slow to bulk up, then good weed suppressor. Regular topping. Taproots – will break up compacted soil/pans. In different family from all cash crops.
Fodder radish	NH	WS (early)	April-September	15-25	STS	Frost-sensitive annual. Catch, cover crop on all soil types. Flowers after 6-8 weeks. Very weed competitive. Host for clubroot – will upset rotation for brassicas. Can be topped.
Grazing rye	NH, NL	WS, WA	March-May or September-October	180-200	LT, STS, STW	Large seeds, high seeding rate, so expensive. Catch, cover crop. Very frost tolerant – can be sown later than other green manures. Especially for heavy clay-rich soils. Excellent weed control.
Italian ryegrass	NH, NL	WS (early)	March-April or August-late September	30	LT	Short-lived perennial. Rapid early growth, good early weed suppression. Needs regular topping.
Mustard	NL, NH	WS (early)	April-August	20-30	STS	Annual. Rapid early growth, flowers at 4-6 weeks. Catch, cover crop. Excellent weed suppression. Poor frost tolerance. Clubroot host –

Plant	N effect[1]	Weed effect[2]	Sowing date	Sowing rate (kg/ha)	Green manure type[3]	Comments
						upsets brassica rotation. No topping. Needs fertile soil.
Perennial ryegrass	NH	WS	Spring or Autumn	35	LT	Regular topping (or grazing). Commonly in ley with red clover. Can delay release of N after green manure incorporation.
Phacelia	NH, NL	WS (early)	After March	10-20	STS	Annual, very rapid early growth; can germinate at lower temperatures. Moderate frost tolerance. Good weed suppression, though leaves are dissected. Deep roots, improves soil structure. No topping. Grows on wide range of soils. Flowers after 6-8 weeks.
Tillage radish	NH	WS (early)	April-August	5-10	STS	Fast-growing frost-sensitive annual. Catch, cover crop. Forms taproot, which breaks up compacted soil/pans, improves soil structure.
Westerwolds ryegrass	NH	WS (early)	Spring or Autumn	30-40	STS, STW	Winter-hardy annual. Can be sown late in the autumn (September-October). Very good early weed control. Can be topped. Excellent catch crop, especially in the winter.

[1]NF: N-Fixer; NH: N-Holder (catch crop); N-Lifter (moves N to upper soil horizons); [2]WS: Weed suppressor (competitive); WA: Weed allelopathic (releases chemicals to inhibit weeds); [3]LT: long-term green manure; STS: short-term summer green manure; STW: short-term winter green manure.

5.10.4.2 Seed sowing

Spring and autumn are the best seasons for sowing green manures (suitable soil temperatures, moisture content), especially clovers (April/May or August) though short-term summer green manures can be sown in June with irrigation where needed. A suitable seed bed should be prepared in the usual way. If the site has a serious weed seed bank problem, consider using the stale seed bed technique, surface cultivating the soil 10-14 days after the initial cultivation, to kill off the first flush of weeds. Clovers have small seeds and can be slow to establish, so a clean seed bed is important. Seed can be broadcast (needs a higher seeding rate) or drilled, and seeds can be covered by surface cultivation. After sowing, the seed bed should be rolled to increase seed-soil contact, especially for the smaller-seeded green manures like clovers. Green manure mixtures can be problematic in terms of consistency of seed delivery and seed depth, especially in grass/legume mixtures, such as large-seeded rye and small-seeded clovers.

5.10.4.3 Green manure management

Problems to be avoided with green manures include competition with weeds, like charlock, and flowering of the green manure plants. Flowering green manure plants tend to be fibrous and slow to decompose and run the risk of releasing seeds into the seed bank. To prevent either, the green manure can be topped (once for short-term green manures and more regularly e.g., every 3-4 weeks during the summer for long-term green manures) before flowering at a height which will allow the green manure plants to re-grow e.g., 5-10 cm for rye, ryegrass, phacelia, higher for clovers such as Persian clover, red clover (15-20 cm). After topping, legume-based green manures will fix more N if the toppings are removed. Shortest-term summer green manures or green manures containing plants like vetch should not be topped.

5.10.4.4 Green manure incorporation

Prior to incorporation of the green manure into the soil, the shoots should be removed and cut up with a mulcher or flail mower. If the green manure is very leafy, it should be allowed to wilt for a few days. High-N (e.g., clovers) or leafy (e.g., mustard) green manures decompose faster than, say, rye or ryegrass. The faster the decomposition, the earlier, the cash crop can be planted. Rather than incorporation with traditional deep ploughing, the aim is to incorporate through the top 10-15 cm of the soil, with several passes with a cultivator or rotavator. During incorporation, one or more 0.5-m wide strips of the green manure, connected to a headland or hedgerow, can be retained as a refuge for beneficial insects, like ground beetles, and allowing green manure plants to flower to attract pollinators and beneficial insects, such as hoverflies. Cash crop transplants can be planted as early as two weeks after green manure incorporation, though greater delays are recommended after rye-based green manures, especially prior to direct drilling, particularly with respect to small-seeded crops, or planting with lettuce transplants which are particularly sensitive to the allelopathic effects of rye.

5.10.5 Can green manures fit into your farming system?

Short- or long-term green manures involve extra expense (organic green manure seed) and workload (site preparation, green manure topping, incorporation) which may give growers second thoughts. But, carried out properly, with selection of appropriate green manures, sowing dates and management, green manures will provide long- and short-term benefits that can exceed any immediate crop losses. Long-term green manures take land for cash crops out of production, but the benefits in terms of increased production in the next 2-3 crops over the medium term (largely, as N supply from legume or grass/legume green manures) more than makes up for lost production. In addition, other beneficial effects of green manures (organic matter, soil structure, weed and pest control) should also be taken into account. Short-term green manures tend to exploit soil which is already unproductive, between successive crops, meaning no loss of production, although sowing a winter legume-containing green manure in September, to maximise growth and N-fixing potential, may necessitate digging-in the last few plants of the vegetable cash crop. The shorter growth period of short-term green manures reduces the impact on N supply, but cost-benefit analysis on MOPS green manure trials on three summer and three winter green manures, with two vegetable cash crops for each of summer and winter green manures, in which N-fixation was blocked by manipulating the sowing and incorporation dates, showed that, of the 12 green manure/cash crop combinations, 11 showed significant increases in net profit (after taking account of seed costs, labour costs, etc.) above the no-green-manure control. The increases cannot be attributed to a single factor, though most of the beneficial effects were exhibited in the green manure plots, such as increased soil minerals, increased beneficial insects, increased weed control, greater soil organic matter, improved soil structure, and greater microbial biodiversity in the soil. The increases in profit were associated with greater head/bulb weights, resulting in a higher proportion of harvestable size. The green manures resulted in faster growth of the cash crops; planting only half a site under green manures could spread the harvest period of the cash crop. Beneficial effects in subsequent years were not taken into account. The only green manure/cash crop which failed to generate an increased profit was lettuce after a rye-based winter green manure. Growth of the transplants was inhibited, as a result of allelopathic effects, when planted two weeks after incorporation. Delaying this to four weeks or reducing the rye percentage to 30% instead of 60%, eliminated the inhibition and restored the increased net profit.

5.11 Additional information and references

5.11.1 Useful sources of information

- Irish Organic Association (IOA): http://www.irishorganicassociation.ie/
- Department of Agriculture, Food and the Marine (DAFM): https://www.agriculture.gov.ie/
- International Federation of Organic Agriculture Movements (IFOAM): https://www.ifoam-eu.org/en/node
- European Union (EU): https://europa.eu/european-union/index_en
- Department of Agriculture, Environment and Rural Affairs: https://www.daera-ni.gov.uk/
- Research Institute of Organic Agriculture (FiBL): https://www.fibl.org/en.html
- Teagasc Agriculture and Food Development Authority: https://www.teagasc.ie/
- Food Safety Authority of Ireland (FSAI): https://www.fsai.ie/
- Composting and Anaerobic Digestion Association of Ireland (cré): http://www.cre.ie/web/
- Soil Association: https://www.soilassociation.org/
- Agriculture and Horticulture Development Board (AHDB): https://ahdb.org.uk/horticulture
- Waste and Resources Action Programme (WRAP): https://www.wrap.org.uk/
- European Compost Network: https://www.compostnetwork.info/
- Codex Alimentarius Commission: http://www.fao.org/fao-who-codexalimentarius/codex-texts/codes-of-practice/en/
- Organic Trust: https://organictrust.ie/
- Organic Research Centre: http://www.organicresearchcentre.com/

Table 16 Conversion tables [2, 16, 25].

Length		
10 cm	3.94 inches	
2.54 cm	1 inch	
Area		
1 hectare (ha)	2.47 acre	
0.405 ha	1 acre	
Volume		
1 m^3	220 gallons	
4.5 m^3	1,000 gallons	
Mass		
1 tonne	1,000 kilogram, kg	
1 tonne	20 hundredweights (cwt)	
1 kg	2 units	
0.5 kg	1 unit	
1 unit	1 % of 1 cwt, or 1.12 lbs	
Yield and rate		
1 tonne/ha	0.4 tons/acre	
2.5 tonnes/ha	1 ton/acre	
100 kg/ha	80 units/acre	
125 kg/ha	100 units/acre	
1 kg/tonne	2 units/ton	
0.5 kg/tonne	1 unit/ton	
1 m^3/ha	90 gallons/acre	
11 m^3/ha	1,000 gallons/acre	
1 kg/m^3	9 units/1000 gallons	
Concentrations	**multiply by**	
percent, %	10	gram per kilogram, g/kg
part per million, ppm	1	milligram per kilogram, mg/kg
ppm	1	milligram per litre, mg/l
milliequivalents per 100 grams	1	centimole per kilogram, cmol/kg
1 ppm	1,000	parts per billion, ppb

Table 17 Guide use only. Typical nutrient content of organic materials. Reproduced from the Nutrient Management Guide (RB209) [1] with permission from AHDB.

Fresh weight	DM %	Unit	Total N	P_2O_5	K_2O	SO_3	MgO
Cattle farmyard manure	25	kg/t	6	3.2	9.4	2.4	1.8
Pig farmyard manure	25	kg/t	7	6	8	3.4	1.8
Sheep farmyard manure	25	kg/t	7	3.2	8	4	2.8
Duck farmyard manure	25	kg/t	6.5	5.5	7.5	2.6	2.4
Horse farmyard manure	25	kg/t	5	5	6	1.6	1.5
Goat farmyard manure	40	kg/t	9.5	4.5	12	2.8	1.9
Poultry manure	20	kg/t	9.4	8	8.5	3	2.7
Poultry manure	40	kg/t	19	12	15	5.6	4.3
Poultry manure	60	kg/t	28	17	21	8.2	5.9
Poultry manure	80	kg/t	37	21	27	11	7.5
Cattle slurry	2	Kg/m^3	1.6	0.6	1.7	0.3	0.2
Cattle slurry	6	Kg/m^3	2.6	1.2	2.5	0.7	0.6
Cattle slurry	10	Kg/m^3	3.6	1.8	3.4	1	0.9
Dirty water	0.5	Kg/m^3	0.5	0.1	1	0.1	0.1
Pig slurry liquid	2	Kg/m^3	3	0.8	1.8	0.4	0.4
Pig slurry liquid	4	Kg/m^3	3.6	1.5	2.2	0.7	0.7
Pig slurry liquid	6	Kg/m^3	4.4	2.2	2.6	1	1
Pig slurry separated liquid portion	3	Kg/m^3	3.6	1.1	2	-	-
Pig slurry separated solid portion	20	Kg/t	5	3.7	2	-	-
Compost green	60	Kg/t	7.5	3	6.8	3.4	3.4
Compost green/food	60	Kg/t	11	4.9	8	5.1	3.4
Digestate food-based whole	4.1	Kg/m^3	4.8	1.1	2.4	0.7	0.2
Digestate food-based separated liquid	3.8	Kg/m^3	4.5	1	2.8	1	0.2
Digestate food-based separated fibre	27	Kg/t	8.9	10.2	3	4.1	2.2
Digestate farm-sourced whole	5.5	Kg/m^3	3.6	1.7	4.4	0.8	0.6
Digestate farm-sourced separated liquid	3	Kg/m^3	1.9	0.6	2.5	<0.1	0.4
Digestate farm-sourced separated fibre	24	Kg/t	5.6	4.7	6	2.1	1.8
Paper crumble chemically/physically treated	40	Kg/t	2	0.4	0.2	0.6	1.4
Paper crumble biologically treated	30	Kg/t	7.5	3.8	0.4	2.4	1
Spent mushroom compost	35	Kg/t	6	5	9	-	-
Water treatment cake	25	Kg/t	2.4	3.4	0.4	5.5	0.8
Food industry waste dairy	4	Kg/t	1	0.8	0.2	-	-
Food industry waste soft drinks	4	Kg/t	0.3	0.2	Trace	-	-
Food industry waste brewing	7	Kg/t	2	0.8	0.2	-	-
Food industry waste general	5	Kg/t	1.6	0.7	0.2	-	-

Table 18 Guide use only. Available nutrient content of organic manures Teagasc guide [23].

	Unit	Nitrogen	Phosphorus	Potassium
Liquid manures		Based on Nitrates Directive (Actual)		
Cattle (7 % DM)	Kg/m^3	2 (0.7)	0.6	3.3
Pig (4 % DM)	Kg/m^3	2.1 (2.1)	0.8	1.9
Soiled water	Kg/m^3	0.48	0.08	0.6
Solid manures				
Dungstead manure	kg/t	1.4	0.9	4.2
Farmyard manure	kg/t	1.35	1.2	6
Poultry				
Broiler/deep litter	kg/t	5.5	6	12
Layers (30 % DM)	kg/t	6.85	2.9	6
Layers (55 % DM)	kg/t	11.5	5.5	12
Turkeys	kg/t	14	13.8	12
Spent mushroom compost	kg/t	1.6	1.5	8

Based on Nitrates Directive total nutrient content values e.g., Total N 5 kg/m^3

Actual based on Total N 2.4 kg/m^3 at 30 % N availability cattle slurry. Pig slurry without incorporation assumes 35 % N availability. Incorporation of pig slurry within 3 hours of application assumes 50 % N availability

Reduce P availability to 50 % on Index 1 and 2 soils

Table 19 Guide use only. Typical carbon and nitrogen contents and C:N ratio of some organic materials [2, 22].

Organic material	**% C**	**% N**	**C:N ratio**
Vegetable wastes	30	3	10:1
Cabbage	43	3.6	12:1
Farmyard manure	30	2.15	14:1
Grass clippings	58	3.4	17:1
Broccoli residues	35	1.9	18:1
Seaweed	36	1.9	19:1
Farmyard manure	41	2.1	20:1
Potato haulm	38	1.5	25:1
Rye cover crop vegetative stage	40	1.5	26:1
Horse manure	48	1.6	30:1
Tree prunings	50	1.0	50:1
Straw wheat	38	0.5	80:1
Sawdust	50	0.1	500:1

Carbon-to-nitrogen ratio (C:N ratio) is the ratio of the weight of organic carbon (C) to the weight of total nitrogen (N) in organic material. Microorganisms use carbon and nitrogen in organic materials for energy, growth, essential protein and reproduction. The C:N ratio of organic materials applied to soil is important for two main reasons: (1) competition occurs among microorganisms for available soil nitrogen when organic materials with high C:N ratio are added to soils. So high C:N ratio organic material depletes the soil's supply of soluble nitrogen, causing plants to suffer from nitrogen deficiency; (2) the C:N ratio of organic materials gives an indication of their rate of decay and the rate at which nitrogen is made available to plants. The decay of organic materials can be delayed if sufficient nitrogen to support microbial growth is not present in the material undergoing decomposition nor available in the soil. For composting, the correct C:N ratio is required to ensure efficient decomposition and to conserve nitrogen in the final product. If the C:N ratio is greater than 40:1, nitrogen will be a limiting factor in decomposition and longer composting times are required for microorganisms to use the excess carbon. With C:N ratios below 20:1, the available carbon is utilised without stabilising all of the excess nitrogen, which is lost as ammonia.

5.11.2 References

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6 Dissemination

6.1 Introduction

A key objective of the MOPS EIP project was to build capacity within the group of project growers and also the organic food sector and wider community, e.g., growers, producers and trainers/educators, through sharing information and findings from the group and project activities. A communication and dissemination plan was therefore developed to share knowledge, information and practices along with findings and insights from the project so that, for example, growing techniques, or parts of them, might be replicated or used as demonstrative examples of the different approaches that the project growers use to optimise production of organic horticultural crops. The communication and dissemination plan was designed to involve and actively engage relevant stakeholders in the project with all potential target audiences in mind. This included research into their information needs and activities with content released on various channels based on those needs. Inclusive communication was a key feature of this plan and there was regular input from the Operational Group right throughout the project to ensure that communication on the project remained relevant and targeted.

