

# MOPS

## MAXIMIZING ORGANIC PRODUCTION SYSTEMS

# GROWERS REPORT

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

PARTICIPATING IN
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# MOPS project Growers Report summary

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 (DAFM) and the European Commission. This Growers Report has been collated from the MOPS EIP project, which was led by the Irish Organic Association in partnership with the participant organic growers and other practitioners. Each section of the report provides practical information on the main elements from the project of interest and relevance to growers, producers and trainers/educators.

Sections 1 and 2 outline the background to the MOPS project and trade/market insights that were gained during the project. The condensed MOPS project market report (Section 2), which focuses on retail/supermarket sales, provides a synopsis of the volume of organic horticultural fresh produce being sold through multiples in Ireland. It lists projected volumes for the main organic vegetables in 2021, as well as best sellers, and identifies gaps in the range of organic vegetables and the growth opportunities for Irish organic producers. The positive response to the research from the multiples stands out in the market report, some stating during the survey that they could double sales of organic horticultural fresh produce if Irish grown, clearly highlighting the opportunities that exist for Irish organic growers. Trade and market insights from the perspective of the participant MOPS project farm businesses during the project, and their routes to market, are presented in Section 1.

Section 3 gives details on the types of organic crops and cultivars being produced by the MOPS project growers. Section 4 includes links to short videos from each project farm that were captured to complement the crop specific areas of interest. The MOPS project Growers Report and videos are being disseminated to the wider community so that these growing techniques, or parts of them, may be replicated or used as demonstrative examples of the different approaches that the project growers use to optimise production of organic horticultural crops. Section 5 describes the importance of on-farm climate records.

Section 6 provides a technical note on organic materials used in organic production that was collated during the project 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.

Section 7 summarises the key findings from the MOPS project green manure trial. Managing soil health and fertility to achieve crop yields is key in organic production where emphasis is on self-sustaining systems rather than reliance on external inputs. A practical on-farm green manure trial was, therefore, conducted for the duration of the project to demonstrate the potential benefits to soil health, crop yields, weed management, biodiversity and the cost of production of adopting this approach.

# 1 MOPS project overview and insights

## 1.1 Background to the MOPS project

The Maximising Organic Production Systems (MOPS) European Innovation Partnership (EIP) project was initiated by the Irish Organic Association when asked by some of their horticultural members to examine how Irish organic growers might become more sustainable, whilst improving their economic performance and overall increasing the supply of Irish-grown crops to multiple retailers and for direct-selling.

Consequently, the main aim of the project was to optimise vegetable production for 11 organic horticulture farms located across the country (Figure 1) in order to meet market demand for more locally produced organic crops, thereby creating more efficient short supply chains whilst improving the sustainability and economic performance of the organic farms involved.

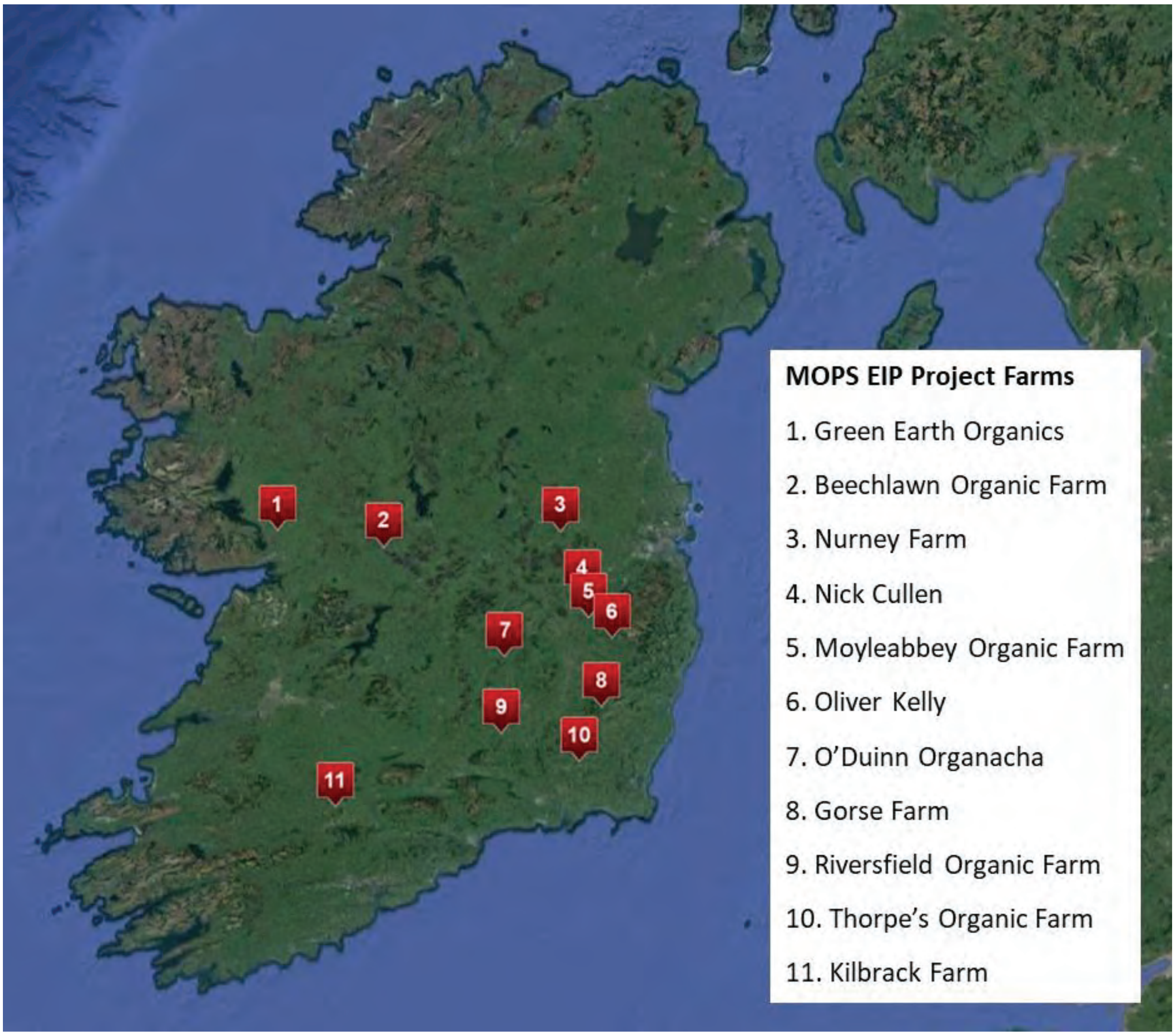



***Figure 1** Locations of the MOPS EIP project farms. Figure source Google Maps annotated using Scribble Maps (Scribble Maps, 2021).*

The 11 participating certified organic project farms ranged in size from circa 1 hectare to 100 hectares (Figure 2). All experienced growers with various routes to market including multiples/supermarkets, independent retail, farmers markets, box schemes, farm shops and food service. The MOPS project commenced in June 2018 and finished in May 2021, with all farms actively involved for the duration of the project.

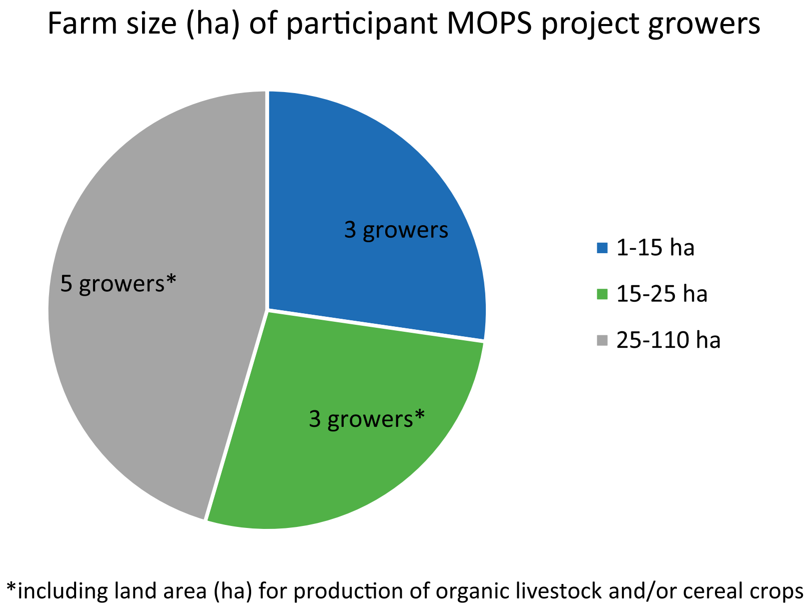



*Figure 2 Farm size in hectares (ha) of the 11 participant MOPS project farms.*
*Farm size land area (ha) data used with permission from the Irish Organic Association.*

## 1.2 Collaborative approach to growing and supplying organic horticultural fresh produce

The organic horticultural sector tends to be comprised of many smaller farms that are widely distributed throughout Ireland. The scale and geographical location of some of these organic farms can limit access to larger markets, but at the same time this offered a unique advantage for the MOPS project growers if they could adopt a collaborative approach to supplying their produce. Taking advantage of the differing geographical farm locations, their proximity to various commercial centres, existing grower expertise 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 meet the market demand.

Individual farm cropping plans were required, each designed to correspond to and complement the output of the other project farms, thereby stimulating new 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. 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 project.

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. Ongoing market research and retail specifications correspondingly guided the design of the annual cropping plans for each farm. With sustainability being an essential component of future farm business, an on-farm green manure trial was conducted in Co. Wexford, to demonstrate the value of adopting green cover crops to maintain and build soil health and fertility. 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. Both the trial and technical note offer practical information on options for farmers to consider to help optimise soil health and fertility, crop production and the economic performance and sustainability of their farm businesses.

The MOPS project not only focussed on optimising soils and crop production for each project farm and the group overall but importantly, in line with the main aim of the project, facilitated collaboration between the growers for trade of organic produce. 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. 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.

Over the duration of the project some of the growers changed their market outlets to increase direct-selling, while others increased supply to retail. By reorientating their supply and sales routes, balancing persistence with flexibility, in order to continue supplying the year-over-year increase in Irish consumer demand for organic produce, as a group the MOPS project growers increased their combined total sales turnover by +112% between December 2017 and December 2020 (Figure 3). Furthermore, during the final year of the project trade between the project growers increased by +62% year-over-year, and fresh produce purchases by the project growers from other certified organic growers in Ireland increased by +371%, within an overall increase in importing/purchasing of organic produce to meet the demand for organically produced horticultural fresh produce in Ireland (Table 1).

## 1.3 The Irish market for organic horticultural fresh produce

Sales of organic fruit and vegetables have risen considerably in Ireland over the past few years. According to Bord Bia (Irish Food Board), sales of organic horticultural fresh produce through the multiples and supermarkets (excluding sales to independent retailers and direct sales through farmers markets, farm shops, box deliveries or food service) increased from circa €55 million in 2015 to €83 million in the first three quarters of 2020 (personal communication with Bord Bia). Ireland has the potential to produce a great deal more quality Irish-grown organic fresh produce to meet this growing demand, as demonstrated by the 11 MOPS project growers who increased sales of their own-grown crops by +11% year-over-year in the final year of the project (Table 1). Currently, approximately 70% of organic horticultural produce is imported (DAFM, 2019) and despite increased land area under organic horticulture, up 36.5% since 2017 (personal communication with DAFM), the level of imported 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 (Table 1), in support of shorter supply chains, and substituted some imports compared to the previous year (Figure 6), within the overall year-over-year greater increase in value of imported fresh produce, needed to meet higher market demand levels.

## 1.4 Key MOPS project finding: strong increase in sales of organic horticultural fresh produce with total sales turnover growth at +112% between 2017 and 2020 for the 11 MOPS project growers

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 3).

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.

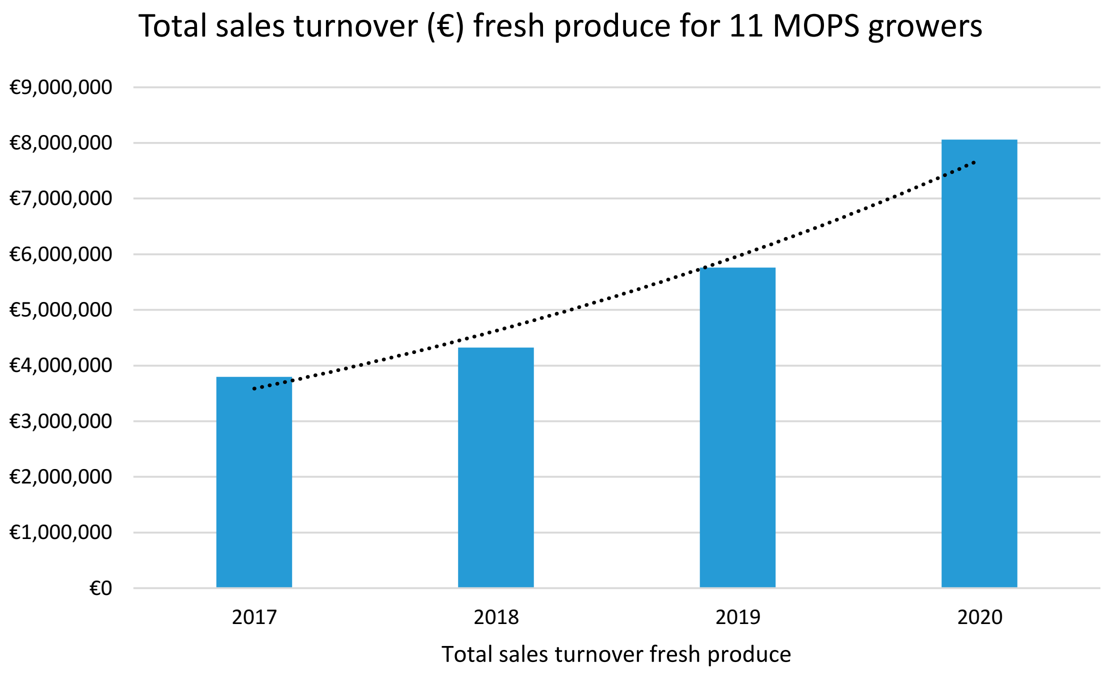



*Figure 3 The total sales turnover (€) from organic horticultural fresh produce sales (2017-2020) for the 11 growers that participated in the MOPS project.*

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 (Table 1). For the same period, total sales of all own-grown organic crops produced by the MOPS project growers increased by +11% in comparison with the previous year.

**Table 1 Year-over-year trade growth for the 11 MOPS project growers in the final year of the project.**

| Trade growth between 2019/2020 and 2020/2021 | Year-Over-Year Growth |
|---|---|
| Total sales turnover organic fresh produce for 11 MOPS project growers | ↑40% |
| Total sales own-grown organic crops for 11 MOPS project growers | ↑11% |
| Trade between MOPS project growers | ↑62% |
| Fresh produce purchases from ROI/NI suppliers/growers other than MOPS growers | ↑371% |
| Imported non-Irish organic fresh produce | ↑119% |

## 1.5 Key MOPS project finding: dynamic growth and sustained increase in market demand for organic horticultural fresh produce for the MOPS project growers

Figure 4 shows the dynamic growth in total sales turnover experienced by the MOPS project growers between 2019 and 2021. Total sales turnover from produce sales to retailers 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% 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 as displayed in Figure 3, along with the findings of the MOPS market report, emphasises the increased market demand that exists for more organic fresh produce.

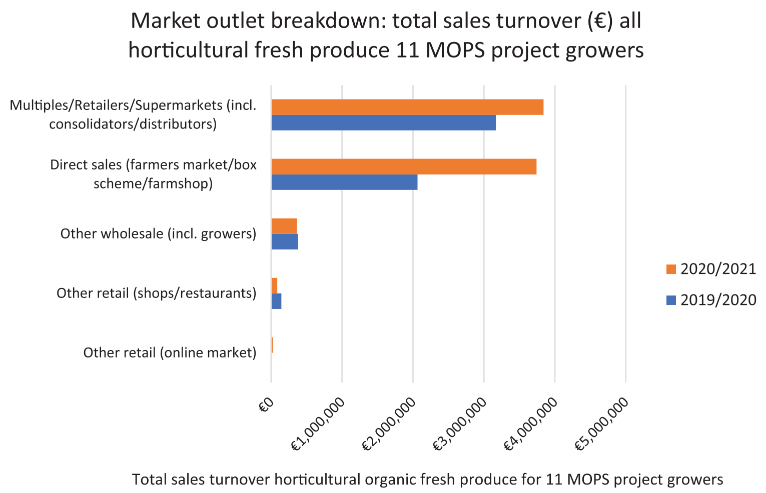
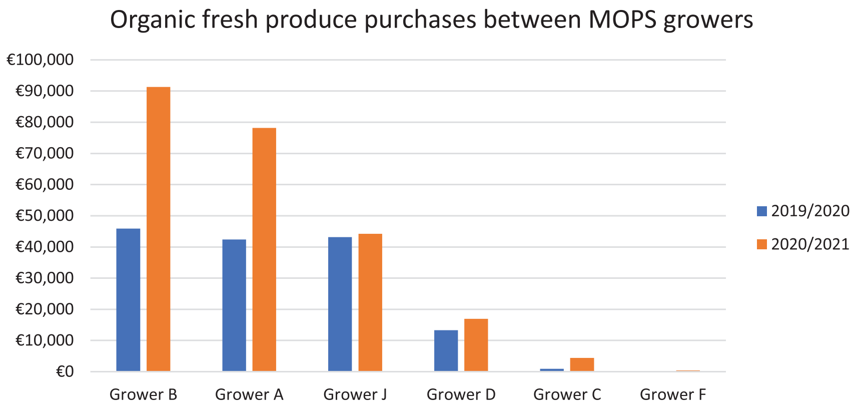



*Figure 4 Breakdown of routes to market and market demand trends for two years of the MOPS project. Shown are figures for total sales turnover (€) from all horticultural fresh produce sales for the 11 MOPS project growers 2019/20 to 2020/21.*

## 1.6 Key MOPS project finding: increased trade in organic horticultural fresh produce between the MOPS project growers to supply market demand

Trade (purchasing and selling) of organic horticultural fresh produce between MOPS project growers increased by +62% year-over-year by the final year of the project (Table 1). The increase in trade between the MOPS project growers and the contribution of the individual MOPS growers to this trade is shown in Figure 5. Not all of the project farms purchased crops from the other growers in the project, instead they opted to supply their produce. These findings further highlight the potential and opportunities that exist in taking a collaborative approach to supply, especially when mindful that the sales figures presented here are only representative of 11 Irish farms of various sizes supplying their range of organic produce to retail and direct sales outlets.



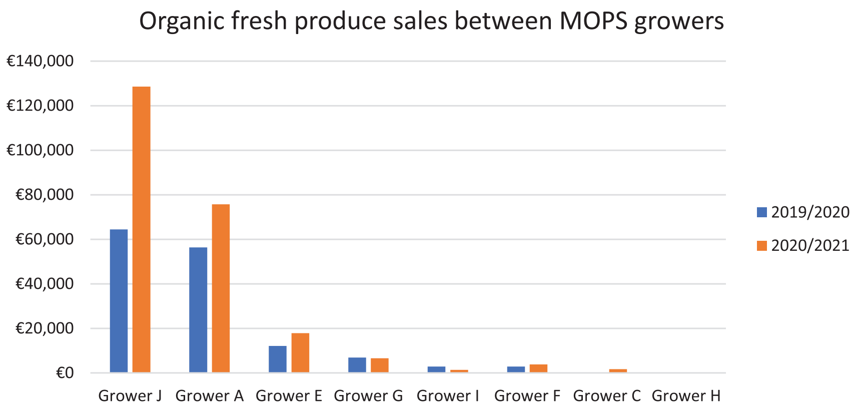




Figure 5 Trade of organic horticultural fresh produce between MOPS project growers and contribution of individual growers to the purchasing and selling in 2019/2020 and 2020/2021.

*Figure 5 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.*

## 1.7 Key MOPS project finding: greater purchasing of local Irish organic horticultural fresh produce by MOPS project growers within overall increase in purchasing/ importing of organic fresh produce to supply continued growth in demand from consumers in Ireland

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 (Table 1). The purchase of imported produce, with an overall greater value, increased by +119% compared to the previous year. Figure 6 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 outwith the MOPS project. The value of purchases of both Irish and non-Irish imported produce increased year-over-year (Table 1), 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.

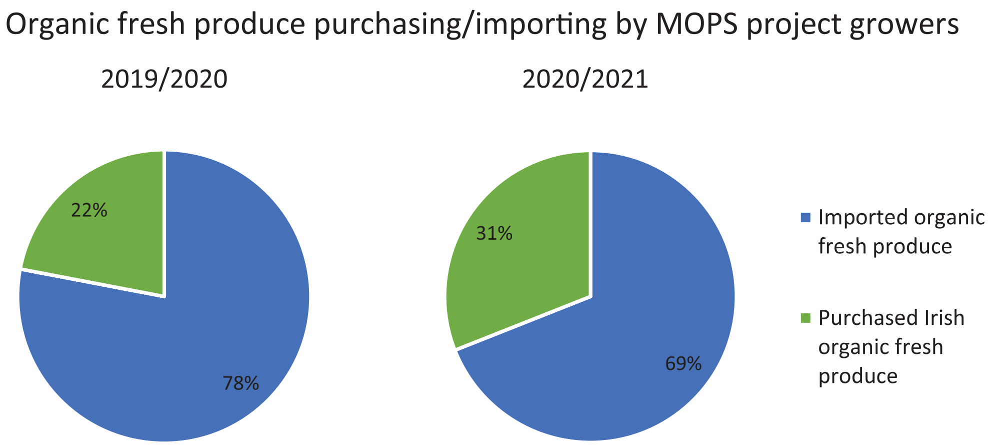



*Figure 6 Breakdown of Irish purchased and non-Irish imported organic horticultural fresh produce (percent of total value € imports/purchases) by MOPS project growers in 2019/2020 and 2020/2021.*

## 1.8 References

Department of Agriculture, Food and the Marine (DAFM), 2019.
Review of organic food sector and strategy for its development 2019-2025. [Online] Available at: *https://www.gov.ie/en/publication/fc7c8-organic-farming/ [Accessed 31 August 2021].*

Scribble Maps, 2021. https://www.scribblemaps.com/create/. [Online] Available at: *https://www.scribblemaps.com/ [Accessed 31 August 2021].*

# 2 MOPS project market report

An independent research company was used to carry out the final phase of the 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 for the MOPS project. The research reviewed the level of demand for organic vegetables, lists deficit in supply for Irish produced organic vegetables and identifies the potential that exists for the organic horticulture sector. A summary of the key findings from the report are presented in this section.

## 2.1 Introduction

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 were 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 MOPS project 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.

Although some may consider the target of 25% of land in the European Union to be organic by 2030 as ambitious, the research conducted for this report for MOPS suggests the climate is right amongst Irish trade buyers and consumers to change production in line with national goals and significantly increase organic production.

## 2.2 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, 2020c).

25% of Irish consumers have purchased more organic food since 2019 – the biggest cohort are in Dublin aged 25-34. 67% would choose 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 reasons) 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, 2020b; Bord Bia, 2020d).

## 2.3 Organics and Irishness

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

According to Mintel in its Insight report "Organic veg may be too expensive for its key audience" (Mintel, 2020a), 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 do 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. Although the Irish organic horticulture sector is fragmented, this could be used to their advantage given the 'local' preference.

## 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.

- "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 some of the larger conventional growers - 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 often came up in stakeholder interviews and is becoming increasingly 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. Bags 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 currently is 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 Best sellers and Gaps in Range

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

#### 2.5.1 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

#### 2.5.2 Gaps in Range of Organic Vegetables

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

## 2.6 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.

## 2.7 Total Organic Vegetables Sales Volumes in Irish Multiple Retailers for 2020

Multiple retailer sales volumes of organic vegetables for the year 2020 in terms of packs and tonnage are estimated below:

- 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.**

**2.7.1 Sales volumes of specific Organic Vegetables in Irish Multiple Retailers for 2020**
The approximate 2020 sales volume of main and less mainstream organic vegetables sold by Irish multiple retailers is set out in Table 1, 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.

**Table 1 Volume of Specific Organic Vegetables sold in Irish Multiple Retailers 2020.**

| Product | Unit or packs | Average weight Unit 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.

## 2.8 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.

Projected sales volume for main and less mainstream organic vegetables for 2021 (units or packs) sold in Irish multiple retailers are shown in Tables 2 and 3. 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.

**Table 2 Projected Volume for Main Organic Vegetables For 2021 (units or packs) sold in Irish Multiple Retailers.**

| Product | Worst Case 10% | Medium Case 15% | Best Case 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 |

**Table 3 Projected Volume For Less Mainstream Organic Vegetables For 2021 (units or packs) sold in Irish Multiple Retailers.**

| Product | Worst Case 10% | Medium Case 15% | Best Case 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 |

## 2.9 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 with 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. [Note: Irish Organic 'rules', or Standards are taken from the EU Organic Regulations and are the same for every Member State].

- **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 organic growing 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 and steady rise which peaked during the pandemic. The organic share however, remains small and the overall population lacks the density of other countries resulting in a limited market size.

- **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 stored 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.

- **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.

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# 3 MOPS project cropping programmes and production

This section of the MOPS project grower report provides an overview of the production of organic horticultural crops in Ireland by the 11 growers that participated in the MOPS project. In doing so, the section gives an outline of the crop planning and growing work that was carried out by the growers and consultant agronomist during the MOPS project.

A summary of some key findings and recommendations are presented, along with examples of cropping programmes that were developed with the MOPS project growers to optimise their crop production systems.

The crops included in this section were selected on the basis of: sales figures from the MOPS project growers; data for purchased/imported organic horticultural fresh produce that highlight potential for import substitution; and the survey findings in the MOPS project market report and reports contained therein.

The information and data provided are based on the best information available to the MOPS project. Some production area figures and crop cultivar names were unavailable. Estimated production figures, denoted est., and cultivar names from cropping plans have been included to allow for better interpretation. Unavailable cultivar names are denoted †.

## 3.1 Organic potato production area and cultivars

The total organic potato production area for growers in the MOPS project was 22.14 hectares (ha) in 2019 and 34.33 ha in 2020. Figure 1 shows a breakdown of the 2020 potato production area by cultivar.

Seven MOPS growers produced potatoes in 2019, eight growers in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois, Wexford and Wicklow. Key market outlets are supermarkets/retailers, direct selling (box delivery, farmers markets, farmgate) and restaurants. Examples of potato cropping programmes for MOPS growers are shown in Table 1.

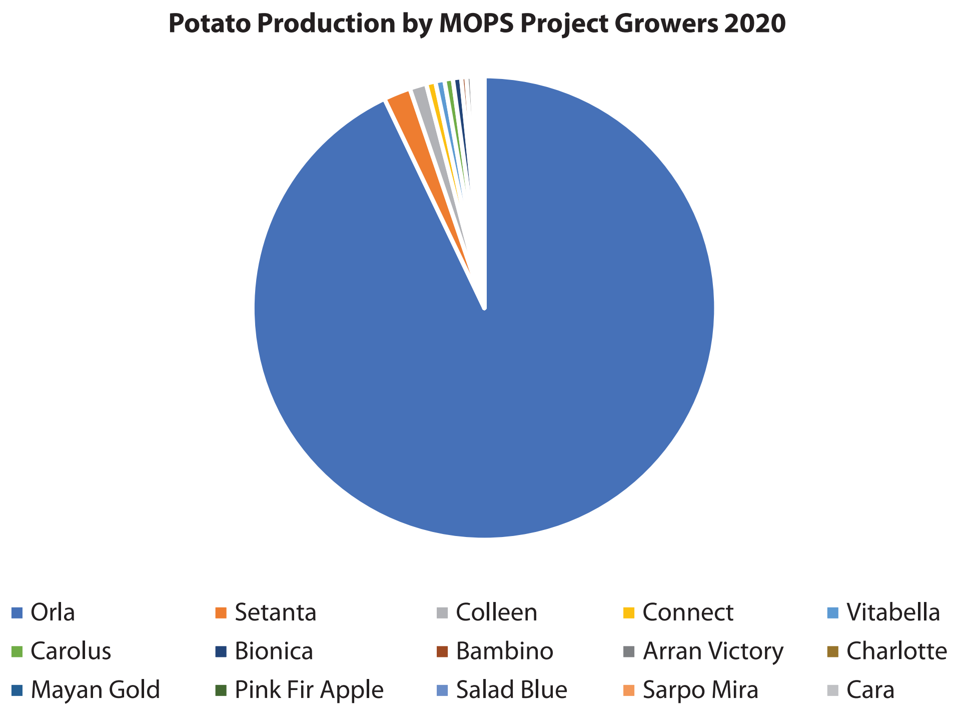



*Figure 1 Potato production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.1.1 Cropping programmes

**Table 1 Example potato cropping programmes for MOPS project growers consisting of earlies, second earlies and maincrop cultivars.**

| Cultivar | Planting | Spacing (cm) | Days to maturity | Plant density/m$^2$ | Expected harvest |
|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | |
| Premier | Early Apr | 75 × 35 | 85 + | 3.8 tubers | Early Jul + |
| Premier | Early Apr | 75 × 30 | 95 + | 4.4 tubers | Mid Jul + |
| Orla | Mid Apr | 75 × 30 | 100 + | 4.4 tubers | Early Aug + |
| Colleen | Mid Apr | 75 × 30 | 115 + | 4.4 tubers | Mid Aug + |
| **Cropping programme 2** | | | | | |
| Vitabella | Mid Apr | 60 × 40 | 75 + | 4.2 tubers | Late Jun + |
| Colleen | Mid Apr | 60 × 40 | 85 + | 4.2 tubers | Mid Jul + |
| Charlotte | Mid Apr | 60 × 30 | 95 + | 5.6 tubers | Late Jul + |
| Cara | Mid Apr | 60 × 30 | 100 + | 5.6 tubers | Early Aug + |
| Connect | Mid Apr | 60 × 30 | 100 + | 5.6 tubers | Early Aug + |
| Carolus | Mid Apr | 60 × 30 | 100 + | 5.6 tubers | Early Aug + |
| Setanta | Mid Apr | 60 × 30 | 120 + | 5.6 tubers | Late Aug + |
| **Cropping programme 3** | | | | | |
| Red Duke of York | Mid Apr | 80 × 35 | 90 + | 3.6 tubers | Mid Jul + |
| Orla | Mid Apr | 80 × 35 | 90 + | 3.6 tubers | Mid Jul + |
| Ambo | Mid Apr | 80 × 30 | 120 + | 4.2 tubers | Mid Aug + |
| Charlotte | Mid Apr | 80 × 30 | 130 + | 4.2 tubers | Late Aug + |
| Setanta | Mid Apr | 80 × 30 | 160 + | 4.2 tubers | Late Sep + |
| Arran Victory | Mid Apr | 80 × 30 | 180 + | 4.2 tubers | Late Oct + |
| Bambino | Mid Apr | 80 × 30 | 130 + | 4.2 tubers | Late Aug + |
| **Cropping programme 4** | | | | | |
| Orla | Mid Apr | 90 × 30 | 130 + | 3.7 tubers | Late Aug + |
| Setanta | Mid Apr | 90 × 30 | 140 + | 3.7 tubers | Late Sep + |
| Orla | Late Apr | 90 × 30 | 120 + | 3.7 tubers | Mid Sep + |
| **Cropping programme 5** | | | | | |
| Orla | Early Apr | 80 × 32 | 100 + | 3.9 tubers | Late Jul + |
| Connect | Mid Apr | 80 × 30 | 130 + | 4.2 tubers | Early Sep + |
| Setanta | Mid Apr | 80 × 30 | 140 + | 4.2 tubers | Late Sep + |
| Charlotte | Mid Apr | 80 × 30 | 100 + | 4.2 tubers | Late Jul + |
| Carolus | Mid Apr | 80 × 30 | 140 + | 4.2 tubers | Late Sep + |
| **Cropping programme 6** | | | | | |
| Vitabella | Early Apr | 75 × 35 | 95 + | 3.8 tubers | Early Jul + |
| Orla | Early Apr | 75 × 35 | 90 + | 3.8 tubers | Early Jul + |
| Salad Blue | Early Apr | 75 × 35 | 130 + | 3.8 tubers | Mid Aug + |
| Connect | Late Apr | 75 × 35 | 150 + | 3.8 tubers | Mid Sep + |
| Sarpo Mira | Late Apr | 75 × 35 | 150 + | 3.8 tubers | Mid Sep + |
| **Cropping programme 7** | | | | | |
| Charlotte | Early Apr | 75 × 35 | 90 + | 3.8 tubers | Early Jul + |
| Vitabella | Early Apr | 75 × 30 | 95 + | 4.4 tubers | Early Jul + |
| Charlotte | Late Apr | 75 × 30 | 80 + | 4.4 tubers | Early Aug + |

### 3.1.2 Crop yields

The production of potatoes increased from 604 tonnes (t) in 2019 to 1331 t in 2020 (+120%).