6.2 Materials and methods

6.2.1 MOPS project videos

For the three-year duration of the MOPS project a series of video footage was taken on the 11 participating farms during scheduled planning visits. The aim of including video footage was to capture what was happening on the farm(s) on a given day, with the main focus being agronomy and crop growing practices and associated challenges. The videos were designed to give information about specific crops and their production requirements. This information was extremely beneficial to the other organic growers in the Operational Group and also growers beyond the MOPS project.

The videos are hosted on the website of the lead partner, the Irish Organic Association, and can be found at www.mopsorganic.ie. Examples of the video listings are presented in the result section 6.3 below.

6.2.2 Social media

The communication campaign focused on Twitter as its primary social media platform. This was used during the project to post videos, highlight information and findings related to the project. The Twitter account also engaged and interacted with relevant postings to boost engagement. The Twitter handle @MOPSorganic was used for the duration of the project and will continue to exist into the future to promote key findings from the MOPS project.

6.2.3 Print media

The MOPS project was featured in the following publications on a regular basis throughout the project:

- Farming Independent
- Organic Matters Magazine
- OGA Magazine (Organic Growers Magazine UK)

The central aim with the print articles was to raise awareness, initially about the MOPS project itself and subsequently, to inform interested stakeholders about the key project findings. The range of articles was extensive and all assisted in achieving the aim of promotion and engagement with the MOPS project and knowledge sharing.

6.2.4 Events

The Irish Organic Association hosted farm walks on participating MOPS project farms and the green manure field trial site as part of their Field Talk programme. These were open to wider stakeholders in the industry and also to primary producers and researchers. While events were curtailed due to the Covid-19 pandemic, several public lectures were given by the Project Manager and Communications Officer over the course of the project, which successfully raised the profile of the MOPS project. It is proposed that this will continue into the future in order to widely disseminate key project findings.

6.2.5 Blogs and community outreach

At several stages during the MOPS project the Project Manager engaged with the National Rural Network, a component of Ireland's Rural Development Programme, to provide content for various blogs on the MOPS project. This featured early interviews with the Operational Group and subsequently explored the benefits from a farmers' perspective on the experience of participating in an EIP project.

Community outreach flyers were designed, printed and distributed by the Irish Organic Association to raise awareness about the MOPS project. The flyers included the aims of the project and key aspects such as the green manure trial. These were widely distributed at events and by the Operational Group members through their sales channels to customers and interested parties.

6.2.6 QR codes

A series of films were crafted and delivered via QR codes. These were animated films with no narrative included. The films highlighted the core messages of the project such as the potential of short supply chains, collaborative production among the organic growers, benefits of organic food production for sustainability, agro-ecosystems, promotion of family farms, and overall ambition to reduce waste and increase productivity. The films were designed to operate as QR codes. Each of the 11 participating farms had a specific film on their business. In addition, there were more general films directed at increasing consumer awareness of organic production and the MOPS project.

The films will be released to the public via the social media channels associated with the project and operated by the Irish Organic Association. Members of the Operational Group can use their individual QR codes on their packaging and social media channels to highlight their participation in the MOPS project. The films will be issued over the coming months which will increase longevity of the project. All films include a call to action and direct viewers to the soft copy of the MOPS Project Growers Report.

6.3 Results

See Appendix 3 section 8 for a full list of MOPS project communication and dissemination activities.

6.3.1 Visual graphics of the communication methods that were used for dissemination during the MOPS project

6.3.1.1 Videos

Samples of some of the videos are presented below. A full listing of the videos can be found at www.mopsorganic.ie

Potatoes #1

This video captures mechanical potato harvesting in a 10 acre field. The potato variety being harvested is Orla, which has a pale skin colour with yellow flesh and is grown as a first or second early, or as a maincrop. In this video Emmett Dunne from O'Duinn Organacha explains his production process from sowing, weeding, ridging to storage for over-winter supply.

Potatoes #2

Application of fertiliser to potato crops can be difficult especially for field-scale production. Emmett Dunne from O'Duinn Organacha evaluates the benefits of applying an approved organic fertiliser at the time of sowing the potato crop.

Kale #3

Desmond and Olive Thorpe supply kale to some of the major grocery retailers and also independent stores. Here Desmond outlines his cultivation system for the kale variety Oldenbor. He also introduces a new crop, Kalettes, which are a cross between kale and Brussels sprouts.

Kale #4

Vincent Grace from Riversfield Organic Farm grows both the curly green kale variety Reflex and the red kale variety Redbor. His main markets are direct-selling to consumers and restaurants. He grows the plants through a bio-degradable mulch to reduce competition with weeds. Crop management techniques to ensure continued supply are discussed.

Kale #5

Green Earth Organics are trialling a new approach with their kale crop by growing a green manure (subterranean clover) underneath the crop plants. Rhizobia in the roots of subterranean clover fix nitrogen from the air which is absorbed by the kale plants throughout the long growing season.

6.3.1.2 Social media

A sample of one of the many social media posts used to promote the MOPS project is presented below.

6.3.1.3 Print media

The article below about the MOPS project featured in the Farming Independent in July 2020. The article is a sample of one of the many print articles on the MOPS project that were published over the course of the project.

Farming

Organics

How specialist support is boosting the viability of organic farmers

A Department of Agriculture and EU partnership is delivering tangible results for organics farmers, reports Grace Maher

Dunne Organics

Collective: The shared knowledge from the MOPS project is improving quality and profits for its member, says Liam Ryan

Being part of the project has dramatically improved farm efficiencies for growers

Grace Maher is development officer with the Irish Organic Association, grace.maher@irishoa.ie

Putting the theory into practice at ground level

6.3.1.4 Events

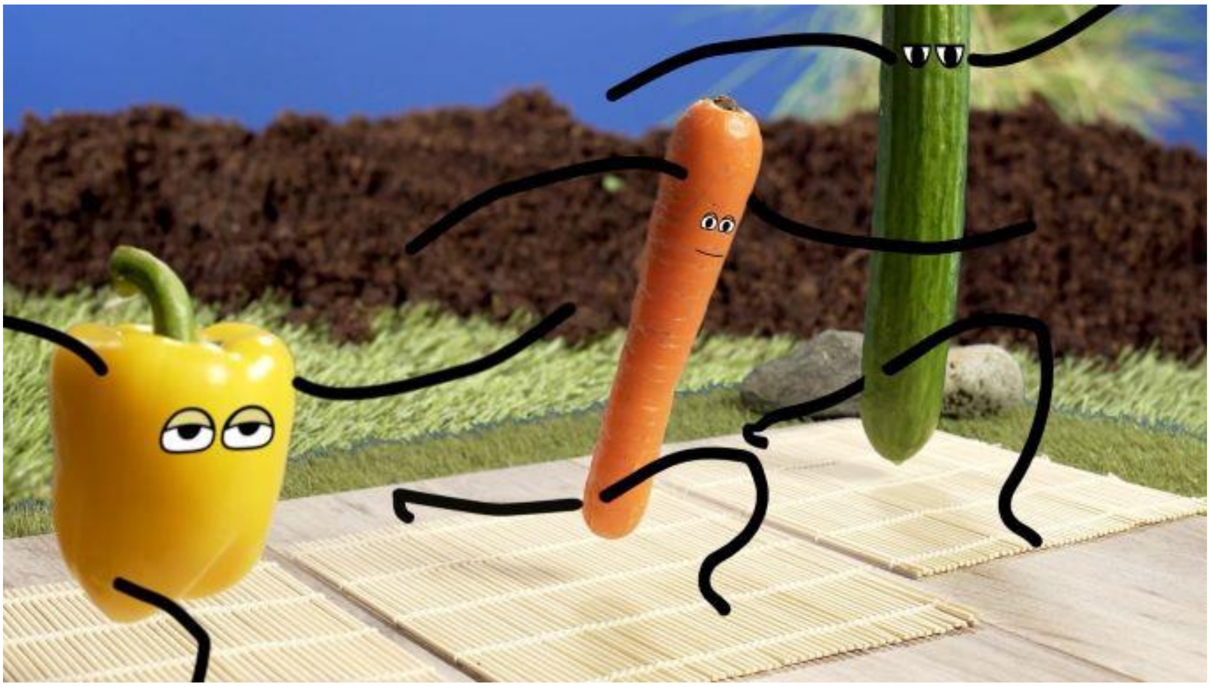
The image below was taken during a farm walk that was hosted by Nurney Farm who participated in the MOPS project. In the image, Gillian Westbrook Project Manager for the MOPS project, outlines the aims of the MOPS project for a video that was widely circulated on social media.

6.3.1.5 Blogs and community outreach flyers

The image below shows Louise Rankin from Moyleabbey Organic Farm in her blog for the National Rural Network (NRN) outlining how valuable participating in the MOPS project was for their business.

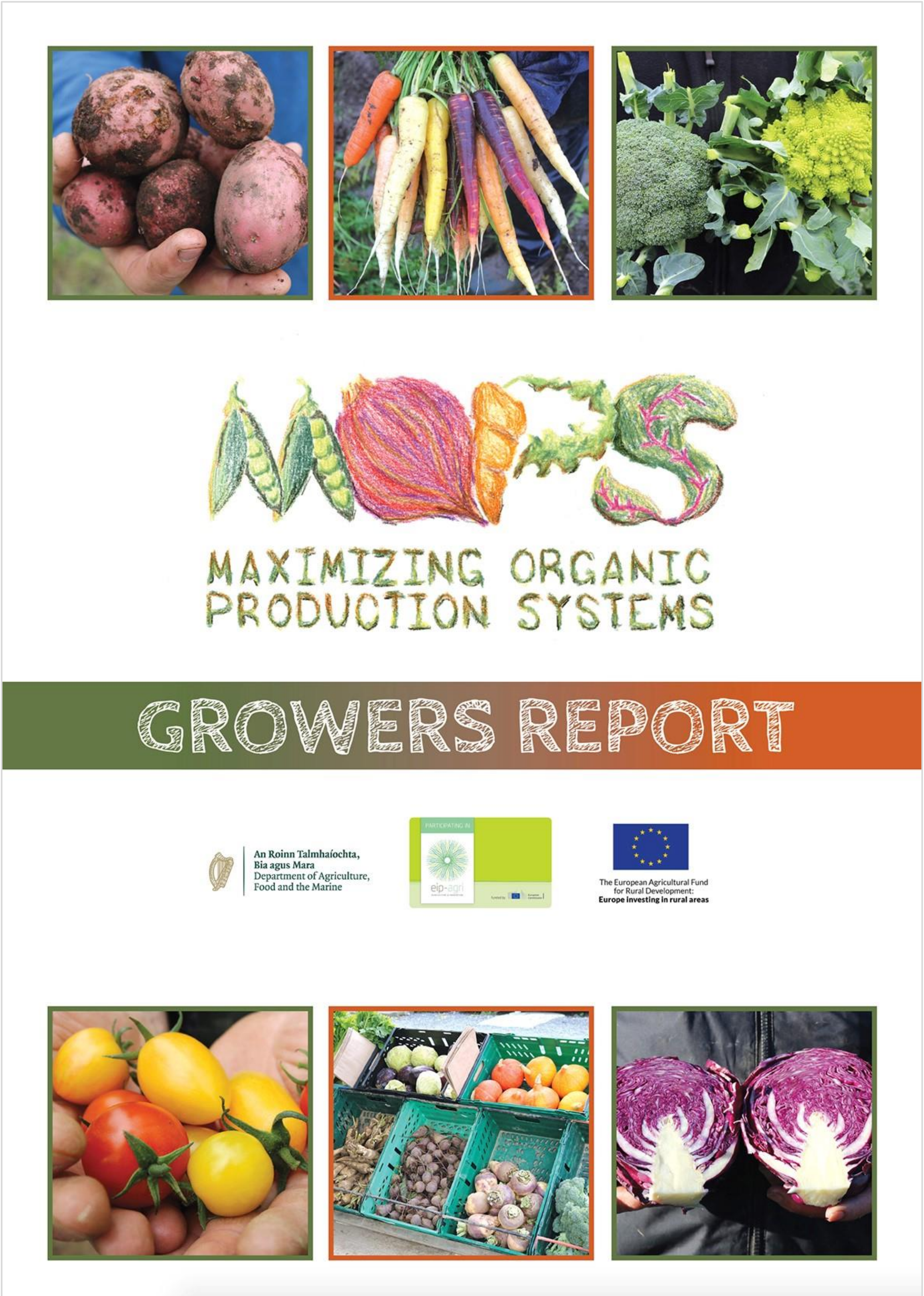
6.3.1.6 QR codes

Below are still images of the animations that were used in the QR codes created for the member of the MOPS project Operational Group and for the films released to the general public.



6.3.1.7 Growers Report

A Growers Report was produced during the MOPS project to provide practical information on the main elements from the project of interest and relevance to existing and new growers and producers, trainers/educators and others. A hard copy of the MOPS Growers Report is available from the Irish Organic Association, 13 Inish Carraig, Golden Island, Athlone, Co. Westmeath, N37 N1W4. Email: info@irishoa.ie, tel: 090 6433680.



7 Concluding remarks

7.1 MOPS project contribution to Rural Development priorities and future policy prospects

Key findings from the MOPS project have contributed to the overall goals and objectives of the common agricultural policy (CAP), notably the Rural Development priorities on farm viability and competitiveness (Priority 2) and food chain organisation and risk management (Priority 3). As well as informing the relevant interventions under Ireland's CAP Strategic Plan, the project results can support effective implementation of Ireland's Food Vision 2030, notably the government's forthcoming roadmap for the horticulture industry to 2030. Integrating MOPS' key learning outcomes into these new policies can help the organic horticulture sector in Ireland to respond to growing market demand sustainably, but also deliver on the ambitions of the European Green Deal, in particular the Farm to Fork Strategy. Indeed, the Farm to Fork Strategy highlights the need for a greater emphasis on a plant-based diet with more fruits and vegetables to reduce both risks of life-threatening diseases, as well as negative environmental impacts of the food system. These, are all areas where the organic horticulture sector offers huge potential with the right policies in place.

7.2 Farm viability and competitiveness

Farm economic performance can be significantly impacted by crop losses, and under or over availability of soil nutrients is an important factor that determines crop yields. The level and frequency of soil and compost sampling and subsequent analytical results have shown the MOPS project growers the value of using more frequent and targeted testing for more efficient soil fertility management. A technical note on organic materials used in organic production was subsequently developed and published to complement the nutrient analysis results from the project, and provide growers with an overview of the potential nutrients available from a variety of approved and commonly used organic inputs.

Plant tissue sampling and analysis were conducted when signs of crop deficiency appeared, which allowed for remedial and preventative action to be taken. The growers used the analysis results to mitigate the risk of crop damage/losses thereby avoiding possible economic loss. The relatively minor expense of laboratory analyses does not compare to economic losses that are associated with reduced crop yields and quality marketable produce.

Developing cropping plans, while cognisant of the market demands, has demonstrability improved economic performance over the combined group of farms. Documenting an annual crop plan sets a formal approach to the management of the farm business, as well as acts as a historic reference to review when required. Recording crop details provides the necessary information to make an informed decision for forecasting future crop planning to ensure adequate supply is available to meet market demands throughout the season. In addition, it provides useful information to compare and discuss crop performance with other growers.

The use of climate monitors, in particular for soil temperature recording, was new to some of the growers. Using innovative farm technology can help farmers better plan for climatic risks by having a more informed understanding of what is actually happening on their land and in their crops. Beyond the MOPS project, installation of real-time data displays would be hugely beneficial for the growers. Although the project data was largely used historically to explain why a crop may not have performed as expected, real-time data would help growers with day-to-day monitoring and timely management decisions. For example, controlling temperature and humidity in protected crops. The use of technology in this regard offers a tangible risk prevention strategy to avoid crop loss and disruption to produce quality and supply.

The farms participating in the MOPS project are experienced commercial organic growers. Early on in the project they identified the lack of an Irish source of organic plant transplants as a barrier to farm efficiency. The demand for organic transplants that was highlighted by the MOPS project growers has facilitated the entrance to the sector of a new business dedicated to raising organic transplants. In 2021, this business grew organic transplants specifically for the MOPS growers and there are plans to expand this particular business in the future to service a wider range of organic growers in Ireland.

Specialised equipment for crop production is expensive and often difficult to source. At the same time, it is necessary for many growers to consider these options as organic horticultural production is technical and very labour intensive. The interaction of the Operational Group allowed a knowledge network to develop and resulted in the modernisation of existing machinery and equipment on several farms. Irrigation, sowing and harvesting were the main areas where this occurred and overall, the MOPS project growers report that it has resulted in increased on-farm efficiency.

Failure to meet supermarket/retail specifications in relation to finished crop size/length or weight will always be a challenge for the grower. Farm profitability is threatened when the grower supplies a product that weighs more than the desired weight, be it under or overweight. Nonetheless, exercising agronomist's guidance and continually reviewing and relating sampling results throughout the project has helped the growers provide the required product specifications by improving planting techniques, distances, methods, changing inputs or choosing a transplant instead of a seed, to meet the retail requirements and maximise crop performance.