**3.1.3 Summary of key findings and recommendations:**

- Good soil preparation including subsoiling, tilling, stone separation/destoning and ridging is very important.
- On stony soil, removing stones reduces tuber damage during harvesting. Destoning equipment is especially important for growing at scale to maintain harvester output.
- Adequate soil nutrition is needed to achieve yield potential using soil test results to guide nutrient application rates.
- Base cultivar selection on key factors such as yield, market/consumer eating quality preference, days to maturity; keeping quality, disease resistance and seed availability.
- Chitting of seed prior to planting produces an earlier more even emergence and uniform crop growth.
- Target favourable soil conditions at planting e.g., minimum temperature of 8-10°C, and precise placing of seed.
- Weed management can be achieved using the stale seedbed technique with a gas weed burner and inter-row cultivators and ridging equipment for mechanical weeding.
- Irrigation improves skin set and increases yields.
- Gas burning and haulm flailing can control potato blight and improves skin finish. If potato blight occurs before maturity, remove haulms to prevent/reduce the risk of tuber infection. If potatoes are becoming too big before expected harvest remove haulms.
- Harvesting crops carefully when skins are fully set minimises waste from damage and disease, vital for long-term storage. Early cultivars can have poorer skin set.
- Lifting crops before soils get too cold and wet (e.g., by mid-October) reduces numbers of diseased and rotten tubers.
- Growing summer and early autumn crops of potatoes when a premium price is available, e.g., early maturing cultivars Orla and Premier, can avert difficulties in harvesting late maturing cultivars particularly on wet soils. Maincrop potatoes can be purchased from other growers harvesting these later maturing crops if needed i.e., for continuity of supply. Unique cultivars for niche markets offer opportunities for growers finding it difficult to compete with larger scale producers.

## 3.2 Organic Kale production area and cultivars

The total organic kale production area for MOPS growers was 5.18 ha in 2019 and 5.81 ha in 2020. Figure 2 shows a breakdown of the 2020 kale production area by cultivar. 10 MOPS growers produced kale in 2019, and the same number of growers again in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois, Wexford and Wicklow. Important market outlets are supermarkets/retailers, direct selling (box delivery, farmers markets, farmgate), restaurants and shops. Examples of kale cropping programmes for MOPS growers are shown in Table 2.

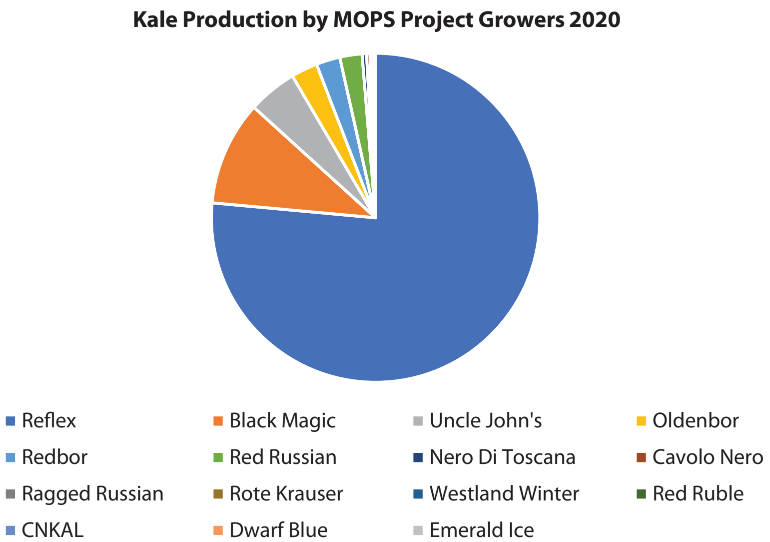



***Figure 2 Kale production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.2.1 Cropping programmes

**Table 2 Example kale cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Black Magic | Mid Feb | Early Apr | 75 × 35 | 90 + | 3.8 plants | Early Jul + |
| Oldenbor | Mid Feb | Early Apr | 75 × 35 | 85 + | 3.8 plants | Early Jul + |
| Oldenbor | Late Mar | Mid May | 75 × 35 | 80 + | 3.8 plants | Early Aug + |
| Black Magic | Early May | Mid Jun | 75 × 35 | 100 + | 3.8 plants | Late Sep + |
| Oldenbor | Early May | Mid Jun | 75 × 35 | 90 + | 3.8 plants | Mid Sep + |
| Oldenbor | Early Jun | Mid Jul | 75 × 35 | 120 + | 3.8 plants | Mid Nov + |
| Red Russian | Early Jun | Mid Jul | 75 × 35 | 110 + | 3.8 plants | Mid Nov + |
| Uncle John's | Bought in | Mid Jul | 75 × 35 | 180 + | 3.8 plants | Dec + |
| **Cropping programme 2** | | | | | | |
| Cavolo Nero | Early Mar | Mid Apr | 45 × 40 | 70 + | 5.6 plants | Late Jun + |
| Red Russian | Early Mar | Mid Apr | 45 × 40 | 70 + | 5.6 plants | Late Jun + |
| Cavolo Nero | Early Apr | Mid May | 45 × 40 | 65 + | 5.6 plants | Late Jul + |
| Red Russian | Early Apr | Mid May | 45 × 40 | 65 + | 5.6 plants | Late Jul + |
| Cavolo Nero | Early May | Mid Jun | 45 × 40 | 65 + | 5.6 plants | Late Aug + |
| Red Russian | Early May | Mid Jun | 45 × 40 | 65 + | 5.6 plants | Late Aug + |
| Redbor | Early May | Mid Jun | 45 × 40 | 65 + | 5.6 plants | Late Aug + |
| Pentland Brig | Early May | Mid Jun | 45 × 40 | 65 + | 5.6 plants | Late Aug + |
| **Cropping programme 3** | | | | | | |
| Cavolo Nero | Purchase plants | Mid Apr | 75 × 45 | 100 + | 3 plants | Late July + |
| Oldenbor | Purchase plants | Mid Apr | 75 × 45 | 90 + | 3 plants | Mid Jul + |
| Oldenbor | Purchase plants | Early Jun | 75 × 45 | 85 + | 3 plants | Late Aug + |
| Cavolo Nero | Purchase plants | Mid Jun | 75 × 50 | 120 + | 2.7 plants | Mid Oct + |
| Oldenbor | Purchase plants | Early Jul | 75 × 50 | 95 + | 2.7 plants | Early Oct + |
| Red Russian | Purchase plants | Early Jul | 75 × 50 | 100 + | 2.7 plants | Early Oct + |
| **Cropping programme 4** | | | | | | |
| Reflex | Early Feb | Early Apr | 55 × 45 | 85 + | 4 plants | Mid Jun + |
| Reflex | Early Apr | Mid May | 55 × 40 | 80 + | 4.5 plants | Early Aug + |
| Reflex | Early Jun | Mid Jul | 55 × 45 | 140 + | 4 plants | Mid Dec + |
| **Cropping programme 5** | | | | | | |
| Cavalo Nero | Purchase plants | Mid May | 80 × 35 | 90 + | 3.6 plants | Late Jul + |
| Redbor | Purchase plants | Mid May | 80 × 35 | 90 + | 3.6 plants | Mid Aug + |
| Reflex | Purchase plants | Mid May | 80 × 35 | 85 + | 3.6 plants | Early Jul + |
| Cavalo Nero | Purchase plants | Mid Jun | 80 × 35 | 100 + | 3.6 plants | Early Oct + |
| Reflex | Purchase plants | Mid Jun | 80 × 35 | 100 + | 3.6 plants | Early Oct + |
| Redbor | Purchase plants | Mid Jun | 80 × 35 | 100 + | 3.6 plants | Mid Sep + |
| Uncle John's | Purchase plants | Mid Jun | 80 × 35 | 230 + | 3.6 plants | Feb + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 6** | | | | | | |
| Westland Winter | Mid Feb | Mid Apr | 25 × 45 | 100 + | 8.9 plants | Mid Jul + |
| Nero di Tuscany | Mid Feb | Mid Apr | 25 × 45 | 100 + | 8.9 plants | Mid Jul + |
| Red Russian | Mid Feb | Mid Apr | 25 × 45 | 100 + | 8.9 plants | Mid Jul + |
| Rote Kauser | Mid Feb | Mid Apr | 25 × 45 | 100 + | 8.9 plants | Mid Jul + |
| Nero di Tuscany | Mid Mar | Mid May | 25 × 45 | 90 + | 8.9 plants | Mid Aug + |
| Red Russian | Mid Mar | Mid May | 25 × 45 | 90 + | 8.9 plants | Mid Aug + |
| Rote Kauser | Mid Mar | Mid May | 25 × 45 | 90 + | 8.9 plants | Mid Aug + |
| Westland Winter | Mid Mar | Mid May | 25 × 45 | 90 + | 8.9 plants | Mid Aug + |
| Westland Winter | Mid May | Mid Jul | 25 × 45 | 110 + | 8.9 plants | Mid Nov + |
| Red Russian | Mid May | Mid Jul | 25 × 45 | 110 + | 8.9 plants | Mid Nov + |
| Rote Kauser | Mid May | Mid Jul | 25 × 45 | 110 + | 8.9 plants | Mid Nov + |
| Nero di Tuscany | Mid May | Mid Jul | 25 × 45 | 110 + | 8.9 plants | Mid Nov + |
| Nero di Tuscany | Early Sep | Mid Oct | 25 × 45 | 150 + | 8.9 plants | Mid Mar + |
| **Cropping programme 7** | | | | | | |
| Reflex | Purchase plants | Late Apr | 60 × 50 | 115 + | 3.3 plants | Mid Aug + |
| Black Magic | Purchase plants | Mid May | 60 × 60 | 120 + | 2.8 plants | Mid Sep + |
| Oldenbor | Purchase plants | Mid May | 60 × 50 | 110 + | 3.3 plants | Early Sep + |
| Redbor | Purchase plants | Mid May | 60 × 50 | 120 + | 3.3 plants | Mid Sep + |
| Black Magic | Purchase plants | Late May | 60 × 60 | 110 + | 2.8 plants | Late Sep + |
| Reflex | Purchase plants | Late May | 60 × 50 | 110 + | 3.3 plants | Mid Sep + |
| Black Magic | Purchase plants | Early Jun | 60 × 60 | 110 + | 2.8 plants | Early Oct + |
| Oldenbor | Purchase plants | Mid Jun | 60 × 50 | 120 + | 3.3 plants | Early Oct + |
| Black Magic | Purchase plants | Late Jun | 60 × 60 | 120 + | 2.8 plants | Late Oct + |
| Reflex | Purchase plants | Late Jun | 60 × 60 | 130 + | 2.8 plants | Early Nov + |
| Oldenbor | Purchase plants | Late Jun | 60 × 60 | 140 + | 2.8 plants | Mid Nov + |
| Redbor | Purchase plants | Late Jun | 60 × 50 | 120 + | 3.3 plants | Late Oct + |

### 3.2.2 Crop yields

The production of kale was 46 t in 2019 and 45 t in 2020 (-2%).

### 3.2.3 Summary of key findings and recommendations

- For outdoor crops of kale, free-draining soil with sufficient nutrition is important especially where there are multiple harvests over the winter months. Soil with pH 6.5 is desirable as are good levels of organic matter and adequate nitrogen, phosphorus and potassium. It is advisable to avoid late planting in wetter locations and soils. In general, late plantings can be planted in drills/ridges similar to potato drills to ensure crop roots remain out of wet or saturated soils. Drills/ridges, rather than flat beds, are especially beneficial on heavier clay soils. Growing kale in fields with good air movement reduces leaf disease incidence during the wetter months of winter. Tall growing crops like kale can be grown in blocks to encourage plants to compete for light, which gives taller individual plants that produce greater yield and quality. Protected kale can produce early summer crops.

- Wider row spacing and fewer plants per square metre can improve air movement to reduce risk of leaf disease and give larger leaves with thicker stems that contribute to higher yields. Where a market requires smaller leaves plant density can be increased, which reduces leaf size and gives taller plants. This growing approach, however, can increase the risk of leaf disease, which reduces quality and increases waste due to the lack of air movement. In addition, taller plants may be at more risk of lodging in exposed fields.

- Cultivar selection e.g., Reflex, Oldenbor and Uncle John's can give an extra two to three weeks extension to the season. Successional planting extends the season and continuity of supply, and improves quality. The curly kale cultivars Reflex and Oldenbor are similar, which is useful if seed of one cultivar has limited availability.
- Early weed management is important. Good weed control can be achieved using e.g., multiple passes of a brush weeder, Einböck tined weeder, triple k harrow and Pierce ridger, which greatly reduces the need for hand weeding. A final earthing up before autumn reduces weeds and aerates the soil.
- Earlier harvesting of curly and Tuscan kale is possible by picking the bottom three to four leaves after 65 to 70 days. High yields are achievable with regular harvesting every three to four weeks. This practice also improves air movement around the plants, which reduces disease incidence. Where kale crops are not being harvested at maturity, and yellow leaves appear at the base, removing these unmarketable leaves will give better quality for subsequent harvests.
- Kale florets can be marketed to specialist shops and restaurants.

## 3.3 Organic lettuce and salad leaf production area and cultivars

The total organic lettuce and salad leaf production area for growers in the MOPS project was 1.24 ha in 2019 and 1.08 ha in 2020. Figures 3 and 4 provide a breakdown of the 2020 lettuce and salad leaf production area by cultivar. Nine MOPS growers produced lettuce and salad leaves in 2019, and in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois, Wexford and Wicklow. Key market outlets are supermarkets, direct selling (box delivery, farmers markets, farmgate), restaurants and shops. Examples of lettuce and salad leaf cropping programmes for MOPS growers are shown in Table 3.

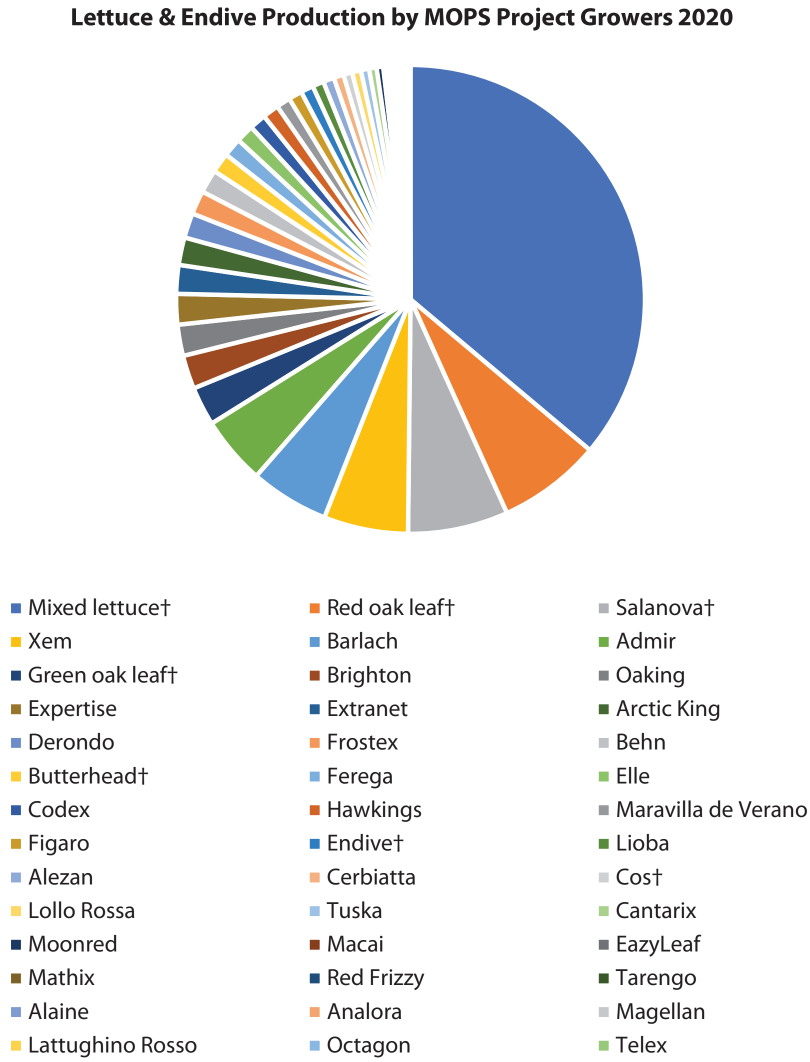



***Figure 3 Lettuce and endive production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

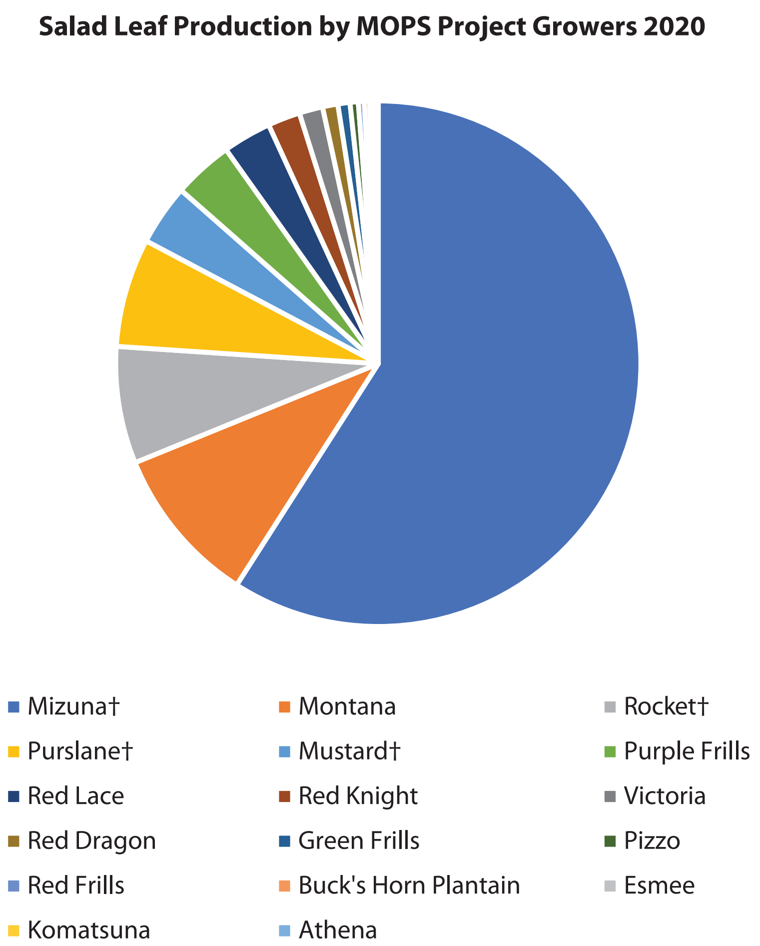



*Figure 4 Salad leaf production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.3.1 Cropping programmes

**Table 3 Example lettuce and salad leaf cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting (cm) | Spacing maturity | Days to density/m$^2$ | Plant harvest | Expected |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Codex | Early Mar | Mid Apr | 20 × 20 | 40 + | 25 plugs | Late May + |
| Xem | Early Mar | Mid Apr | 20 × 20 | 40 + | 25 plugs | Late May + |
| Barlach | Early Mar | Mid Apr | 20 × 20 | 45 + | 25 plugs | Early June + |
| Deronda | Early Mar | Mid Apr | 20 × 20 | 40 + | 25 plugs | Late May + |
| Extranet | Early Mar | Mid Apr | 20 × 20 | 40 + | 25 plugs | Late May + |
| Behn | Early Mar | Mid Apr | 20 × 20 | 40 + | 25 plugs | Late May + |
| Oaking | Early Mar | Mid Apr | 20 × 20 | 40 + | 25 plugs | Late May + |
| Brighton | Mid Aug | Late Sep | 30 × 30 | 60 + | 11 plants | Late Nov + |
| Barlach | Mid Aug | Late Sep | 30 × 30 | 60 + | 11 plants | Late Nov + |
| Figaro | Mid Aug | Late Sep | 30 × 30 | 60 + | 11 plants | Late Nov + |
| Cerbiatta | Mid Aug | Late Sep | 30 × 30 | 60 + | 11 plants | Late Nov + |
| Winter Gem | Mid Aug | Late Sep | 30 × 30 | 60 + | 11 plants | Late Nov + |
| Ginko | Mid Aug | Late Sep | 30 × 30 | 60 + | 11 plants | Late Nov + |
| Brighton | Mid Sep | Mid Oct | 30 × 30 | 75 + | 11 plants | Dec + |
| Barlach | Mid Sep | Mid Oct | 30 × 30 | 75 + | 11 plants | Dec + |
| Figaro | Mid Sep | Mid Oct | 30 × 30 | 75 + | 11 plants | Dec + |
| Cerbiatta | Mid Sep | Mid Oct | 30 × 30 | 75 + | 11 plants | Dec + |
| Winter Gem | Mid Sep | Mid Oct | 30 × 30 | 75 + | 11 plants | Dec + |
| Ginko | Mid Sep | Mid Oct | 30 × 30 | 75 + | 11 plants | Dec + |

| Cultivar | Sowing | Planting (cm) | Spacing maturity | Days to density/m² | Plant harvest | Expected |
|---|---|---|---|---|---|---|
| **Cropping programme 2** | | | | | | |
| Ferega | Late Apr | Early Jun | 55 × 15 | 50 + | 12 plants | Late Jul + |
| Barlach | Late Apr | Early Jun | 55 × 15 | 50 + | 12 plants | Late Jul + |
| Kamalia | Late Apr | Early Jun | 55 × 15 | 50 + | 12 plants | Late Jul + |
| Ferega | Early May | Mid Jun | 55 × 15 | 50 + | 12 plants | Early Aug + |
| Barlach | Early May | Mid Jun | 55 × 15 | 50 + | 12 plants | Early Aug + |
| Kamalia | Early May | Mid Jun | 55 × 15 | 50 + | 12 plants | Early Aug + |
| Ferega | Mid Jun | Late Jul | 55 × 15 | 50 + | 12 plants | Mid Aug + |
| Barlach | Mid Jun | Late Jul | 55 × 15 | 50 + | 12 plants | Mid Aug + |
| Kamalia | Mid Jun | Late Jul | 55 × 15 | 50 + | 12 plants | Mid Aug + |
| Ferega | Late Jun | Mid Aug | 55 × 15 | 55 + | 12 plants | Early Oct + |
| Barlach | Late Jun | Mid Aug | 55 × 15 | 55 + | 12 plants | Early Oct + |
| Kamalia | Late Jun | Mid Aug | 55 × 15 | 55 + | 12 plants | Early Oct + |
| Ferega | Mid Jul | Late Aug | 55 × 15 | 55 + | 12 plants | Late Oct + |
| Barlach | Mid Jul | Late Aug | 55 × 15 | 55 + | 12 plants | Late Oct + |
| Kamalia | Mid Jul | Late Aug | 55 × 15 | 55 + | 12 plants | Late Oct + |
| **Cropping programme 3** | | | | | | |
| Lea | Bought in | Late Apr | 30 × 30 | 45 + | 11 plants | Mid Jun + |
| Stelix | Bought in | Late Apr | 30 × 30 | 45 + | 11 plants | Mid Jun + |
| Olana | Bought in | Late Apr | 30 × 30 | 45 + | 11 plants | Mid Jun + |
| Marcord | Bought in | Late Apr | 30 × 30 | 45 + | 11 plants | Mid Jun + |
| Barlach | Bought in | Late Apr | 30 × 30 | 55 + | 11 plants | Late Jun + |
| Lea | Bought in | Late May | 30 × 30 | 40 + | 11 plants | Mid Jul + |
| Stelix | Bought in | Late May | 30 × 30 | 40 + | 11 plants | Mid Jul + |
| Marcord | Bought in | Late May | 30 × 30 | 40 + | 11 plants | Mid Jul + |
| Barlach | Bought in | Late May | 30 × 30 | 50 + | 11 plants | Mid Jul + |
| Lea | Bought in | Late Jun | 30 × 30 | 45 + | 11 plants | Mid Aug + |
| Stelix | Bought in | Late Jun | 30 × 30 | 45 + | 11 plants | Mid Aug + |
| Marcord | Bought in | Late Jun | 30 × 30 | 45 + | 11 plants | Mid Aug + |
| Barlach | Bought in | Late Jun | 30 × 30 | 50 + | 11 plants | Mid Aug + |
| **Cropping programme 4** | | | | | | |
| Mizuna | late Mar | - | 10 × 1.5 | 40 + | 600 seeds | Early May |
| Red Sorrel | late Mar | - | 10 × 1.5 | 45 + | 600 seeds | Mid May |
| Purple Frills | late Mar | - | 10 × 1.5 | 40 + | 600 seeds | Early May |
| Purple Streaks | late Mar | - | 10 × 1.5 | 40 + | 600 seeds | Early May |
| Green in Snow | late Mar | - | 10 × 1.5 | 40 + | 600 seeds | Early May |
| Red Dragon | late Mar | - | 10 × 1.5 | 40 + | 600 seeds | Early May |
| Letizia | late Mar | - | 10 × 1.5 | 45 + | 600 seeds | Early May |
| Esmee | late Mar | - | 10 × 1.5 | 45 + | 600 seeds | Early May |
| Purslane | Early May | Mid May | 15 × 15 | 40 + | 45 × 6-8 seeds | Late May + |
| Purslane | Mid May | Late May | 15 × 15 | 40 + | 45 × 6-8 seeds | Late Jun + |
| Purslane | Mid Jun | Late Jun | 15 × 15 | 40 + | 45 × 6-8 seeds | Early Aug + |
| Purslane | Mid Jul | Late Jul | 15 × 15 | 40 + | 45 × 6-8 seeds | Early Sep + |
| Purslane | Early Aug | Mid Aug | 15 × 15 | 50 + | 45 × 6-8 seeds | Late Sep + |
| Purslane | Mid Aug | Late Aug | 15 × 15 | 55 + | 45 × 6-8 seeds | Early Oct + |
| Piro | Early Feb | Early Apr | 20 × 20 | 30 + | 25 plants | Early May + |
| Cerbiatta | Early Feb | Early Apr | 20 × 20 | 30 + | 25 plants | Early May + |
| Saragossa | Early Feb | Early Apr | 20 × 20 | 30 + | 25 plants | Early May + |
| Cantarix | Early Feb | Early Apr | 20 × 20 | 30 + | 25 plants | Early May + |