Opportunities for new entrants (farmers) is also important to support the long-term development of the organic horticulture sector. Six of the participating project farms host an apprentice under the Organic Growers of Ireland Apprenticeship Scheme funded by the Department of Agriculture Food and Marine. They are taking on new entrants (farmers) who wish to upskill and/or share their knowledge. This capacity-building approach to engage and encourage generation renewal motivated the project to add an additional aspect, namely the Growers Report and link it in with the on-farm video recordings to be used to educate and share knowledge on various farming techniques used in the MOPS project.

Policy Prospects: The experience of the MOPS project participating farms demonstrates that organic growers face many agronomic challenges to deliver good quality produce and ensure continuity of supply to their customers. Central to these challenges is that organic growers tend to have highly diversified systems which require a high level of technical know-how to establish and maintain a viable farm business. In particular:

- appropriate technical advice and knowledge transfer groups as well as grant aid for capital investments are needed to allow new and experienced organic growers to upskill and optimise their enterprises
- upskilling in particular, should build on entry-level training such as the Organic Horticulture Internship Programme to stimulate a culture of continuous learning and improvement.

7.3 Food chain organisation and risk management

Alternative routes to market for quality organic fresh produce can be important, be it for crops that don't meet prescribed supermarket specifications on size/weight, or simply due to changing shopping patterns. Building flexibility into the farm business model by supplying a number of markets can reduce business risk and provides options to sell produce. This was evident over the duration of the MOPS project, none more so than during the COVID-19 pandemic. The pandemic clearly demonstrated the benefits to having various routes to market and/or selling directly to the consumer. This was especially important for those growers who had mainly catering sales and/or farmers markets, as both market options closed overnight. These growers had to pivot in order to find other markets for their produce. Meanwhile, growers supplying supermarkets required more produce as supermarkets doubled their orders in two weeks (16th March to 31st March 2020) due to increased demand. In addition, these growers needed an outlet for out of spec produce.

Collaborative approaches to supply meant the MOPS project participating farms could work together to find mutually beneficial solutions. For example, using their mobile phones and the MOPS project WhatsApp group the project growers were able to quickly share information on both surplus and demand to trade amongst themselves to respond to the growing demand. For produce not traded within the group, an alternative route to the consumer needed to be sought quickly for fresh crops. Albeit outside of the scope of the project, but aware of the pending economic loss to producers, the Irish Organic Association as the lead partner in the MOPS project immediately engaged social media postings to promote and connect consumers to local farms selling direct. As a central point of contact, the Irish Organic Association were able to act quickly and direct consumers to those selling direct and provide a contact for buyers (retail) seeking organic produce. Immediate action and combined effort by organic producers resulted in a significant increase in direct and online sales, as illustrated in the MOPS project results showing sales growth during the final year of the project, thereby offering new business opportunities to some of the project farmers, and alternative routes to market, that have continued to grow since spring 2020. It improved trade amongst the MOPS project group as they became more reliant on the support and cooperation/collaboration of the other project growers. The increase in sales, seeking alterative markets and improved cooperation was apparent before the pandemic, but necessity drove business change. Connecting growers further increased the supply to retail, as reflected in sales.

The collaboration further intensified MOPS trade with certified Irish growers outside the project farms, increasing off-farm imports of Irish grown produce by 371% in the last 12 months of the project. Thereby increasing market participation and orientation of supply and improving short supply chains amongst the project group and wider organic community supplying to them.

As some markets may be difficult to supply into due to their highly competitive nature, growers often have to work together to improve their position in the supply chain in order not to unreasonably compete with one another. Indeed, it is probably better to refuse a sale, than sell below cost. Below cost selling is possibly the biggest challenge to the sector. With group collaboration and maintaining various market outlets they can not only potentially reduce waste from unsold crops, and consequently improve farm economics, they can help reduce risk from an unexpected turn of events outside of their control, be it climatic and/or global pandemics.

Understanding how big business operates proved to be a useful skill, with potential business engagement from the catering sector coming about as the growers started to appreciate how to increase their market participation and how to better integrate into the agri-food chain. Large agri-food business not involved in export, are keen to shorten supply chains, building on their sustainability credentials and cooperate responsibility.

Building capacity and confidence to be able to commit to a contract for supply is challenging without collaboration with other growers. Without group supply, the same degree of sales/business would not be available to the project growers. The collaboration of the MOPS growers exemplifies the networking capacity of the farms in a relatively short time. Along with the COVID pandemic, Brexit naturally had an impact, as Irish buyers (wholesale, retail and consumer/direct sales) sought more supply of home-grown organic crops. Shortening the supply chain, however, is not only a policy objective, it’s also a sales factor. Irish consumer demand for home-grown organic crops is supported by the industry feedback and also the level of sales over the past few years. Industry feedback suggests at least a 100% increase in sales if the organic produce is grown in Ireland. This offers a huge potential for Irish organic growers to respond to this demand and go beyond the scope of the MOPS project to further realise an expanding market.

Some growers in the project are giving serious consideration to setting up a more formal supply arrangement, possibly in the form of a producer group. They are starting to see that by working together their ethos of fair play and loyalty does not have to be eroded if they wish to supply into larger markets, and if they want to have balanced bargaining power, continuity of supply and remain competitive.

Policy Prospects: Growing demand for organic fresh fruit and vegetables amongst Irish consumers presents significant prospects for new and existing organic growers. While current figures indicate that a significant proportion of organic fruit and vegetables is imported, the experience from the MOPS project shows that giving growers the infrastructure to collaborate (e.g., via the EIP Operational Group) can help them respond to new and existing market opportunities and improve their position within the supply chain. In particular:

- options to establish either producer groups or EU recognised producer organisations, could play an important role in developing and expanding short supply chains that benefit both growers and consumers.
- furthermore, support for short supply chains, including the development of 'bio districts'[1] should be an integral part of forthcoming local development strategies developed by local action groups under the LEADER programme.

7.4 Lessons learned from MOPS project

7.4.1 Operational approaches

Legal structure: Ensuring the correct legal structure that reflects the project foundation is critical. Correct formation of the Company or Partnership at the start should complement the overall intended management of the project and avoid any future dispute regarding the operational control of the legal entity. Although any project can encounter disagreement, it is essential that time is not taken up with potentially legal control or administrative issues that should have been foreseen and therefore avoided by prescribed constitutional or contractual terms.

The Operational Group need to be clear of their legal obligations. Taking time to ensure all signatories are fully furnished with sufficient knowledge about their legal responsibilities at the start of a project helps to build formal collaboration in a project group. MOPS was set up as a Company Limited by Guarantee, had two Directors responsible for the administration of the Company and the remainder of the Operational Group were members of the MOPS CLG. Thereby ensuring smooth and compliant administration of the legal entity, without any dispute, for the duration of the project.

Insurance: To ensure adequate cover in case of incident, the lead partner paid the insurance costs to cover all project personnel, as opposed to relying on indemnity cover from self-employed project staff. This avoided any ambiguity with insurance protection while on project farms and in turn made the contract terms of the EIP Partnership Agreement more easily met. Furthermore, it provided a safeguard for the lead partner and the legal Company it represented, as well as the farmers and project operational staff.

Finance: Maintaining financial records suitable for audit will make the interaction with the DAFM much easier. MOPS used worksheets that accompanied every human resource day invoiced. Days claimed were recorded on a simple Excel spreadsheet tracker which displayed the up-to-date running account of both days claimed and cost to date. In a project where there is a high proportion of labour costs, having worksheets to accompany each day claimed, provides an effective verification system for financial control. It is also a useful tool for highlighting the actual work days against those

[1] The 'bio district' concept is a key action for the Member States under new EU Organic Action Plan (Action 14) designed to promote the short trade circuit in the EU.

captured in the initial project plan. Administration of accounts in MOPS, for example, was almost triple the days allocated in the project plan. It wasn't due to any one factor, instead it was small but many instances, but when combined resulted in extra days required. This further highlights the need for contingency costs within the initial project budget. The MOPS project was delivered within budget (see Appendix 4) but as mentioned above, some specific cost headings within the project may go over the allocated time, and these may not be supported by another financial heading, i.e., monies taken from another area of the project, for some projects that could be financially significant.

Confidentiality: MOPS was an unusual project in that it contained, handled and collated commercially sensitive data. The lead partner, Irish Organic Association, had been handling business information for the past 40 years and therefore regarded as an appropriate body to maintain confidentiality. When early indications suggested the market feedback would be very positive, the lead partner suggested the appointment of an independent market research company to collate the final industry feedback. Thereby maintaining the all-important impartial approach to sensitive market data and possible conflict of interests.

COVID: The COVID pandemic commenced in the spring of 2020, while agriculture was deemed an essential service and as such travel was not restricted, nonetheless it caused some disruption to the smooth running of the project. Physical farm visits continued as planned, as long as there were no positive COVID or close contact cases, and HSE guidelines adhered to at all times. This continued throughout the remainder of the project. On-farm visits were the least impacted by COVID, as all meetings were conducted outdoors. Physical off-farm meetings however, which were normally held in Athlone, were challenging as everyone was confined to remote meetings. This made group communication difficult at times due to poor rural broadband and lack of focus in a remote meeting as opposed to being physically present. While privacy was maintained, it was disconcerting to discuss commercially sensitive information remotely and therefore the project manager opted to communicate with each grower directly on the telephone and email. The Horticultural Team meetings were reconfigured towards the latter part of the project to accommodate a reduced team that could work to produce both the Growers Report and Final Report. COVID restrictions had an impact on dissemination as public farm walks and project team meetings on-farm ceased, resulting in new approaches to inform the wider community including the use of QR codes on packaging and social media promotion of the project results.

7.4.2 Improving a future project

Timing: Data collection for MOPS may have been made considerably less complex if the project had started in January, as opposed to mid-year, to correlate with seasonal planting. For projects involving horticultural data collection, January is probably the most suited time to commence and end a project, even if group enthusiasm is eager and keen to get started mid-year.

Finance Allocation: The project plan for MOPS did not allocate sufficient time for writing reports, both quarterly status and final report. Had MOPS spent more time at the initial design phase of the feasibility planning to establish how information was to be presented and how much on-farm existing data was available, it would have provided a better representation of the workdays actually required to complete the project.

Duration: MOPS would have benefited from being conducted over a longer period of time. By the time the project had investigated exactly what it had to work with, information available and its use for wider dissemination, the project was several months into the first year. A five-year project, with the first year acting as a pilot study, would have been a better approach and provided a more focused outcome on specific areas of interest.

8 Appendices

8.1 Appendix 1: Crop production area and cultivars

Table 1 Crop production area (ha) and cultivars that were grown by the 11 MOPS project growers in the 2019/2020 growing season. Some production area data (denoted †) and cultivar names unavailable.

Crop/cultivar/type	Crop production area ha	MOPS project grower
Aubergine Black Beauty	0.0013	Grower H
Aubergine Black Pearl	0.0025	Grower C
Aubergine Leonidia	0.0007	Grower H
Aubergine Long Purple	0.0006	Grower H
Basil	0.0010	Grower K
Basil Deep Purple	0.0007	Grower H
Basil Nufar	0.0007	Grower H
Basil Thai	0.0007	Grower H
Bean Aquadulce Claudia	0.0035	Grower C
Bean Cobra	†	Grower B
Bean Cobra	0.0126	Grower K
Bean Cobra	0.0058	Grower D
Bean Cobra	0.0040	Grower C
Bean Cobra	0.0056	Grower F
Bean Dwarf French	0.0130	Grower A
Bean Faraday	0.0022	Grower H
Bean Faraday	0.0006	Grower C
Bean Hangdown Green	0.0065	Grower K
Bean Helda	0.0005	Grower C
Bean Helios	0.0011	Grower H
Bean Stanley	0.0358	Grower I
Bean Witkiem	0.0202	Grower D
Beetroot	0.0030	Grower K
Beetroot Alvro Mono	0.0002	Grower K
Beetroot Alvro Mono	0.0065	Grower C
Beetroot Avalanche	0.0092	Grower F
Beetroot Boldor	0.0222	Grower A
Beetroot Boldor	0.0092	Grower F
Beetroot Boro	†	Grower B
Beetroot Boro	†	Grower G
Beetroot Boro	0.1000	Grower E
Beetroot Bull's Blood	0.0031	Grower H
Beetroot Chiossa	0.0001	Grower A
Beetroot Cylindra	0.0016	Grower H
Beetroot Cylindra	†	Grower C
Beetroot Detroit	0.0198	Grower K
Beetroot Golden	†	Grower H
Beetroot Golden	0.0067	Grower K
Beetroot Golden	†	Grower C
Beetroot Golden	0.0200	Grower E
Beetroot Jannis	0.0006	Grower C
Beetroot Pablo	0.5275	Grower A
Beetroot Pablo	3.3600	Grower J
Beetroot Pablo	0.1000	Grower E
Beetroot Pablo	0.0138	Grower F

Crop/cultivar/type	Crop production area ha	MOPS project grower
Beetroot Rhonda	†	Grower H
Beetroot Taunus	0.0200	Grower E
Broccoli Belstar	0.0125	Grower C
Broccoli Belstar	0.4275	Grower J
Broccoli Corvina	0.0526	Grower A
Broccoli Corvina	0.0083	Grower C
Broccoli Delano	0.1425	Grower J
Broccoli Larsson	0.2850	Grower J
Broccoli Parthenon	1.9330	Grower A
Broccoli Parthenon	0.7396	Grower I
Broccoli Parthenon	0.5340	Grower B
Broccoli Parthenon	0.0591	Grower G
Broccoli Parthenon	0.0756	Grower C
Broccoli Parthenon	1.4250	Grower J
Broccoli Steel	0.0596	Grower B
Broccoli Triton	0.2632	Grower A
Brussel sprout Brendan	0.0300	Grower D
Brussel sprout Doric	0.0444	Grower C
Brussel sprout Nautic	0.0309	Grower B
Brussel sprout Nautic	0.0278	Grower C
Brussel sprout Neptuno	0.2424	Grower A
Brussel sprout Neptuno	0.1758	Grower I
Brussel sprout Neptuno	0.0606	Grower E
Brussel sprout Petrus	0.3030	Grower A
Brussel sprout Petrus	0.0968	Grower E
Brussel sprout Trafalgar	0.0300	Grower D
Buck's Horn Plantain	0.0027	Grower H
Cabbage	0.0040	Grower E
Cabbage Barbosa	0.0364	Grower G
Cabbage Buscaro	0.0233	Grower F
Cabbage Cantasa	0.1316	Grower A
Cabbage Cantasa	0.0415	Grower B
Cabbage Cantasa	0.0210	Grower G
Cabbage Cantasa	0.0098	Grower C
Cabbage Cantasa	0.0164	Grower J
Cabbage Cantasa	0.0408	Grower F
Cabbage Caraflex	0.5886	Grower A
Cabbage Caraflex	0.0616	Grower B
Cabbage Caraflex	0.0012	Grower K
Cabbage Caraflex	0.0380	Grower G
Cabbage Caraflex	0.0085	Grower C
Cabbage Caraflex	0.0368	Grower J
Cabbage Chinese Karoka	0.0028	Grower C
Cabbage Deadon	0.1071	Grower I
Cabbage Deadon	†	Grower B
Cabbage Deadon	0.0082	Grower J
Cabbage Deadon	0.0040	Grower E
Cabbage Deadon	0.0410	Grower F
Cabbage Famosa	0.0476	Grower I
Cabbage Famosa	0.0249	Grower B
Cabbage Famosa	0.0217	Grower G
Cabbage Famosa	0.0164	Grower J
Cabbage Impala	0.0789	Grower A

Crop/cultivar/type	Crop production area ha	MOPS project grower
Cabbage Klimaro	0.1316	Grower A
Cabbage Klimaro	0.1143	Grower I
Cabbage Klimaro	0.0122	Grower C
Cabbage Klimaro	0.0416	Grower E
Cabbage Langedijker	0.0244	Grower C
Cabbage Lennox	0.0405	Grower I
Cabbage Lennox	0.0415	Grower C
Cabbage Melissa	0.1714	Grower I
Cabbage Monarchy	0.0082	Grower J
Cabbage Paresa	0.1818	Grower A
Cabbage Paresa	0.0445	Grower I
Cabbage Paresa	0.0831	Grower B
Cabbage Paresa	0.0364	Grower G
Cabbage Paresa	0.0041	Grower J
Cabbage Paresa	0.0926	Grower F
Cabbage Rodyna	0.0002	Grower H
Cabbage Rodynda	0.0024	Grower C
Cabbage savoy	0.0002	Grower H
Cabbage Stanton	0.0381	Grower I
Cabbage Stanton	0.0410	Grower F
Cabbage Vertus	0.0146	Grower C
Carrot	†	Grower C
Carrot Autumn King	0.0011	Grower H
Carrot Miami	0.3333	Grower A
Carrot Miami	†	Grower C
Carrot Miami	0.1780	Grower E
Carrot Milan	0.0005	Grower H
Carrot Nairobi	0.4444	Grower A
Carrot Nairobi	†	Grower G
Carrot Nairobi	3.6400	Grower J
Carrot Nairobi	0.1440	Grower E
Carrot Napoli	0.1111	Grower A
Carrot Napoli	†	Grower B
Carrot Napoli	0.0035	Grower C
Carrot Napoli	0.2230	Grower E
Carrot Norfolk	†	Grower G
Carrot Norfolk	0.0510	Grower E
Carrot Rainbow	0.1530	Grower E
Carrot Rainbow Mix	0.0170	Grower F
Carrot Solvita	†	Grower C
Carrot Sugar Snax	0.0128	Grower F
Carrot Yellowstone	0.0005	Grower H
Carrot Yellowstone	0.0096	Grower K
Cauliflower Belot	0.0333	Grower A
Cauliflower Belot	0.0068	Grower G
Cauliflower Belot	0.0146	Grower C
Cauliflower Belot	0.0205	Grower E
Cauliflower Benidorm	0.0667	Grower E
Cauliflower Clarissa	0.0238	Grower G
Cauliflower Fletcher	0.0692	Grower I
Cauliflower Fortaleza	†	Grower B
Cauliflower Graffiti	0.0050	Grower F
Cauliflower Janvel	0.0063	Grower C

Crop/cultivar/type	Crop production area ha	MOPS project grower
Cauliflower Liria	0.0544	Grower G
Cauliflower Liria	0.5760	Grower J
Cauliflower Liria	0.0089	Grower E
Cauliflower Liria	0.0614	Grower F
Cauliflower Mardi	0.0219	Grower C
Cauliflower Medallion	0.0049	Grower C
Cauliflower Naruto	0.0823	Grower J
Cauliflower Navalo	0.0068	Grower G
Cauliflower Navalo	0.0800	Grower J
Cauliflower Skywalker	0.0444	Grower A
Cauliflower Skywalker	0.0136	Grower G
Cauliflower Skywalker	0.0326	Grower C
Cauliflower Skywalker	0.3290	Grower J
Cauliflower Skywalker	0.0192	Grower E
Cauliflower Skywalker	0.0409	Grower F
Cauliflower Snowball	0.0004	Grower H
Cauliflower Triomphant	0.0068	Grower G
Cauliflower Vogue	0.0462	Grower I
Celeriac	0.0002	Grower H
Celeriac Brilliant	†	Grower C
Celeriac Brilliant	0.0600	Grower E
Celery	0.0094	Grower A
Celery Daybreak	0.0074	Grower C
Celery Green Sleeves	0.0048	Grower D
Celery Jive	0.0200	Grower A
Celery Tango	0.0032	Grower C
Celery Victoria	0.0436	Grower A
Celery Victoria	0.0065	Grower B
Celery Victoria	0.0032	Grower D
Celery Victoria	0.0300	Grower E
Chard	0.0001	Grower A
Chard	0.0008	Grower K
Chard	0.0063	Grower C
Chard Bright Lights	0.0263	Grower A
Chard Bright Lights	0.0039	Grower F
Chard Rainbow	0.0030	Grower A
Chard Rainbow	0.0030	Grower K
Chard Rainbow	0.0053	Grower C
Chard Rainbow	0.0039	Grower F
Chard Ruby	0.0032	Grower C
Chicory	†	Grower H
Coriander Filtro	†	Grower C
Corn Salad (Lamb's Lettuce)	0.0085	Grower D
Corn Salad (Lamb's Lettuce)	†	Grower C
Courgette	0.0114	Grower A
Courgette	0.0259	Grower K
Courgette Cocozelle	0.0063	Grower D
Courgette Cocozelle	0.0065	Grower F
Courgette Costata Romanesco	0.0052	Grower F
Courgette Dunja	0.1818	Grower I
Courgette Dunja	0.0743	Grower B
Courgette Dunja	0.0007	Grower D
Courgette Dunja	0.0080	Grower G

Crop/cultivar/type	Crop production area ha	MOPS project grower
Courgette Dunja	0.0054	Grower C
Courgette Dunja	0.0206	Grower F
Courgette Floridor	0.0013	Grower H
Courgette Floridor	0.0053	Grower F
Courgette Geode	0.0003	Grower F
Courgette Gold Rush	0.0005	Grower H
Courgette Gold Rush	0.0106	Grower F
Courgette Goldy	0.0007	Grower D
Courgette Goldy	0.0054	Grower C
Courgette Nero Di Milano	0.0074	Grower C
Courgette Tosca	0.0531	Grower A
Cress	0.0025	Grower K
Cress	†	Grower C
Cucamelon	0.0002	Grower H
Cucumber	0.0041	Grower A
Cucumber	0.0009	Grower C
Cucumber Akito	0.0012	Grower D
Cucumber Crystal Lemon	0.0002	Grower H
Cucumber Hokus	0.0002	Grower H
Cucumber Kalunga	0.0041	Grower A
Cucumber Kalunga	†	Grower B
Cucumber Kalunga	0.0020	Grower K
Cucumber Kalunga	0.0193	Grower C
Cucumber Marketmore	0.0010	Grower K
Cucumber Marketmore	0.0014	Grower C
Cucumber Passandra	0.0005	Grower H
Cucumber Picolino	0.0012	Grower C
Cucumber Styx	0.0037	Grower C
Cucumber Tyria	0.0169	Grower C
Dill	0.0436	Grower C
Dill Tetra	†	Grower C
Edible Flowers	0.0027	Grower K
Edible Flowers Calendula	0.0001	Grower K
Edible Flowers Cornflowers	0.0011	Grower K
Edible Flowers Viola tricolour	0.0011	Grower K
Edible Flowers Borage	0.0003	Grower K
Endive	0.0064	Grower K
Endive Pancalieri	0.0020	Grower H
Endive Pancalieri	†	Grower C
Endive Wallone	0.0032	Grower H
Fennel Fino	0.0773	Grower C
Fennel Rondo	0.0666	Grower A
Fennel Rondo	0.0321	Grower I
Garlic	0.0072	Grower K
Garlic Matador	0.0023	Grower H
Garlic Messidrome	0.0156	Grower D
Garlic Vallelado	0.0046	Grower H
Green oak leaf lettuce	0.0039	Grower K
Jerusalem artichoke	0.0403	Grower K
Kale	0.0021	Grower H
Kale	0.1008	Grower B
Kale	0.0272	Grower K
Kale Black Magic	0.1079	Grower A

Crop/cultivar/type	Crop production area ha	MOPS project grower
Kale Black Magic	0.2821	Grower I
Kale Black Magic	0.0151	Grower E
Kale Cavolo Nero	†	Grower A
Kale Cavolo Nero	†	Grower B
Kale Cavolo Nero	0.0396	Grower D
Kale Cavolo Nero	0.0625	Grower C
Kale Cavolo Nero	0.0295	Grower F
Kale Darkibor	0.0817	Grower F
Kale Kadet	0.0050	Grower D
Kale Kapral	0.0033	Grower D
Kale Nero Di Toscana	0.0277	Grower F
Kale Oldenbor	1.3066	Grower I
Kale Ragged Russian	0.0050	Grower D
Kale Red Ruble	0.0006	Grower D
Kale Red Russian	0.2632	Grower A
Kale Red Russian	0.0013	Grower H
Kale Red Russian	†	Grower B
Kale Red Russian	0.0007	Grower K
Kale Red Russian	0.0031	Grower C
Kale Red Russian	0.0045	Grower F
Kale Redbor	0.0075	Grower D
Kale Redbor	0.0068	Grower G
Kale Redbor	0.0151	Grower E
Kale Redbor	0.0845	Grower F
Kale Reflex	1.5458	Grower A
Kale Reflex	0.3555	Grower I
Kale Reflex	0.1335	Grower B
Kale Reflex	0.0068	Grower G
Kale Reflex	0.0303	Grower E
Kale Reflex	0.0730	Grower F
Kale Rote Krauser	0.0004	Grower K
Kale Uncle John's	0.4167	Grower A
Kale Uncle John's	0.0021	Grower H
Kale Westland Winter	0.0020	Grower K
Kale Westland Winter	0.0955	Grower C
Kale Westland Winter	0.0321	Grower F
Kalette Christmas Rose	0.0727	Grower I
Kalette Garden Mix	0.1588	Grower F
Kohlrabi	0.0001	Grower H
Kohlrabi Korist	0.0259	Grower G
Kohlrabi Noriko	0.0038	Grower C
Leek	0.0144	Grower K
Leek Autumn Mammoth 2 Hannibal	0.0031	Grower K
Leek Bandit	0.0279	Grower C
Leek Cherokee	0.0031	Grower K
Leek Chinook	0.0031	Grower K
Leek Chinook	0.0349	Grower C
Leek Duraton	0.3250	Grower J
Leek Krypton	0.4011	Grower A
Leek Krypton	†	Grower B
Leek Krypton	0.3250	Grower J
Leek Krypton	0.1040	Grower E
Leek Lexton	0.3040	Grower A

Crop/cultivar/type	Crop production area ha	MOPS project grower
Leek Longton	0.2000	Grower A
Leek Navajo	0.0839	Grower C
Leek Pluston	1.0000	Grower A
Leek Pluston	0.1616	Grower I
Leek Pluston	†	Grower B
Leek Pluston	0.0409	Grower D
Leek Pluston	0.0641	Grower E
Leek Shafton	0.0304	Grower A
Leek Striker	0.0015	Grower G
Leek Triton	0.3600	Grower A
Leek Triton	0.1486	Grower I
Leek Triton	0.0800	Grower B
Leek Triton	0.0321	Grower E
Leek Triton	0.0811	Grower F
Lettuce	0.0028	Grower H
Lettuce	0.0598	Grower B
Lettuce	0.0118	Grower D
Lettuce	0.0154	Grower C
Lettuce	0.1122	Grower F
Lettuce Admir	0.0227	Grower A
Lettuce Admir	0.0286	Grower B
Lettuce Aferdita	0.0253	Grower C
Lettuce Alanela	0.0041	Grower F
Lettuce Alanena	0.0082	Grower C
Lettuce Analora	0.0154	Grower A
Lettuce Arctic Density	0.0052	Grower B
Lettuce Avenir	0.0019	Grower K
Lettuce Brighton	0.0043	Grower H
Lettuce Brighton	0.0052	Grower B
Lettuce Brighton	0.0031	Grower K
Lettuce Brighton	0.0041	Grower F
Lettuce Cantarix	0.0009	Grower H
Lettuce Cartarix	0.0003	Grower H
Lettuce Celinet	0.0009	Grower D
Lettuce Cerbiatta	0.0021	Grower H
Lettuce Cerbiatta	0.0003	Grower D
Lettuce Cornouai	0.0103	Grower A
Lettuce Cornouai	0.0251	Grower B
Lettuce Cos	0.0003	Grower H
Lettuce Deronda	0.0015	Grower D
Lettuce Descartes	0.0156	Grower A
Lettuce Descartes	0.0156	Grower B
Lettuce Descartes	0.0011	Grower C
Lettuce Descartes	0.0019	Grower F
Lettuce Diablo	0.0012	Grower D
Lettuce Eduardo	0.0030	Grower G
Lettuce Expertise	0.0097	Grower A
Lettuce Expertise	0.0042	Grower H
Lettuce Expertise	0.0011	Grower C
Lettuce Expertise	0.0039	Grower F
Lettuce Ferega	0.0045	Grower H
Lettuce Ferega	0.0030	Grower G
Lettuce Ferega	0.0041	Grower F

Crop/cultivar/type	Crop production area ha	MOPS project grower
Lettuce Figaro	0.0044	Grower H
Lettuce Ginko	0.0041	Grower F
Lettuce Green Salad Bowl	0.0021	Grower H
Lettuce Kamalia	0.0030	Grower G
Lettuce Kamalia	0.0149	Grower C
Lettuce Lea	0.0102	Grower I
Lettuce Lioba	0.0014	Grower C
Lettuce Little Gem	0.0026	Grower H
Lettuce Little Leprechaun	0.0026	Grower H
Lettuce Little Leprechaun	0.0005	Grower C
Lettuce Lollo Rossa	0.0057	Grower H
Lettuce Magellan	0.0059	Grower H
Lettuce Maravilla de Verano	0.0012	Grower H
Lettuce Marcord	0.0056	Grower I
Lettuce Matilda	0.0009	Grower H
Lettuce Maureen	0.0182	Grower C
Lettuce Maureen	0.0040	Grower F
Lettuce Oaking	0.0006	Grower D
Lettuce Oaking	0.0101	Grower F
Lettuce Octagon	0.0042	Grower H
Lettuce Red Salad Bowl	0.0003	Grower H
Lettuce Red Salad Bowl	0.0001	Grower K
Lettuce Rosalo	0.0020	Grower H
Lettuce Rosalo	0.0003	Grower D
Lettuce salanova	0.0032	Grower H
Lettuce salanova	0.0026	Grower B
Lettuce salanova	0.0105	Grower K
Lettuce salanova	0.0475	Grower C
Lettuce salanova Barlach	0.0148	Grower A
Lettuce salanova Barlach	0.0042	Grower H
Lettuce salanova Barlach	0.0156	Grower B
Lettuce salanova Barlach	0.0011	Grower C
Lettuce salanova Barlach	0.0034	Grower F
Lettuce Stelix	0.0056	Grower I
Lettuce Stelix	0.0154	Grower C
Lettuce Tarengo	0.0024	Grower H
Lettuce Telex	0.0042	Grower H
Lettuce Telex	0.0017	Grower B
Lettuce Telex	0.0011	Grower C
Lettuce Telex	0.0042	Grower F
Lettuce Till	0.0013	Grower K
Lettuce Totana	0.0065	Grower F
Lettuce Tuska	0.0015	Grower H
Lettuce Vidotex	0.0139	Grower B
Lettuce Winter Density	0.0052	Grower B
Melon Sivan	0.0005	Grower H
Mixed salad	0.0816	Grower B
Mixed salad	0.0304	Grower D
Mixed salad	0.0036	Grower C
Mixed salad	0.1326	Grower F
Mixed salad	0.0930	Grower A
Mizuna	0.0026	Grower H
Mizuna	0.0158	Grower K

Crop/cultivar/type	Crop production area ha	MOPS project grower
Mustard Green in Snow	0.0006	Grower H
Mustard Moutarde Rouge Metis	†	Grower C
Mustard Purple Frills	0.0006	Grower H
Mustard Purple Frills	0.0003	Grower D
Mustard Ruby Frills	0.0026	Grower H
Mustard Ruby Streaks	0.0034	Grower H
Mustard Scarlet Frills	†	Grower H
Mustard Scarlet Frills	0.0003	Grower D
Onion	0.0164	Grower D
Onion Hercules	0.0014	Grower F
Onion Hylander	0.0227	Grower A
Onion Hylander	0.0480	Grower B
Onion Hylander	0.0602	Grower E
Onion Radar	0.0007	Grower H
Onion Radar	0.0027	Grower K
Onion Red Baron	0.0122	Grower K
Onion Sturon	0.0153	Grower K
Onion Sturon	†	Grower C
Onion Troy	0.0178	Grower K
Parsley	0.0010	Grower H
Parsley	0.0021	Grower B
Parsley	0.0059	Grower K
Parsley Italian Giant	0.0056	Grower A
Parsley Italian Giant	0.0043	Grower K
Parsley Italian Giant	0.0025	Grower E
Parsley Krausa	0.0025	Grower E
Parsley Moss Curled	0.0033	Grower F
Parsnip Halblange White	†	Grower C
Parsnip Javelin	0.3333	Grower A
Parsnip Javelin	†	Grower B
Parsnip Panorama	0.0304	Grower G
Parsnip Panorama	0.1000	Grower E
Parsnip Picador	0.1000	Grower E
Pea	0.0023	Grower K
Pea Ambassador	0.0480	Grower D
Pea Hurst Greenshaft	0.0025	Grower H
Pea Hurst Greenshaft	†	Grower C
Pea Mange Tout	†	Grower C
Pea Sugar Snap	†	Grower C
Pepper Arwen	0.0005	Grower C
Pepper Buda	0.0014	Grower C
Pepper Corno Di Toro	0.0013	Grower H
Pepper Fiesta	0.0013	Grower H
Pepper Hungarian Hot Wax	0.0013	Grower H
Pepper Kyra	0.0026	Grower H
Pepper Padron	0.0082	Grower F
Pepper Ramiro	0.0018	Grower C
Pepper Slim Jim	0.0004	Grower C
Pepper Sprinter	0.0013	Grower H
Pepper Zazu	0.0019	Grower C
Plantain	†	Grower C
Potato Ambo	0.0714	Grower G
Potato Arran Victory	0.0476	Grower G