| Cultivar | Sowing | Planting (cm) | Spacing maturity | Days to density/m$^2$ | Plant harvest | Expected |
|---|---|---|---|---|---|---|
| Red Salad Bowl | Early Feb | Early Apr | 20 × 20 | 30 + | 25 plants | Early May + |
| Barlach | Early Feb | Mid Apr | 20 × 20 | 45 + | 25 plants | Mid May + |
| Extranet | Early Feb | Mid Apr | 20 × 20 | 45 + | 25 plants | Mid May + |
| Telex | Early Feb | Mid Apr | 20 × 20 | 45 + | 25 plants | Mid May + |
| Xem | Early Feb | Mid Apr | 20 × 20 | 45 + | 25 plants | Mid May + |
| Behn | Early Feb | Mid Apr | 20 × 20 | 45 + | 25 plants | Mid May + |
| Octagon | Early Feb | Mid Apr | 20 × 20 | 45 + | 25 plants | Mid May + |
| Piro | Late Feb | Mid Apr | 20 × 20 | 30 + | 25 plants | Mid May + |
| Cerbiatta | Late Feb | Mid Apr | 20 × 20 | 30 + | 25 plants | Mid May + |
| Saragossa | Late Feb | Mid Apr | 20 × 20 | 30 + | 25 plants | Mid May + |
| Cantarix | Late Feb | Mid Apr | 20 × 20 | 30 + | 25 plants | Mid May + |
| Red Salad Bowl | Late Feb | Mid Apr | 20 × 20 | 30 + | 25 plants | Mid May + |
| Barlach | Early Mar | Late Apr | 20 × 20 | 40 + | 25 plants | Early Jun + |
| Extranet | Early Mar | Late Apr | 20 × 20 | 40 + | 25 plants | Early Jun + |
| Telex | Early Mar | Late Apr | 20 × 20 | 40 + | 25 plants | Early Jun + |
| Xem | Early Mar | Late Apr | 20 × 20 | 40 + | 25 plants | Early Jun + |
| Behn | Early Mar | Late Apr | 20 × 20 | 40 + | 25 plants | Early Jun + |
| Octagon | Early Mar | Late Apr | 20 × 20 | 40 + | 25 plants | Early Jun + |
| Piro | Early May | Early Jun | 20 × 20 | 25-30 | 25 plants | Early Jul |
| Cerbiatta | Early May | Early Jun | 20 × 20 | 25-30 | 25 plants | Early Jul |
| Saragossa | Early May | Early Jun | 20 × 20 | 25-30 | 25 plants | Early Jul |
| Cantarix | Early May | Early Jun | 20 × 20 | 25-30 | 25 plants | Early Jul |
| Red Salad Bowl | Early May | Early Jun | 20 × 20 | 25-30 | 25 plants | Early Jul |
| Wallone | Early May | Early Jun | 20 × 20 | 30-35 | 25 plants | Early Jul |
| Barlach | Early May | Mid Jun | 20 × 20 | 35-40 | 25 plants | Mid Jul + |
| Extranet | Early May | Mid Jun | 20 × 20 | 40 + | 25 plants | Mid Jul + |
| Telex | Early May | Mid Jun | 20 × 20 | 40 + | 25 plants | Mid Jul + |
| Xem | Early May | Mid Jun | 20 × 20 | 40 + | 25 plants | Mid Jul + |
| Behn | Early May | Mid Jun | 20 × 20 | 40 + | 25 plants | Mid Jul + |
| Octagon | Early May | Mid Jun | 20 × 20 | 40 + | 25 plants | Mid Jul + |
| Piro | Early Jun | Early Jul | 20 × 20 | 35 + | 25 plants | Mid Aug + |
| Cerbiatta | Early Jun | Early Jul | 20 × 20 | 35 + | 25 plants | Mid Aug + |
| Saragossa | Early Jun | Early Jul | 20 × 20 | 35 + | 25 plants | Mid Aug + |
| Cantarix | Early Jun | Early Jul | 20 × 20 | 35 + | 25 plants | Mid Aug + |
| Red Salad Bowl | Early Jun | Early Jul | 20 × 20 | 35 + | 25 plants | Mid Aug + |
| Wallone | Early Jun | Early Jul | 20 × 20 | 35 + | 25 plants | Mid Aug + |
| Barlach | Early Jun | Mid Jul | 20 × 20 | 45 + | 25 plants | Late Aug + |
| Extranet | Early Jun | Mid Jul | 20 × 20 | 45 + | 25 plants | Late Aug + |
| Telex | Early Jun | Mid Jul | 20 × 20 | 45 + | 25 plants | Late Aug + |
| Xem | Early Jun | Mid Jul | 20 × 20 | 45 + | 25 plants | Late Aug + |
| Behn | Early Jun | Mid Jul | 20 × 20 | 45 + | 25 plants | Late Aug + |
| Octagon | Early Jun | Mid Jul | 20 × 20 | 45 + | 25 plants | Late Aug + |
| Malis/Brighton | Early Aug | Mid Sep | 20 × 20 | 60 + | 25 plants | Mid Nov + |
| Anizel/Ferega | Early Aug | Mid Sep | 20 × 20 | 60 + | 25 plants | Mid Nov + |
| Magellan | Early Aug | Mid Sep | 20 × 20 | 60 + | 25 plants | Mid Nov + |
| Lattughino Rosso | Early Aug | Mid Sep | 20 × 20 | 60 + | 25 plants | Mid Nov + |
| Barlach | Early Aug | Mid Sep | 20 × 20 | 70 + | 25 plants | Mid Nov + |
| Alezan | Early Aug | Mid Sep | 20 × 20 | 60 + | 25 plants | Mid Nov + |
| Heathrow | Early Aug | Mid Sep | 20 × 20 | 60 + | 25 plants | Mid Nov + |
| Malis/Brighton | Mid Aug | Late Sep | 20 × 20 | 80 + | 25 plants | Mid Dec + |

| Cultivar | Sowing | Planting (cm) | Spacing maturity | Days to density/m² | Plant harvest | Expected |
|---|---|---|---|---|---|---|
| Anizel/Ferega | Mid Aug | Late Sep | 20 × 20 | 80 + | 25 plants | Mid Dec + |
| Magellan | Mid Aug | Late Sep | 20 × 20 | 80 + | 25 plants | Mid Dec + |
| Lattughino Rosso | Mid Aug | Late Sep | 20 × 20 | 80 + | 25 plants | Mid Dec + |
| Barlach | Mid Aug | Late Sep | 20 × 20 | 90 + | 25 plants | Late Dec + |
| Alezan | Mid Aug | Late Sep | 20 × 20 | 80 + | 25 plants | Mid Dec + |
| Heathrow | Mid Aug | Late Sep | 20 × 20 | 80 + | 25 plants | Mid Dec + |
| Purple Frills | Mid Jul | Mid Aug | 10 × 7 | 30-35 | 140 plugs × 6-8 seeds | Mid Sep + |
| Purple Streaks | Mid Jul | Mid Aug | 10 × 7 | 30-35 | 140 plugs × 6-8 seeds | Mid Sep + |
| Red Dragon | Mid Jul | Mid Aug | 10 × 7 | 30-35 | 140 plugs × 6-8 seeds | Mid Sep + |
| Green Fire | Mid Jul | Mid Aug | 10 × 7 | 30-35 | 140 plugs × 6-8 seeds | Mid Sep + |
| Green in Snow | Mid Jul | Mid Aug | 10 × 7 | 30-35 | 140 plugs × 6-8 seeds | Mid Sep + |
| Letizia | Mid Jul | Mid Aug | 10 × 7 | 30-35 | 140 plugs × 6-8 seeds | Mid Sep + |
| Salad Rocket | Mid Jul | Mid Aug | 10 × 7 | 30-35 | 140 plugs × 6-8 seeds | Mid Sep + |
| Purple Frills | Early Aug | Early Sep | 10 × 7 | 35-40 | 140 plugs × 6-8 seeds | Mid Oct + |
| Purple Streaks | Early Aug | Early Sep | 10 × 7 | 35-40 | 140 plugs × 6-8 seeds | Mid Oct + |
| Red Dragon | Early Aug | Early Sep | 10 × 7 | 35-40 | 140 plugs × 6-8 seeds | Mid Oct + |
| Green Fire | Early Aug | Early Sep | 10 × 7 | 35-40 | 140 plugs × 6-8 seeds | Mid Oct + |
| Green in Snow | Early Aug | Early Sep | 10 × 7 | 35-40 | 140 plugs × 6-8 seeds | Mid Oct + |
| Letizia | Early Aug | Early Sep | 10 × 7 | 35-40 | 140 plugs × 6-8 seeds | Mid Oct + |
| Sweet Intensity | Early Aug | Early Sep | 10 × 7 | 35-40 | 140 plugs × 6-8 seeds | Mid Oct + |
| Purple Frills | Early Aug | Mid Sep | 10 × 7 | 40-50 | 140 plugs × 6-8 seeds | Mid Nov + |
| Purple Streaks | Early Aug | Mid Sep | 10 × 7 | 40-50 | 140 plugs × 6-8 seeds | Mid Nov + |
| Red Dragon | Early Aug | Mid Sep | 10 × 7 | 40-50 | 140 plugs × 6-8 seeds | Mid Nov + |
| Green Fire | Early Aug | Mid Sep | 10 × 7 | 40-50 | 140 plugs × 6-8 seeds | Mid Nov + |
| Green in Snow | Early Aug | Mid Sep | 10 × 7 | 40-50 | 140 plugs × 6-8 seeds | Mid Nov + |
| Letizia | Early Aug | Mid Sep | 10 × 7 | 40-50 | 140 plugs × 6-8 seeds | Mid Nov + |
| Sweet Intensity | Early Aug | Mid Sep | 10 × 7 | 40-50 | 140 plugs × 6-8 seeds | Mid Nov + |
| Claytonia | Mid Aug | Mid Sep | 15 × 15 | 60 + | 45 plugs × 8-10 seeds | Mid Nov + |
| Claytonia | Early Sep | Early Oct | 15 × 15 | 70 + | 45 plugs × 8-10 seeds | Late Nov + |
| Claytonia | Early Sep | Mid Oct | 15 × 15 | 90 + | 45 plugs × 8-10 seeds | Jan + |

### 3.3.2 Crop yields

The production of lettuce and salad leaves was 14 t and 15,112 units in 2019, and 11 t (-21%) and 22,710 units (+50%) in 2020.

### 3.3.3 Summary of key findings and recommendations

- Balancing outdoor and protected crops of lettuce and salad leaves increases continuity of supply. Planting outdoors can commence when soil conditions allow. Depending on the weather, the first outdoor planting may need to be protected with fleece. It is advisable to have most late planting of indoor winter lettuce completed by early October in order to have sufficient growth before winter. This means finishing and removing summer crops in advance e.g., late September/early October. Indoor production during winter months can be more difficult where temperatures and natural light levels are low.

- Soil preparation using a bed former gives a slightly raised bed, good soil tilth and subsequent crop establishment. Weed management can be achieved by planting into a freshly made bed or by the stale seedbed technique using a gas burner. Hand hoeing is usually needed two to three weeks after planting.

- Regular sowing of summer leaves gives greater continuity of supply of clean produce with less burden of weeds compared with multiple harvests from the same crop.

- Where space for protected crops of lettuce and oriental leaves is limited, reducing plant spacing to 20 × 20 cm can be more efficient and increase yields. Wider plant spacing can produce larger heads with less disease incidence, particularly in autumn and winter crops.

- In general, salanova takes 10 to 15 days longer to grow to the required size than true lettuce types. An important factor especially for mixed leaf growers. Where both types of lettuce are cropping together, salanova needs to be sown and planted two weeks earlier.
- Harvesting small immature leaves by hand using a knife can be labour intensive. Depending on market specification, producing crops to larger leaves/heads improves labour efficiency and increases volumes harvested, especially for production without a salad leaf harvester.
- For all leaf production, irrigation should take place earlier in the day to avoid wet leaves and lower temperatures at night. Reduced watering can slow the crop from maturing too quickly.
- It is very important to protect mustards and rocket crops with insect netting to prevent pest damage. Ensure that all net edges are tightly secured.
- Good air movement in crops reduces the risk of leaf diseases e.g., downy mildew.
- Pest and disease resistance is an important factor when selecting cultivars.

## 3.4 Organic leek production area and cultivars

The total organic leek production area for growers in the MOPS project was 3.83 ha in 2019 and 6.14 ha in 2020. Figure 5 shows a breakdown of the 2020 leek production area by cultivar. 10 MOPS growers produced leeks in 2019, and in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois, Wexford and Wicklow. Key market outlets are supermarkets/retailers and direct selling (box delivery, farmers markets, farmgate). Examples of leek cropping programmes for MOPS growers are shown in Table 4.

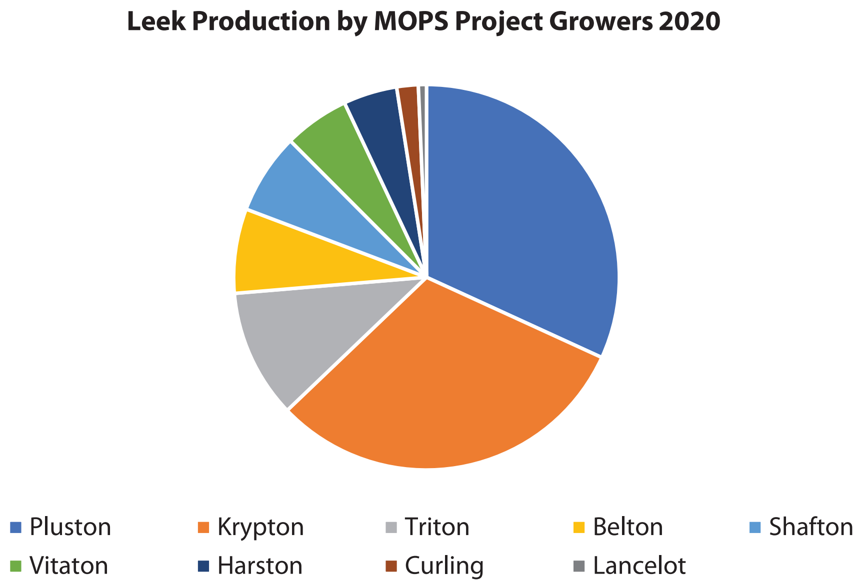



*Figure 5 Leek production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area*

### 3.4.1 Cropping programmes

**Table 4 Example leek cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Rally | Purchase plants | Mid Apr | 75 × 12 | 85 + | 11 plants | Mid Jul + |
| Krypton | Purchase plants | Mid Apr | 75 × 10 | 95 + | 13.3 plants | Early Aug + |
| Krypton | Purchase plants | Mid May | 75 × 10 | 85 + | 13.3 plants | Mid Aug + |
| Krypton | Purchase plants | Mid Jun | 75 × 10 | 90 + | 13.3 plants | Mid Sep + |
| Pluston | Purchase plants | Mid Jun | 75 × 10 | 110 + | 13.3 plants | Early Oct + |
| Pluston | Purchase plants | Early Jul | 75 × 10 | 130 + | 13.3 plants | Mid Nov + |
| Triton | Purchase plants | Early Jul | 75 × 10 | 180 + | 13.3 plants | Jan + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 2** | | | | | | |
| Krypton | Purchase plants | Mid May | 40 × 10 | 90 + | 25 plants | Mid Aug + |
| Krypton | Purchase plants | Early Jun | 40 × 10 | 90 + | 25 plants | Early Sep + |
| Pluston | Purchase plants | Early Jun | 40 × 10 | 120 + | 25 plants | Early Oct + |
| Krypton | Purchase plants | Mid Jun | 40 × 10 | 100 + | 25 plants | Late Sep + |
| Pluston | Purchase plants | Mid Jun | 40 × 10 | 130 + | 25 plants | Mid Oct + |
| Triton | Purchase plants | Late Jun | 40 × 10 | 180 + | 25 plants | Mid Feb + |
| **Cropping programme 3** | | | | | | |
| Krypton | Early April | - | 55 × 3 | 165 + | 61 seeds | Mid Sep + |
| Pluston | Early April | - | 55 × 4 | 190 + | 45 seeds | Mid Oct + |
| Krypton | Bought in | Mid Apr | 55 × 10 | 100 + | 18 plants | Late Jul + |
| Pluston | Bought in | Mid Apr | 55 × 10 | 120 + | 18 plants | Late Aug + |
| Krypton | Bought in | Mid Jun | 55 × 10 | 100 + | 18 plants | Late Sep + |
| Pluston | Bought in | Mid Jun | 55 × 10 | 130 + | 18 plants | Mid Oct + |
| **Cropping programme 4** | | | | | | |
| Shafton | Purchase plants | Mid Apr | 55 × 12 | 125 + | 15 plants | Mid Aug + |
| Krypton | Purchase plants | Mid Apr | 55 × 12 | 130 + | 15 plants | Mid Aug + |
| Krypton | Purchase plants | Late Apr | 55 × 10 | 120 + | 18 plants | Late Aug + |
| Krypton | Purchase plants | Mid May | 55 × 10 | 120 + | 18 plants | Mid Sep + |
| Pluston | Purchase plants | Mid May | 55 × 10 | 130 + | 18 plants | Late Sep + |
| Pluston | Purchase plants | Early Jun | 55 × 10 | 150 + | 18 plants | Late Oct + |
| Pluston | Purchase plants | Mid Jul | 55 × 12 | 200 + | 15 plants | Mid Jan + |
| Vivaton | Purchase plants | Mid Jul | 55 × 12 | 240 + | 15 plants | Late Feb + |
| Triton | Purchase plants | Mid Jul | 55 × 12 | 260 + | 15 plants | Mid Mar |
| **Cropping programme 5** | | | | | | |
| Shafton | Purchase plants | Early Apr | 80 × 12 | 90 + | 10.5 plants | Mid Jul + |
| Krypton | Purchase plants | Early Apr | 80 × 12 | 100 + | 10.5 plants | Late Jul + |
| Krypton | Purchase plants | Early May | 80 × 10 | 90 + | 12.5 plants | Early Aug + |
| Pluston | Purchase plants | Early May | 80 × 10 | 120 + | 12.5 plants | Early Sep + |
| Pluston | Purchase plants | Early Jun | 80 × 10 | 125 + | 12.5 plants | Early Oct + |
| Vivaton | Purchase plants | Early Jun | 80 × 10 | 180 + | 12.5 plants | Early Jan + |
| Pluston | Purchase plants | Early Jul | 80 × 10 | 190 + | 12.5 plants | Jan + |
| Triton | Purchase plants | Early Jul | 10 × 12 | 230 + | 10.5 plants | Mar + |
| **Cropping programme 6** | | | | | | |
| Krypton | Purchase plants | Early Jun | 60 × 12 | 115 + | 14 plants | Early Oct + |
| Pluston | Purchase plants | Early Jun | 60 × 12 | 130 + | 14 plants | Mid Oct + |
| Pluston | Purchase plants | Late Jun | 60 × 12 | 130 + | 14 plants | Mid Nov + |
| Triton | Purchase plants | Late Jun | 60 × 12 | 150 + | 14 plants | Mid Nov-Mid Feb |
| Skater | Purchase plants | Late Jun | 60 × 12 | 150 + | 14 plants | Mid Nov + |
| **Cropping programme 7** | | | | | | |
| Krypton | Purchase plants | Early May | 30 × 20 | 100 + | 17 plants | Mid Aug + |
| Krypton | Purchase plants | Late May | 30 × 20 | 90 + | 17 plants | Early Sep + |
| Pluston | Purchase plants | Late May | 30 × 20 | 120 + | 17 plants | Early Oct + |
| Pluston | Purchase plants | Mid Jun | 30 × 20 | 140 + | 17 plants | Mid Nov + |
| Vivaton | Purchase plants | Mid Jun | 30 × 20 | 190 + | 17 plants | Jan + |
| Bandit | Purchase plants | Mid Jun | 30 × 20 | 200 + | 17 plants | Jan + |

### 3.4.2 Crop yields

The production of leeks increased from 42 t in 2019 to 75 t in 2020 (+79%).

### 3.4.3 Summary of key findings and recommendations

- Leeks can be grown to provide a long season of supply from early autumn until late spring using early, maincrop and late cultivars, which offers great potential for import substitution. Black mulch film can improve early production and weed control. Purchasing plants early in the season and planting by hand into soil that is covered by black mulch film can achieve harvest in early July.
- Early leeks that are planted in April may suffer from colder weather in some seasons so covering with fleece may be necessary.
- Leek growers can benefit from using bare root leeks rather than module raised leek seedlings or direct sowing especially for reducing planting costs and weed management. Specialist leek transplanters, e.g., a BASRIJS planter, is beneficial for precise planting of bare root leeks to a uniform depth and plant spacing. A punch hole film layer, e.g., Samco, further reduces planting labour costs.
- Leek crops grow well at pH 6.5-7.5 and with good levels of organic matter. Uniform application of composted farmyard manure improves the yield and crop quality. Irrigation at planting may be required especially if the weather is dry.
- Leaf disease resistance and seasonality are important factors when selecting cultivars.
- Wide drills can improve air movement in the crop and reduce disease pressure. Closer planting in the row can encourage longer white shanked leeks. Wider spacing can produce leeks with shorter white shanks.
- Continuous grubbing to manage weeds, using various machines, reduces manual weeding labour considerably. Most of these machines also help to aerate some of the heavier soils which stimulates better root formation. Bigger drills/ridges help with hand harvesting by making leeks easier to pull. Undercutting e.g., using an Edwards Machinery Ltd. undercutter, is also easier to perform.
- Because leeks grow mostly above-ground, it is a crop that can be grown in wetter soils and harvested much easier than root crops.
- Leeks can provide valuable sales during April and May.
- Depending on growing conditions, crops grown for a baby leek market will be ready for harvest 35 to 40 days after planting.

## 3.5 Organic carrot production area and cultivars

The total organic carrot production area for growers in the MOPS project was 5.32 ha in 2019 and 11.67 ha in 2020. Figure 6 provides a breakdown of the 2020 carrot production area by cultivar. Nine MOPS growers produced carrots in 2019, seven growers in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois, Wexford and Wicklow. Key market outlets are supermarkets/retailers, direct selling (box delivery, farmers markets, farmgate), restaurants and shops. Examples of carrot cropping programmes for MOPS growers are shown in Table 5.

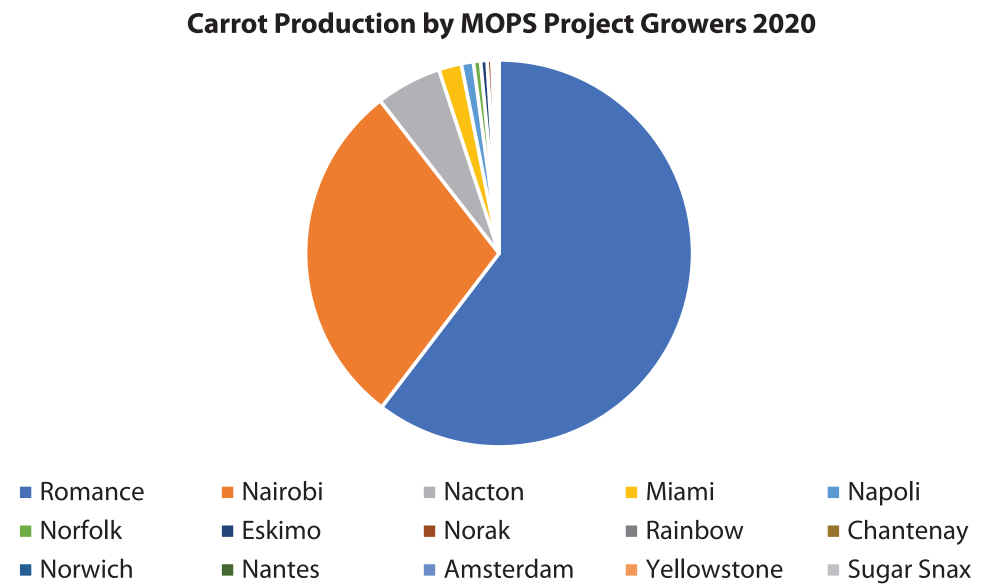



***Figure 6 Carrot production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.5.1 Cropping programmes

**Table 5 Example carrot cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | |
| Napoli | Early May | 75 × 1.5 | 95 + | 90 seeds | Early Aug + |
| Miami | Early May | 75 × 1.5 | 115 + | 90 seeds | Late Aug + |
| **Cropping programme 2** | | | | | |
| Mokum | Mid Apr | 30 × 3 | 75 + | 110 seeds | Mid Jul + |
| Napoli | Mid Apr | 30 × 3 | 95 + | 110 seeds | Late Jul + |
| Mokum | Mid May | 30 × 3 | 80 + | 110 seeds | Mid Aug + |
| Napoli | Mid May | 30 × 3 | 90 + | 110 seeds | Late Aug + |
| Yellowstone | Mid May | 30 × 3 | 90 + | 110 seeds | Late Aug + |
| **Cropping programme 3** | | | | | |
| Mokum | Early Apr | 80 × 1.75 | 110 + | 72 seeds | Early Jul + |
| Miami | Early Apr | 80 × 1.75 | 125 + | 72 seeds | Mid Jul + |
| Mokum | Early May | 80 × 1.25 | 100 + | 100 seeds | Early Aug + |
| Miami | Early May | 80 × 1.25 | 120 + | 100 seeds | Late Sep + |
| Nairobi | Early May | 80 × 1.25 | 115 + | 100 seeds | Late Sep + |
| Mokum | Late May | 80 × 1.25 | 105 + | 100 seeds | Early Sep + |
| Miami | Late May | 80 × 1.25 | 120 + | 100 seeds | Mid Sep + |
| Nairobi | Late May | 80 × 1.25 | 120 + | 100 seeds | Mid Sep + |
| Norfolk | Late May | 80 × 1.25 | 135 + | 100 seeds | Late Sep + |
| Rainbow | Late May | 80 × 1.25 | 130 + | 100 seeds | Late Sep + |
| Mokum | Mid Jun | 80 × 1.25 | 120 + | 100 seeds | Mid Oct + |
| **Cropping programme 4** | | | | | |
| Romance | Mid May | 38 × 2 | 110 + | 130 seeds | Early Sep + |
| Romance | Late May | 38 × 1.6 | 110 + | 165 seeds | Late Sep + |
| Nairobi | Late May | 38 × 1.6 | 115 + | 165 seeds | Early Oct + |
| **Cropping programme 5** | | | | | |
| Napoli | Early Apr | 80 × 2 | 100 + | 62 seeds | Mid Jul + |
| Miami | Mid May | 80 × 1.2 | 120 + | 104 seeds | Mid Sep + |
| Nairobi | Mid May | 80 × 1.2 | 115 + | 104 seeds | Mid Sep + |
| Rainbow Mix | Mid May | 80 × 1.2 | 130 + | 104 seeds | Late Sep + |
| Miami | Mid Jun | 80 × 1.2 | 140 + | 104 seeds | Mid Oct + |
| Nairobi | Mid Jun | 80 × 1.2 | 130 + | 104 seeds | Mid Oct + |
| Norfolk | Mid Jun | 80 × 1.5 | 130 + | 83 seeds | Mid Oct + |
| **Cropping programme 6** | | | | | |
| Mokum | Mid Feb | 30 × 2.5 | 95 + | 130 seeds | Mid May + |
| Mokum | Mid Apr | 30 × 2.5 | 90 + | 130 seeds | Mid Jul + |
| Yellowstone | Mid Apr | 30 × 2.5 | 140 + | 130 seeds | Late Aug + |
| Purple Haze | Mid Apr | 30 × 2.5 | 100 + | 130 seeds | Late Jul + |
| Miami | Late May | 30 × 2 | 120 + | 160 seeds | Late Sep + |
| Yellowstone | Late May | 30 × 2 | 130 + | 160 seeds | Late Sep + |
| Purple Haze | Late May | 30 × 2 | 95 + | 160 seeds | Late Aug + |

| Cultivar | Sowing | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|
| **Cropping programme 7** | | | | | |
| Sugar Snax | Mid Apr | 75 × 1.5 | 80 + | 90 seeds | Late Jun |
| Mokum | Mid Apr | 75 × 1.5 | 80 + | 90 seeds | Late Jun |
| Sugar Snax | Mid May | 75 × 1.25 | 75 + | 105 seeds | Early Aug + |
| Mokum | Mid May | 75 × 1.25 | 70 + | 105 seeds | Early Aug + |
| Rainbow mix | Mid May | 75 × 1.25 | 80 + | 105 seeds | Early Aug + |
| Sugar Snax | Mid Jun | 75 × 1.25 | 80 + | 105 seeds | Mid Sep + |
| Mokum | Mid Jun | 75 × 1.25 | 80 + | 105 seeds | Mid Sep + |
| Rainbow mix | Mid Jun | 75 × 1.25 | 90 + | 105 seeds | Mid Sep + |

### 3.5.2 Crop yields

The production of carrots increased from 142 t and 2,219 units in 2019 to 252 t (+77%) and 2,647 units (+19%) in 2020.

### 3.5.3 Summary of key findings and recommendations

- Large-scale production of organic carrots can be achieved using an Agricola precision seeder, Garford hoeing equipment, large lazy bed weeders, gentle harvesting machinery and appropriate cleaning, washing and packing equipment.
- On suitable land, carrot sowing can commence as early as March if conditions are good and soil temperature is approximately 8-9°C. Light seed rates for earlier sowings will give earlier maturing roots. Early sown carrot crops should be covered with a fleece for protection and to give early maturity. Carrots are sown twice in the season or once, which will normally be completed towards the end of May when the risk from carrot root fly is reduced.
- Good weed control is essential. Raised beds are made as soon as conditions permit to allow for black plastic technique and flame burning to beds pre-sowing. Carrots soils are prepared in a similar fashion to potatoes but are grown on flat raised beds rather than drills/ridges. It is common practice to have the beds prepared well in advance of sowing to allow emerged weeds to be controlled using a gas burner. This may entail more than one burn at a cost of e.g., €50 each time for the gas depending on the crop area. A further burning will usually take place again just before crop emergence. This approach to weed control before crop emergence reduces the weed burden significantly and lessens the labour costs involved in both lazy bed and mechanical weeding. Carrot crop maintenance mostly requires some hand weeding or hoeing. A lazy bed weeder can be the most efficient method for completing this job.
- Soils are de-stoned for more efficient mechanical harvesting.
- Irrigation may be applied on a number of occasions to assist crop emergence, maintain uniform growth and to increase overall yields and quality.
- Carrot crops are susceptible to forking if fresh farmyard manure is applied before sowing. Ensure sufficient organic matter and nutrition is applied to the previous crop and top up with rock phosphate or sulphate of potash if required. Nutrition of carrots is vital and it is important to base applications on soil sampling and laboratory analysis results. Precise applications of the major and minor nutrients need to be applied to give the required quality and yield. In addition to base applications, regular quantities of foliar nutrients and bio stimulants can be applied based on leaf analysis results.
- Main crop cultivars need to be monitored regularly for adult carrot root fly. Beyond timing sowing to avoid carrot root fly peak periods of activity, attacks can be managed with frequent applications of garlic products. Insect netting is used, but for some growers it can hamper and add cost to the weeding process with lazy bed weeders or mechanical inter-row cultivations.
- Harvesting normally commences in late September and is typically completed shortly after Christmas. Commercial crops tend not to be covered with straw for frost protection. Carrots are harvested with a trail harvester that loads the roots directly into a field trailer via a swan neck elevator. For this, the experience and skill of the operator is very important to ensure that the roots are not physically damaged or broken. The crop is transported in bulk trailers to the packhouse for pre-cleaning, washing, grading and packing on a dedicated processing line before being placed into a cold room.