Crop/cultivar/type	Crop production area ha	MOPS project grower
Potato Bionica	†	Grower C
Potato Carolus	0.0024	Grower H
Potato Carolus	0.0060	Grower G
Potato Carolus	0.0946	Grower F
Potato Charlotte	0.1300	Grower E
Potato Charlotte	0.0541	Grower F
Potato Colleen	†	Grower C
Potato Connect	0.0005	Grower H
Potato Connect	0.0750	Grower K
Potato Connect	0.0800	Grower E
Potato Connect	0.0405	Grower F
Potato Nicola	0.0714	Grower G
Potato Orla	0.0012	Grower H
Potato Orla	0.1191	Grower G
Potato Orla	†	Grower C
Potato Orla	20.3000	Grower J
Potato Orla	0.4000	Grower E
Potato Orla	0.0541	Grower F
Potato Pink Fir Apple	0.0800	Grower E
Potato Pink Fir Apple	0.0270	Grower F
Potato Salad Blue	0.0383	Grower K
Potato Sarpo Mira	0.0006	Grower H
Potato Sarpo Mira	0.0025	Grower K
Potato Setanta	0.0014	Grower H
Potato Setanta	0.1190	Grower G
Potato Setanta	†	Grower C
Potato Setanta	0.1500	Grower E
Potato Vitabella	0.1780	Grower K
Pumpkin	0.0492	Grower A
Pumpkin	0.0400	Grower B
Pumpkin Big Max	0.0005	Grower D
Pumpkin Green Hokkaido	0.0025	Grower D
Pumpkin Jack Be Little	0.0050	Grower D
Pumpkin Jack O' Lantern	0.0925	Grower B
Pumpkin Jack O' Lantern	0.0225	Grower K
Pumpkin Jack O' Lantern	0.0050	Grower D
Pumpkin Jack O' Lantern	0.0001	Grower F
Pumpkin Jack O' Lantern	†	Grower C
Pumpkin Knucklehead	0.0025	Grower D
Pumpkin Mariana di Choggia	0.0010	Grower D
Pumpkin Mars	0.0229	Grower B
Pumpkin Sombra	0.0011	Grower D
Purple sprouting broccoli	0.0001	Grower H
Purple sprouting broccoli	0.0675	Grower B
Purple sprouting broccoli	0.0063	Grower C
Purple sprouting broccoli Mendocino	0.0568	Grower A
Purple sprouting broccoli Red Admiral	0.0491	Grower B
Purple sprouting broccoli Red Fire	0.0372	Grower B
Purple sprouting broccoli Red Fire	0.0881	Grower F
Purple sprouting broccoli Rioja	0.0945	Grower A
Purple sprouting broccoli Rioja	0.0063	Grower C
Purple sprouting broccoli Rudolph	0.1088	Grower F
Purple sprouting broccoli Santee	0.0500	Grower C

Crop/cultivar/type	Crop production area ha	MOPS project grower
Purslane	0.0145	Grower H
Purslane	0.0179	Grower K
Purslane	0.0101	Grower D
Purslane	†	Grower C
Purslane	0.0064	Grower F
Radicchio Palla Rossa	†	Grower C
Radicchio Palla Rossa	0.0032	Grower F
Radicchio Red Verona	0.0022	Grower F
Radish	†	Grower H
Radish Rudolf	†	Grower H
Radishes Celeste	†	Grower B
Red oak leaf lettuce	0.0030	Grower A
Red oak leaf lettuce	0.0165	Grower B
Red oak leaf lettuce	0.0050	Grower K
Rhubarb	†	Grower D
Rhubarb Reed's Early Superb	0.0044	Grower D
Rhubarb Timperley Early	0.0028	Grower D
Rocket	0.0009	Grower A
Rocket	0.0078	Grower B
Rocket	0.0122	Grower K
Rocket Athena	0.0043	Grower A
Rocket Dragon's Tongue	0.0016	Grower A
Rocket Esmee	0.0015	Grower D
Rocket Letizia	0.0016	Grower H
Rocket Montana	0.0299	Grower A
Rocket Rucola	0.0017	Grower H
Rocket Salad	†	Grower H
Rocket Wild	0.0015	Grower C
Romanesco	0.0218	Grower C
Romanesco Veronica	0.0902	Grower B
Romanesco Veronica	0.0216	Grower G
Romanesco Veronica	0.0089	Grower E
Romanesco Veronica	0.0200	Grower F
Sage	0.0033	Grower F
Scallion	0.0001	Grower A
Scallion Carel	0.0590	Grower J
Scallion Ishikura	0.0280	Grower C
Scallion Kosma	0.2060	Grower J
Scallion Parade	0.0889	Grower A
Scallion Parade	0.0031	Grower B
Scallion Parade	0.0052	Grower D
Scallion Parade	0.2950	Grower J
Scallion Parade	0.0028	Grower F
Scallion Ramrod	0.0033	Grower D
Scallion Totem	0.0013	Grower A
Spinach	†	Grower A
Spinach	†	Grower B
Spinach	0.0043	Grower K
Spinach	0.0268	Grower D
Spinach Beet	0.0021	Grower C
Spinach Beet Erbette	0.0107	Grower H
Spinach Beet Erbette	0.0116	Grower K
Spinach Beet Erbette	0.0009	Grower D

Crop/cultivar/type	Crop production area ha	MOPS project grower
Spinach Beet Erbette	0.0179	Grower C
Spinach Beet Erbette	0.0539	Grower F
Spinach Beet Everglade	0.1512	Grower A
Spinach Beet Everglade	†	Grower B
Spinach Renegade	†	Grower C
Sprouting broccoli Early	0.0491	Grower B
Squash	†	Grower H
Squash Amoro	0.0050	Grower C
Squash Black Beauty	†	Grower H
Squash Black Futsu	0.0001	Grower F
Squash Blue Ballet	0.0001	Grower F
Squash Butternut	0.0060	Grower C
Squash Crown Prince	0.0225	Grower K
Squash Custard White	0.0007	Grower C
Squash Custard White	0.0001	Grower F
Squash Fictor	0.0050	Grower C
Squash Jaune	0.0006	Grower C
Squash Jaune	0.0001	Grower F
Squash Sweet Dumpling	0.0001	Grower F
Squash Uchiki Kuri	0.0001	Grower F
Swede Ion	†	Grower C
Swede Lomonde	†	Grower C
Swede Magres	†	Grower B
Swede Tweed	0.2267	Grower I
Swede Tweed	†	Grower G
Swede Tweed	2.9880	Grower J
Swede Tweed	0.1260	Grower E
SwedesHelenor	†	Grower A
SwedesHelenor	0.0400	Grower E
Sweetcorn Earlyibird	0.0098	Grower D
Sweetcorn Golden Bantam	0.0013	Grower H
Sweetcorn Lark	0.0131	Grower D
Sweetcorn Sweet Gold	0.0003	Grower H
Sweetcorn Swift	0.0229	Grower D
Sweetcorn Tramunt	0.0078	Grower C
Sweetcorn True Gold	0.0012	Grower H
Sweetcorn True Gold	0.0078	Grower C
Sweetcorn True Platinum	0.0035	Grower H
Tomato	0.0075	Grower A
Tomato	0.0074	Grower D
Tomato Berner Rose	0.0056	Grower K
Tomato Black Cherry	0.0024	Grower K
Tomato Black Cherry	0.0029	Grower C
Tomato Black Cherry	0.0083	Grower F
Tomato Blush	0.0083	Grower F
Tomato Bolzano	0.0017	Grower C
Tomato cherry Roma	0.0023	Grower C
Tomato cherry Roma	0.0093	Grower F
Tomato Cindel	0.0044	Grower K
Tomato Cindel	0.0024	Grower C
Tomato Esterina	0.0027	Grower F
Tomato Gardener's Delight	0.0017	Grower K
Tomato Goldiana	0.0013	Grower C

Crop/cultivar/type	Crop production area ha	MOPS project grower
Tomato Grazer	0.0010	Grower F
Tomato Green Zebra	0.0014	Grower K
Tomato Isis Candy	0.0062	Grower F
Tomato Miele	0.0004	Grower H
Tomato Miele	0.0078	Grower F
Tomato Orange Fizz	0.0009	Grower H
Tomato Purple Bumblebee	0.0114	Grower F
Tomato Red Brandy Wine	0.0004	Grower H
Tomato Sakura	0.0157	Grower A
Tomato Sakura	0.0009	Grower H
Tomato Sakura	0.0003	Grower B
Tomato Sakura	0.0040	Grower C
Tomato Sakura	0.0207	Grower F
Tomato San Mariano	0.0004	Grower H
Tomato San Marzano	0.0035	Grower C
Tomato Shirley	0.0029	Grower A
Tomato Starlight	0.0009	Grower F
Tomato Sungold	0.0015	Grower H
Tomato Sungold	0.0105	Grower F
Tomato Sunrise	0.0036	Grower F
Tomato Supernova	0.0010	Grower F
Tomato Sweet Apertif	0.0004	Grower H
Tomato Trilly	0.0004	Grower H
Tomato Trilly	0.0051	Grower F
Tomato Violet	0.0078	Grower F
Tomato Yellow Submarine	0.0017	Grower K
Tomato Yellow Submarine	0.0006	Grower C
Tomato Matina	0.0024	Grower C

Table 2 Crop production area (ha) and cultivars that were grown by the 11 MOPS project growers in the 2020/2021 growing season. Some production area data (denoted †) and cultivar names unavailable.

Crop/cultivar/type	Crop production area ha	Grower code
Asparagus Bucklim	0.0033	Grower D
Asparagus Gijnlim	0.0033	Grower D
Aubergine	0.0047	Grower J
Aubergine Black Pearl	0.0007	Grower H
Basil	0.0006	Grower H
Basil	0.0012	Grower K
Basil	0.0019	Grower J
Basil Red	0.0007	Grower F
Basil Sweet Genovese	0.0021	Grower F
Bean Cobra	0.0003	Grower A
Bean Cobra	0.0020	Grower B
Bean Cobra	0.0107	Grower K
Bean Cobra	0.0239	Grower D
Bean Cobra	0.0062	Grower F
Bean Cupidon	0.0004	Grower H
Bean Hangdown Green	0.0057	Grower K
Bean Monica	0.0019	Grower H

Crop/cultivar/type	Crop production area ha	Grower code
Bean Witkiem	0.0070	Grower D
Bean French climbing	0.0016	Grower H
Bean French climbing	0.0093	Grower J
Beetroot	0.0023	Grower H
Beetroot	†	Grower B
Beetroot	0.0047	Grower K
Beetroot Alvro Mono	0.0041	Grower H
Beetroot Alvro Mono	0.0072	Grower C
Beetroot Avalanche	0.0001	Grower F
Beetroot Boldor	0.0001	Grower F
Beetroot Boro	0.0200	Grower A
Beetroot Boro	0.1656	Grower G
Beetroot Bull's Blood	0.0007	Grower D
Beetroot Chioggia	0.0001	Grower F
Beetroot Cylindra	0.0018	Grower H
Beetroot Golden	0.0018	Grower H
Beetroot Pablo	0.4479	Grower A
Beetroot Pablo	0.0500	Grower E
Beetroot Pablo	0.0001	Grower F
Beetroot Rhonda	0.0004	Grower H
Broccoli	1.6188	Grower J
Broccoli Parthenon	1.0393	Grower A
Broccoli Parthenon	1.2538	Grower I
Broccoli Parthenon	0.3483	Grower B
Broccoli Parthenon	0.0596	Grower G
Broccoli Steel	0.0834	Grower B
Brussel sprout Doric	0.0222	Grower E
Brussel sprout Nautic	0.0909	Grower B
Brussel sprout Nautic	0.0593	Grower E
Brussel sprout Neptuno	0.1515	Grower A
Brussel sprout Neptuno	0.1515	Grower I
Brussel sprout Neptuno	†	Grower G
Brussel sprout Neptuno	0.0963	Grower E
Brussel sprout Petrus	0.6697	Grower A
Brussel sprout Petrus	0.0200	Grower D
Brussel sprout Petrus	0.1110	Grower E
Brussel sprout Pontus	0.1515	Grower A
Brussel sprout Trafalgar	0.0417	Grower D
Buck's Horn Plantain	0.0018	Grower H
Butterhead lettuce	0.0040	Grower A
Butterhead lettuce	0.0032	Grower J
Cabbage Barbosa	0.0200	Grower G
Cabbage Buscaro	0.1250	Grower I
Cabbage Buscaro	0.0033	Grower G
Cabbage Buscaro	0.0714	Grower F

Crop/cultivar/type	Crop production area ha	Grower code
Cabbage Cantasa	0.5556	Grower A
Cabbage Cantasa	0.0925	Grower I
Cabbage Cantasa	0.0788	Grower B
Cabbage Cantasa	0.0463	Grower G
Cabbage Cantasa	0.0400	Grower F
Cabbage Caraflex	0.2119	Grower A
Cabbage Caraflex	0.0455	Grower B
Cabbage Caraflex	0.0576	Grower G
Cabbage Chateaurenard	0.0004	Grower H
Cabbage Deadon	0.1364	Grower B
Cabbage Deadon	0.0688	Grower F
Cabbage Famosa	0.0825	Grower I
Cabbage Famosa	0.0200	Grower B
Cabbage Famosa	0.0264	Grower G
Cabbage Farao	0.0066	Grower G
Cabbage Farao	0.0200	Grower E
Cabbage Impala	0.0100	Grower G
Cabbage Integro	0.0066	Grower G
Cabbage January King	0.0025	Grower H
Cabbage Kaluga	0.4737	Grower A
Cabbage Kaluga	0.0600	Grower E
Cabbage Klimaro	0.8421	Grower A
Cabbage Klimaro	0.1700	Grower E
Cabbage Klimaro	0.0714	Grower F
Cabbage Lennox	0.0526	Grower A
Cabbage Lennox	0.0938	Grower I
Cabbage Lennox	0.0870	Grower E
Cabbage Paresa	0.1025	Grower I
Cabbage Paresa	0.1515	Grower B
Cabbage Paresa	0.0297	Grower G
Cabbage Paresa	0.1144	Grower F
Cabbage Rodyna	0.0004	Grower H
Cabbage savoy	2.2258	Grower J
Cabbage Stanton	0.0432	Grower F
Cabbage Typhoon	0.3200	Grower E
Cabbage Violaceo de Verona	0.0004	Grower H
Carrot	0.0067	Grower H
Carrot	10.6799	Grower J
Carrot Chantenay	0.0116	Grower G
Carrot Eskimo	0.0630	Grower E
Carrot Miami	0.0523	Grower G
Carrot Miami	0.1700	Grower E
Carrot Nairobi	0.3428	Grower G
Carrot Nairobi	0.0630	Grower E
Carrot Nantes	0.0072	Grower C

Crop/cultivar/type	Crop production area ha	Grower code
Carrot Napoli	0.1150	Grower E
Carrot Norak	0.0465	Grower G
Carrot Norfolk	0.0697	Grower G
Carrot Norwich	0.0116	Grower G
Carrot Rainbow	0.0320	Grower E
Carrot Rainbow	0.0005	Grower F
Carrot Rainbow	0.0033	Grower H
Carrot Rainbow	0.0058	Grower F
Carrot Sugar Snax	0.0003	Grower F
Carrot Yellowstone	0.0023	Grower K
Cauliflower	0.0011	Grower H
Cauliflower	1.6188	Grower J
Cauliflower Belot	0.0165	Grower G
Cauliflower Cartagena	0.1731	Grower I
Cauliflower Chester	0.1727	Grower I
Cauliflower Flamenco	0.0165	Grower G
Cauliflower Goodman	0.0273	Grower F
Cauliflower Jerome	0.1731	Grower I
Cauliflower Liria	0.0660	Grower G
Cauliflower Liria	0.0409	Grower F
Cauliflower Medallion	0.0010	Grower H
Cauliflower Navalo	0.0690	Grower B
Cauliflower Navalo	0.0248	Grower G
Cauliflower Skywalker	0.0015	Grower H
Cauliflower Skywalker	0.0330	Grower G
Cauliflower Triomphant	0.0370	Grower B
Cauliflower Triomphant	0.0165	Grower G
Cauliflower Violetta	0.0016	Grower H
Cauliflower Vogue	0.1731	Grower I
Celeriac	0.0006	Grower H
Celeriac Brilliant	0.0520	Grower E
Celeriac Prinz	0.0300	Grower A
Celeriac Prinz	0.0370	Grower E
Celery	3.2376	Grower J
Celery Green Sleeves	0.0048	Grower D
Celery Red Stalk	0.0001	Grower H
Celery Tall Utah	0.0002	Grower H
Celery Tango	0.0001	Grower H
Celery Victoria	0.0333	Grower A
Celery Victoria	0.0535	Grower B
Celery Victoria	0.0032	Grower D
Celery Victoria	0.0380	Grower E
Chard	0.0072	Grower K
Chard Bright Lights	0.0548	Grower A
Chard Five Colours	0.0029	Grower F