- Smaller-scale carrot producers can grow for the autumn and early winter market when harvesting is easier, before wetter weather, and prices tend to be higher. Hand harvesting in late autumn and winter, particularly where soil is wet, can make carrot production prohibitively expensive. Later harvesting of carrots with green foliage attached can be achieved on suitable land e.g., July until December. This can be more lucrative than selling loose carrots after Christmas. For wetter land, there is opportunity in late summer early autumn harvesting during drier conditions when larger scale growers may not have crop available. To achieve this, precision sowing as early as possible in April, using e.g., an Agricola or Stanhay vacuum seeder, irrigation if required and covering with insect netting are key. Erratic, inaccurate sowing or sowing too heavy should be avoided. This can happen, for example, with an unsuitable seeder. Carrot size is mostly determined by plant density and sowing date. Higher seed density produces a shorter root length. Sowing depth is normally 18-20 mm. The seed may need to be pressed into the soil especially in dry conditions. Sowing can be carried out in May for harvesting of bunches in July to September. Successional sowings can extend continuity of supply.
- Destoning pre-sowing, particularly where machinery is available, improves harvester efficiency.
- Carrots should only be sown where fresh farmyard manure has been applied in the previous season as manure with a straw content can cause forking of roots. Nitrogen levels are kept to a minimum to reduce forking and over-vigorous foliage.
- Good weed control is important by having beds raised early with a bed former to encourage weed emergence for gas burning before sowing. A bed former also improves soil tilth and subsequent germination. Accurate sowing of seed density is imperative to give uniform size at harvest. A further gas flame burning between sowing and emergence. Ensure insect netting is applied before crop emergence and is properly secure at all edges. If using older netting make sure any holes are repaired to reduce risk of carrot root fly entry. A lazy bed weeder can greatly reduce labour costs.
- Having ridge width the same as other crops, e.g., potatoes, can increase labour efficiency for weeding and harvesting. Settings on mechanical inter-row cultivators will not need to be changed. Earthing up will protect the crop from hard frost damage.
- An Edwards root crop under-cutter can reduce labour requirements, especially when the soil has compacted after a period of dry weather.
- A Harrison barrel washer and inspection line can greatly improve cleaning and packing efficiency and reduce damage and breakages.

## 3.6 Organic broccoli (calabrese) production area and cultivars

The total organic broccoli (calabrese) production area for growers in the MOPS project was 6.02 ha in 2019 and 4.4 ha in 2020. Figure 7 shows a breakdown of the 2020 broccoli production area by cultivar. Six MOPS growers produced broccoli in 2019, five growers in 2020 in counties Galway, Kildare, Laois and Wexford. Key market outlets are supermarkets/retailers and direct selling (box delivery, farmers markets, farmgate). Examples of broccoli cropping programmes for MOPS growers are shown in Table 6.

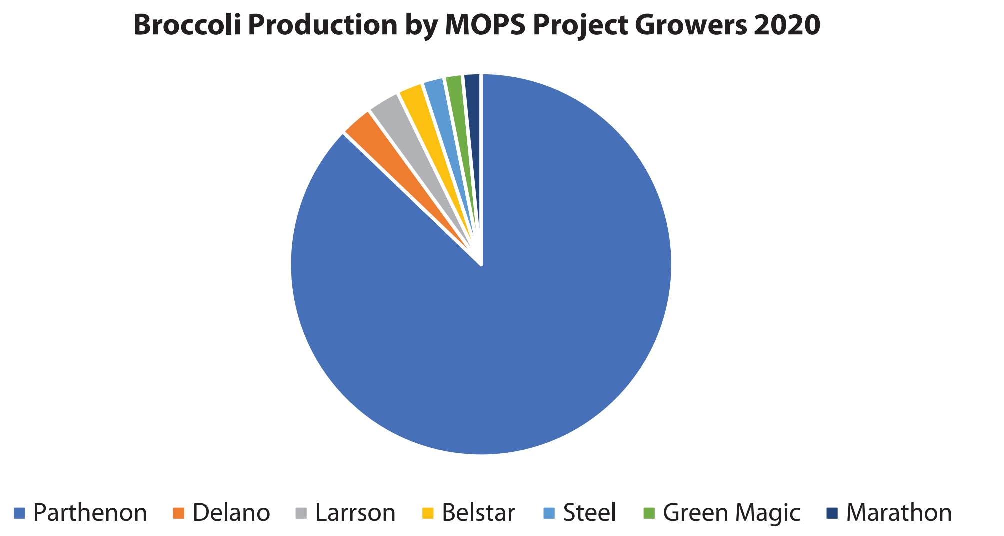



***Figure 7 Broccoli production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.6.1 Cropping programmes

**Table 6 Example broccoli cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Parthenon | Early Feb | Early Apr | 75 × 40 | 90 + | 3.3 plants | Early Jul + |
| Parthenon | Mid Feb | Mid Apr | 75 × 40 | 90 + | 3.3 plants | Mid Jul + |
| Parthenon | Early Mar | Late Apr | 75 × 35 | 85 + | 3.8 plants | Late Jul + |
| Parthenon | Mid Mar | Early May | 75 × 35 | 80 + | 3.8 plants | Early Aug + |
| Parthenon | Early Apr | Mid May | 75 × 35 | 80 + | 3.8 plants | Mid Aug + |
| Parthenon | Mid Apr | Late May | 75 × 35 | 80 + | 3.8 plants | Late Aug + |
| Parthenon | Early May | Mid Jun | 75 × 35 | 85 + | 3.8 plants | Mid Sep + |
| Parthenon | Mid May | Early Jul | 75 × 40 | 90 + | 3.3 plants | Late Sep + |
| Larsson | Mid May | Early Jul | 75 × 40 | 100 + | 3.3 plants | Mid Oct + |
| Triton | Mid May | Early Jul | 75 × 40 | 105 + | 3.3 plants | Late Oct + |
| Parthenon | Late May | Mid Jul | 75 × 40 | 95 + | 3.3 plants | Early Nov + |
| Larsson | Late May | Mid Jul | 75 × 40 | 105 + | 3.3 plants | Mid Nov + |
| **Cropping programme 2** | | | | | | |
| Parthenon | Purchase plants | Mid Apr | 75 × 45 | 85 + | 3 plants | Early Jul + |
| Steel | Purchase plants | Mid Apr | 75 × 45 | 90 + | 3 plants | Mid Jul + |
| Parthenon | Purchase plants | Late Apr | 75 × 45 | 85 + | 3 plants | Late Jul + |
| Steel | Purchase plants | Late Apr | 75 × 45 | 90 + | 3 plants | Early Aug + |
| Parthenon | Purchase plants | Mid May | 75 × 45 | 80 + | 3 plants | Mid Aug + |
| Steel | Purchase plants | Mid May | 75 × 45 | 85 + | 3 plants | Mid Aug + |
| Parthenon | Purchase plants | Late May | 75 × 45 | 80 + | 3 plants | Late Aug + |
| Steel | Purchase plants | Late May | 75 × 45 | 85 + | 3 plants | Late Aug + |
| Parthenon | Purchase plants | Mid Jun | 75 × 45 | 80 + | 3 plants | Early Sep + |
| Steel | Purchase plants | Mid Jun | 75 × 45 | 85 + | 3 plants | Mid Sep + |
| Parthenon | Purchase plants | Late Jun | 75 × 45 | 85 + | 3 plants | Late Sep + |
| Steel | Purchase plants | Late Jun | 75 × 45 | 90 + | 3 plants | Late Sep + |
| Parthenon | Purchase plants | Early Jul | 75 × 45 | 95 + | 3 plants | Early Oct + |
| Steel | Purchase plants | Mid Jul | 75 × 45 | 105 + | 3 plants | Mid Oct + |
| **Cropping programme 3** | | | | | | |
| Parthenon | Late Feb | Mid Apr | 55 × 40 | 90 + | 4.5 plants | Mid Jul + |
| Steel | Late Feb | Mid Apr | 55 × 40 | 100 + | 4.5 plants | Late Jul + |
| Parthenon | Mid Mar | Early May | 55 × 40 | 85 + | 4.5 plants | Early Aug + |
| Steel | Mid Mar | Early May | 55 × 40 | 95 + | 4.5 plants | Mid Aug + |
| Parthenon | Mid Apr | Late May | 55 × 40 | 80 + | 4.5 plants | Late Aug + |
| Steel | Mid Apr | Late May | 55 × 40 | 95 + | 4.5 plants | Mid Sep + |
| Parthenon | Early May | Mid Jun | 55 × 40 | 85 + | 4.5 plants | Mid Sep + |
| Steel | Early May | Mid Jun | 55 × 40 | 100 + | 4.5 plants | Late Sep + |
| Parthenon | Late May | Early Jul | 55 × 40 | 90 + | 4.5 plants | Mid Oct + |
| Steel | Early Jun | Mid Jul | 55 × 40 | 110 + | 4.5 plants | Late Oct + |
| **Cropping programme 4** | | | | | | |
| Parthenon | Mid Feb | Mid Apr | 55 × 45 | 90 + | 4 plants | Mid Jul |
| Parthenon | Early Mar | Late Apr | 55 × 45 | 90 + | 4 plants | Late Jul |
| Parthenon | Early Mar | Late Apr | 55 × 45 | 85 + | 4 plants | Early Aug |
| Parthenon | Mid Mar | Early May | 55 × 42 | 80 + | 4.3 plants | Early Aug |
| Parthenon | Late Mar | Mid May | 55 × 42 | 80 + | 4.3 plants | Mid Aug |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| Parthenon | Late Mar | Late May | 55 × 42 | 80 + | 4.3 plants | Mid Aug |
| Parthenon | Early Apr | Late May | 55 × 42 | 80 + | 4.3 plants | Late Aug |
| Parthenon | Mid Apr | Early Jun | 55 × 42 | 80 + | 4.3 plants | Early Sep |
| Parthenon | Late Apr | Early Jun | 55 × 42 | 85 + | 4.3 plants | Early Sep |
| Parthenon | Late Apr | Mid Jun | 55 × 45 | 85 + | 4 plants | Mid Sep |
| Parthenon | Early May | Late Jun | 55 × 45 | 85 + | 4 plants | Late Sep |
| Parthenon | Mid May | Late Jun | 55 × 45 | 90 + | 4 plants | Early Oct |
| Parthenon | 21st May | Early Jul | 55 × 45 | 90 + | 4 plants | Early Oct |
| Parthenon | Late May | Mid Jul | 55 × 45 | 95 + | 4 plants | Mid Oct |
| Larson | Late May | Mid Jul | 55 × 45 | 100 + | 4 plants | Mid Oct |
| Steel | Late May | Mid Jul | 55 × 45 | 105 + | 4 plants | Late Oct |
| Parthenon | Early Jun | Late Jul | 55 × 50 | 95 + | 3.6 plants | Late Oct |
| Larson | Early Jun | Late Jul | 55 × 50 | 105 + | 3.6 plants | Early Nov |
| Steel | Early Jun | Late Jul | 55 × 50 | 110 + | 3.6 plants | Early Nov |
| **Cropping programme 5** | | | | | | |
| Parthenon | Purchase plants | Mid Apr | 60 × 45 | 90 + | 3.7 plants | Mid Jul + |
| Parthenon | Purchase plants | Late Apr | 60 × 45 | 85 + | 3.7 plants | Late Jul + |
| Parthenon | Purchase plants | Mid May | 60 × 45 | 80 + | 3.7 plants | Early Aug + |
| Parthenon | Purchase plants | Late May | 60 × 45 | 80 + | 3.7 plants | Late Aug + |
| Steel | Purchase plants | Late May | 60 × 45 | 90 + | 3.7 plants | Mid Sep + |
| Parthenon | Purchase plants | Early Jun | 60 × 45 | 85 + | 3.7 plants | Early Sep + |
| Steel | Purchase plants | Early Jun | 60 × 45 | 90 + | 3.7 plants | Mid Sep + |
| Parthenon | Purchase plants | Late Jun | 60 × 50 | 85 + | 3.3 plants | Late Sep + |
| Steel | Purchase plants | Late Jun | 60 × 50 | 95 + | 3.3 plants | Early Oct + |
| Parthenon | Purchase plants | Early Jul | 60 × 50 | 90 + | 3.3 plants | Mid Oct + |
| Steel | Purchase plants | Early Jul | 60 × 50 | 105 + | 3.3 plants | Late Oct + |

### 3.6.2 Crop yields

The production of broccoli was 38 t in 2019 and 36 t in 2020 (-5%).

### 3.6.3 Summary of key findings and recommendations

- For broccoli production, it is important to have a minimum of seven plantings with at least two cultivars to ensure regular continuity of supply, whilst reducing waste due to gluts. The cultivar Steel is generally five to seven days later maturing and more cold tolerant than Parthenon so can extend the season and continuity of supply.

- Planting can commence in mid-April and normally finishes in early to mid-July. Later plantings in July may not be successful in some locations due to early frosts. Crops planted in April will normally be covered with fleece or netting to protect from cold winds and bird attacks.

- Depending on market specification, reducing the plant density produces a bigger head piece with a thicker stalk and gives overall better yield and longer shelf life. In addition, wider spacing reduces disease levels because of more air movement between the crop plants. Bacterial soft rot, for example, tends to be more prevalent during cold and damp conditions especially in late Autumn. Plantings for harvesting late in the season should be on land that receives good air flow. Broccoli that has been grown too quickly and soft, e.g., due to excessive nitrogen, tends to be more affected than slower growing crops with a good wax on the broccoli crown. The wider spacing also accommodates frequent interrow cultivation with either the inter-row rotavator; steerage hoe or ridger.

- Establishing plants quickly after planting is very important and irrigation is necessary during prolonged periods of dry weather.

- Weed control is achieved by preparing the beds well in advance to encourage weed germination. Beds are subsequently gas burned two to three times before planting if time allows. The gas cost can be in excess of €100 per hectare for each pass, for example, depending on crop area but this approach can be more viable than manual hand weeding. Once the crop has become well established (three to five weeks after planting) further mechanical inter-row cultivation can be carried out.
- A good fertile soil is important for crop nutrition, with good levels of organic matter. Nutrient applications are based on soil analysis results. The desired pH for the broccoli is 6.5. Broccoli has a high requirement for both boron and calcium. Where boron is low, additional quantities may need to be applied in the base or by foliar application. Caution is needed with excessive nitrogen, which may lead to bacterial soft rot and hollow stem especially in periods of high humidity.
- In general, crops are hand harvested into field crates or bins which can require two to three passes per crop. Crops are best harvested in the early mornings to minimise field heat and transported into cold rooms at the earliest opportunity to increase shelf life and reduce waste.

## 3.7 Organic cabbage production area and cultivars

The total organic cabbage production area for growers in the MOPS project was 2.53 ha in 2019 and 7.78 ha in 2020. Figure 8 shows a breakdown of the 2020 cabbage production area by cultivar. 10 MOPS growers produced cabbage in 2019, nine growers in 2020 in counties Galway, Kildare, Kilkenny, Laois, Wexford and Wicklow. Key market outlets are supermarkets/retailers and direct selling (box delivery, farmers markets, farmgate). Examples of cabbage cropping programmes for MOPS growers are shown in Table 7.

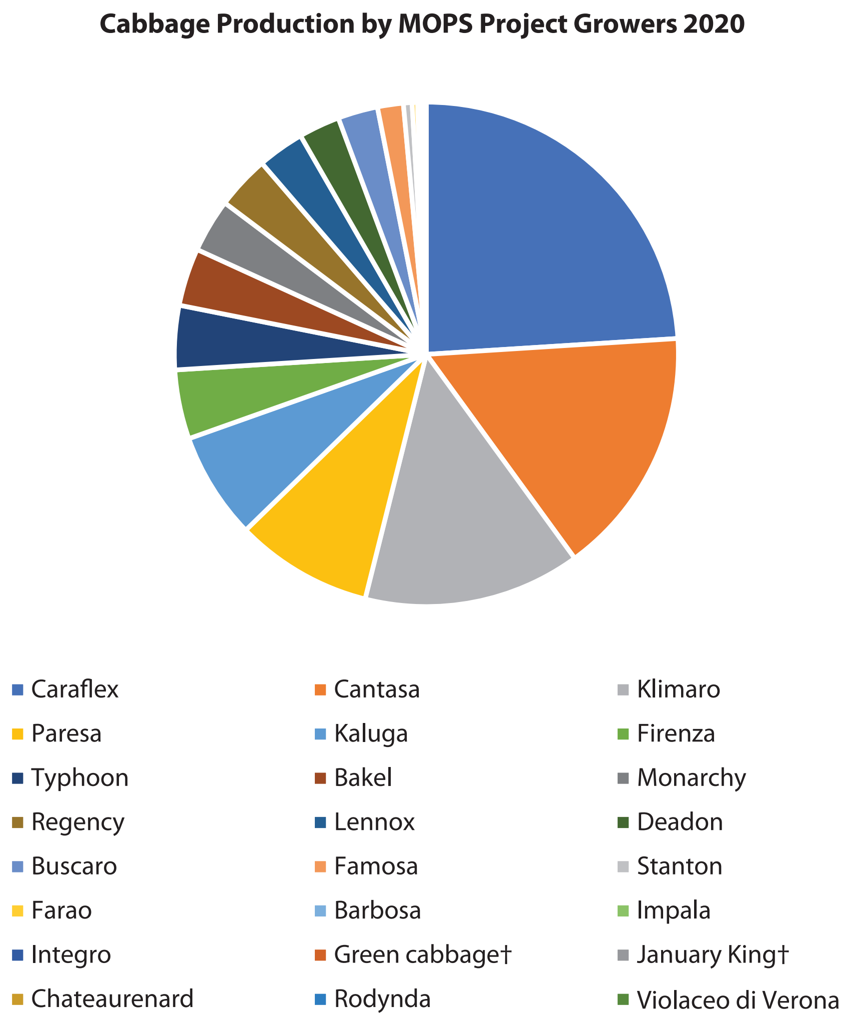



***Figure 8 Cabbage production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.7.1 Cropping programmes

**Table 7 Example cabbage cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Ovasa | Mid May | Early Jul | 75 × 40 | 110 + | 3.3 plants | Mid Oct + |
| Cantasa | Mid May | Early Jul | 75 × 40 | 120 + | 3.3 plants | Early Nov + |
| Paresa | Mid May | Early Jul | 75 × 40 | 180 + | 3.3 plants | Dec + |
| Stanton | Mid Apr | Early Jun | 75 × 40 | 130 + | 3.3 plants | Mid Oct + |
| Stanton | Mid May | Early Jul | 75 × 40 | 150 + | 3.3 plants | Dec + |
| Deadon | Mid Jun | Early Jul | 75 × 40 | 130 + | 3.3 plants | Mid Oct + |
| Integro | Late Feb | Early May | 75 × 30 | 90 + | 4.4 plants | Early Aug + |
| Klimaro | Late Feb | Mid Apr | 75 × 30 | 135 + | 4.4 plants | Mid Sep + |
| Klimaro | Late Feb | Mid May | 75 × 45 | 145 + | 3 plants | Oct + |
| Caraflex | Mid Feb | Early Apr | 75 × 30 | 80 + | 4.4 plants | Early Jul + |
| Caraflex | Early Mar | Mid Apr | 75 × 30 | 75 + | 4.4 plants | Mid Jul + |
| Caraflex | Mid Mar | Early May | 75 × 30 | 75 + | 4.4 plants | Late Jul + |
| Caraflex | Early Apr | Mid May | 75 × 30 | 70 + | 4.4 plants | Early Aug + |
| Caraflex | Mid Apr | Early Jun | 75 × 30 | 70 + | 4.4 plants | Mid Aug + |
| Caraflex | Early May | Mid Jun | 75 × 30 | 75 + | 4.4 plants | Early Sep + |
| Caraflex | Mid May | Early Jul | 75 × 30 | 75 + | 4.4 plants | Mid Sep + |
| Caraflex | Early Jun | Mid Jul | 75 × 30 | 80 + | 4.4 plants | Early Oct + |
| Caraflex | Mid Jun | Early Aug | 75 × 30 | 85 + | 4.4 plants | Mid Oct + |
| **Cropping programme 2** | | | | | | |
| January King | Early May | Early Jul | 70 × 45 | 100 + | 3.2 plants | Oct + |
| Robin | Mid May | Mid Jul | 70 × 45 | 120 + | 3.2 plants | Nov + |
| Deadon | Mid May | Mid Jul | 70 × 45 | 130 + | 3.2 plants | Dec + |
| **Cropping programme 3** | | | | | | |
| Caraflex | Late Feb | Mid Apr | 55 × 35 | 75 + | 5.2 plants | Late Jun + |
| Caraflex | Mid Mar | Early May | 55 × 35 | 70 + | 5.2 plants | Mid Jul + |
| Caraflex | Mid Apr | Late May | 55 × 35 | 70 + | 5.2 plants | Early Aug + |
| Caraflex | Early May | Mid Jun | 55 × 35 | 70 + | 5.2 plants | Early Sep + |
| Caraflex | Early Jun | Mid Jul | 55 × 35 | 70 + | 5.2 plants | Early Oct + |
| Caraflex | Early Jun | Late Jul | 55 × 35 | 80 + | 5.2 plants | Mid Oct + |
| Regency | Early Jun | Late Jul | 55 × 35 | 95 + | 5.2 plants | Late Oct + |
| Monarchy | Early Jun | Late Jul | 55 × 35 | 105 + | 5.2 plants | Mid Nov + |
| Klimaro | Mid Mar | Early May | 55 × 35 | 135 + | 5.2 plants | Early Oct + |
| Kaluga | Mid Mar | Early May | 55 × 35 | 130 + | 5.2 plants | Early Oct + |
| Famosa | Mid Mar | Early May | 55 × 40 | 75 + | 4.5 plants | Late Jul + |
| Famosa | Mid Apr | Late May | 55 × 40 | 75 + | 4.5 plants | Mid Aug + |
| Cantasa | Mid Apr | Late May | 55 × 40 | 125 + | 4.5 plants | Mid Oct + |
| Cantasa | Early May | Mid Jun | 55 × 40 | 130 + | 4.5 plants | Mid Nov + |
| Barbosa | Mid May | Early Jul | 55 × 45 | 145 + | 4 plants | Dec + |
| Paresa | Mid May | Early Jul | 55 × 45 | 190 + | 4 plants | Jan + |
| Bakel | Mid May | Early Jul | 55 × 45 | 225 + | 4 plants | Feb + |
| **Cropping programme 4** | | | | | | |
| Caraflex | Mid Feb | Early Apr | 55 × 42 | 80 + | 4.3 plants | Late Jun + |
| Caraflex | Late Feb | Early Apr | 55 × 42 | 80 + | 4.3 plants | Early Jul + |
| Caraflex | Early Mar | Mid Apr | 55 × 40 | 80 + | 4.5 plants | Mid Jul + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| Caraflex | Early Mar | Early May | 55 × 40 | 75 + | 4.5 plants | Late Jul + |
| Caraflex | Mid Mar | Early May | 55 × 40 | 75 + | 4.5 plants | Early Jul + |
| Caraflex | Late Mar | Mid May | 55 × 40 | 75 + | 4.5 plants | Mid Jul + |
| Caraflex | Late Mar | Late May | 55 × 40 | 75 + | 4.5 plants | Late Jul + |
| Caraflex | Early Apr | Late May | 55 × 40 | 75 + | 4.5 plants | Early Aug + |
| Caraflex | Mid Apr | Early Jun | 55 × 40 | 75 + | 4.5 plants | Mid Aug + |
| Caraflex | Late Apr | Mid Jun | 55 × 40 | 75 + | 4.5 plants | Late Aug + |
| Caraflex | Late Apr | Late Jun | 55 × 40 | 75 + | 4.5 plants | Early Sep + |
| Caraflex | Early May | Late Jun | 55 × 40 | 75 + | 4.5 plants | Mid Sep + |
| Caraflex | Mid May | Early Jul | 55 × 40 | 80 + | 4.5 plants | Late Sep + |
| Regency | Mid May | Early Jul | 55 × 42 | 90 + | 4.3 plants | Early Oct + |
| Monarchy | Mid May | Early Jul | 55 × 42 | 100 + | 4.3 plants | Mid Oct + |
| Regency | Late May | Mid Jul | 55 × 42 | 95 + | 4.3 plants | Late Oct + |
| Monarchy | Late May | Mid Jul | 55 × 42 | 100 + | 4.3 plants | Late Oct + |
| Firenza | Early May | Late Jun | 55 × 45 | 140 + | 4 plants | Mid Nov + |
| Cantasa | Mid May | Early Jul | 55 × 45 | 160 + | 4 plants | Mid Dec + |
| Paresa | Mid May | Early Jul | 55 × 50 | 210 + | 3.6 plants | Mid Jan + |
| Bakel | Mid May | Early Jul | 55 × 50 | 220 + | 3.6 plants | Mid Feb + |
| Klimaro | Late Mar | Mid May | 55 × 40 | 140 + | 4.5 plants | Dec + |
| Kaluga | Late Mar | Mid May | 55 × 40 | 120 + | 4.5 plants | Mid Sep |
| **Cropping programme 5** | | | | | | |
| Integro | Purchase plants | Mid Apr | 80 × 40 | 100 + | 3.1 plants | Late Jul + |
| Klimaro | Purchase plants | Early May | 80 × 35 | 140 + | 3.6 plants | Late Aug + |
| Klimaro | Purchase plants | Early May | 80 × 40 | 150 + | 3.1 plants | |
| Kaluga | Purchase plants | Early May | 80 × 35 | 130 + | 3.6 plants | Early Sep + |
| Passat | Purchase plants | Early May | 80 × 45 | 115 + | 2.8 plants | Mid Aug + |
| Krautkaiser | Purchase plants | Early May | 80 × 45 | 140 + | 2.8 plants | Mid Sep + |
| Lennox | Purchase plants | Early May | 80 × 45 | 150 + | 2.8 plants | Late Sep + |
| **Cropping programme 6** | | | | | | |
| Famosa | Purchase plants | Late Apr | 60 × 40 | 75 + | 4.2 plants | Mid Jul + |
| Famosa | Purchase plants | Mid May | 60 × 40 | 75 + | 4.2 plants | Early Aug + |
| Famosa | Purchase plants | Mid Jun | 60 × 40 | 80 + | 4.2 plants | Mid Sep + |
| Melisa | Purchase plants | Mid Jul | 60 × 50 | 90 + | 3.3 plants | Early Oct + |
| Paresa | Purchase plants | Mid Jun | 60 × 50 | 180 + | 3.3 plants | Mid Dec + |
| Paresa | Purchase plants | Mid Jul | 60 × 50 | 190 + | 3.3 plants | Late Jan + |
| Deadon | Purchase plants | Mid Jun | 60 × 50 | 110 + | 3.3 plants | Early Oct + |
| Buscaro | Purchase plants | Early May | 60 × 40 | 110 + | 4.2 plants | Late Sep + |
| Klimaro | Purchase plants | Early May | 60 × 40 | 135 + | 4.2 plants | Early Nov + |
| Lennox | Purchase plants | Early May | 60 × 40 | 140 + | 4.2 plants | Early Oct + |

### 3.7.2 Crop yields

The production of cabbage increased from 17 t and 37,735 units in 2019 to 27 t (+59%) and 61,231 units (+62%) in 2020.

### 3.7.3 Summary of key findings and recommendations

- Large-scale production of summer, autumn and winter cabbage can involve 14-16 successional plantings to give continuity of supply from June to late September. Planting commences in mid-April and is normally completed in mid-July. In addition to the cultivar Caraflex, other pointed cabbage cultivars like Regency and Monarchy that perform well in the colder conditions of late autumn can extend the season of supply to the late October. Savoy cabbages are grown to follow after the last pointed cabbages are harvested.
- Cabbage production matches well with growing other brassica crops e.g., broccoli, Brussels sprouts and kale, as most of the growing requirements are similar such as soil nutrition and machinery. Cabbage, like other above-ground brassica crops, can be relatively easily harvested during the winter months once the soil does not get waterlogged. Similar row spacing to other brassica crops helps air movement, which in turn dries the outer leaves reducing the onset of leaf diseases such as Alternaria.
- For some growers, sales of summer cabbage can be variable so this is factored in to crop planning. Equally, red cabbage sales can be limited to around the Christmas period.
- Different plant spacings are for smaller or larger heads depending on market specification.
- Using a transplanter, e.g., a Checchi & Magli module transplanter, can improve the crop uniformity for growers by achieving more precise densities and planting depth.
- The choice of suitable cultivars to withstand severe winter weather can reduce waste and increase harvesting efficiency for growers in colder areas. Later cultivars, e.g., Paresa and Deadon (January King), have proved to be quite frost hardy and have also shown good disease resistance, especially to ringspot, which can be a serious problem due to the number of days that have precipitation.
- Red cabbage is similar to white cabbage in its management and harvesting requirements. It is a very flexible crop that requires less weeding because of its large canopy, and is less demanding in its harvesting requirements. A large quantity can be harvested and prepared at any one time when there is less pressure on available labour units.
- Under normal weather conditions, white cabbage can be harvested before the onset of severe frosts and put into a cold store. It is important to handle each head very gently and to place heads neatly into suitable storage boxes, otherwise, severe losses due to rots will occur. If winters are very mild, the crop can be stored on site until early April, which is a big saving on energy and labour costs.
- Savoy cabbage is quite winter hardy and can be left in the field until approximately mid-March at which time the crop will start bursting and going to seed. If the winter is severe, then placing netting over the crop can reduce the level of frost damage and also prevent pigeon damage. In general, covering crops with netting helps greatly with overall yields and reduces crop losses and waste caused by pigeon and/or insect damage. Insect netting gives good control against aphids provided the mesh size is sufficiently small, but cabbage white butterfly and diamond back moth caterpillars are much more difficult to control as they can lay their eggs through the netting. Use of applications of approved insecticide substances may be necessary. For spring greens, keep a watchful eye on pigeon picking and keep the crop covered with bird netting for protection.
- Cabbage can have a high requirement for boron and calcium in order to avoid internal browning. Higher pH levels and potash give strong cell wall strength which is vital for good storage.
- Irrigation is beneficial, especially for crop establishment, and also reducing internal tipburn.
- Multiple harvestings of different plots of cabbage crops ensures that only large heads, in prime condition, are picked at any one time, which increases overall yield and gives the less vigorous pieces further days to grow.
- Having cold room facilities for short term storage of pointed, green and savoy cabbages is of great benefit in achieving continuity of supply and alleviating the issues of shortages and surpluses. Owning, or being able to rent/lease long term cold storage at a reasonable cost from either other growers or commercial facilitators is important for long season supply of both red and white cabbage.

## 3.8 Organic parsnip production area and cultivars

The total organic parsnip production area for growers in the MOPS project was 1.52 ha in 2019 (est.) and 1.47 ha in 2020. Figure 9 shows a breakdown of the 2020 parsnip production area by cultivar. Five MOPS growers produced parsnips in 2019, four growers in 2020 in counties Galway, Kildare, and Wicklow. Key market outlets are supermarkets and direct selling (box delivery, farmers markets, farmgate). Examples of parsnip cropping programmes for MOPS growers are shown in Table 8.

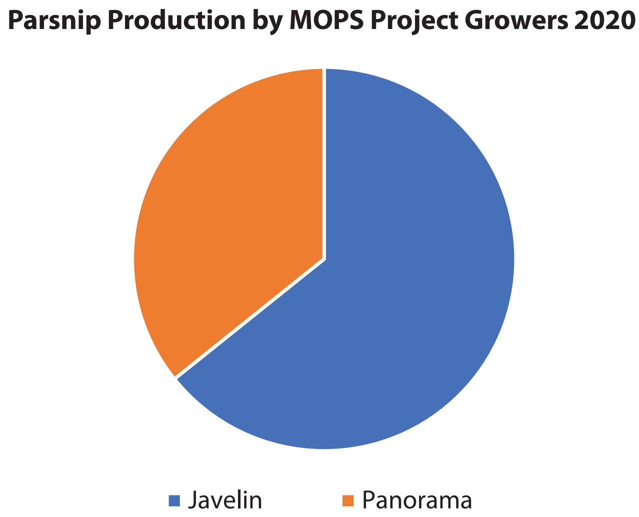



*Figure 9 Parsnip production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.8.1 Cropping programmes

**Table 8 Example parsnip cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | |
| Javelin | Early Apr | 75 × 4 | 125 + | 33 seeds | Mid Aug + |
| Javelin | Mid May | 75 × 2.5 | 140 + | 52 seeds | Oct + |
| Panorama | Mid May | 75 × 2.5 | 150 + | 52 seeds | Nov + |
| **Cropping programme 2** | | | | | |
| Javelin | Mid May | 75 × | 140 + | 45 seeds | Early Oct + |
| Panorama | Mid May | 75 × 3 | 130 + | 45 seeds | Early Oct + |
| **Cropping programme 3** | | | | | |
| Picador | Early Apr | 80 × 2.5 | 140 + | 50 seeds | Mid Sep + |
| Panorama | Early Apr | 80 × 2.5 | 160 + | 50 seeds | Mid Sep + |
| Panorama | Late May | 80 × 2.5 | 150 + | 50 seeds | Late Oct + |
| **Cropping programme 4** | | | | | |
| Picador | Mid Apr | 80 × 3 | 140 + | 41 seeds | Mid Sep + |
| Panorama | Mid Apr | 80 × 2.5 | 150 + | 50 seeds | Late Sep + |
| Panorama | Early Jun | 80 × 2.5 | 160 + | 50 seeds | Nov + |

### 3.8.2 Crop yields

The production of parsnips was 27 t in 2019 and 26 t in 2020 (-4%).

### 3.8.3 Summary of key findings and recommendations

- Like carrots, parsnips are an important crop that provide a supply of root vegetables during the autumn and winter months. Good parsnip crop yields can be achieved by selecting cultivars that are high yielding with resistance to both brown and orange canker. Cultivars with stronger outer skins have fewer losses due to bruising.

- Parsnips can have two sowing dates to give continuity of supply, and benefit from being sown with a precision seeder e.g., Stanhay vacuum seeder. Inaccurate sowing can impact overall saleable yield. A bed former produces a good seed tilth and better germination.
- Parsnips require similar growing conditions to carrots in terms of soils, nutrients and management skills (see notes for carrots). This root crop, however, can have a higher requirement for nitrogen than carrots so benefits from top dressing depending on the growing season.
- Weed and pest control techniques employed for carrots also apply to parsnips.
- Parsnip crops harvested by hand can benefit from being sown on 75 cm drills, especially on wetter land. Growing in drills keeps the crop roots out of saturated soil and makes manual harvesting less labour intensive. Growing on flat beds in wet soil creates challenges for harvesting.
- Growers can sell bunched parsnips until the tops die down in December, and loose thereafter. It can be worthwhile to make a later sowing in late May to give a higher volume of marketable yield in the following spring.

## 3.9 Organic scallion production area and cultivars

The total organic scallion production area for growers in the MOPS project was 0.69 ha in 2019 and 0.14 ha in 2020. Figure 10 shows a breakdown of the 2020 scallion production area by cultivar. Six MOPS growers produced Scallions in 2019, eight growers in 2020 in counties Cork, Galway, Kildare, Kilkenny, Wexford, and Wicklow. Key market outlets are supermarkets and direct selling (box delivery, farmers markets, farmgate). Examples of scallion cropping programmes for MOPS growers are shown in Table 9.

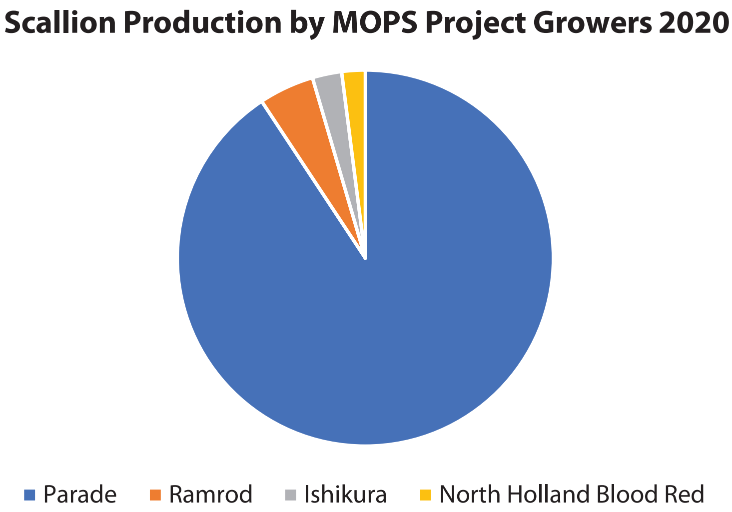



*Figure 10 Scallion production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.9.1 Cropping programmes

**Table 9 Example scallion cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m$^2$ | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Parade | Late Jan | Early Apr | 25 × 15 | 70 + | 40 cells × 6-7 seeds | Mid May + |
| Parade | Mid Feb | Late Apr | 25 × 15 | 65 + | 40 cells × 6-7 seeds | Late Jun + |
| Performer | Mid Feb | Late Apr | 25 × 15 | 70 + | 40 cells × 6-7 seeds | Late Jun + |
| Parade | Early Mar | Mid May | 25 × 15 | 60 + | 40 cells × 6-7 seeds | Mid Jul + |
| Performer | Early Mar | Mid May | 25 × 15 | 65 + | 40 cells × 6-7 seeds | Mid Jul + |
| Parade | Late Mar | Late May | 25 × 15 | 60 + | 40 cells × 6-7 seeds | Late Jul + |
| Performer | Late Mar | Late May | 25 × 15 | 65 + | 40 cells × 6-7 seeds | Late Jul + |
| Parade | Mid Apr | Mid Jun | 25 × 15 | 60 + | 40 cells × 6-7 seeds | Early Aug + |
| Performer | Mid Apr | Mid Jun | 25 × 15 | 65 + | 40 cells × 6-7 seeds | Early Aug + |
| Parade | Late Apr | Late Jun | 25 × 15 | 60 + | 40 cells × 6-7 seeds | Late Aug + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| Performer | Late Apr | Late Jun | 25 × 15 | 65 + | 40 cells × 6-7 seeds | Late Aug + |
| Parade | Mid May | Mid Jul | 25 × 15 | 60 + | 40 cells × 6-7 seeds | Early Sep + |
| Performer | Mid May | Mid Jul | 25 × 15 | 65 + | 40 cells × 6-7 seeds | Early Sep + |
| **Cropping programme 2** | | | | | | |
| Parade | Early Feb | Early Apr | 38 × 12 | 65 + | 22 plants | Mid Jun + |
| Pearl | Early Feb | Early Apr | 38 × 12 | 70 + | 22 plants | Mid Jun + |
| Parade | Early Mar | Early May | 38 × 12 | 65 + | 22 plants | Mid Jul + |
| Pearl | Early Mar | Early May | 38 × 12 | 65 + | 22 plants | Mid Jul + |
| Parade | Early Apr | Early Jun | 38 × 12 | 70 + | 22 plants | Mid Aug + |
| Pearl | Early Apr | Early Jun | 38 × 12 | 70 + | 22 plants | Mid Aug + |
| Parade | Early May | Early Jul | 38 × 12 | 80 + | 22 plants | Mid Sep + |
| Pearl | Early May | Early Jul | 38 × 12 | 80 + | 22 plants | Mid Sep + |
| **Cropping programme 3** | | | | | | |
| Parade | Purchase plants | Early Apr | 40 × 12 | 65 + | 24 cells | Early Jun + |
| Parade | Purchase plants | Late Apr | 40 × 12 | 60 + | 24 cells | Late Jun + |
| Parade | Purchase plants | Mid May | 40 × 12 | 60 + | 24 cells | Mid Jul + |
| Parade | Purchase plants | Mid Jun | 40 × 12 | 65 + | 24 cells | Mid Aug + |
| Parade | Purchase plants | Early Jul | 40 × 12 | 70 + | 24 cells | Early Sep + |
| Parade | Purchase plants | Late Jul | 40 × 12 | 80 + | 24 cells | Mid Oct + |
| Parade | Purchase plants | Mid Aug | 40 × 12 | 80 + | 24 cells | Early Nov + |
| **Cropping programme 4** | | | | | | |
| Parade | Early Feb | Early Apr | 20 × 20 | 40 + | 25 plugs × 7-8 seeds | Mid May + |
| Parade | Early Feb | Mid Apr | 20 × 20 | 50 + | 25 plugs × 7-8 seeds | Lat May + |
| Parade | Early Mar | Mid May | 20 × 20 | 50 + | 25 plugs × 7-8 seeds | Early Jul + |
| Parade | Early Apr | Early Jun | 20 × 20 | 50 + | 25 plugs × 7-8 seeds | Mid Jul + |
| Parade | Mid May | Early Jul | 20 × 20 | 50 + | 25 plugs × 7-8 seeds | Aug + |
| Parade | Mid Jun | Late Jul | 20 × 20 | 60 + | 25 plugs × 7-8 seeds | Early Sep + |
| Ramrod | Sep | | 20 × 2 | 200 + | 250 seeds | Early Apr + |
| **Cropping programme 5** | | | | | | |
| Parade | Mid Feb | Mid Apr | 55 × 12 | 65 + | 15 plugs | Mid Jun + |
| Parade | Mid Mar | Mid May | 55 × 12 | 60 + | 15 plugs | Mid Jul + |
| Parade | Mid Apr | Mid Jun | 55 × 12 | 60 + | 15 plugs | Mid Aug + |
| Parade | Mid May | Mid Jul | 55 × 12 | 65 + | 15 plugs | Mid Sep + |
| Parade | Late May | Late Jul | 55 × 12 | 70 + | 15 plugs | Mid Oct + |

### 3.9.2 Crop yields
The production of scallions was 10 t in 2019 and 3 t in 2020 (-70%).

### 3.9.3 Summary of key findings and recommendations
- The following provides example propagation sowings for module raised scallion transplants: 1) deep 216 cell trays with six to seven seeds per cell for the first two sowings then 345 cell trays; 2) sowing six to eight seeds per cell into 308 module trays and planting every two weeks for continuity of supply; 3) for scallion bunches of approximately 130 g, sow seeds in larger 88 cell tray with 7 to 8 seeds per cell. In general, too many seedlings per cell leads to thinner plants.
- The spring onion cultivar Parade is more suitable for summer months than Ramrod, which is more cold hardy for winter months.

- Protected cropping extends the spring onion season. Transplanting indoor crops can give earlier production.
- Scallions can be produced to supply bunches from June to September depending on market demands. Regular planting of module raised plants is important for continuity of supply. Purchased plants typically have six to eight seeds sown in each cell. To be successful with direct sown spring onions, several gas flame burnings are needed to manage weeds.
- For some growers, planting outdoor from early April and finishing in mid to late July can produce very satisfactory crops and yields. Parade has proved to be a good choice with strong erect leaves. Planting four to five rows on a flat bed covered with black biodegradable film can be hugely beneficial. This system greatly reduces the cost of both mechanical and manual weeding. An added bonus is the ability of the bio mulch to heat up the soil, especially in early spring. It also helps to retain soil moisture, particularly during dry periods. A poly laying machine, e.g., Samco, can firm in the edges better with less damage caused by high winds. This type of poly layer can also punch holes through the plastic which reduces labour costs and gives more precise spacings.
- Ensuring that the top of each module is slightly below soil level when planting assists greatly at harvesting. Quick establishment is very important so watering is necessary. A pH 6.5 and above is ideal for spring onions.
- A field with good air movement will reduce risk of downy mildew.

## 3.10 Organic beetroot production area and cultivars

The total organic beetroot production area for growers in the MOPS project was 4.22 ha in 2019 and 3.6 ha in 2020 (est.). Figure 11 provides a breakdown of the 2020 beetroot production area by cultivar. Nine MOPS growers produced beetroot in 2019, the same number again in 2020 in counties Cork, Galway, Kildare, Kilkenny, Wexford and Wicklow. Key market outlets are direct selling (box delivery, farmers markets, farmgate) and shops. Examples of beetroot cropping programmes for MOPS growers are shown in Table 10.

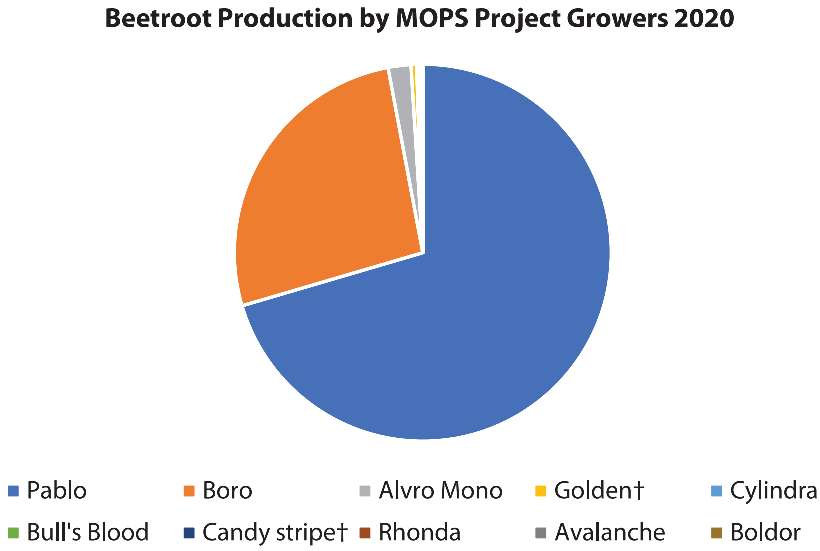



***Figure 11 Beetroot production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.10.1 Cropping programmes

**Table 10 Example beetroot cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Pablo | Early Feb | Early Apr | 40 × 15 | 85 + | 16 modules | Late Jun + |
| Pablo | Early Apr | - | 40 × 2.5 | 100 + | 100 seeds | Mid Jul + |
| Pablo | Early May | - | 40 × 2.5 | 90 + | 100 seeds | Early Aug + |
| Pablo | Mid May | - | 40 × 2.5 | 90 + | 100 seeds | Mid Aug + |
| Pablo | Early Jun | - | 40 × 3 | 95 + | 80 seeds | Mid Sep + |
| Bettolo | Early Jun | - | 40 × 3 | 100 + | 80 seeds | Mid Sep + |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Cropping programme 2** | | | | | | |
| Boro | Purchase plants | Early Feb | 40 × 12 | 90 + | 21 plugs | Early May + |
| Boro | Mid Apr | - | 40 × 3 | 95 + | 83 seeds | Early Jul + |
| Boro | Early May | - | 40 × 3 | 85 + | 83 seeds | Mid Jul + |
| Boro | Mid Jun | - | 40 × 3 | 90 + | 83 seeds | Late Jul + |
| **Cropping programme 3** | | | | | | |
| Boro | Early Apr | - | 55 × 2 | 110 + | 90 seeds | Late Jul + |
| Boro | Early May | - | 55 × 2 | 95 + | 90 seeds | Mid Aug + |
| Boro | Early Jun | - | 55 × 2 | 100 + | 90 seeds | Late Sep + |
| Bettolo | Early Jun | - | 55 × 2 | 120 + | 90 seeds | Mid Oct + |
| **Cropping programme 4** | | | | | | |
| Pablo | Early Apr | - | 38 × 3 | 120 + | 86 seeds | Early Jul + |
| Pablo | Late Apr | - | 38 × 2.5 | 110 + | 105 seeds | Early Aug + |
| Chioggia | Late Apr | - | 38 × 2.5 | 115 + | 105 seeds | Early Aug + |
| Pablo | Mid May | - | 38 × 2.5 | 120 + | 105 seeds | Early Sep + |
| Bettolo | Mid May | - | 38 × 2.5 | 130 + | 105 seeds | Early Sep + |
| **Cropping programme 5** | | | | | | |
| Boro | Purchase plants | Mid Apr | 80 × 15 | 80 + | 12.5 cells | Mid Jul + |
| Boro | Mid Apr | - | 80 × 2 | 120 + | 62 seeds | Early Aug + |
| Boro | Mid May | - | 80 × 1.5 | 110 + | 83 seeds | Late Sep + |
| Boro | Mid Jun | - | 80 × 2 | 120 + | 62 seeds | Mid Oct + |
| Boro | Mid Jul | - | 80 × 2.5 | 140 + | 50 seeds | Mid Dec + |
| Boro | Purchase plants | Mid Jul | 35 × 15 | 150 + | 12.5 cells | Dec + |
| **Cropping programme 6** | | | | | | |
| Alvro Mono | Early Apr | - | 30 × 4 | 95 + | 83 seeds | Early Jul + |
| Golden | Early Apr | - | 30 × 4 | 100 + | 83 seeds | Early Jul + |
| Alvro Mono | Early May | - | 30 × 4 | 90 + | 83 seeds | Early Aug + |
| Golden | Early May | - | 30 × 4 | 95 + | 83 seeds | Early Aug + |
| Alvro Mono | Early Jun | - | 30 × 4 | 110 + | 83 seeds | Mid Sep + |
| Golden | Early Jun | - | 30 × 4 | 110 + | 83 seeds | Mid Sep + |
| Candy stripe | Early Jun | - | 30 × 4 | 110 + | 83 seeds | Mid Sep + |
| **Cropping programme 7** | | | | | | |
| Pablo/Boro | Mid Apr | - | 75 × 2 | 90 + | 66 seeds | Mid Jul + |
| Boldor | Mid Apr | - | 75 × 2 | 90 + | 66 seeds | Mid Jul + |
| Avalanche | Mid Apr | - | 75 × 2 | 100 + | 66 seeds | Late Jul + |
| Pablo/Boro | Early May | - | 75 × 2 | 80 + | 66 seeds | Late Jul + |
| Boldor | Early May | - | 75 × 1 | 80 + | 66 seeds | Late Jul + |
| Avalanche | Early May | - | 75 × 1 | 90 + | 66 seeds | Mid Jul + |
| Pablo | Mid Jun | - | 75 × 1.5 | 100 + | 66 seeds | Early Sep + |

### 3.10.2 Crop yields

The production of beetroot was 28 t and 2,066 units in 2019, and 23 t (-18%) and 2,518 (+22%) units in 2020.

### 3.10.3 Summary of key findings and recommendations

- Before sowing beetroot in the field, it is advisable to check by germination, whether the seed is monogerm or multigerm to establish plant density.
- Precision sowing can be achieved using e.g., an Agricola vacuum seeder, which produces a very uniform crop with roots in the 45 to 85 cm range. Poor dispersal of seeds results in variable beetroot sizes that may impact saleable yield. Using a bed former gives much better soil tilth and germination.

- Increasing seeding rate reduces root size. For direct seeding, sow the first early sowing of beetroot seeds lighter (e.g., 33 seeds per linear metre) than the maincrop (e.g., 50 seeds per linear metre). Beetroot can be handpicked earlier if a twin line seeding coulter is used.
- For earlier harvest by three to four weeks when prices tend to be better, sow into large cell module trays that produce multi seedling plants for planting out into soil with black mulch film, e.g., in early April. A further two or three direct sowings from early April until the end of May or early/mid-June will produce a continuous supply of beetroot for almost 10 months of the year. Late sowings in early August will typically give medium size roots in late October. The last of the crop can be stored in ambient or cold storage to extend the season. Earlier harvest can also be achieved by transplanting into a polytunnel. Beetroots can be harvested before maturity if there is a market for baby beets.
- Beetroot leaves for salad leaf mixes can be produced by direct sowing at e.g., 30 × 3 cm spacing.
- If leaving the beetroot crop overwinter in the field, it may be necessary to cover the crop with fleece or netting for low temperature protection. Damage from rodents can be a risk in winter.

## 3.11 Organic spinach production area and cultivars

The total organic spinach production area for growers in the MOPS project was 0.86 ha in 2019 (est.) and 1.14 ha in 2020 (est.). Figure 12 shows a breakdown of the 2020 spinach production area by cultivar. Seven MOPS growers produced spinach in 2019, eight growers in 2020 in counties Cork, Galway, Kildare, Kilkenny, Wexford and Wicklow. Key market outlets are direct selling (box delivery, farmers markets, farmgate), restaurants and shops. Examples of spinach cropping programmes for MOPS growers are shown in Table 11.

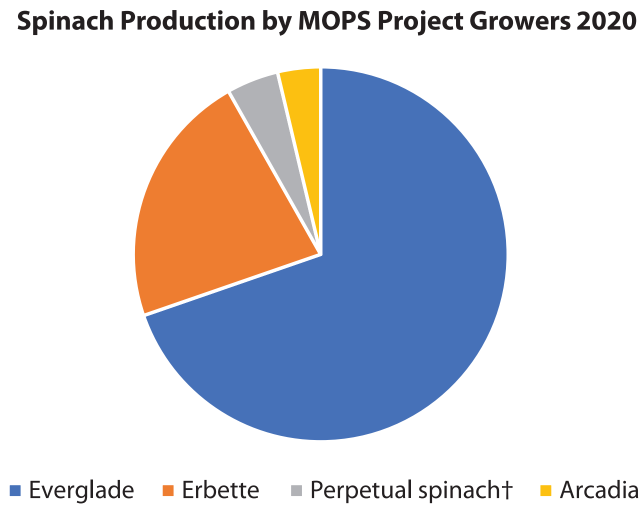



*Figure 12 Spinach production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.11.1 Cropping programmes

**Table 11 Example spinach cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Everglade | Purchase blocks | Early Apr | 40 × 20 | 50 + | 12.5 blocks | Mid May + |
| Everglade | Purchase blocks | Mid Apr | 40 × 20 | 50 + | 12.5 blocks | Early Jun + |
| Everglade | Purchase plants | Mid May | 40 × 20 | 40 + | 12.5 plants | Late Jun + |
| Everglade | Purchase plants | Mid Jun | 40 × 20 | 40 + | 12.5 plants | Early Aug + |
| Everglade | Purchase plants | Mid Jul | 40 × 20 | 50 + | 12.5 plants | Early Sep + |
| Everglade | Purchase plants | Mid Aug | 40 × 20 | 60 + | 12.5 plants | Mid Oct + |
| Everglade | Purchase plants | Mid Sept | 40 × 20 | 100 + | 12.5 plants | Jan + |
| **Cropping programme 2** | | | | | | |
| Erbette | Mid Feb | Early Apr | 20 × 20 | 50 + | 25 plugs | Late May + |
| Erbette | Mid Mar | Late Apr | 20 × 20 | 50 + | 25 plugs | Mid Jun + |
| Erbette | Mid Mar | Late Apr | 20 × 20 | 60 + | 25 plugs | Late Jun + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| Erbette | Early Apr | - | 20 × 4 | 70 + | 125 seeds | Mid Jun + |
| Erbette | Early Jun | - | 20 × 4 | 60 + | 125 seeds | Early Aug + |
| Everglade | Early Jul | - | 20 × 4 | 70 + | 125 seeds | Mid Sep + |
| Everglade | Mid Aug | Late Sep | 20 × 20 | 80 + | 25 plants | Jan + |
| **Cropping programme 3** | | | | | | |
| Everglade | Purchase plants | Early Feb | 40 × 15 | 70 + | 16.5 plants | Mid Apr + |
| Everglade | Purchase plants | Mid Apr | 40 × 15 | 60 + | 16.5 plants | Mid Jun + |
| Everglade | Purchase plants | Mid Aug | 40 × 15 | 70 + | 16.5 plants | Late Oct + |
| Everglade | Early Apr | - | 40 × 4 | 65 + | 60 seeds | Early Jun + |
| Everglade | Mid Apr | - | 40 × 4 | 60 + | 60 seeds | Late Jun + |
| Everglade | Early May | - | 40 × 4 | 55 + | 60 seeds | Early Jul + |
| Everglade | Late May | - | 40 × 4 | 55 + | 60 seeds | Late Jul + |
| Everglade | Mid Jun | - | 40 × 4 | 55 + | 60 seeds | Mid Aug + |
| Everglade | Late Jun | - | 40 × 4 | 60 + | 60 seeds | Early Sep + |
| Everglade | Mid Jul | - | 40 × 4 | 70 + | 60 seeds | Late Sep + |
| **Cropping programme 4** | | | | | | |
| Arcadia | Direct sow | - | - | 30-40 | - | - |
| Cherville | Direct sow | - | - | 30-40 | - | - |
| Yucon | Direct sow | - | - | 30-40 | - | - |
| Everglade | Early Feb | Late Mar | 12 × 12 | 50 + | 25 cells | Early May + |
| Everglade | Early Mar | Mid Apr | 12 × 12 | 50 + | 25 cells | Early Jun + |
| Erbette | Early May | Mid Jun | 20 × 20 | 50 + | 25 cells | Early Aug + |
| Everglade | Early Jun | Mid Jul | 20 × 20 | 60 + | 25 cells | Mid Sep + |
| Erbette | Early Jul | Mid Aug | 20 × 20 | 70 + | 25 cells | Late Oct + |
| Everglade | Late Jul | Mid Sep | 20 × 20 | 70 + | 25 cells | Early Dec + |
| **Cropping programme 5** | | | | | | |
| Renegade | Early Feb | - | - | 50 | 25-28 g | Late Mar + |
| Renegade | Early Mar | - | - | 45 | 25-28 g | Mid Apr + |
| Renegade | Early Apr | - | - | 40 | 25-28 g | Early May + |
| Renegade | Early May | - | - | 35 | 25-28 g | Early Jun + |
| Renegade | Early Jun | - | - | 35 | 25-28 g | Early Jul + |
| Renegade | Early Jul | - | - | 40 | 25-28 g | Early Aug + |
| Perpet. spin. | Aug | - | - | 55 | 10-12 g | Late Sep + |
| Perpet. spin. | Sep | - | - | 60 | 10-12 g | Late Oct + |
| **Cropping programme 6** | | | | | | |
| Erbette | Late Jan | Mid Mar | 12 × 12 | 45 + | 70 cells × 3-4 seeds | Early May + |
| Erbette | Late Feb | Mid Apr | 15 × 15 | 50 + | 45 cells × 3-4 seeds | Late May + |
| Erbette | Late Mar | Mid May | 15 × 15 | 50 + | 45 cells × 3-4 seeds | Late Jun + |
| Erbette | Late Apr | Mid Jun | 15 × 15 | 50 + | 45 cells × 3-4 seeds | Early Aug + |
| Erbette | Late May | Mid Jul | 15 × 15 | 50 + | 45 cells × 3-4 seeds | Early Sep + |
| Erbette | Late Jun | Late Aug | 15 × 15 | 65 + | 45 cells × 3-4 seeds | Early Nov + |
| Erbette | Mid Aug | Late Sep | 15 × 15 | 80 + | 45 cells × 3-4 seeds | Mid Dec + |
| Erbette | Late Aug | Mid Oct | 12 × 12 | 100 + | 45 cells × 3-4 seeds | Mid Jan + |
| **Cropping programme 7** | | | | | | |
| Erbette | Early Mar | Mid Apr | 30 × 15 | 45 + | 22 plugs × 4 seeds | Early Jun + |
| Erbette | Early Apr | Mid May | 30 × 15 | 40 + | 22 plugs × 4 seeds | Late Jun + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| Erbette | Early May | Mid Jun | 30 × 15 | 40 + | 22 plugs × 4 seeds | Early Aug + |
| Erbette | Early Jun | Mid Jul | 30 × 15 | 45 + | 22 plugs × 4 seeds | Early Sep + |
| Erbette | Early Jul | Mid Aug | 30 × 15 | 55 + | 22 plugs × 4 seeds | Early Oct + |
| Erbette | Mid Aug | Late Sep | 20 × 20 | 70 + | 25 plugs × 4 seeds | Dec-Jan + |
| Erbette | Mid Aug | Mid Oct | 20 × 20 | 85 + | 25 plugs × 4 seeds | Jan-Feb + |

### 3.11.2 Crop yields

The production of spinach increased from 6 t in 2019 to 8 t in 2020 (+33%).