Crop/cultivar/type	Crop production area ha	Grower code
Chard Intense	0.0552	Grower A
Chard Ruby	0.0016	Grower E
Coriander	0.0012	Grower H
Coriander	0.0019	Grower J
Courgette	0.0097	Grower K
Courgette	0.0174	Grower D
Courgette	0.0050	Grower J
Courgette Atena	0.0020	Grower F
Courgette Dunja	†	Grower A
Courgette Dunja	0.0909	Grower I
Courgette Dunja	0.0020	Grower H
Courgette Dunja	†	Grower B
Courgette Dunja	0.0205	Grower G
Courgette Dunja	0.0070	Grower F
Courgette Floridor	0.0006	Grower H
Courgette Nero Di Milano	0.0027	Grower K
Courgette Sunstripe	0.0020	Grower F
Courgette Tosca	0.0120	Grower A
Courgette Zephyr	0.0020	Grower F
Cucumber	0.0021	Grower J
Cucumber Akito	0.0005	Grower D
Cucumber Kalunga	0.0032	Grower A
Cucumber Kalunga	0.0005	Grower D
Cucumber Kalunga	0.0025	Grower F
Cucumber Marketmore	0.0007	Grower K
Cucumber Marketmore	†	Grower C
Cucumber Passandra	0.0011	Grower H
Cucumber Passandra	0.0005	Grower D
Cucumber Picolino	0.0002	Grower H
Cucumber Picolino	†	Grower C
Cucumber Tyria	0.0027	Grower K
Edible Flowers	0.0010	Grower K
Edible Flowers	0.0002	Grower D
Edible Flowers Calendula	†	Grower F
Edible Flowers Cornflower	0.0013	Grower K
Edible Flowers Viola	0.0002	Grower D
Endive	0.0010	Grower A
Endive	0.0036	Grower K
Fennel Rondo	0.1183	Grower A
Fennel Rondo	0.0274	Grower B
Fennel Rondo	0.0218	Grower G
Garlic	0.0068	Grower H
Garlic	0.0024	Grower C
Garlic	0.0093	Grower J
Garlic Messidor	0.0046	Grower H

Crop/cultivar/type	Crop production area ha	Grower code
Garlic Messidor	0.0075	Grower D
Garlic Vallelado	0.0023	Grower H
Garlic Vallelado	0.0075	Grower D
Green cabbage	0.0036	Grower C
Green oak leaf lettuce	0.0136	Grower A
Green oak leaf lettuce	0.0005	Grower K
Jerusalem artichoke Fuseau	0.0280	Grower K
Jerusalem artichoke Gerard	0.0280	Grower K
Jerusalem artichoke Rema	0.0300	Grower F
Kale	0.0694	Grower A
Kale	0.0051	Grower H
Kale	0.0120	Grower K
Kale	0.0850	Grower D
Kale	†	Grower J
Kale Black Magic	0.0972	Grower A
Kale Black Magic	0.4530	Grower I
Kale Black Magic	0.0170	Grower E
Kale Black Magic	0.0295	Grower F
Kale Cavolo Nero	0.0020	Grower H
Kale Cavolo Nero	0.0175	Grower D
Kale CNKAL	0.0010	Grower F
Kale Dwarf Blue	0.0010	Grower F
Kale Emerald Ice	0.0005	Grower F
Kale Nero Di Toscana	0.0062	Grower K
Kale Nero Di Toscana	0.0193	Grower F
Kale Oldenbor	0.1227	Grower F
Kale Red Ruble	0.0029	Grower F
Kale Red Russian	0.0020	Grower H
Kale Red Russian	0.0370	Grower B
Kale Red Russian	0.0068	Grower F
Kale Redbor	0.0170	Grower E
Kale Redbor	0.1032	Grower F
Kale Reflex	2.6212	Grower A
Kale Reflex	1.5970	Grower I
Kale Reflex	0.1716	Grower B
Kale Reflex	0.0099	Grower G
Kale Reflex	0.0170	Grower E
Kale Rote Krauser	0.0060	Grower K
Kale Uncle John's	0.2632	Grower A
Kale Uncle John's	0.0150	Grower D
Kale Westland Winter	0.0060	Grower K
Kalette	0.2273	Grower F
Kohlrabi	0.0017	Grower H
Kohlrabi Korist	0.0122	Grower G
Leek	0.0016	Grower H

Crop/cultivar/type	Crop production area ha	Grower code
Leek	0.2049	Grower B
Leek	0.0149	Grower K
Leek	2.4282	Grower J
Leek Belton	0.0508	Grower B
Leek Curling	0.1108	Grower I
Leek Krypton	1.1654	Grower A
Leek Krypton	0.0900	Grower E
Leek Lancelot	0.0417	Grower G
Leek Pluston	0.8271	Grower A
Leek Pluston	0.2162	Grower I
Leek Pluston	0.0500	Grower D
Leek Pluston	0.0700	Grower E
Leek Pluston	0.0991	Grower F
Leek Triton	0.4511	Grower A
Leek Triton	0.0856	Grower I
Leek Triton	0.1269	Grower B
Leek Vitaton	0.0700	Grower E
Leek Vitaton	0.0360	Grower F
Lettuce	0.0701	Grower A
Lettuce	0.0057	Grower H
Lettuce	0.0013	Grower B
Lettuce	0.0038	Grower C
Lettuce Admir	0.0247	Grower B
Lettuce Alaine	0.0008	Grower B
Lettuce Alezan	0.0040	Grower F
Lettuce Analora	0.0008	Grower A
Lettuce Arctic King	0.0100	Grower B
Lettuce Behn	0.0043	Grower H
Lettuce Behn	0.0042	Grower F
Lettuce Brighton	0.0041	Grower H
Lettuce Brighton	0.0041	Grower K
Lettuce Brighton	0.0040	Grower F
Lettuce Cantarix	0.0027	Grower H
Lettuce Cerbiatta	0.0036	Grower H
Lettuce Codex	0.0018	Grower H
Lettuce Codex	0.0042	Grower F
Lettuce Cos	0.0032	Grower J
Lettuce Derondo	0.0090	Grower F
Lettuce EazyLeaf	0.0012	Grower D
Lettuce Elle	0.0065	Grower B
Lettuce Expertise	0.0017	Grower H
Lettuce Expertise	0.0094	Grower B
Lettuce Extranet	0.0062	Grower H
Lettuce Extranet	0.0042	Grower F
Lettuce Ferega	0.0028	Grower H

Crop/cultivar/type	Crop production area ha	Grower code
Lettuce Ferega	0.0040	Grower F
Lettuce Figaro	0.0049	Grower H
Lettuce Frostex	0.0086	Grower B
Lettuce Hawkings	0.0059	Grower H
Lettuce Lattughino Rosso	0.0007	Grower H
Lettuce Lioba	0.0041	Grower B
Lettuce Lollo Rossa	0.0032	Grower J
Lettuce Macai	0.0016	Grower B
Lettuce Magellan	0.0008	Grower H
Lettuce Maravilla de Verano	0.0051	Grower H
Lettuce Mathix	0.0011	Grower H
Lettuce Moonred	0.0024	Grower B
Lettuce Oaking	0.0113	Grower F
Lettuce Octagon	0.0005	Grower H
Lettuce Red Frizzy	0.0010	Grower B
Lettuce salanova	0.0080	Grower A
Lettuce salanova	0.0216	Grower D
Lettuce salanova	0.0036	Grower C
Lettuce salanova	0.0032	Grower J
Lettuce salanova Barlach	0.0024	Grower A
Lettuce salanova Barlach	0.0084	Grower H
Lettuce salanova Barlach	0.0136	Grower B
Lettuce salanova Barlach	0.0042	Grower F
Lettuce Tarengo	0.0010	Grower H
Lettuce Telex	0.0003	Grower H
Lettuce Tuska	0.0030	Grower H
Lettuce Xem	0.0067	Grower H
Lettuce Xem	0.0197	Grower B
Lettuce Xem	0.0042	Grower F
Melon Crimson Sweet	0.0002	Grower H
Melon Kiwano	0.0005	Grower H
Melon Sivan	0.0004	Grower H
Mixed salad	0.0090	Grower H
Mixed salad	†	Grower B
Mixed salad	0.0232	Grower K
Mixed salad	0.0597	Grower D
Mixed salad	0.0172	Grower A
Mizuna	0.2500	Grower A
Mizuna	0.0047	Grower H
Mizuna	0.0405	Grower B
Mizuna	0.0306	Grower K
Mustard	0.0134	Grower H
Mustard	0.0072	Grower H
Mustard Green Frills	0.0022	Grower H
Mustard Green Frills	0.0019	Grower F

Crop/cultivar/type	Crop production area ha	Grower code
Mustard Komatsuna	0.0011	Grower H
Mustard Pizzo	0.0028	Grower H
Mustard Purple Frills	0.0083	Grower H
Mustard Purple Frills	0.0120	Grower D
Mustard Red Dragon	0.0027	Grower H
Mustard Red Dragon	0.0025	Grower F
Mustard Red Frills	0.0020	Grower B
Mustard Red Knight	0.0110	Grower B
Mustard Red Lace	0.0165	Grower B
Onion	0.0168	Grower A
Onion	0.0060	Grower H
Onion Buan	0.0100	Grower A
Onion Hylander	0.1900	Grower A
Onion Radar	0.0040	Grower H
Onion Radar	0.0027	Grower K
Onion Red Baron	0.0500	Grower A
Onion Red Baron	0.0087	Grower K
Onion Sakura	0.0060	Grower K
Onion Santero	0.0485	Grower K
Onion Sturon	0.0400	Grower A
Parsley	0.0036	Grower A
Parsley	0.0102	Grower H
Parsley	†	Grower B
Parsley	0.0036	Grower K
Parsley	0.0024	Grower C
Parsley	0.0019	Grower J
Parsley Italian Giant	0.0040	Grower E
Parsley Krausa	0.0039	Grower E
Parsley Krausa	0.0047	Grower F
Parsley Laura	0.0047	Grower F
Parsnip	0.2080	Grower B
Parsnip Javelin	0.7381	Grower A
Parsnip Panorama	0.3265	Grower G
Parsnip Panorama	0.2000	Grower E
Pea	0.0093	Grower J
Pea Ambassador	0.0219	Grower D
Pea Blauwschokkler	0.0039	Grower H
Pea Hurst Greenshaft	0.0048	Grower H
Pea Sugar Snap	0.0034	Grower H
Pea Mange Tout	0.0055	Grower D
Pepper	0.0112	Grower J
Pepper Bendigo	0.0006	Grower A
Pepper Goat Horn	0.0009	Grower H
Pepper Hungarian Hot Wax	0.0006	Grower H
Pepper Jalapeno	0.0008	Grower A

Crop/cultivar/type	Crop production area ha	Grower code
Pepper Love Apple	0.0007	Grower H
Pepper Padron	0.0008	Grower H
Pepper Padron	0.0027	Grower F
Pointed cabbage	1.2141	Grower J
Potato Arran Victory	0.1224	Grower G
Potato Bambino	0.1224	Grower G
Potato Bionica	0.2000	Grower C
Potato Cara	0.0015	Grower H
Potato Carolus	0.0015	Grower H
Potato Carolus	0.2000	Grower E
Potato Charlotte	0.0015	Grower H
Potato Charlotte	0.0880	Grower F
Potato Colleen	0.4000	Grower A
Potato Colleen	0.0015	Grower H
Potato Connect	0.0015	Grower H
Potato Connect	0.1900	Grower E
Potato earlies	30.7568	Grower J
Potato maincrop	0.0302	Grower K
Potato Mayan Gold	0.0800	Grower E
Potato Orla	0.0800	Grower A
Potato Orla	0.2448	Grower G
Potato Orla	0.2144	Grower C
Potato Orla	0.6000	Grower E
Potato Pink Fir Apple	0.0800	Grower E
Potato Salad Blue	0.0336	Grower K
Potato Sarpo Mira	0.0168	Grower K
Potato Setanta	0.0015	Grower H
Potato Setanta	0.2448	Grower G
Potato Setanta	0.2000	Grower C
Potato Setanta	0.2000	Grower E
Potato Vitabella	0.0840	Grower K
Potato Vitabella	0.1320	Grower F
Pumpkin	0.0317	Grower D
Pumpkin Jack O' Lantern	0.0100	Grower A
Pumpkin Jack O' Lantern	0.0115	Grower K
Pumpkin Kaori Kuri	0.0200	Grower A
Pumpkin Knucklehead	0.0041	Grower F
Purple sprouting broccoli Cardinal	0.0308	Grower D
Purple sprouting broccoli Cardinal	0.1188	Grower F
Purple sprouting broccoli Claret	0.0303	Grower B
Purple sprouting broccoli Claret	0.0500	Grower D
Purple sprouting broccoli Claret	0.0594	Grower F
Purple sprouting broccoli Mendocino	0.0303	Grower B
Purple sprouting broccoli Mendocino	0.0806	Grower F
Purple sprouting broccoli Red Fire	0.0938	Grower F

Crop/cultivar/type	Crop production area ha	Grower code
Purple sprouting broccoli Rioja	0.0303	Grower B
Purple sprouting broccoli Rudolph	0.1063	Grower F
Purple sprouting broccoli Santee	0.0031	Grower H
Purple sprouting broccoli Santee	0.0933	Grower B
Purslane	0.0240	Grower H
Purslane	0.0006	Grower B
Purslane	0.0123	Grower K
Red oak leaf lettuce	0.0112	Grower A
Red oak leaf lettuce	0.0200	Grower I
Red oak leaf lettuce	0.0007	Grower H
Red oak leaf lettuce	0.0049	Grower B
Red oak leaf lettuce	0.0007	Grower K
Rocket	0.0108	Grower H
Rocket	0.0253	Grower K
Rocket Athena	0.0007	Grower H
Rocket Esmee	0.0011	Grower H
Rocket Montana	0.0540	Grower A
Rocket Rucola	0.0036	Grower H
Rocket Victoria	0.0080	Grower F
Romanesco	0.0021	Grower H
Romanesco Veronica	0.0966	Grower B
Romanesco Veronica	0.0232	Grower G
Romanesco Veronica	0.0416	Grower F
Rosemary	0.0080	Grower F
Sage	0.0001	Grower K
Sage	0.0078	Grower F
Scallion	0.0018	Grower H
Scallion	0.0021	Grower K
Scallion Ishikura	0.0035	Grower C
Scallion North Holland Blood Red	0.0028	Grower F
Scallion Parade	0.1082	Grower A
Scallion Parade	0.0027	Grower B
Scallion Parade	0.0005	Grower D
Scallion Parade	0.0059	Grower E
Scallion Parade	0.0047	Grower F
Scallion Ramrod	0.0066	Grower D
Spinach	0.0010	Grower A
Spinach	0.0105	Grower B
Spinach	0.0052	Grower K
Spinach Arcadia	0.0181	Grower D
Spinach Beet	0.0219	Grower G
Spinach Beet Erbette	0.0251	Grower H
Spinach Beet Erbette	0.0177	Grower K
Spinach Beet Erbette	0.0194	Grower D
Spinach Beet Erbette	0.0048	Grower E

Crop/cultivar/type	Crop production area ha	Grower code
Spinach Beet Erbette	0.0357	Grower F
Spinach Beet Everglade	0.3064	Grower A
Spinach Beet Everglade	0.0224	Grower D
Sprouting broccoli Early	0.0667	Grower B
Squash Crown Prince	0.0300	Grower A
Squash Crown Prince	0.0115	Grower K
Squash Crown Prince	0.0100	Grower F
Squash Kabocha	0.0023	Grower F
Squash Patty Pan	0.0030	Grower F
Squash Tuffy	0.0047	Grower F
Squash Turk's Turban	0.0050	Grower F
Squash Uchiki Kuri	0.0035	Grower F
Strawberries	0.0090	Grower D
Swede	0.0030	Grower H
Swede Helenor	0.6197	Grower A
Swede Helenor	0.0950	Grower E
Swede Tweed	0.1190	Grower I
Swede Tweed	0.0444	Grower G
Swede Tweed	0.1200	Grower E
Sweetcorn Earlibird	0.0104	Grower D
Sweetcorn Goldcrest	0.0208	Grower D
Sweetcorn Golden Gate	0.0104	Grower D
Sweetcorn Lark	0.0104	Grower D
Sweetcorn Swift	0.0208	Grower D
Thyme	0.0019	Grower J
Thyme	0.0035	Grower F
Tomato	0.0027	Grower K
Tomato	0.0056	Grower D
Tomato	0.0073	Grower J
Tomato Atomic Grape	0.0010	Grower F
Tomato Berner Rose	0.0052	Grower K
Tomato Black Cherry	0.0013	Grower F
Tomato Bocati	0.0020	Grower A
Tomato Bronze Torch	0.0010	Grower F
Tomato Clementine	0.0016	Grower K
Tomato Colour Mix	0.0018	Grower F
Tomato Gardener's Delight	0.0054	Grower K
Tomato Green Zebra	0.0036	Grower K
Tomato Honeycomb	0.0021	Grower H
Tomato Lucky Tiger	0.0023	Grower F
Tomato Miele	0.0020	Grower H
Tomato Miele	0.0013	Grower F
Tomato Moneymaker	0.0010	Grower H
Tomato Mortgage Lifter	0.0011	Grower H
Tomato Pink Bumblebee	0.0038	Grower F

Crop/cultivar/type	Crop production area ha	Grower code
Tomato Red Brandy Wine	0.0012	Grower H
Tomato Roma	0.0010	Grower H
Tomato Sakura	0.0084	Grower A
Tomato Sakura	0.0020	Grower H
Tomato Sakura	0.0360	Grower B
Tomato Sakura	0.0075	Grower F
Tomato Sungold	0.0021	Grower H
Tomato Sungold	0.0038	Grower F
Tomato Sunrise Bumblebee	0.0025	Grower F
Tomato Tiger Cherry	0.0010	Grower F
Tomato Tigerella	0.0010	Grower A
Tomato Trilly	0.0014	Grower H
Tomato Trilly	0.0025	Grower F
Tomato Yellow Pear	0.0027	Grower K
Turnip	0.0092	Grower K
Turnip Purple Top Milan	0.0015	Grower H

8.2 Appendix 2: climate and weather monitoring

8.2.1 Syncronous day of the year charts

SDY CHART - NORMAL YEAR

JAN		FEB		MAR		APR		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC	
	SDY		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*
1	1	1	32	1	60	1	91	1	121	1	152	1	182	1	213	1	244	1	274	1	305	1	335
2	2	2	33	2	61	2	92	2	122	2	153	2	183	2	214	2	245	2	275	2	306	2	336
3	3	3	34	3	62	3	93	3	123	3	154	3	184	3	215	3	246	3	276	3	307	3	337
4	4	4	35	4	63	4	94	4	124	4	155	4	185	4	216	4	247	4	277	4	308	4	338
5	5	5	36	5	64	5	95	5	125	5	156	5	186	5	217	5	248	5	278	5	309	5	339
6	6	6	37	6	65	6	96	6	126	6	157	6	187	6	218	6	249	6	279	6	310	6	340
7	7	7	38	7	66	7	97	7	127	7	158	7	188	7	219	7	250	7	280	7	311	7	341
8	8	8	39	8	67	8	98	8	128	8	159	8	189	8	220	8	251	8	281	8	312	8	342
9	9	9	40	9	68	9	99	9	129	9	160	9	190	9	221	9	252	9	282	9	313	9	343
10	10	10	41	10	69	10	100	10	130	10	161	10	191	10	222	10	253	10	283	10	314	10	344
11	11	11	42	11	70	11	101	11	131	11	162	11	192	11	223	11	254	11	284	11	315	11	345
12	12	12	43	12	71	12	102	12	132	12	163	12	193	12	224	12	255	12	285	12	316	12	346
13	13	13	44	13	72	13	103	13	133	13	164	13	194	13	225	13	256	13	286	13	317	13	347
14	14	14	45	14	73	14	104	14	134	14	165	14	195	14	226	14	257	14	287	14	318	14	348
15	15	15	46	15	74	15	105	15	135	15	166	15	196	15	227	15	258	15	288	15	319	15	349
16	16	16	47	16	75	16	106	16	136	16	167	16	197	16	228	16	259	16	289	16	320	16	350
17	17	17	48	17	76	17	107	17	137	17	168	17	198	17	229	17	260	17	290	17	321	17	351
18	18	18	49	18	77	18	108	18	138	18	169	18	199	18	230	18	261	18	291	18	322	18	352
19	19	19	50	19	78	19	109	19	139	19	170	19	200	19	231	19	262	19	292	19	323	19	353
20	20	20	51	20	79	20	110	20	140	20	171	20	201	20	232	20	263	20	293	20	324	20	354
21	21	21	52	21	80	21	111	21	141	21	172	21	202	21	233	21	264	21	294	21	325	21	355
22	22	22	53	22	81	22	112	22	142	22	173	22	203	22	234	22	265	22	295	22	326	22	356
23	23	23	54	23	82	23	113	23	143	23	174	23	204	23	235	23	266	23	296	23	327	23	357
24	24	24	55	24	83	24	114	24	144	24	175	24	205	24	236	24	267	24	297	24	328	24	358
25	25	25	56	25	84	25	115	25	145	25	176	25	206	25	237	25	268	25	298	25	329	25	359
26	26	26	57	26	85	26	116	26	146	26	177	26	207	26	238	26	269	26	299	26	330	26	360
27	27	27	58	27	86	27	117	27	147	27	178	27	208	27	239	27	270	27	300	27	331	27	361
28	28	28	59	28	87	28	118	28	148	28	179	28	209	28	240	28	271	28	301	28	332	28	362
29	29			29	88	29	119	29	149	29	180	29	210	29	241	29	272	29	302	29	333	29	363
30	30			30	89	30	120	30	150	30	181	30	211	30	242	30	273	30	303	30	334	30	364
31	31			31	90			31	151			31	212	31	243			31	304			31	365

SDY CHART - LEAP YEAR

JAN		FEB		MAR		APR		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC	
	SDY		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*		*SDY*
1	1	1	32	1	61	1	92	1	122	1	153	1	183	1	214	1	245	1	275	1	306	1	336
2	2	2	33	2	62	2	93	2	123	2	154	2	184	2	215	2	246	2	276	2	307	2	337
3	3	3	34	3	63	3	94	3	124	3	155	3	185	3	216	3	247	3	277	3	308	3	338
4	4	4	35	4	64	4	95	4	125	4	156	4	186	4	217	4	248	4	278	4	309	4	339
5	5	5	36	5	65	5	96	5	126	5	157	5	187	5	218	5	249	5	279	5	310	5	340
6	6	6	37	6	66	6	97	6	127	6	158	6	188	6	219	6	250	6	280	6	311	6	341
7	7	7	38	7	67	7	98	7	128	7	159	7	189	7	220	7	251	7	281	7	312	7	342
8	8	8	39	8	68	8	99	8	129	8	160	8	190	8	221	8	252	8	282	8	313	8	343
9	9	9	40	9	69	9	100	9	130	9	161	9	191	9	222	9	253	9	283	9	314	9	344
10	10	10	41	10	70	10	101	10	131	10	162	10	192	10	223	10	254	10	284	10	315	10	345
11	11	11	42	11	71	11	102	11	132	11	163	11	193	11	224	11	255	11	285	11	316	11	346
12	12	12	43	12	72	12	103	12	133	12	164	12	194	12	225	12	256	12	286	12	317	12	347
13	13	13	44	13	73	13	104	13	134	13	165	13	195	13	226	13	257	13	287	13	318	13	348
14	14	14	45	14	74	14	105	14	135	14	166	14	196	14	227	14	258	14	288	14	319	14	349
15	15	15	46	15	75	15	106	15	136	15	167	15	197	15	228	15	259	15	289	15	320	15	350
16	16	16	47	16	76	16	107	16	137	16	168	16	198	16	229	16	260	16	290	16	321	16	351
17	17	17	48	17	77	17	108	17	138	17	169	17	199	17	230	17	261	17	291	17	322	17	352
18	18	18	49	18	78	18	109	18	139	18	170	18	200	18	231	18	262	18	292	18	323	18	353
19	19	19	50	19	79	19	110	19	140	19	171	19	201	19	232	19	263	19	293	19	324	19	354
20	20	20	51	20	80	20	111	20	141	20	172	20	202	20	233	20	264	20	294	20	325	20	355
21	21	21	52	21	81	21	112	21	142	21	173	21	203	21	234	21	265	21	295	21	326	21	356
22	22	22	53	22	82	22	113	22	143	22	174	22	204	22	235	22	266	22	296	22	327	22	357
23	23	23	54	23	83	23	114	23	144	23	175	23	205	23	236	23	267	23	297	23	328	23	358
24	24	24	55	24	84	24	115	24	145	24	176	24	206	24	237	24	268	24	298	24	329	24	359
25	25	25	56	25	85	25	116	25	146	25	177	25	207	25	238	25	269	25	299	25	330	25	360
26	26	26	57	26	86	26	117	26	147	26	178	26	208	26	239	26	270	26	300	26	331	26	361
27	27	27	58	27	87	27	118	27	148	27	179	27	209	27	240	27	271	27	301	27	332	27	362
28	28	28	59	28	88	28	119	28	149	28	180	28	210	28	241	28	272	28	302	28	333	28	363
29	29	29	60	29	89	29	120	29	150	29	181	29	211	29	242	29	273	29	303	29	334	29	364
30	30			30	90	30	121	30	151	30	182	30	212	30	243	30	274	30	304	30	335	30	365
31	31			31	91			31	152			31	213	31	243			31	305			31	366

8.2.2

(1) Python code ST

(2) Python code TRH – Field

(3) Pythion code TRH – Cover

8.2.3

(1) Raw data files

(2) Processed data files

(3) Site specific data summary documents

8.3 Appendix 3: Dissemination

Table 3 Year 1 of the MOPS project June 2018 to May 2019

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
22/05/18	Article exploring EIP potential in agriculture and introducing the MOPS project	General public	Grace Maher	National newspaper- Farming Independent	Interest expressed to IOA about project and EIP process
Jun 2018	Register MOPS project on the EIP-Agri Content Format	Inform the EIP community about MOPS project	Gillian Westbrook	Online	Encouraging to be part of wider EIP network
Jun 2018	NRN Collaboration	Poster to be circulated by NRN as part of EIP-Agri Network	Gillian Westbrook	Online	Informative collective infographic circulated
27/06/18	Social media account established on Twitter, social media postings ongoing for the project duration	Target general public, over 2,500 engagements with videos and images posted to date	Grace Maher	Online	Some good engagement on social media, will build on it as project develops
29/06/18	IOA E-Newsletter	IOA Members informing them about project commencement	Grace Maher	Online	IOA members supportive of the project
07/07/18	Article introducing MOPS project	Certified organic farmers, growers, processors and retailers, policy makers, relevant stakeholders	Gillian Westbrook	Organic Matters Magazine, Issue 139. Publication circulated nationally August 2018	Feedback people welcome the MOPS project, interested in developing their own EIP's
25/07/18	Overview of MOPS project at Teagasc Organic Farm Walk, requested by Teagasc	Organic farmers, interested public, policy makers	Gillian Westbrook	Nurney Farm, Kildare. OG member	Specifically interested in climate monitoring aspect of project
26/08/18	Presentation & distribution of community flyer at Sustainability Festival field talk event	General public	Gillian Westbrook	Green Earth Organics, Galway. OG member	Public feedback; they would like more organic food on retail shelves
11/09/18	Field talk event at participating MOPS project farm	Organic producers, chefs and general public	Gillian Westbrook	Riversfield Organic Farm. Kilkenny. OG member	Interactive audience growers, students. Events like this important as

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
					part of the project
16/09/18	Presentation at a farm walk and cookery demonstration/field talk event	General public	Gillian Westbrook and Padraig Fahy	Beechlawn Organic Farm, Galway. OG member	Practical method focusing on local organic horticultural products
25/09/18	Article on EIP-Why farmers feel project is useful to them, profiled farmer Vincent Grace from Riversfield Organic Farm	General public	Grace Maher	National newspaper-Farming Independent	Feedback on why EIP have potential to assist farmers
25/10/18	Presentation to chefs at Food on the Edge about MOPS project	Professional chefs and restaurant owners, international audience	Gillian Westbrook	Organic farm excursion, Limerick	Good exposure to highlight what is going on at farm level to high end chefs
20/11/18	Organic Farm to School Project	Transition Years Students – 2 of the farms participating in the project are part of MOPS and on the OG	Irish Organic Association	Scoil Chonglais Baltinglass with Oliver Kelly, St. Peters College Wexford with Desmond Thorpe	Students like visiting organic horticultural farms, as for many students this is their first exposure to field scale vegetable production
21/11/18	Farm walk and presentation on MOPS project to CERERE group on one of MOPS project OG farms, Galway	Researchers, academics, farmers, & advisors from across the EU	Gillian Westbrook	Green Earth Organics, Galway. OG member	Network with audience involved in variety of research at EU level
27/11/18	Organic Growers Ireland conference 'Future Growers'	Irish growers	Janet Power (OG farmer)	Tullamore, Co. Offaly	Inform growers about the MOPS project
03/12/18	Article on climate monitoring as part of the MOPS project	Certified organic farmers, growers, processors and retailers, policy makers, relevant stakeholders	Gillian Westbrook and Grace Maher	Organic Matters Magazine, Issue 140. Publication circulated nationally & EU certification bodies	Great interest from readership particularly as severe drought in 2018, very relevant
06/12/18	Videos edited and uploaded onto Vimeo,	General public	Grace Maher	Irish Organic Association	Will expand scope and

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
	ongoing for the project duration			website EIP page & Vimeo	details of on farm videos as project continues
07/12/18	Article on the green manure trial	Certified organic farmers, growers, processors and retailers, policy makers, relevant stakeholders	Grace Maher	Organic Matters Magazine, Issue 140. Publication circulated nationally & EU certification bodies	First article showing results of trial to date, positive feedback from members as relevant to many of them
Ongoing	Operational Group Outreach		Gillian Westbrook and Grace Maher		Multi-channel communication with OG group
22/12/18	OGI Apprenticeship Scheme 2019 – 7 of the 12 host farms in the Apprenticeship Scheme are participating in MOPS project and are on the Operational Group	Future apprentices in organic horticulture		Nationwide-Farmers in the OG group are training new people both in practical methods and business management	Potential to build capacity and transfer knowledge from established experienced organic growers to new entrants
02/01/19	Social media posts continuing for 2019	Inform general public about MOPS project and farmers	Grace Maher and Gillian Westbrook	Online	Important to continue to have a social media presence
04/02/19	Planning visit, video recording at Nurney Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Carbury, Co. Kildare	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
06/02/19	Planning visit, video recording at Moyleabbey Organic Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Ballytore, Co. Kildare	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
14/02/19	Planning visit, video recording at Emmett Dunne's farm (O'Duinn Organacha)	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Durrow, Co. Laois	Crop planning key focus at this time of the year, less opportunity to record a wide

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
					variety of crops in the field
15/02/19	Planning visit, video recording at Des Thorpe's farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Old Ross, Co. Wexford	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
19/02/19	Planning visit, video recording at Gorse Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Bunclody, Co. Wexford	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
20/02/19	Planning visit, video recording at Riversfield Organic Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Callan, Co. Kilkenny	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
25/02/19	Planning visit, video recording at Beechlawn Organic Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Ballinasloe, Co. Galway	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
28/02/19	Planning visit, video recording at Nick Cullen's farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Ballysax, Co. Kildare	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
28/02/19	Presentation on the MOPS EIP project at DAFM event	Inform participants and farming representative bodies about the aims and delivery of MOPS by the Project Manager	Gillian Westbrook	Tullamore, Co. Offaly	Genuine interest in what MOPS is trying to achieve and how farmers can benefit from the EIP programme

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
05/03/19	Planning visit, video recording at Green Earth Organics	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Corandulla, Co. Galway	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
07/03/19	Planning visit, video recording at Kilbrack Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Doneraile, Co. Cork	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
12/03/19	Planning visit, video recording at Oliver Kelly's Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	John Hogan, William Deasy, Grace Maher	Baltinglass Co. Wicklow	Crop planning key focus at this time of the year, less opportunity to record a wide variety of crops in the field
28/03/19	Social media	Social media campaign - ongoing	Gillian Westbrook/Grace Maher	Online	Continue to inform the public about MOPS project
11/04/19	Sustainable Food Production & SDG's Conference	Information presented on MOPS project and organic food production	Grace Maher	Croke Park Dublin	Potential new audience to disseminate information about MOPS to
17/04/19	EIP booklet launch- DAFM	DAFM event and other EIP projects and stakeholders	Gillian Westbrook and Grace Maher	Agriculture House Dublin	Network with other projects and those interested in developing projects
15/05/19	Social media	Continuation of the social media campaign- ongoing	Gillian Westbrook and Grace Maher	Online	Continue to inform the public about MOPS project

Table 4 Year 2 of the MOPS project June 2019 to May 2020

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
19/06/19	Teagasc Organic Demonstration Farm Programme	Nurney Farm host farm walk and spoke about MOPS project	Gillian Westbrook and Grace Maher	Carbury, Kildare	Members of the public interested in organic food. Project Manager spoke