### 3.11.3 Summary of key findings and recommendations

- True spinach crops can be sown outdoors from e.g., April until July. In warm weather, germination will occur in six to ten days. Bolting can more readily occur during warmer weather e.g., sowing in very warm late May, June and July. For continuity of supply, sow every 10 to 12 days. Protected crops of true spinach can be sown from e.g., mid-August until early September.
- Perpetual spinach can yield better than true spinach but may not be as tender. This crop can produce almost all year by transplanting both protected and outdoor crops and/or direct sowing outdoors when conditions allow. It can tolerate colder conditions both outdoors and under cover. Early planting outdoor will need to be covered with a fleece during colder weather. Perpetual spinach generally does not go to seed during warmer summer months like true spinach can. Outdoor sowing from September can be variable and dependent on soil and air temperatures. Some later sowings, e.g., autumn, may mature sufficiently for November/December. In other growing seasons, the same sowing times may not mature until January/February. Once outer leaves are a sufficient size, harvesting can commence. Harvest dates can vary depending on whether handpicking, cut and come again, or carrying out one overall harvest. Perpetual spinach harvested young can be sold as baby leaf. If the crop goes too mature, leaves can be cut to encourage fresh regrowth.
- Depending on crop scale and whether planting on a regular basis, accurate direct sowing can be achieved using e.g., a Stanhay air drill. A seeder such as Planet Jr. can be used but crop yields and quality and efficiency can be improved with a more precise seeder.
- Early spinach planting can be achieved by purchasing plants for protected cropping before subsequent transplanting and sowing of field crops. Protected crops can be planted in late August and early spring.
- For own-produced transplants, sow three to four seeds per block/module e.g., 216 tray. Some growers use four to five seeds per cell. Too many seedlings in a cell will lead to spindly weak plants.
- Irrigation is important for crop establishment and during the growing season.
- Transplanting into flat beds covered with black mulch film assists with weed control.
- Spinach has a requirement for boron, which may need to be applied before sowing and as a foliar feed depending on soil and leaf analysis results.
- Note that true spinach, in particular, can be susceptible to downy mildew during warm moist conditions or when planted at higher density.

## 3.12 Organic tomato production area and cultivars

The total organic tomato production area for growers in the MOPS project was 0.18 ha in 2019 and 0.13 ha in 2020. Figure 13 gives a breakdown of the 2020 tomato production area by cultivar. Seven MOPS growers produced tomatoes in 2019, and again in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois and Wexford. Important market outlets are direct selling (box delivery, farmers markets, farmgate) and restaurants. Examples of tomato cropping programmes for MOPS growers are shown in Table 12.

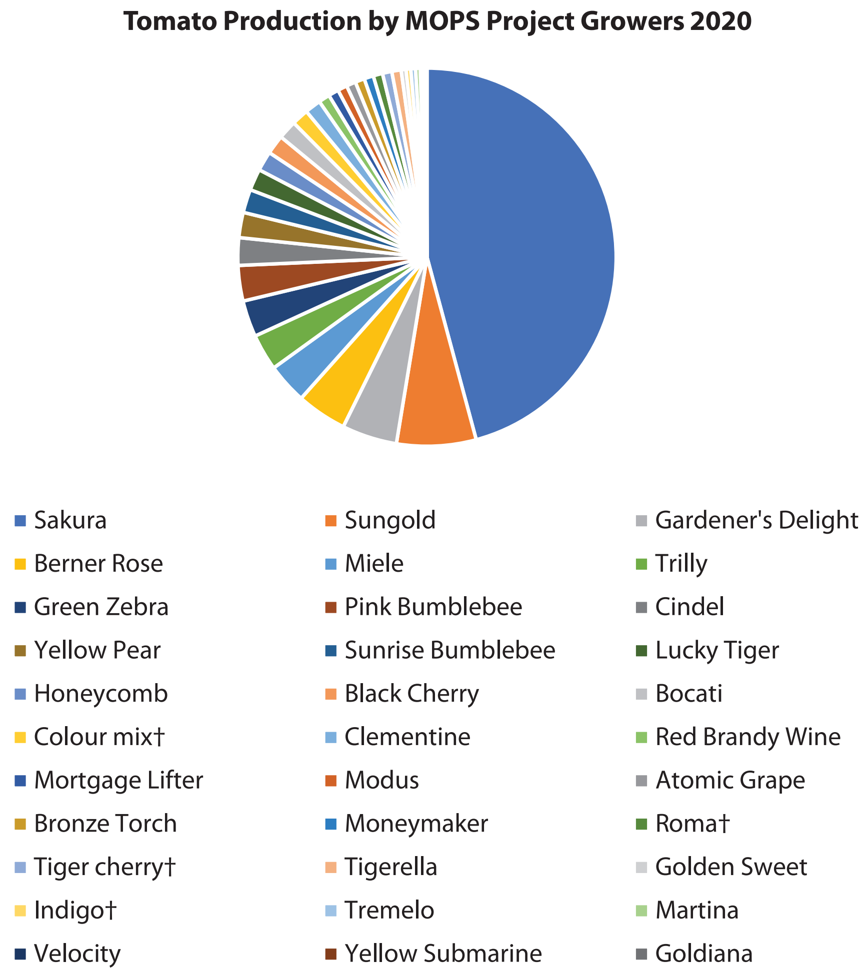



*Figure 13 Tomato production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 13.12.1 Cropping programmes

**Table 12 Example tomato cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Sakura | Mid Feb | Mid May | 45 × 45 | 75 + | 5 plants | Mid Jul |
| Sungold | Mid Feb | Mid May | 45 × 45 | 80 + | 5 plants | Late Jul |
| Blue | Mid Feb | Mid May | 45 × 45 | 80 + | 5 plants | Late Jul |
| Bocati | Mid Feb | Mid May | 45 × 45 | 85 + | 5 plants | Late Jul |
| Pink Bumblebee | Mid Feb | Mid May | 45 × 45 | 80 + | 5 plants | Late Jul |
| Roma | Mid Feb | Mid May | 45 × 45 | 80 + | 5 plants | Late Jul |
| Miele | Mid Feb | Mid May | 45 × 45 | 80 + | 5 plants | Late Jul |
| Violet | Mid Feb | Mid May | 45 × 45 | 80 + | 5 plants | Late Jul |
| **Cropping programme 2** | | | | | | |
| Sakura | Purchase plants | Early May | 45 × 45 | 80 + | 3 plants | Late Jul + |
| Sakura | Purchase plants | Mid May | 45 × 45 | 75 + | 3 plants | Early Aug + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 3** | | | | | | |
| Modus | Late Feb | Mid May | 50 × 50 | 75 + | 2 plants | Late Jul + |
| Sakura | Mid Feb | Mid May | 50 × 50 | 75 + | 2 plants | Late Jul + |
| Miele | Mid Feb | Mid May | 50 × 50 | 75 + | 2 plants | Late Jul + |
| Sungold | Mid Feb | Mid May | 50 × 50 | 75 + | 2 plants | Late Jul + |
| Blue/black | Mid Feb | Mid May | 50 × 50 | 75 + | 2 plants | Late Jul + |
| Golden Sweet | Mid Feb | Mid May | 50 × 50 | 75 + | 2 plants | Late Jul + |
| Indigo | Mid Feb | Mid May | 50 × 50 | 75 + | 2 plants | Late Jul + |
| **Cropping programme 4** | | | | | | |
| Cindel | Early Mar | Mid May | 60 × 45 | 75 + | 3.7 plants | Early Jul + |
| Sakura | Early Mar | Mid May | 60 × 45 | 70 + | 3.7 plants | Late Jun + |
| **Cropping programme 5** | | | | | | |
| Martina | Early Mar | Mid May | 65 × 50 | 80 + | 2 plants | Late Jul |
| Cindel | Early Mar | Mid May | 65 × 50 | 85 + | 2 plants | Late Jul |
| Green Zebra | Early Mar | Mid May | 65 × 50 | 90 + | 2 plants | Early Aug |
| Clementine | Early Mar | Mid May | 65 × 50 | 80 + | 2 plants | Late Jul |
| Yellow Submarine | Early Mar | Mid May | 65 × 50 | 80 + | 2 plants | Late Jul |
| Gardener's Delight | Early Mar | Mid May | 65 × 50 | 80 + | 2 plants | Late Jul |
| Goldiana | Early Mar | Mid May | 65 × 50 | 80 + | 2 plants | Late Jul |
| Black Cherry | Early Mar | Mid May | 65 × 50 | 85 + | 2 plants | Late Jul |
| Velocity | Early Mar | Mid May | 65 × 50 | 90 + | 2 plants | Early Aug |
| Berner Rose | Early Mar | Mid May | 65 × 50 | 85 + | 2 plants | Late Jul |
| **Cropping programme 6** | | | | | | |
| Sakura | Late Feb | Mid May | 70 × 55 | 75 + | 4 plants | Mid Jul + |
| Sungold | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Trilly | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Pink Bumblebee | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Sunrise Bumblebee | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Lucky Tiger | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Black Cherry | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Bronze Torch | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Miele | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Atomic Grape | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Tiger cherry | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |
| Purple Bumblebee | Late Feb | Mid May | 70 × 55 | 80 + | 4 plants | Late Jul + |

### 3.12.1 Crop yields

The production of tomatoes was 7 t in 2019 and 6 t in 2020 (-14%).

### 3.12.2 Summary of key findings and recommendations

- Tomatoes can be sown in late January/early February. Single seeds can be planted into black module trays, e.g., 77, 96 and/or 150 cells, until they are approximately 8-10 cm in height before being transplanted to individual 9 cm pots, following which they can be planted out in e.g., mid to late May. Some earlier plantings can be exposed to an unexpected late frost and consequently struggle to give a worthwhile yield. It is very important that tomatoes do not get checked by cold weather during propagation and it is essential to protect seedlings and plants by having a heated bench or other method of giving frost protection. For example, crop fleece can be used in the event of a sudden drop in temperatures. Avoid planting into an unheated polythene tunnel before mid-May.

- The nutrition of the tomato crop is generally supplied with well composed farmyard manure guided by soil analysis results.
- Tomato crops are labour intensive e.g., training and harvesting.
- Harvesting of tomatoes in late autumn can prevent the planting of early winter salads e.g., spinach, lettuce and winter purslane. To maximise yield of late tomatoes and to facilitate the planting of the winter crops underneath, cut off the top 60-70 cm of each tomato plant and hang the vines across the growing wires.

## 3.13 Organic Brussels sprout production area and cultivars

The total organic Brussels sprout production area for growers in the MOPS project was 1.04 ha in 2019 and 1.57 ha in 2020. Figure 14 shows a breakdown of the 2020 Brussels sprout production area by cultivar. Six MOPS growers produced Brussels sprouts in 2019, the same number again in 2020 in counties Galway, Kildare, Wexford and Wicklow. Key market outlets are supermarkets and direct selling (box delivery, farmers markets, farmgate). Examples of Brussels sprout cropping programmes for MOPS growers are shown in Table 13.

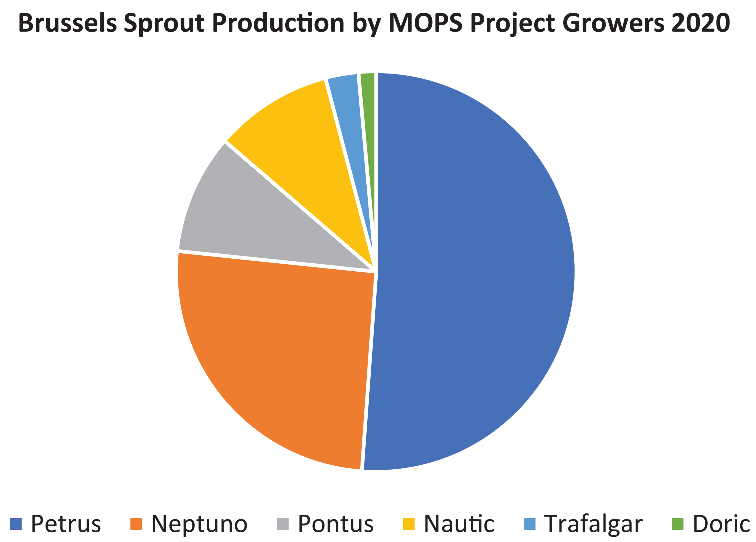



***Figure 14 Brussels sprout production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.13.1 Cropping programmes

**Table 13 Example Brussels sprout cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Neptuno | Late Mar | Late May | 75 × 40 | 180 + | 3.3 plants | Late Nov + |
| Pontus | Mid Mar | Mid May | 75 × 40 | 210 + | 3.3 plants | Mid Dec + |
| Petrus | Mid Mar | Mid May | 75 × 45 | 235 + | 3 plants | Mid/late Dec + |
| Petrus | Late Mar | Late May | 75 × 45 | 250 + | 3 plants | Jan + |
| **Cropping programme 2** | | | | | | |
| Neptuno | Purchase plants | Mid May | 75 × 50 | 185 + | 2.6 plants | Mid Nov + |
| Petrus | Purchase plants | Mid May | 75 × 50 | 210 + | 2.6 plants | Late Nov + |
| Nautic | Purchase plants | Mid May | 75 × 60 | 225 + | 2.2 plants | Mid/late Dec + |
| **Cropping programme 3** | | | | | | |
| Neptuno | Early Mar | Early May | 70 × 55 | 180 + | 2.5 plants | Early Nov+ |
| Trafalgar | Late Mar | Mid May | 70 × 55 | 190 + | 2.5 plants | Late Nov + |
| Petrus | Late Mar | Mid May | 70 × 55 | 210 + | 2.5 plants | Mid/late Dec + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 4** | | | | | | |
| Neptuno | Purchase plants | Mid Apr | 80 × 40 | 180 + | 3.1 plants | Mid Oct + |
| Pontus | Purchase plants | Mid May | 80 × 38 | 200 + | 3.3 plants | Mid Nov + |
| Petrus | Purchase plants | Mid May | 80 × 38 | 230 + | 3.3 plants | Dec + |
| Petrus | Purchase plants | Early Jun | 80 × 40 | 250 + | 3.1 plants | Late Jan + |
| Splendus | Purchase plants | Early Jun | 80 × 40 | 270 + | 3.1 plants | Feb + |

#### 3.13.2 Crop yields

The production of Brussels sprouts was 9 t and 321 units in 2019, and 11 t (+22%) and 146 units (-55%) in 2020.

#### 3.13.3 Summary of key findings and recommendations

- Brussels sprouts benefit from free draining heavier soil. It is very important that overwintered Brussels sprouts have a strong fibrous root system that can absorb the required nutrients and also help with good anchorage to support against crop lodging, which can lead to considerable waste. Brussels sprouts will not give a satisfactory yield if the roots are limited by a lack of air due to saturated soil.
- This crop works very well in a cropping plan as the harvesting normally commences when other crops are finishing e.g., scallions, onions and celery. Good yields are achievable through cultivar selection, correct spacings, nutrition including top dressing with nitrogen, foliar feeding, slug control and multiple hand pickings when buttons are sufficiently mature.
- Cultivars like Neptuno and Petrus are more productive than other cultivars and can supply quality buttons from October to February. Both are also less susceptible to leaf diseases e.g., Alternaria. Neptuno should be picked when 8-10 buttons at the base are mature. Petrus gives great quality at Christmas.
- Using a transplanter such as the Checchi & Magli module transplanter is very important in getting this crop established uniformly as it is accurate in both depth of planting and plant distance within the row.
- Brussels sprouts have a high requirement for good nutrition. It is important to apply the necessary base dressing of organic manures and also supplementary topdressing of nitrogen (e.g., chicken manure pellets). Additional foliar applications of boron and other trace elements can also be applied.
- It is vital to monitor for various pests, especially early infestation of aphids. Field slugs can contribute to high waste levels, especially in wetter areas with soil organic matter. Apply slug pellets at the appropriate times. Where brassica leaf diseases are a problem, wider 75 cm rows and wider spacings (45 cm in row) can greatly reduce the waste generated by black rots.
- Harvesting the lower buttons on the plant when the size is approximately 30 to 35 mm in diameter is very important in reducing waste and increasing crop yield and quality. The cultivar Neptuno normally gets three separate harvestings i.e., in October 10 percent of the crop, Christmas 70 percent and late January 20 percent. Petrus can be harvested on two occasions i.e., at Christmas 70 percent and February 30 percent.
- Poorer yields can occur due to either the wrong choice of cultivar or, more importantly, possibly planting too late. Understanding the days from planting to 50 percent crop maturity is important.
- Good weed control can be achieved using various interrow cultivators, similar to other brassica crops. The wider 75 cm spacing between rows can make weed management easier. This crop also benefits from a final ridging up of soil, which both helps with weed control and anchorage of the roots to prevent lodging during strong winds.

## 3.14 Organic celery production area and cultivars

The total organic celery production area for growers in the MOPS project was 0.13 ha in 2019 and 3.37 ha in 2020. Figure 15 provides a breakdown of the 2020 celery production area by cultivar. Five MOPS growers produced celery in 2019, six growers in 2020 in counties Galway, Kildare, Wexford and Wicklow. Key market outlets are direct selling (box delivery, farmers markets, farmgate) and supermarket/retailers. Examples of celery cropping programmes for MOPS growers are shown in Table 14.

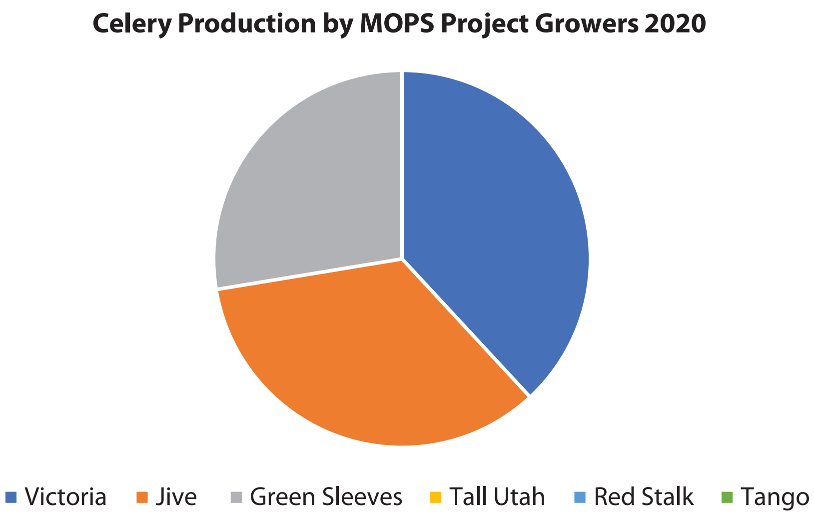



*Figure 15 Celery production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.14.1 Cropping programmes

**Table 14 Example celery cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m$^2$ | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Frevo | Early Feb | Mid Apr | 30 × 25 | 90 + | 13 plants | Mid Jul + |
| Frevo | Mid Feb | Late Apr | 30 × 25 | 85 + | 13 plants | Late Jul + |
| Frevo | Mid Mar | Late May | 30 × 25 | 75 + | 13 plants | Mid Aug + |
| Frevo | Mid Apr | Late Jun | 30 × 25 | 80 + | 13 plants | Mid Sep + |
| Green Sleeves | Mid May | Late Jul | 30 × 25 | 95 + | 13 plants | Early Nov + |
| Green Sleeves | Mid May | Mid Aug | 30 × 25 | 105 + | 13 plants | Early Dec + |
| **Cropping programme 2** | | | | | | |
| Jive | Purchase plants | Mid Apr | 30 × 30 | 85 + | 11 plants | Early Jul + |
| Jive | Purchase plants | Mid May | 30 × 30 | 90 + | 11 plants | Mid Aug + |
| Jive | Purchase plants | Early Jun | 30 × 30 | 95 + | 11 plants | Mid Aug+ |
| Green Sleeves | Purchase plants | Mid Jun | 30 × 30 | 100 + | 11 plants | Mid Oct-Dec |
| Green Sleeves | Purchase plants | Mid Jul | 30 × 30 | 130 + | 11 plants | Mid/late Dec |
| **Cropping programme 3** | | | | | | |
| Victoria | Mid Feb | Late Apr | 30 × 30 | 90 + | 11 plants | Late Jul + |
| Victoria | Mid Feb | Early May | 30 × 30 | 110 + | 11 plants | Early Aug + |
| Victoria | Mid Mar | Early Jun | 30 × 30 | 110 + | 11 plants | Late Aug + |
| Victoria | Mid Apr | Mid Jun | 30 × 30 | 120 + | 11 plants | Late Sep + |
| Victoria | Mid May | Early Jul | 30 × 30 | 120 + | 11 plants | Late Oct + |
| Victoria | Late May | Late Jul | 30 × 30 | 120 + | 11 plants | Dec + |
| **Cropping programme 4** | | | | | | |
| Frevo | Early Mar | Mid May | 55 × 20 | 85 + | 9 plants | Early Aug + |
| Frevo | Early Apr | Mid Jun | 55 × 20 | 90 + | 9 plants | Early Sep + |
| Frevo | Early May | Mid Jul | 55 × 20 | 100 + | 9 plants | Mid Oct + |
| Frevo | Early May | Late Jul | 55 × 20 | 110 + | 9 plants | Nov + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 5** | | | | | | |
| Tango | Late Jan | Mid Apr | 38 × 30 | 85 + | 8.8 plants | Mid Jul + |
| Tango | Early Mar | Mid May | 38 × 30 | 80 + | 8.8 plants | Mid Aug + |
| Tango | Early Apr | Mid Jun | 38 × 30 | 85 + | 8.8 plants | Mid Sep + |
| Green Sleeves | Early May | Mid Jul | 38 × 30 | 95 + | 8.8 plants | Mid Oct + |
| Green Sleeves | Late May | Early Aug | 38 × 30 | 100 + | 8.8 plants | Mid Nov + |
| **Cropping programme 6** | | | | | | |
| Victoria | Purchase plants | Late Apr | 35 × 30 | 90 + | 9.5 plants | Early Aug + |
| Victoria | Purchase plants | Late May | 35 × 30 | 85 + | 9.5 plants | Late Aug + |
| Victoria | Purchase plants | Late Jun | 35 × 30 | 95 + | 9.5 plants | Early Oct + |
| Victoria | Purchase plants | Mid Jul | 35 × 30 | 110 + | 9.5 plants | Mid Nov + |
| Green Sleeves | Purchase plants | Mid Jul | 35 × 30 | 120 + | 9.5 plants | Mid Nov + |
| Green Sleeves | Purchase plants | Late Jul | 30 × 25 | 130 + | 16.6 plants | Mid/late Dec |
| **Cropping programme 7** | | | | | | |
| Victoria | Late Jan | Mid Apr | 30 × 25 | 85 + | 13 plants | Mid Jul + |
| Victoria | Late Jan | Mid Apr | 30 × 30 | 95 + | 11 plants | Early Aug |
| Victoria | Mid Feb | Early May | 30 × 30 | 90 + | 11 plants | Mid Aug |
| Victoria | Mid Mar | Early Jun | 30 × 30 | 95 + | 11 plants | Mid Sep |
| Victoria | Mid Apr | Early Jul | 30 × 30 | 100 + | 11 plants | Early Oct |
| Victoria | Early May | Mid Jul | 30 × 30 | 110 + | 11 plants | Early Nov |

### 3.14.2 Crop yields

The production of celery increased from 10,377 units in 2019 to 27,728 units in 2020 (+167%).

### 3.14.3 Summary of key findings and recommendations

- Both field and protected celery crops can be successfully grown by ensuring that this crop gets the proper nutrition, irrigation and weed control. Irrigation is important, especially for protected crops. Celery yields will not be sufficient to cover the growing and management costs if weed control is poor, too little irrigation is applied and also a lack of applications for control of celery leaf spot. There is a good market for celery but the crop has high establishment costs and demands for irrigation and labour.
- It is important that beds are prepared well in advance of planting to eliminate weeds as much as possible. Weed management is achieved using the stale seedbed technique or gas burning before planting. Weeding mechanically post planting is very difficult due to the close distances between plants, e.g., 30 × 30 cm, but it is important to plant at these close spacings in order to get long petioles and self-blanching. If planting distances are too wide the crop grows to a bushy shape rather than the preferred erect long head.
- The first planting, e.g., in April, can be a protected crop, with the balance being planted outdoor from mid-May after risk of frost has passed. It may be necessary to cover with fleece if cold wind is forecast, which can lead to bolting.
- Plantings from April to mid-July can give a consistent supply of crop from early August to mid-November. The choice of cultivars with good vigour, strong disease resistance and cold tolerance to light frosts in October and November gives a high percentage crop harvest. Planting through black mulch film can control weeds and reduces labour for weeding. It also leaves the base of the plant clean of soil, which eliminates the need for washing or cleaning.
- Celery can benefit from heavy dressings of farmyard manure as it helps to hold moisture in the soil. It also produces strong uniform growth, which encourages root development and greatly reduces stress and waste. Celery has a high requirement for both boron and calcium. Boron deficiency causes 'cat claw', and brown heart is due to calcium deficiency. Apply sufficient boron in the base dressing and foliar boron and calcium.
- Wet conditions can make the control of celery leaf spot extremely difficult. Controlling Septoria leaf diseases by regular applications of plant stimulants and foliar nutrients is key to achieving very good quality with reduced crop losses and waste.

## 3.15 Organic onion production area and cultivars

The total organic onion production area for growers in the MOPS project was 0.2 ha in 2019 and 0.38 ha in 2020. Figure 16 shows a breakdown of the 2020 onion production area by cultivar. Eight MOPS growers produced onions in 2019, three growers in 2020 in counties Cork, Galway and Wexford. Important market outlets are supermarkets/retailers, direct selling (box delivery, farmers markets, farmgate) and restaurants. Examples of onion cropping programmes for MOPS growers are shown in Table 15.

**Onion Production by MOPS Project Growers 2020**

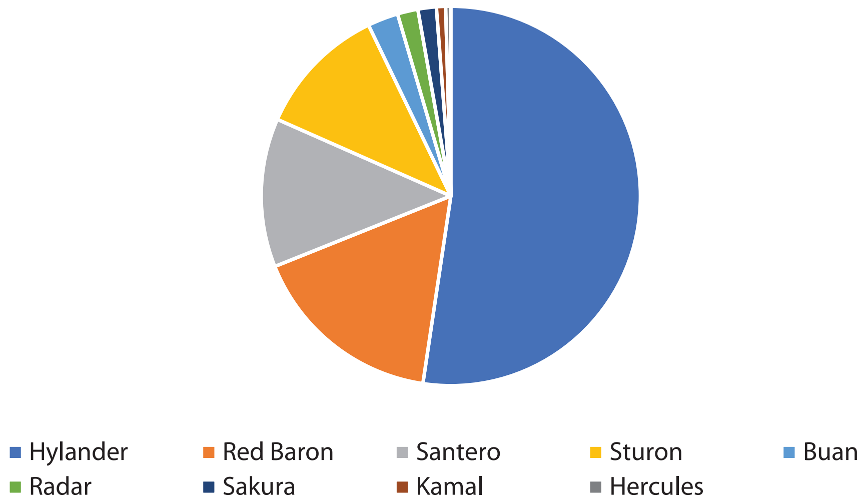



***Figure 16 Onion production by MOPS project growers in 2020. C ultivars listed largest to smallest cropping area.***

### 3.15.1 Cropping programmes

**Table 15 Example onion cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Hercules | - | Early Apr | 40 × 3 | 100 + | 83 sets | Mid Jul + |
| Red Baron | - | Early Apr | 40 × 3 | 110 + | 83 sets | Late Jul + |
| Troy | - | Oct | 40 × 3 | 180 + | 83 sets | May + |
| Hylander | Mid Feb | Mid Apr | 40 × 15 | 100 + | 16 cells × 5-6 seeds | Mid Aug + |
| Red Baron | Mid Feb | Mid Apr | 40 × 15 | 120 + | 16 cells × 5-6 seeds | Late Aug + |
| Redspark | Mid Feb | Mid Apr | 40 × 15 | 130 + | 16 cells × 5-6 seeds | Early Sep + |
| **Cropping programme 2** | | | | | | |
| Sturon | - | Mid Mar | 30 × 5 | 100 + | 66 sets | Late Jun + |
| Kamal | - | Mid Mar | 30 × 5 | 100 + | 66 sets | Early Jul + |
| **Cropping programme 3** | | | | | | |
| Hylander | Purchase plants | Mid Apr | 40 × 20 | 80 + | 12.5 plants | Early Jul + |
| Rossa Da Inverno Sel Rubino | | Purchase plants | | Early Apr | 40 × 20 | 75 + 12.5 |
| plants | Early Jul + | | | | | |
| **Cropping programme 4** | | | | | | |
| Sturon | - | Late Mar | 20 × 20 | 90 + | 25 sets | Early Jul |
| Hylander | Late Jan | Late Mar | 20 × 20 | 120 + | 25 plugs | Early Aug + |
| Red Baron | Late Jan | Late Mar | 20 × 20 | 120 + | 25 plugs | Early Aug + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 5** | | | | | | |
| Forum | - | Early Apr | 55 × 3 | 120 + | 61 sets | Mid Aug + |
| Red Baron | - | Early Apr | 55 × 3 | 120 + | 61 sets | Mid Aug + |
| Hybing | Early Apr | - | - | 150 + | 72 seeds | Early Sep + |
| Redspark | Early Apr | - | - | 170 + | 72 seeds | Late Sep + |
| **Cropping programme 6** | | | | | | |
| Hylander | Early Feb | Early Apr | 38 × 15 | 135 + | 17.5 plants | Mid Aug + |
| Red Baron | Early Feb | Early Apr | 38 × 15 | 140 + | 17.5 plants | Mid Aug + |
| Kosma | Early Feb | Early Apr | 38 × 15 | 140 + | 17.5 plants | Mid Aug + |
| **Cropping programme 7** | | | | | | |
| Hercules | | Early Apr | 40 × 4 | 100 + | 62 sets | Mid Jul + |
| Hylander | Purchase plants | Mid Apr | 40 × 15 | 120 + | 16.7 plants | Mid Aug+ |
| Hystore | Purchase plants | Mid Apr | 40 × 15 | 150 + | 16.7 plants | Mid Sep + |
| Red Baron | Purchase plants | Mid Apr | 40 × 15 | 140 + | 16.7 plants | Early Sep + |
| **Cropping programme 8** | | | | | | |
| Stur B.C. | | Early Apr | 30 × 8 | 85 + | 42 sets | Late Jun + |
| Hylander | Early Feb | Mid Apr | 30 × 10 | 115 + | 33 plugs | Mid Aug + |
| Red Baron | Early Feb | Mid Apr | 30 × 10 | 120 + | 33 plugs | Late Aug + |

### 3.15.2 Crop yields

The production of onions increased from 7 t and 1,737 units in 2019 to 15 t (+114%) and 3,370 units (+94%) in 2020.