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
					about MOPS project
20/06/19	EIP Article-Innovation at farm level	Nurney Farm, Kildare	Grace Maher	Nationwide	National newspaper – Farming Independent
Ongoing	Operational Group Outreach		Gillian Westbrook and Grace Maher		Multi-channel communication with OG group
01/08/19	Farm walk at Desmond Thorpe's where the green manure trial is taking place	Disseminate the findings at the end of year one of the trial.	Irish Organic Association	Wexford	There was a strong level of public interest in the dissemination of the results. Including from agronomists, farmers and growers.
14/08/19	Circulation of articles on MOPS project to the Organic Growers Alliance in the UK	Inform organic growers in the UK about MOPS project	Irish Organic Association	United Kingdom	Organic growers in the UK are interested in the MOPS project and learnings to be shared.
20/08/19	Planning visit, video recording at Moyleabbey Organic Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Ballytore, Co. Kildare	Crop walk to asses crop production and performance to date. Evaluation of crop plan with on-farm activity.
27/08/19	Planning visit, video recording at Nurney Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Carbury, Co. Kildare	Crop walk to asses crop production and performance to date. Evaluation of crop plan with on-farm activity.
12/09/19	Planning visit, video recording at Nick Cullen's organic farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Ballysax, Co. Kidare	Crop walk to asses crop production and performance to date. Evaluation of crop plan with

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
					on-farm activity.
13/09/19	Design of flyer disseminating results of the green manure trial at the end of year 1	Inform the public about results of the trail to date.	Irish Organic Association	For distribution at the National Ploughing Championships 2019	Positive feedback from members of the general public when engaged on the topic. Will distribute it at other events.
Jul-Sep 2019	Social media	Ongoing continuation of the social media campaign	Project Manager and Communications Officer	Online	Continue to inform people and MOPS and disseminate key results from the project
02/10/19	Planning visit, video recording at Riversfield Organic Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Vincent Grace's farm in Callan, Co. Kilkenny	Crop walk to monitor crop production and performance to date. Evaluation of crop plan with on-farm activity.
08/10/19	Planning visit, video recording at Beechlawn Organic Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Padraig Fahy, Ballinasloe, Co. Galway	Crop walk to monitor crop production and performance to date. Evaluation of crop plan with on-farm activity.
12/10/19	Organic producers event Marley Park	Promote the MOPS project to the general public and organic consumers	Irish Organic Association and 2 members of the OG	Marley Park, Dublin – open event free to the public	People interested in finding out more about the growers who supply near them
24/10/19	Planning visit, video recording at Emmett Dunne's farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Emmett Dunne, Durrow, Co. Laois	Crop walk to monitor crop production and performance to date. Evaluation of crop plan with on-farm activity.

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
07/11/19	Planning visit, video recording at Thorpe's Organic Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Des Thorpe, New Ross, Co. Wexford	Crop walk to monitor crop production and performance to date. Evaluation of crop plan with on-farm activity.
12/11/19	Planning visit, video recording at Gorse Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Bunclody, Co. Wesford	Crop walk to monitor crop production and performance to date. Evaluation of crop plan with on-farm activity.
19/11/19	Planning visit, video recording at Green Earth Organics	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Corandulla, Co. Galway	Crop walk to monitor crop production and performance to date. Evaluation of crop plan with on-farm activity.
20/11/19	Planning visit, video recording at Kilbrack Farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Doneraile, Co. Cork	Crop walk to monitor crop production and performance to date. Evaluation of crop plan with on-farm activity.
25/11/19	OG Group meeting, Athlone				
26/11/19	Organic Farm to School Project	MOPS project OG members Nurney Farm involved in school project	Nurney Farm	Kildare	Visits to school and then farm visit for TY students about organic farming
26/11/19	Planning visit, video recording at Oliver Kelly's organic farm	Discuss farm crop plan for 2019, record, edit and upload relevant videos to IOA website	Members of the Horticulture Team	Baltinglass, Co. Wicklow	Crop walk to asses crop production and performance to date. Evaluation of crop plan with on-farm activity.

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
27/11/19	Circulation of articles on MOPS project to the Organic Growers Alliance in the UK-Winter 2019 Edition 49	Inform organic growers in the UK about MOPS project	Irish Organic Association	United Kingdom	A lot of interest in the last article we shared so submitted more for OGA in the UK for their magazine
16/12/19	Circulation of articles on MOPS project published in Organic Matters Magazine Winter 2019 Issue 142	Two articles; Input from OG members, and end of year update on green manure trial	Irish Organic Association	Nationwide	Magazine articles to stimulate debate and interest in MOPS project
22/12/19	OGI Apprenticeship Scheme 2019. Six of the 11 host farms in the Apprenticeship Scheme are participating in MOPS project and are on the Operational Group	Future apprentices in organic horticulture		Nationwide – Farmers in the OG group are training new entrants to the sector	Excellent opportunity to build capacity and transfer knowledge
Oct-Dec 2019	Social media	Ongoing continuation of the social media campaign	Project Manager and Communications Officer	Online	Continue to inform people and MOPS project and disseminate key results from the project
21/01/20	Planning visit, video recording at Riversfield Organic Farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm.	Members of the Horticulture Team	Vincent Grace's farm in Callan, Co. Kilkenny	Farm aware of the importance of crop planning and plan for specific markets.
23/01/20	Planning visit, video recording at Nurney Farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm.	Members of the Horticulture Team	Nurney Farm in Carbury, Co. Kildare	Change of business model for this farm due to information gathered on cost of crop production.

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
28/01/20	Planning visit, video recording at Nick Cullen’s farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm	Members of the Horticulture Team	Nick Cullen’s farm at Ballysax, Co. Kildare	Farmers aware of the importance of crop planning and plan for specific markets.
30/01/20	Planning visit, video recording at Beechlawn Organic Farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm	Members of the Horticulture Team	Beechlawn Organic Farm in Ballinasloe, Co. Galway	Farmers aware of the importance of crop planning and plan for specific markets.
31/01/20	Planning visit, video recording at Green Earth Organics	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm	Members of the Horticulture Team	Green Earth Organics in Corandulla, Co. Galway	Farm aware of the importance of crop planning and plan for specific markets
04/02/20	Planning visit, video recording at Gorse Farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm	Members of the Horticulture Team	Gorse Farm in Bunclody, Co. Wexford	Specific crop plan for main crops and some additional markets
05/02/20	Planning visit, video recording at Desmond Thorpe's farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm	Members of the Horticulture Team	Thorpe’s Organic Farm in Co. Wexford	Farm aware of the importance of crop planning and plan for specific markets
11/02/20	Planning visit, video recording at Emmett Dunne's farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm	Members of the Horticulture Team	Emmett Dunne’s farm in Durrow, Co. Laois	The 2020 crop plan was edited and new varieties and crops were added to the design
13/02/20	Planning visit, video recording at Oliver Kelly’s farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between	Members of the Horticulture Team	Oliver Kelly’s farm in Co. Wicklow	Farm aware of the importance of crop planning and plan for

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
		farmer/agronomist on the farm			specific markets
17/02/20	Planning visit, video recording at Moyleabbey Organic Farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm	Members of the Horticulture Team	Liam Ryan and staff at Moyleabbey Organic Farm	Farm aware of the importance of crop planning and plan for specific markets
20/02/20	Planning visit, video recording at Kilbrack Farm	Review crop performance in 2019. Design key aspects of crop plan for 2020. Video interaction between farmer/agronomist on the farm	Members of the Horticulture Team	Patrick Frankel at Kilbrack Farm in Doneraile, Co. Cork	Farm aware of the importance of crop planning and plan for specific markets
Jan-Mar 2020	Social media	Ongoing continuation of the social media campaign	Project Manager and Communications Officer	Online	Continue to inform people and MOPS project and disseminate key results from the project
05/05/20	National Rural Network blog	Disseminate findings to date with MOPS project in EIP network and beyond	Gillian Westbrook	Online	Explore lessons learned to date in MOPS project
Ongoing	Operational Group Outreach		Gillian Westbrook and Grace Maher		
22/05/20	Green manure trial Update for Organic Matters	Article to circulate to IOA members on trial to date	Peter Jones	Organic Matters Magazine (circulated in June 2020)	Disseminate findings at the end of Year 2 of the trial
15/05/20	Social media posts	Ongoing continuation of the social media campaign	Project Manager and Communications Officer	Online	Continue to inform people and MOPS project and disseminate key results from the project
30/5/20 & 31/5/20	Horticulture Team meetings	Meeting #6 of the Horticulture Team		Online	Review status at the end of Year 2 and plan

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
					for forthcoming year

Table 5 Year 3 of the MOPS project June 2020 to March 2021

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
16/06/20	Planning visit, video recording at Riversfield Organic Farm	Review crop plan 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Vincent Grace, Riversfield Organic Farm, Co. Kilkenny	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
18/06/20	Planning visit, video recording at Nick Cullen, Ballysax	Review crop plan 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Nick Cullen, Co. Kildare	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
23/06/20	Planning visit, video recording at Moyleabbey Organic Farm	Review crop plan 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Liam Ryan, Moyleabbey Organic Farm, Co. Kildare	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
25/06/20	Planning visit, video recording at Emmett Dunne’s farm	Review crop plan in 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Emmett Dunne, Co. Laois	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
14/07/20	Planning visit, video recording at Gorse Farm	Review crop plan in 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Janet Power and Jenny Watkins, Gorse Farm. Co. Wexford	Changes in markets and farm structure due to Covid-19. Agronomy challenges.

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
21/07/20	Planning visit, video recording at Beechlawn Organic Farm	Review crop plan in 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Padraig Fahy, Beechlawn Organic Farm, Co. Galway	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
23/07/20	Planning visit, video recording at Oliver Kelly’s farm	Review crop plan 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Oliver Kelly, Co. Wicklow	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
27/07/20	Planning visit, video recording at Nurney Farm	Review crop plan 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Nurney Farm, Co. Kildare	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
28/07/20	Planning visit, video recording at Desmond Thorpe’s farm	Review crop plan 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Desmond Thorpe, Co. Wexford	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
04/08/20	Planning visit, video recording at Green Earth Organics	Review crop plan 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Kenneth Keavey, Green Earth Organics, Co. Galway	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
02/09/20	Planning visit, video recording at Kilbrack Farm	Review crop plan 2020. Discuss crop performance and market challenges. Video recording of farmer/agronomist on crop production issues	Members of the Horticulture Team	Patrick Frankel, Kilbrack Farm, Co. Cork	Changes in markets and farm structure due to Covid-19. Agronomy challenges.
Jun-Sep 2020	Social media posts	Ongoing continuation of the social media campaign	Project Manager and Communications Officer	Online	Continue to inform people and MOPS and

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
					disseminate key results from the project
13/10/20	Planning visit #6, video recording at Green Earth Organics	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Green Earth Organics, Corandula, Co. Galway	Crop evaluation and market updates. Discuss crop plan for 2021
22/10/20	Planning visit #6, video recording at Kilbrack Farm	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Kilbrack Farm, Doneraile, Co. Cork	Crop evaluation and market updates. Discuss crop plan for 2021
27/10/20	Planning visit #6, video recording at Nick Cullen's farm	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Ballysax, The Curragh, Co. Kildare	Crop evaluation and market updates. Discuss crop plan for 2021.
29/10/20	Planning visit #6, video recording at Des Thorpe's farm	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Des Thorpe, Old Ross, Co. Wexford	Crop evaluation and market updates. Discuss crop plan for 2021
03/11/20	Planning visit #6, video recording at Moybleabbey Organic Farm	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Ballytore, Co. Kildare	Crop evaluation and market updates. Discuss crop plan for 2021
05/11/20	Planning visit #6, video recording at Riversfield Organic Farm	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Callan, Co. Kilkenny	Crop evaluation and market updates. Discuss crop plan for 2021
10/11/20	Planning visit #6, video recording at Emmet Dunne's farm	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Durrow, Co. Laois	Crop evaluation and market updates. Discuss crop plan for 2021
12/11/20	Planning visit #6, video recording at Beechlawn Organic Farm	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Ballinasloe, Co. Galway	Crop evaluation and market updates. Discuss crop plan for 2021

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
19/11/20	Planning visit #6, video recording at Oliver Kelly's farm	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Baltinglass, Co. Wicklow	Crop evaluation and market updates. Discuss crop plan for 2021
Nov 2020	MOPS project articles in Organic Matters, Issue 144, Winter 2020	Articles circulated to IOA members on green manure trial & use of organic materials and sampling results from MOPS project	Peter Jones and William Deasy	Organic Matters Magazine (circulated in December 2020)	Disseminate findings of the green manure trial & information on organic materials used in organic production, grower guide to sampling analysis results from MOPS project
01/12/20	Planning visit #6, video recording at Gorse Farm	Crop walk and agronomy issues, market discussion, video crop information with farmer/agronomist	Members of the Horticulture Team	Bunclody, Co. Wexford	Crop evaluation and market updates. Discuss crop plan for 2021
Sep-Dec 2020	Social media posts	Ongoing continuation of the social media campaign	Project Manager and Communications Officer	Online	Continue to inform people and MOPS project and disseminate key results from the project
23/01/21	Radio interview	National promotion of MOPS	Grace Maher	Countrywide RTE radio 1	Engagement focusing on the aims of MOPS project and how it works with growers to achieve those aims
25/01/21	Video webinar	Patrick spoke about his involvement in MOPS and how beneficial it has been for his farm	Patrick Frankel, Kilbrack Farm	Online	Member of the Operational Group promoting MOPS project and encouraging more farmers

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
					to actively engage with EIP's
19/02/21	MOPS project presentation at Teagasc national event	Communication regarding the objectives of MOPS, relevant results to date and projected outcomes	Gillian Westbrook	Online webinar	Presentation from the Project Manager on project approach, and lessons and results as project moves into the final phase
24/02/21	Presentation on MOPS project	Inform final year students about the EIP process and the MOPS project	Grace Maher	Online – Carlow IT to 4th year students of BSc in Sustainable Agriculture and Business Management	Target group involved in farming however little experience with horticulture or process of EIP's
25/05/21	Farming Independent article- Organic Transplant Business	Profile of new business starting based on the demand outlined by MOPS project	Communication Officer	National Newspaper Farming Independent	Profiling expansion of ancillary services based on demand outlined by MOPS project Operational Group
16/02/21	Article in Organic Matters Magazine- Industry Review	Summary of the industry report on the organic horticulture market based on interviews with major retail multiples	Communication Officer and Project Manager	Organic Matters distributed to all members of the Irish Organic Association	The industry report highlights the growth in the sector over the past five years and illustrates future potential for MOPS project growers and the wider sector
16/02/21	Article in Organic Matters Magazine-	Feature article on a business developed on the back of demand	Communication Officer	Organic Matters distributed to all members of the Irish Organic Association	Highlights potential services to support

Date	Action	Targets achieved	Carried out by	Location	Lessons learned
	Organic Transplant Business	from MOPS project growers			growth in the organic sector
29/06/21	EIP-Participating project for NRN-Video Blog with Louise Rankin, Moyleabbey Organic Farm	Video from Moyleabbey Organic Farm outlining benefits of participating in the MOPS project	Communication Officer/NRN	Online Video hosted by NRN	The video outlines how Moyleabbey Organic Farm found participating in the project and how it benefited their farm business
Jul-Oct 2021	MOPS project Growers Report	Compilation of key aspects of the MOPS project for existing producers, new entrants into the sector, trainers and others, including cropping reports and grower videos, market reports, climate monitoring, technical note on organic materials and results from green manure field trials.	MOPS project team	Available in hard copy from the Irish Organic Association www.mopsorganic.ie	Dissemination of key aspects from the MOPS project to existing and new growers and producers entering the sector, trainers and educators, the wider community and other interested parties.

8.4 Appendix 4: MOPS Project Finance

	2018: May to Dec	2019: Jan to Dec	2020: Jan to Dec	2021: Jan to December	Total Project Spend
Income	**122517**	**151203**	**172888**	**137109**	**583717**
Expenditure					
Horticulture meetings	5314	5640	6454	11209	28617
Operational Group Meetings	9532	11393	7612	4703	33240
Initial 5 day farm visits	17200			0	17200
Planning visits	8844	23738	39980	13290	85852
Farm Monitoring visits	13800	42905	34600	13826	105131
Green Manure Trial	5266	8499	10858	5382	30004
Growers Report				32958	32958
Compost Trial Research			4788		4788
Sampling & Analysis	10537	8260	9603	2753	31153
Dissemination	11700	17450	24450	3000	56600
Administration	9984	15836	18944	9875	54639
Data Analyst	3200	6400	14400		24000
Industry Liaison Person	2700	9356	1200	14760	28016
Film Creation Heavy Man				24873	24873
Equipment & Software	24441	1726		480	26647
Total Expenditure	**122517**	**151203**	**172888**	**137109**	**583717**
EIP Projects are co-Funded under the EAFRD EU fund @53%					