### 3.15.3 Summary of key findings and recommendations

- Early crops of onions can be grown from onion sets, whilst the main crop and late storing types can be grown from module raised transplants e.g., sown in early February and planted out from mid-April.
- Planting at the appropriate time in early spring, combined with the use of black mulch film can ensure early harvesting in the late summer with very good skin colour and fewer blemishes. Delayed planting time and poor crop establishment, e.g., in the dry weather, can impact bulb size. Irrigation helps with crop establishment when required. Crop competition from late germinating annual weeds can also contribute to the poor performance.
- Onion sets are planted to achieve earlier harvest but not for late storage. Ideally sets need to be planted in late March or early April to give early maturing bulbs in August. Crops can be planted into black biodegradable film to reduce the labour required in hand weeding and to retain good soil temperatures and moisture.
- For transplants, onion seed is sown into large module cells with four to six seeds per cell which produces multi seeded plants. Three to four seeds can be sown per module cell if large onions are required for a market. Sowing trays indoors on warm benches produces quick even emergence. Plants can then be left in a polytunnel for eight weeks before being planted in early April. Planting multi seeded cells at approximately 33 cells per square metre gives a bulb size of 50-80 mm. Transplanted crops can be planted into black mulch film covered flat beds that are slightly raised. A Samco film layer, for example, can be used for laying the biodegradable film on beds. Transplants are planted through the film using a specialised transplanter, which neatly punches a hole before placing the module into the soil. It is important to ensure that the module is barely covered by the soil.
- Direct sown crops require extra weeding.
- Maturity after planting takes approximately 120 to 140 days depending on cultivar and prevailing weather. The days to maturity are when 50 percent of the top foliage is beginning to go down. Onion sets mature approximately 50 days earlier than direct sown seed but may not keep as well if being stored in an ambient store.

- Large onions can be handpicked earlier if crops can be marketed with green tops or if a customer wants bulbs with green leaves attached.
- For stored onions, it is very important that the onions are harvested dry before being put into late storage.
- Drying and curing can be agreed with a third party to increase saleable yield and extend the season by e.g., two months.

## 3.16 Organic cauliflower production area and cultivars

The total organic cauliflower production area for growers in the MOPS project was 1.68 ha in 2019 and 2.66 ha in 2020. Figure 17 shows a breakdown of the 2020 cauliflower production area by cultivar. Nine MOPS growers produced cauliflower in 2019, six growers in 2020 in counties Galway, Kildare, Kilkenny, Laois and Wexford. Key market outlets are supermarkets/retailers and direct selling (box delivery, farmers markets, farmgate). Examples of cauliflower cropping programmes for MOPS growers are shown in Table 16.

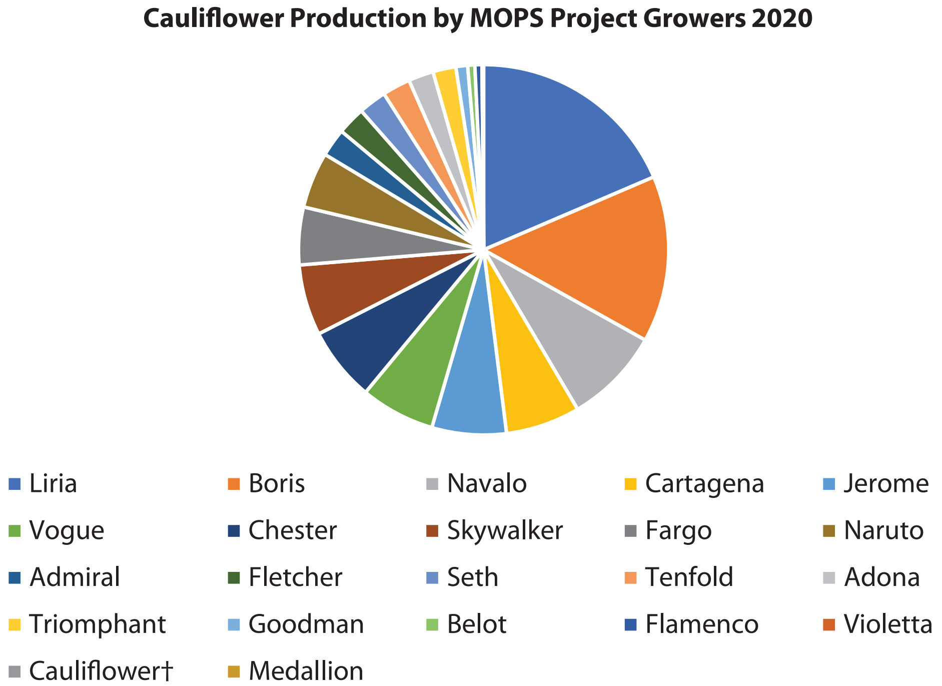



*Figure 17 Cauliflower production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.16.1 Cropping programmes

**Table 16 Example cauliflower cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Liria | Late Feb | Mid Apr | 55 × 50 | 85 + | 3.5 plants | Mid Jul + |
| Liria | Early Mar | Late Apr | 55 × 50 | 85 + | 3.5 plants | Late Jul + |
| Liria | Late Mar | Early May | 55 × 50 | 80 + | 3.5 plants | Early Aug + |
| Liria | Early Apr | Mid May | 55 × 50 | 80 + | 3.5 plants | Mid Aug + |
| Liria | Mid Apr | Late May | 55 × 50 | 80 + | 3.5 plants | Late Aug + |
| Liria | Late Apr | Early Jun | 55 × 50 | 80 + | 3.5 plants | Early Sep + |
| Skywalker | Early May | Mid Jun | 55 × 50 | 90 + | 3.5 plants | Mid Sep + |
| Benidorm | Late May | Early Jul | 55 × 55 | 125 + | 3.2 plants | Early Nov + |
| Skywalker | Early Jun | Mid Jul | 55 × 55 | 95 + | 3.2 plants | Mid Oct + |
| Benidorm | Early Jun | Late Jul | 55 × 55 | 125 + | 3.2 plants | Late Nov + |
| Navalo | Early Jun | Late Jul | 55 × 55 | 135 + | 3.2 plants | Early Dec + |
| Triomphant | Early Jun | Late Jul | 55 × 60 | 145 + | 3 plants | Mid/Late Dec |
| Belot | Early Jun | Late Jul | 55 × 60 | 155 + | 3 plants | Mid/Late Dec |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 2** | | | | | | |
| Adona | Mid Feb | Mid Apr | 55 × 55 | 75 + | 3.3 plants | Early Jul + |
| Liria | Mid Feb | Mid Apr | 55 × 55 | 80 + | 3.3 plants | Early Jul + |
| Boris | Mid Feb | Mid Apr | 55 × 55 | 90 + | 3.3 plants | Mid Jul + |
| Adona | Early Mar | Late Apr | 55 × 55 | 75 + | 3.3 plants | Mid Jul + |
| Liria | Early Mar | Late Apr | 55 × 55 | 80 + | 3.3 plants | Late Jul + |
| Boris | Early Mar | Late Apr | 55 × 55 | 90 + | 3.3 plants | Late Jul + |
| Liria | Mid Mar | Early May | 55 × 50 | 75 + | 3.6 plants | Early Aug + |
| Boris | Mid Mar | Early May | 55 × 50 | 80 + | 3.6 plants | Early Aug + |
| Fargo | Mid Mar | Early May | 55 × 50 | 90 + | 3.6 plants | Early Aug + |
| Liria | Late Mar | Mid May | 55 × 50 | 75 + | 3.6 plants | Mid Aug + |
| Boris | Late Mar | Mid May | 55 × 50 | 80 + | 3.6 plants | Mid Aug + |
| Fargo | Late Mar | Mid May | 55 × 50 | 90 + | 3.6 plants | Mid Aug + |
| Liria | Early Apr | Late May | 55 × 50 | 75 + | 3.6 plants | Late Aug + |
| Boris | Early Apr | Late May | 55 × 50 | 80 + | 3.6 plants | Late Aug + |
| Fargo | Early Apr | Late May | 55 × 50 | 90 + | 3.6 plants | Late Aug + |
| Liria | Mid Apr | Early Jun | 55 × 50 | 80 + | 3.6 plants | Early Sep + |
| Boris | Mid Apr | Early Jun | 55 × 50 | 85 + | 3.6 plants | Early Sep + |
| Fargo | Mid Apr | Early Jun | 55 × 50 | 95 + | 3.6 plants | Early Sep + |
| Liria | Late Apr | Mid Jun | 55 × 50 | 80 + | 3.6 plants | Mid Sep + |
| Boris | Late Apr | Mid Jun | 55 × 50 | 85 + | 3.6 plants | Mid Sep + |
| Fargo | Late Apr | Mid Jun | 55 × 50 | 95 + | 3.6 plants | Mid Sep + |
| Skywalker | Early May | Late Jun | 55 × 55 | 95 + | 3.6 plants | Late Aug + |
| Naruto | Early May | Late Jun | 55 × 55 | 110 + | 3.6 plants | Mid Sep + |
| Navalo | Early May | Late Jun | 55 × 55 | 125 + | 3.6 plants | Late Sep + |
| Skywalker | Mid May | Early Jul | 55 × 55 | 95 + | 3.6 plants | Early Oct + |
| Naruto | Mid May | Early Jul | 55 × 55 | 110 + | 3.6 plants | Mid Oct + |
| Navalo | Mid May | Early Jul | 55 × 55 | 125 + | 3.6 plants | Late Oct + |
| Tenfold | Late May | Mid Jul | 55 × 55 | 280 + | 3.6 plants | Mid Apr + |
| Admiral | Late May | Mid Jul | 55 × 55 | 290 + | 3.6 plants | Late Apr + |
| Fletcher | Late May | Mid Jul | 55 × 55 | 300 + | 3.6 plants | Early May + |
| Seth | Late May | Mid Jul | 55 × 55 | 310 + | 3.6 plants | Mid May + |
| **Cropping programme 3** | | | | | | |
| Goodman | Late Feb | Mid Apr | 80 × 40 | 80-130 | 3.1 plants | Mid Jul-mid Aug |
| Snowman | Late Feb | Mid Apr | 80 × 40 | 75-120 | 3.1 plants | Mid Jul-mid Aug |
| Goodman | Late Apr | Mid Jun | 80 × 40 | 80-130 | 3.1 plants | Mid Aug-mid Sep |
| Snowman | Late Apr | Mid Jun | 80 × 40 | 75-120 | 3.1 plants | Mid Aug-mid Sep |
| Skywalker | Late Apr | Mid Jun | 80 × 45 | 95 + | 2.8 plants | Late Sep + |
| Skywalker | Early May | Early Jul | 80 × 45 | 105 + | 2.8 plants | Mid Oct + |
| Belot | Early May | Early Jul | 80 × 50 | 150 + | 2.5 plants | Early-late Dec |
| **Cropping programme 4** | | | | | | |
| Paciano | Purchase plants | Late Jun | 60 × 80 | 150 + | 2.1 plants | Mid Jan + |
| Baterno | Purchase plants | Late Jun | 60 × 80 | 165 + | 2.1 plants | Early Feb + |
| Medallion | Purchase plants | Mid Jul | 60 × 80 | 180 + | 2.1 plants | Late Feb + |
| Gerona | Purchase plants | Mid Jul | 60 × 80 | 190 + | 2.1 plants | Early Mar + |
| Tempest | Purchase plants | Mid Jul | 60 × 80 | 200 + | 2.1 plants | Late Mar |
| Carantic | Purchase plants | Mid Jul | 60 × 80 | 220 + | 2.1 plants | Late Mar |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| Vogue | Purchase plants | Mid Jul | 60 × 80 | 240 + | 2.1 plants | Early Apr |
| Jerome | Purchase plants | Mid Jul | 60 × 80 | 230 + | 2.1 plants | Late Mar + |
| Chester | Purchase plants | Mid Jul | 60 × 80 | 250 + | 2.1 plants | Mid Apr + |
| Fletcher | Purchase plants | Mid Jul | 60 × 80 | 255 + | 2.1 plants | Apr + |
| Tenfold | Purchase plants | Mid Jul | 60 × 80 | 265 + | 2.1 plants | Apr + |
| Cartagena | Purchase plants | Mid Jul | 60 × 80 | 275 + | 2.1 plants | Mid May + |
| **Cropping programme 5** | | | | | | |
| Telde | Mid May | Early Jul | 75 × 50 | 100 + | 2.7 plants | Mid Oct + |
| Benidorm | Mid May | Early Jul | 75 × 50 | 125 + | 2.7 plants | Early Nov + |
| Telde | Late May | Mid Jul | 75 × 50 | 105 + | 2.7 plants | Late Oct + |
| Benidorm | Late May | Mid Jul | 75 × 50 | 130 + | 2.7 plants | Late Nov + |

### 3.16.2 Crop yields

The production of cauliflower increased from 18,833 units in 2019 to 36,297 units (+93%) in 2020.

### 3.16.3 Summary of key findings and recommendations

- Cauliflower plants can be raised in 308 module trays, which are generally planted out six to seven weeks after sowing. Sowing commences in mid-February and finishes in early June. Seven to eight sowings are made every 10 to 14 days. Planting normally commences in mid-April with the last planting completed in July.
- Nutrition can be supplied by adequate quantities of both poultry and farmyard manure, which are well composed and applied accurately with a dung spreader. Application rates depend on the soil analysis results. Planting can be carried out with a two row Checchi & Magli module planter.
- Depending on market specification, cauliflowers can be harvested when curds have achieved a head size of approximately 12-14 cm in diameter with 8-10 cm of foliage left above the curd.
- Good crop yields and quality is based on the suitability of soils with adequate levels of available nutrients, especially nitrogen, cultivar selection, and irrigation at the crop establishment stage.
- Cauliflower crops need much more attention to nutrition, irrigation, and general crop maintenance than most other brassica crops and as a result can be challenging to achieve returns from. Yields and quality can be impacted by pests e.g., cabbage root fly, aphids, caterpillars and leatherjackets. The crop also demands more attention to irrigation during long dry spells in summer and can be susceptible to minor nutrient deficiencies. Growers have found that where nutrition is applied in the form of farmyard manure, nutrient deficiencies can be less of an issue compared to when only using top dressing of nutrients in the form of poultry manure pellets, ground rock phosphate and potash. Insufficient leaf canopy results in smaller, slightly loose curds with a poorer colour. In addition, poor weed control and cold late autumn temperatures can impact yields.
- In general, cauliflower crops may need more frequent irrigation where soils have rapid drainage and high rates of nutrient leaching. Nitrogen and boron deficiencies have an adverse effect on both yield and quality.

## 3.17 Organic courgette production area and cultivars

The total organic courgette production area for growers in the MOPS project was 0.43 ha in 2019 and 0.17 ha in 2020. Figure 18 provides a breakdown of the 2020 courgette production area by cultivar. Nine MOPS growers produced courgettes in 2019, the same in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois and Wexford. Important market outlets are direct selling (box delivery, farmers markets, farmgate) and supermarkets/retailers. Examples of courgette cropping programmes for MOPS growers are shown in Table 17.

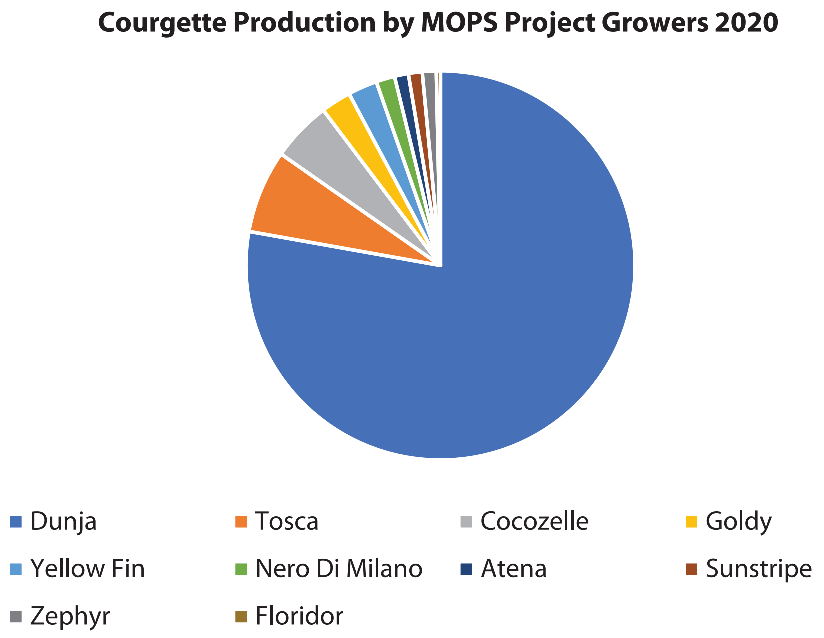



***Figure 18 Courgette production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.17.1 Cropping programmes

**Table 17 Example courgette cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Dunja | Late Mar | Early May | 100 × 100 | 50 + | 1 plant | Mid Jun + |
| Yellowfin | Late Mar | Early May | 100 × 100 | 50 + | 1 plant | Early Jul + |
| Dunja | Late Apr | Late May | 100 × 100 | 45 + | 1 plant | Mid Jul + |
| Yellowfin | Late Apr | Late May | 100 × 100 | 45 + | 1 plant | Mid Jul + |
| **Cropping programme 2** | | | | | | |
| Dunja | Purchase plants | Mid May | 100 × 100 | 50 + | 1 plant | Early Jul + |
| Dunja | Purchase plants | Late May | 100 × 100 | 50 + | 1 plant | Late Jul + |
| Yellowfin | Purchase plants | Late May | 100 × 100 | 50 + | 1 plant | Late Jul + |
| **Cropping programme 3** | | | | | | |
| Dunja | Mid Apr | Mid May | 100 × 100 | 40 + | 1 plant | Late Jun + |
| Cocozelle | Mid Apr | Mid May | 100 × 100 | 40 + | 1 plant | Late Jun + |
| Goldy | Mid Apr | Mid May | 100 × 100 | 40 + | 1 plant | Late Jun + |
| Dunja | Late Apr | Early Jun | 100 × 100 | 40 + | 1 plant | Mid Jul + |
| Cocozelle | Late Apr | Early Jun | 100 × 100 | 40 + | 1 plant | Mid Jul + |
| Goldy | Late Apr | Early Jun | 100 × 100 | 40 + | 1 plant | Mid Jul + |
| **Cropping programme 4** | | | | | | |
| Dunja | Early Apr | Mid May | 80 × 100 | 55 + | 1.3 plants | Mid Jul + |
| Yellowfin | Early Apr | Mid May | 80 × 100 | 55 + | 1.3 plants | Mid Jul + |
| Dunja | Late Apr | Early Jun | 80 × 100 | 60 + | 1.3 plants | Early Aug + |
| Yellowfin | Late Apr | Early Jun | 80 × 100 | 60 + | 1.3 plants | Early Aug + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 5** | | | | | | |
| Dunja | Mid Apr | Mid May | 100 × 100 | 55 + | 1 plant | Mid Jul + |
| Yellowfin | Mid Apr | Mid May | 100 × 100 | 55 + | 1 plant | Mid Jul + |
| Dunja | Mid May | Mid Jun | 100 × 100 | 55 + | 1 plant | Mid Aug |
| Yellowfin | Mid May | Mid Jun | 100 × 100 | 55 + | 1 plant | Mid Aug |
| **Cropping programme 6** | | | | | | |
| Dunja | Purchase plants | Early May | 90 × 90 | 50 + | 1.2 plants | Early Jul + |
| Dunja | Purchase plants | Mid May | 90 × 90 | 50 + | 1.2 plants | Early Aug + |
| Dunja | Purchase plants | Early Jun | 90 × 90 | 50 + | 1.2 plants | Late Aug + |
| Yellowfin | Purchase plants | Early Jun | 90 × 90 | 55 + | 1.2 plants | Late Aug + |
| **Cropping programme 7** | | | | | | |
| Dunja | Early Apr | Mid May | 100 × 100 | 50 + | 1 plant | Early Jul + |
| Cocozelle | Early Apr | Mid May | 100 × 100 | 50 + | 1 plant | Early Jul + |
| Yellowfin | Early Apr | Mid May | 100 × 100 | 50 + | 1 plant | Early Jul + |
| Floridor | Early Apr | Mid May | 100 × 100 | 50 + | 1 plant | Early Jul + |
| Tatume | Early Apr | Mid May | 100 × 100 | 50 + | 1 plant | Early Jul + |

### 3.17.2 Crop yields

The production of courgettes was 7 t and 7,091 units in 2019, and 6 t (-14%) and 100 units (-99%) in 2020. The production of courgette flowers was 1,298 units in 2019 and 125 units (-90%) in 2020.

### 3.17.3 Summary of key findings and recommendations

- Courgette crops should be grown on a well sheltered site protected from strong winds. This crop prefers a site that enjoys plenty of sunshine.
- Protected cropping, e.g., glasshouse, can be used for early production followed by outdoor planting in late May when the risk of frost damage is typically lower. Two to three plantings of courgettes is recommended in case the first planting is damaged by wind or cold. This will also give good continuity of supply for 10 to 12 weeks from early July until mid to late September. Cover the first planting with fleece. Planting too early can result in losses due to frost damage.
- Plants can be planted into biodegradable film covered beds to give a clean fruit without any soil attached. Similar to other crops grown through black mulch film, this reduces the level of labour for hand weeding, whilst also warming up the soil and keeping in the moisture which is imperative for courgettes. Weed control in courgette crops is very difficult so covering the beds with a biodegradable black mulch is advisable.
- Nutrition is very important for this crop and liberal applications of well composted farm yard manure is very beneficial. Courgettes should be grown in a fertile soil which has a high level of organic matter. This assists greatly with soil moisture retention, important in a dry year.
- Good pollinator activity helps with the pollination of courgettes and picking off any malformed and soft fruit promptly reduces waste and increases overall yield.
- Stressed plants can be susceptible to powdery mildew.
- Protected crops of courgettes can produce over 30 fruit per plant with good management of ventilation, nutrition, watering and harvesting when the fruit are small. Courgettes planted in, e.g., a glasshouse, can produce very good yields and quality but depending, may not be the best use of glasshouse space. Outdoor production is more difficult due to changeable weather, especially wind and temperature. Outdoor crops can harvest an average of 16 to 18 fruit per plant. Plants are typically harvested daily when daytime temperatures are above 15-16°C.

## 3.18 Organic cucumber production area and cultivars

The total organic cucumber production area for growers in the MOPS project was 0.057 ha in 2019 and 0.014 ha in 2020. Figure 19 shows a breakdown of the 2020 cucumber production area by cultivar. Six MOPS growers produced cucumbers in 2019, seven growers in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois and Wexford. Key route to market is direct selling (box delivery, farmers markets, farmgate). Examples of cucumber cropping programmes for MOPS growers are shown in Table 18.

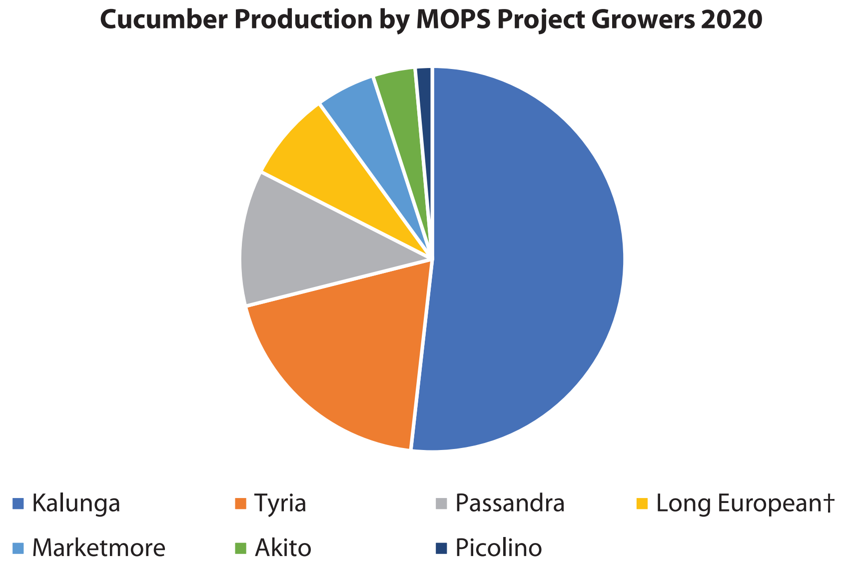



***Figure 19 Cucumber production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.18.1 Cropping programmes

**Table 18 Example cucumber cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Kalunga | Late Mar | Mid May | 45 × 45 | 40 + | 7.5 plants | Late Jun + |
| Kalunga | Mid Apr | Early Jun | 45 × 45 | 35 + | 7.5 plants | Mid Jul + |
| **Cropping programme 2** | | | | | | |
| Passandra | Mid Apr | Mid May | 100 × 30 | 40 + | 3.3 plants | Late Jun |
| Passandra | Mid May | Mid Jun | 100 × 30 | 40 + | 3.3 plants | Late Jul |
| **Cropping programme 3** | | | | | | |
| Kalunga | Late Mar | Mid May | 45 × 45 | 50 + | 3 plants | Mid Jul + |
| Kalunga | Mid Apr | Early Jun | 45 × 45 | 50 + | 3 plants | Late Jul + |
| Passandra | Late Mar | Mid May | 45 × 45 | 45 + | 3 plants | Mid Jul + |
| Passandra | Mid Apr | Early Jun | 45 × 45 | 45 + | 3 plants | Late Jul + |
| **Cropping programme 4** | | | | | | |
| Kalunga | Early Apr | Mid May | 50 × 50 | 40 + | 2 plants | Late Jun + |
| Kalunga | Late Apr | Mid Jun | 50 × 50 | 40 + | 2 plants | Late Jul + |
| Passandra | Early Apr | Mid May | 50 × 50 | 40 + | 2 plants | Late Jun + |
| Passandra | Late Apr | Mid Jun | 50 × 50 | 40 + | 2 plants | Late Jul + |
| **Cropping programme 5** | | | | | | |
| Long European | Mid Mar | Mid May | 60 × 45 | 40 + | 3.7 plants | Early Jun + |
| Kalunga | Mid Mar | Mid May | 60 × 45 | 40 + | 3.7 plants | Early Jun + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 6** | | | | | | |
| Marketmore | Late Mar | Mid May | 45 × 45 | 40 + | 5 plants | Late Jun + |
| Kalunga | Late Mar | Mid May | 45 × 45 | 40 + | 5 plants | Late Jun + |
| Styx | Late Mar | Mid May | 45 × 45 | 40 + | 5 plants | Late Jun + |
| Marketmore | Late Mar | Early Jun | 45 × 45 | 40 + | 5 plants | Late Jul + |
| Kalunga | Late Mar | Early Jun | 45 × 45 | 40 + | 5 plants | Late Jul + |
| Styx | Late Mar | Early Jun | 45 × 45 | 40 + | 5 plants | Late Jul + |
| **Cropping programme 7** | | | | | | |
| Kalunga | Late Mar | Mid May | 40 × 40 | 40 + | 6.2 plants | Mid Jul + |
| Kalunga | Mid Apr | Early Jun | 40 × 40 | 35 + | 6.2 plants | Early Aug + |

### 3.18.2 Crop yields

The production of cucumbers was 991.6 kg and 11,401 units in 2019, and 161.2 kg (-84%) and 7,046 units (-38%) in 2020.

### 3.18.3 Summary of key findings and recommendations

- Protected cucumber crops can produce high yields and quality. A suitable cultivar like Kalunga, for example, is grown as a long type, while Passandra is a shorter cucumber. This crop grows best in a good fertile warm soil with adequate levels of organic matter and good soil moisture retention. Frosts can damage plants, which consequently reduces overall yield and quality.
- For transplanted crops, sowings can be made into small pots in late March and seedlings can be planted in mid-May. Two plantings are advisable to give a longer growing season of better quality fruit, especially in August and September and to reduce the risk of losses if cold weather occurs during the first planting.
- Attention to adequate watering and ventilation is particularly important as is timely de-leafing of lower leaves to allow good light penetration and air movement. Application of a high level of well composted farmyard manure to the soil also contributes to healthy crops.
- Cucumbers can be susceptible to powdery mildew and spider mites. Good hygiene practices are important.
- Harvesting the fruit at the appropriate time can greatly assist achieving high yields.

## 3.19 Organic purple sprouting broccoli production area and cultivars

The total organic purple sprouting broccoli production area for growers in the MOPS project was 0.61 ha in 2019 and 0.8 ha in 2020. Figure 20 provides a breakdown of the 2020 purple sprouting broccoli production area by cultivar. Five MOPS growers produced purple sprouting broccoli in 2019, four growers in 2020 in counties Galway, Kildare, Kilkenny and Wexford. Direct selling (box delivery, farmers markets, farmgate) is a key market outlet. Examples of purple sprouting broccoli cropping programmes for MOPS growers are shown in Table 19.

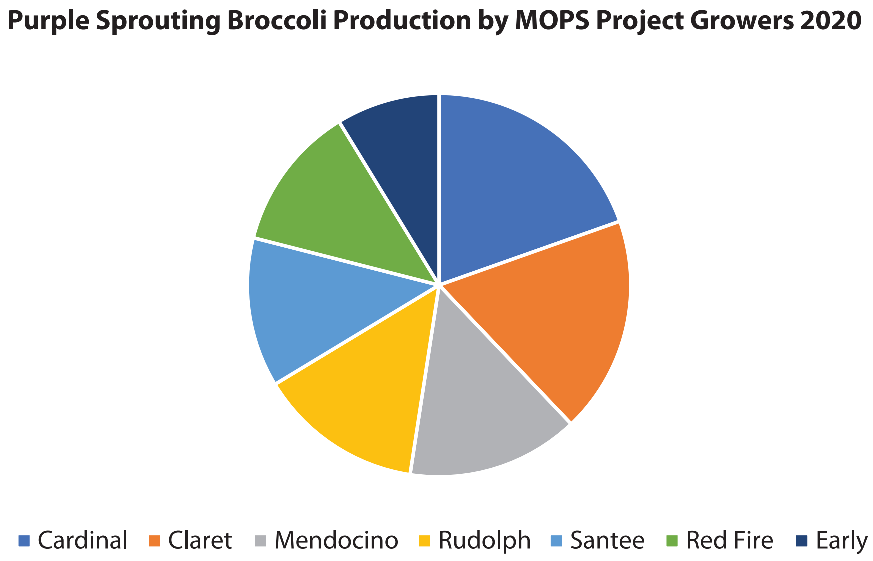



***Figure 20 Purple sprouting broccoli production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.19.1 Cropping programmes

**Table 19 Example purple sprouting broccoli cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Burgundy | Mid Mar | Mid May | 75 × 40 | 80 + | 3.3 plants | Mid Aug + |
| Burgundy | Mid Apr | Mid Jun | 75 × 40 | 90 + | 3.3 plants | Mid Sep + |
| Burgundy | Mid May | Mid Jul | 75 × 40 | 100 + | 3.3 plants | Late Oct + |
| **Cropping programme 2** | | | | | | |
| Santee | Purchase plants | Early Jun | 75 × 90 | 110 + | 1.5 plants | Early Oct + |
| Red Admiral | Purchase plants | Early Jun | 75 × 90 | 130 + | 1.5 plants | Late Oct + |
| Red Fire | Purchase plants | Early Jul | 75 × 90 | 140 + | 1.5 plants | Nov + |
| Claret | Purchase plants | Early Jul | 75 × 90 | 225 + | 1.5 plants | Feb-Mar |
| Bonarda | Purchase plants | Early Jul | 75 × 90 | 240 + | 1.5 plants | Apr + |
| Pozo | Purchase plants | Early Jul | 75 × 90 | 270 + | 1.5 plants | Apr + |
| Cardinal | Purchase plants | Early Jul | 75 × 90 | 300 + | 1.5 plants | Apr-May |
| **Cropping programme 3** | | | | | | |
| Red Fire | Early May | Early Jul | 70 × 60 | 200 + | 2.3 plants | Late Dec + |
| Claret | Mid May | Mid Jul | 70 × 60 | 230 + | 2.3 plants | Late Jan + |
| Cardinal | Mid May | Mid Jul | 70 × 60 | 240 + | 2.3 plants | Late Feb + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 4** | | | | | | |
| Burgundy | Early May | Mid Jun | 55 × 45 | 80 + | 4 plants | Early Sep + |
| Burgundy | Mid May | Late Jun | 55 × 45 | 80 + | 4 plants | Late Sep + |
| Burgundy | Late May | Early Jul | 55 × 45 | 90 + | 4 plants | Early Oct + |
| Burgundy | Early Jun | Mid Jul | 55 × 45 | 90 + | 4 plants | Late Oct + |
| **Cropping programme 5** | | | | | | |
| Burgundy | Mid Feb | Mid Apr | 60 × 45 | 90 + | 3.7 plants | Mid Jul + |
| Burgundy | Mid Mar | Late Apr | 60 × 45 | 90 + | 3.7 plants | Early Aug + |
| Burgundy | Mid Apr | Mid May | 60 × 45 | 85 + | 3.7 plants | Mid Aug + |
| Burgundy | Early May | Mid Jun | 60 × 45 | 80 + | 3.7 plants | Late Aug + |
| Burgundy | Late May | Mid Jul | 60 × 45 | 85 + | 3.7 plants | Late Sep + |
| **Cropping programme 6** | | | | | | |
| Rudolph | Early Jun | Mid Jul | 75 × 55 | 110 + | 2.4 plants | Nov-Feb |
| Rioja | Early Jun | Mid Jul | 75 × 55 | 140 + | 2.4 plants | Jan-Mar |
| Mendocino | Early Jun | Late Jul | 75 × 55 | 200 + | 2.4 plants | Apr-May |
| Red Fire | Early Jun | Late Jul | 75 × 55 | 220 + | 2.4 plants | Apr-May |
| Claret | Early Jun | Late Jul | 75 × 55 | 240 + | 2.4 plants | Apr-May |
| Red Admiral | Early Jun | Late Jul | 75 × 55 | 240 + | 2.4 plants | Apr-May |

### 3.19.2 Crop yields

The production of purple sprouting broccoli was 2 t in 2019 and 1 t (-50%) in 2020.

### 3.19.3 Summary of key findings and recommendations

- Purple sprouting broccoli produces in October to March when many other crops such as pointed cabbage, broccoli, cauliflower, Romanesco and Celery have ceased. It can be a difficult crop to grow in regions with high rainfall during autumn and winter months, which can lead to spear rot. This crop is very tolerant of cold temperatures and will give good yields from November to February in milder areas.
- Generous spacing tends to give better air movement thereby reducing waste, especially due to wet rot. For example, spacing 75 × 70 cm is very beneficial for allowing good air flow to reduce incidences of soft rot.
- Avoiding soft growth by reducing quantities of nitrogen applied pre-autumn is also very important in reducing crop losses and waste.
- Practicing crop rotation reduces the risk of clubroot root disease, along with good pH levels and drainage of the soils.
- This crop is very prone to bird damage, especially pigeon, and requires early laying of bird netting from early November onwards. It is important to only use bird netting with 12-14 mm mesh, as insect netting with smaller mesh will not allow sufficient drying of the crop, which can lead to spear rot.

## 3.20 Organic bean production area and cultivars

The total organic bean production area for growers in the MOPS project was 0.11 ha in 2019 and 0.07 ha in 2020. Figure 21 provides a breakdown of the 2020 bean production area by cultivar. Eight MOPS growers produced beans in 2019, seven growers in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois and Wexford. Direct selling (box delivery, farmers markets, farmgate) is a key market. Examples of bean cropping programmes for MOPS growers are shown in Table 20.

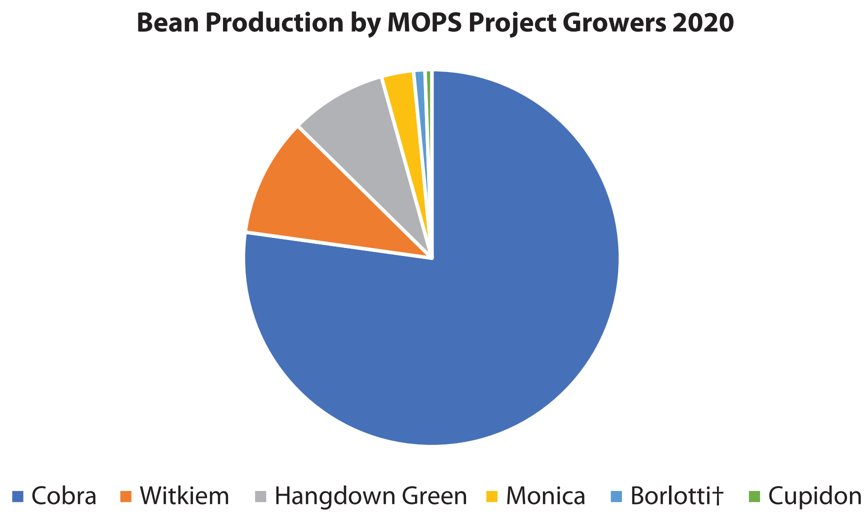



***Figure 21 Bean production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.20.1 Cropping programmes

**Table 20 Example bean cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Cobra | Early Apr | Mid May | 45 × 45 | 65 + | 5 plants | Late Jul |
| Cobra | Early May | Mid Jun | 45 × 45 | 60 + | 5 plants | Mid Aug |
| **Cropping programme 2** | | | | | | |
| Cobra | Early Apr | Mid May | 45 × 20 | 60 + | 11 plants | Mid Jul + |
| Borlotti | Early Apr | Mid May | 45 × 20 | 65 + | 11 plants | Mid Jul + |
| Cobra | Early May | Early Jun | 45 × 20 | 60 + | 11 plants | Early Aug + |
| Borlotti | Early May | Early Jun | 45 × 20 | 65 + | 11 plants | Early Aug + |
| Faraday | Early Apr | Mid May | 45 × 20 | 70 + | 22 plants | Late Jul + |
| Aiguillon | Early Apr | Mid May | 45 × 20 | 70 + | 22 plants | Late Jul + |
| Purple Teepee | Early Apr | Mid May | 45 × 20 | 70 + | 22 plants | Late Jul + |
| Faraday | Early May | Mid Jun | 45 × 20 | 70 + | 22 plants | Late Aug + |
| Aiguillon | Early May | Mid Jun | 45 × 20 | 70 + | 22 plants | Late Aug + |
| Purple Teepee | Early May | Mid Jun | 45 × 20 | 70 + | 22 plants | Late Aug + |
| **Cropping programme 3** | | | | | | |
| Cobra | Purchase plants | Early May | 45 × 20 | 60 + | 11 plants | Mid Jul + |
| Cobra | Purchase plants | Late May | 45 × 20 | 60 + | 11 plants | Late Jul + |
| **Cropping programme 4** | | | | | | |
| Cobra | Early Apr | Mid May | 50 × 30 | 50 + | 6.7 plants | Early Jul + |
| Cobra | Mid Apr | Early Jun | 50 × 30 | 55 + | 6.7 plants | Early Aug + |
| Cobra | Early May | Mid Jun | 50 × 30 | 55 + | 6.7 plants | Late Aug + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| Witkiem | Late Feb | - | 70 × 20 | 75 + | 7 plants | Mid May + |
| Witkiem | Mid Mar | - | 70 × 20 | 70 + | 7 plants | Early Jun + |
| Witkiem | Mid Apr | - | 70 × 20 | 70 + | 7 plants | Early Jul + |
| Witkiem | Mid Nov | - | 70 × 20 | 140 + | 7 plants | Mid Apr + |
| **Cropping programme 5** | | | | | | |
| Paulista | Mid Apr | - | 55 × 10 | 100 + | 18 plants | Early Aug + |
| Paulista | Mid May | - | 55 × 10 | 90 + | 18 plants | Early Sep + |
| **Cropping programme 6** | | | | | | |
| Cobra | Mid Mar | Mid Apr | 90 × 30 | 75 + | 3.7 plants | Late Jun + |
| Cobra | Early Apr | Mid May | 90 × 30 | 70 + | 3.7 plants | Late Jul + |
| **Cropping programme 7** | | | | | | |
| Cobra | Mid Mar | Mid May | 65 × 20 | 60 + | 6.6 plants | Mid Jul + |
| Cobra | Mid Apr | Mid Jun | 65 × 20 | 60 + | 6.6 plants | Mid Aug + |
| Hangdown Green | Early Jan | Early Mar | 50 × 20 | 90 + | 10 plants | Early Jun + |
| Hangdown Green | Early Mar | - | 50 × 10 | 120 + | 20 plants | Early Jul + |
| Hangdown Green | Early Apr | - | 50 × 10 | 95 + | 20 plants | Early Aug + |
| Aquadulce | Early Nov | - | 50 × 10 | 180 + | 20 plants | Mid Apr + |
| **Cropping programme 8** | | | | | | |
| Cobra | Early Apr | Mid May | 70 × 30 | 65 + | 4.8 plants | Late Jul |
| Cobra | Early May | Mid Jun | 70 × 30 | 60 + | 4.8 plants | Mid Aug |
| **Cropping programme 9** | | | | | | |
| Aquadulce Claudia | Mid Mar | Mid Apr | 35 × 35 | 100 + | 8 Plants | Late Jul |
| Aquadulce Claudia | Early Apr | Mid May | 35 × 35 | 100 + | 8 Plants | Mid Aug |
| Hangdown Green | Early Apr | Mid May | 35 × 35 | 100 + | 8 Plants | Late Aug |
| Aquadulce Claudia | Mid Nov | - | 35 × 15 | 175 + | 8 Plants | Late Apr |
| Cobra | Mid Mar | Mid May | 60 × 30 | 70 + | 5.5 plants | Late Jun |
| Faraday | Mid Mar | Mid May | 35 × 20 | 75 + | 14 plants | Late Jun |
| Helda | Early Apr | Mid May | 60 × 30 | 70 + | 5.5 plants | Late Jul |
| Cobra | Early Apr | Mid May | 60 × 30 | 70 + | 5.5 plants | Late Jul |
| Faraday | Early Apr | Mid May | 35 × 20 | 75 + | 14 plants | Late Jul |

### 3.20.2 Crop yields
The production of beans was 2 t in 2019 and 1 t (-50%) in 2020.

### 3.20.3 Summary of key findings and recommendations
- Beans are a useful crop for rotational purposes, but can also give a good financial return per square metre if harvesting is efficient.
- All beans can be sown on large cell trays, e.g., 84, 126 or similar, as bean seed is quite big in size. All beans can also be direct drilled. French beans will do better indoor as they have a poor tolerance to cold wind. Broad beans do not like too much heat and will grow well outdoors even over winter. Climbing beans need training support e.g., two metre high string.
- Both climbing and dwarf beans prefer a soil with good organic matter and a pH above 6.5. Beans are also susceptible to attack from slugs, especially as young plants. Because beans do not like cold winds, avoid planting inside doors of polytunnels or windy areas outside. Frost damages plants and reduces overall yield and quality.

- Two plantings of climbing beans approximately three weeks apart gives a longer growing season and improves continuity of supply.
- To avoid risk of frost, avoid planting before mid-May. Include a third planting for a September harvest. Climbing beans can be sown directly into pots with four seeds sown into each one. Ensure plants are well watered and that they do not get any cold exposure.
- It is advantageous to harvest beans just before they are fully mature, i.e., 90 percent mature, as this will increase yields and the beans will be less stringy in texture to eat.

## 3.21 Organic fennel production area and cultivars

The total organic fennel production area for growers in the MOPS project was 0.18 ha in 2019 and 0.17 ha in 2020. Fennel production in 2020 consisted of one cultivar, Rondo. Three MOPS growers produced fennel in 2019, the same number of growers again in 2020 in counties Galway and Kildare. Direct selling (box delivery, farmers markets, farmgate) is a key route to market. Examples of fennel cropping programmes for MOPS growers are shown in Table 21.

### 3.21.1 Cropping programmes

**Table 21 Example fennel cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Rondo | Early Mar | Mid Apr | 30 × 20 | 85 + | 17 plants | Mid Jul + |
| Rondo | Early Apr | Mid May | 30 × 20 | 75 + | 17 plants | Early Aug + |
| Rondo | Early May | Mid Jun | 30 × 20 | 80 + | 17 plants | Late Aug + |
| Rondo | Late May | Mid Jul | 30 × 20 | 90 + | 17 plants | Mid Oct + |
| **Cropping programme 2** | | | | | | |
| Rondo | Purchase plants | Mid May | 30 × 30 | 90 + | 11 plants | Mid Aug + |
| Rondo | Purchase plants | Early Jun | 30 × 30 | 95 + | 11 plants | Early Sep + |
| Rondo | Purchase plants | Early Jul | 30 × 30 | 100 + | 11 plants | Mid Oct + |
| **Cropping programme 3** | | | | | | |
| Orion | Mid Apr | Late May | 55 × 12 | 70 + | 12 plants | Early Aug + |
| Orion | Mid May | Late Jun | 55 × 12 | 80 + | 12 plants | Mid Sep + |
| Orion | Mid Jun | Late Jul | 55 × 12 | 90 + | 12 plants | Late Oct + |
| **Cropping programme 4** | | | | | | |
| Rondo | Mid Mar | Mid May | 38 × 20 | 70 + | 13 plants | Late Jul + |
| Rondo | Mid Apr | Mid Jun | 38 × 20 | 75 + | 13 plants | Early Sep + |
| Rondo | Mid May | Early Jul | 38 × 20 | 80 + | 13 plants | Late Sep + |
| Rondo | Mid Jun | Early Aug | 38 × 20 | 90 + | 13 plants | Nov + |
| **Cropping programme 5** | | | | | | |
| Fino | Late Apr | Early Jun | 35 × 35 | 90 + | 8 Plants | Late Aug + |
| Fino | Mid May | Late Jun | 35 × 35 | 90 + | 8 Plants | Mid Sep + |
| Fino | Late May | Early Jul | 35 × 35 | 90 + | 8 Plants | Late Sep + |
| Fino | Mid Jun | Mid Jul | 35 × 35 | 90 + | 8 Plants | Mid Oct + |
| Fino | Late Jun | Late Jul | 35 × 35 | 90 + | 8 Plants | Late Oct + |
| Fino | Mid Jul | Mid Aug | 35 × 35 | 95 + | 8 Plants | Early Nov + |

### 3.21.2 Crop yields

The production of fennel was 1 t in 2019 and 2 t (+50%) and 2,650 units in 2020.

### 3.21.3 Summary of key findings and recommendations

- Planting of fennel crops is best avoided until all possibility of frost has passed. Fennel is quite prone to bolting and does not tolerate much stress. Cold winds, in particular, after planting tend to cause bolting so cover with a fleece material. When mature, the crop will tolerate light frosts.
- For transplants, one seed can be sown per cell into e.g., 308 module trays for transplanting five to six weeks later into beds. It is a crop that requires good warm sheltered conditions. Good plant establishment is important, and fennel needs moist conditions especially after transplanting. Irrigation may be necessary to reduce stress risk to plants.
- Fennel benefits from being planted into a soil with well composted farmyard manure.
- Planting through Mypex or biodegradable mulch film can successfully control weeds, which otherwise can be very difficult to manage due to the close spacing.
- Reducing the spacing down to e.g., 25 × 20 cm can still supply a good size head.
- This crop can grow quite quickly indoors only taking approximately 65 days when planted in June, and up to 95 days when planted in late July.
- Fennel can be grown for marketing over 10 to 12 weeks from mid-August until November. The potential for extending the season is very good for both earlier and later production.
- Marketable yield typically tends to be high with very little waste from either pests or diseases. Slug damage, when it occurs, can cause severe losses especially from autumn onwards.
- Fennel can add aroma to a home delivery box.

## 3.22 Organic pumpkin and squash production area and cultivars

The total organic pumpkin and squash production area for growers in the MOPS project was 0.29 ha in 2019 and 0.15 ha in 2020. Figure 22 shows a breakdown of the pumpkin and squash production area by cultivar. Seven MOPS growers produced pumpkin and squash crops in 2019, four growers in 2020 in counties Cork, Galway, Kildare and Kilkenny. Direct selling (box delivery, farmers markets, farmgate) is an important market outlet. Examples of pumpkin and squash cropping programmes for MOPS growers are shown in Table 22.

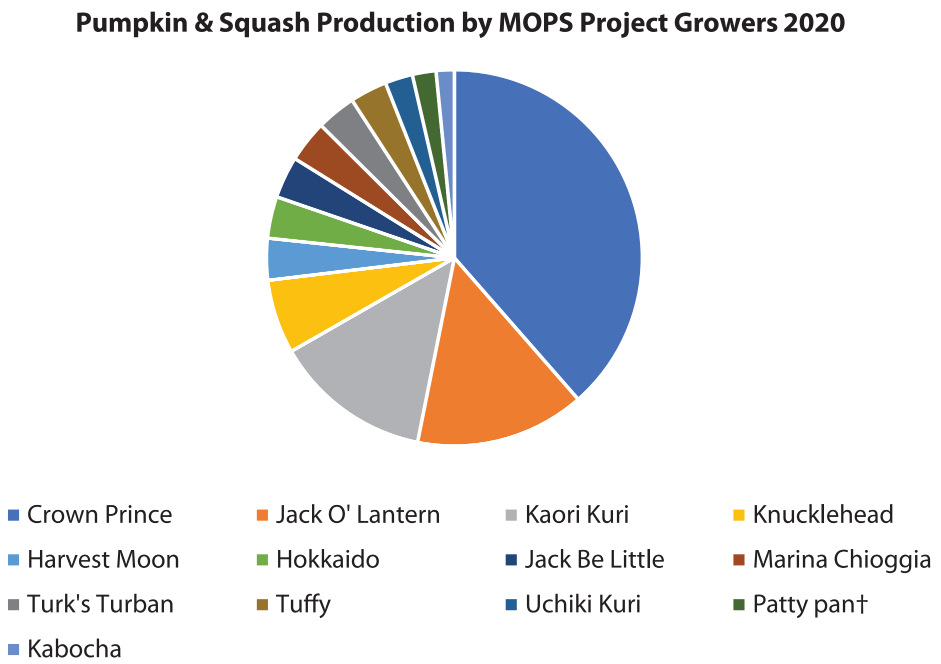



*Figure 22 Pumpkin and squash production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.22.1 Cropping programmes

**Table 22 Example pumpkin and squash cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Crown Prince | Early Apr | Mid May | 100 × 100 | 120 + | 1 plant | Oct + |
| Knuchlehead | Early Apr | Mid May | 100 × 100 | 120 + | 1 plant | Oct + |
| Marina di Chioggia | Early Apr | Mid May | 100 × 100 | 110 + | 1 plant | Late Sep + |
| Flynn | Early Apr | Mid May | 100 × 100 | 120 + | 1 plant | Oct + |
| Spyro | Early Apr | Mid May | 100 × 100 | 110 + | 1 plant | Late Sep + |
| Harvest Moon | Early Apr | Mid May | 100 × 100 | 110 + | 1 plant | Late Sep + |
| **Cropping programme 2** | | | | | | |
| Black Beauty | Mid Apr | Mid May | 100 × 100 | 125 + | 1 plant | Mid Sep + |
| Jack Be Little | Mid Apr | Mid May | 100 × 100 | 120 + | 1 plant | Mid Sep + |
| Buttercup | Mid Apr | Mid May | 100 × 100 | 125 + | 1 plant | Mid Sep + |
| Marina di Chioggia | Mid Apr | Mid May | 100 × 100 | 125 + | 1 plant | Mid Sep + |
| Chameleon | Mid Apr | Mid May | 100 × 100 | 120 + | 1 plant | Mid Sep + |
| **Cropping programme 3** | | | | | | |
| Uchiki Kuri | Purchase plants | Mid May | 100 × 100 | 120 + | 1 plant | Mid Sept + |
| Crown Prince | Purchase plants | Mid May | 100 × 100 | 130 + | 1 plant | Late Sept + |
| Autumn Crown | Purchase plants | Mid May | 100 × 100 | 140 + | 1 plant | Mid Oct + |
| **Cropping programme 4** | | | | | | |
| Harvest Moon | Mid Apr | Mid-late May | 100 × 100 | 110 + | 1 plant | Late Sept + |
| Flynn | Mid Apr | Mid-late May | 100 × 100 | 120 + | 1 plant | Early Oct + |
| Hokkaido | Mid Apr | Mid-late May | 100 × 100 | 120 + | 1 plant | Early Oct + |
| Knucklehead | Mid Apr | Mid-late May | 100 × 100 | 120 + | 1 plant | Early Oct + |
| Crown Prince | Mid Apr | Mid-late May | 100 × 100 | 120 + | 1 plant | Early Oct + |
| Marina di Chioggia | Mid Apr | Mid-late May | 100 × 100 | 110 + | 1 plant | Early Oct + |
| **Cropping programme 5** | | | | | | |
| Crown Prince | Mid Apr | Late May | 80 x 100 | 120 + | 1.2 plants | Early Oct + |
| Flynn | Mid Apr | Late May | 80 x 100 | 110 + | 1.2 plants | Late Sept + |
| Harvest Moon | Mid Apr | Late May | 80 x 100 | 110 + | 1.2 plants | Late Sept + |
| Knucklehead | Mid Apr | Late May | 80 x 100 | 120 + | 1.2 plants | Early Oct + |
| Amoro | Mid Apr | Late May | 80 x 100 | 110 + | 1.2 plants | Early Oct + |
| **Cropping programme 6** | | | | | | |
| Flynn | Mid Apr | Late May | 100 × 100 | 130 + | 1 plant | Mid Oct + |
| Orange Summer | Mid Apr | Late May | 100 × 100 | 130 + | 1 plant | Mid Oct + |
| Kaori Kuri | Mid Apr | Late May | 100 × 100 | 130 + | 1 plant | Mid Oct + |
| Harvest Moon | Mid Apr | Late May | 100 × 100 | 140 + | 1 plant | Late Oct + |
| Crown Prince | Mid Apr | Late May | 100 × 100 | 135 + | 1 plant | Mid Oct + |
| Early Butternut | Mid Apr | Late May | 100 × 100 | 150 + | 1 plant | Mid Oct + |
| **Cropping programme 7** | | | | | | |
| Crown Prince | Mid Apr | Late May | 120 × 100 | 135 + | 0.85 plants | Early Oct + |
| Crown Prince | Late Apr | Mid Jun | 120 × 100 | 140 + | 0.85 plants | Late Oct + |

### 3.22.2 Crop yields
The production of pumpkin and squash was 3 t and 1,082 units in 2019, and 0.5 t (-83%) and 672 units (-38%) in 2020.

### 3.22.3 Summary of key findings and recommendations
- This crop is mostly planned for harvesting around Halloween with cultivars such as Flynn and Crown Prince being grown. Produce will store for four to eight weeks after Halloween if handled carefully.
- The cultivar Crown Prince produces small to medium size fruit delivering an average of two and a half fruit per plant with good pollination and growing conditions. Plants can be sown in 96 cell trays in mid-April and transplanted out four to five weeks later when the risk of frost has passed. Seedlings need to be hardened off in a sheltered area before being planted. Planting in an exposed site needs to be avoided.
- Pumpkin and squash plants can be planted into beds which are covered with Mypex or biodegradable mulch film, which reduces labour inputs involved in hand weeding and keeps the fruit clean of soil splash.
- Nutrition is very important for producing good yields and quality fruit. Crops of pumpkin and squash perform well on soils with high organic matter and will benefit from adequate levels of irrigation during long spells of dry weather.
- Harvesting of some fruit can commence approximately 120 days after planting, with the majority of the fruits being harvested after 135 days. Some smaller fruits can be left to grow until the onset of the first frost.

## 3.23 Organic swede production area and cultivars

The total organic swede production area for growers in the MOPS project was 3.4 ha in 2019 and 1.0 ha in 2020. Figure 23 provides a breakdown of the swede production area by cultivar. Seven MOPS growers produced swede crops in 2019, five growers in 2020 in counties Galway, Kildare, Wexford and Wicklow. Direct selling (box delivery, farmers markets, farmgate) and supermarkets are key market outlets. Examples of swede cropping programmes for MOPS growers are shown in Table 23.

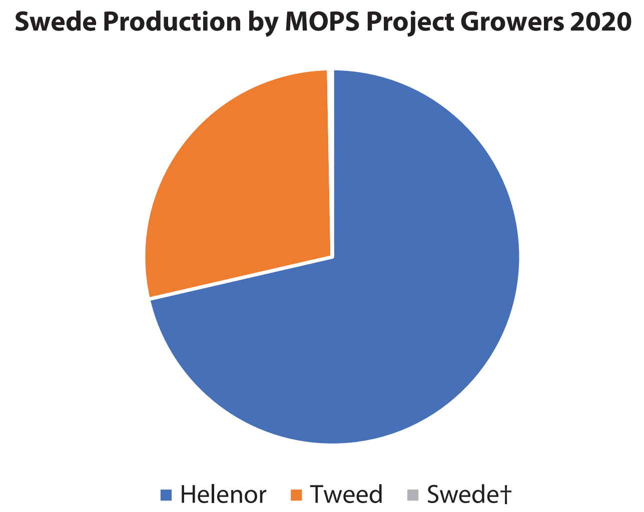



***Figure 23 Swede production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.23.1 Cropping programmes
**Table 23 Example swede cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Helenor | Early Apr | - | 75 × 15 | 110 + | 9 seeds | Late Jul + |
| Tweed | Late May | - | 75 × 12 | 130 + | 11 seeds | Mid Sep + |
| Magres | Late May | - | 75 × 12 | 140 + | 11 seeds | Late Sep + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 2** | | | | | | |
| Helenor | Mid Apr | - | 40 × 18 | 110 + | 14 seeds | Mid Aug + |
| Magres | Late May | - | 40 × 18 | 120 + | 14 seeds | Late Sep + |
| **Cropping programme 3** | | | | | | |
| Helenor | Mid Apr | - | 80 × 10 | 120 + | 50 seeds | Late Jul + |
| Helenor | Mid May | - | 80 × 10 | 110 + | 50 seeds | Mid Sep + |
| Magres | Mid May | - | 80 × 10 | 130 + | 50 seeds | Early Oct + |
| **Cropping programme 4** | | | | | | |
| Helenor | Purchase plants | Mid Apr | 80 × 15 | 90 + | 8.3 plants | Mid Jul + |
| Helenor | Mid Apr | - | 80 × 12 | 95 + | 10. 5 seeds | Late Jul + |
| Tweed | Mid Apr | - | 80 × 12 | 100 + | 10. 5 seeds | Early Aug + |
| Tweed | Late May | - | 80 × 12 | 100 + | 10.5 seeds | Oct + |
| **Cropping programme 5** | | | | | | |
| Helenor | Mid May | - | 75 × 12 | 80 + | 11 seeds | Mid Aug + |
| Helenor | Mid Jun | - | 76 × 12 | 90 + | 11 seeds | Mid Sep + |

### 3.23.2 Crop yields

The production of swede was 4 t and 14,254 units in 2019, and 8 t (+100%) and 13,759 units (-3%) in 2020.

### 3.23.3 Summary of key findings and recommendations

- Swedes can be direct sown in May, approximately seven weeks after bed forming. Black plastic can be put on after bed forming to increase soil temperature and encourage weed germination. The plastic can be taken off approximately two to three days before drilling and burning off using a gas flame burner. Insect netting to control flea beetle and cabbage root fly should be put over the crop shortly after sowing e.g., two to three days. Swede seeds can germinate in five to eight days with adequate moisture and temperature. Early placement of netting is, therefore, important to avoid pest damage. Insect pest attacks can contribute to a high level of unmarketable of crops and waste.
- Swedes can be produced smaller (e.g., 200-250 g) or larger (e.g., 500-600 g) depending on market specification. For example, planting or sowing approximately 10-15 cm on 80 cm ridges can give a high percentage of units in the 600-800 g size range. Swede can be direct sown to a plant stand in the row of 15 cm, and when young plants are at the four to five leaf stage thin out every second plant to give a final plant stand of 30 cm in the row. This will give a swede ranging from 500 g-1 kg. If smaller swedes are needed, e.g., 250-500 g, then there will be no need to thin seedlings out. Wider spacing for the first sowing will give earlier maturity.
- Two sowings of swedes will give a longer harvesting season up until May of the following year. The seasonal supply can be extended by both transplanting the early crop and making a late direct sowing in May for supply up to April the following year. Some cultivars e.g., Tweed keep better in the field in the spring.
- Even emergence is important for a good uniform crop so ensure soil is tilled into a relatively fine seed bed.
- Good weed control is very important. Making raised beds some six to seven weeks in advance of sowing is recommended. Allow for two to three gas flame burnings before direct sowing. It is important to ensure proper selection of the seeding disc, e.g., Agricola seeder, and adjust the singulation mechanism on the seeder to give one seed per hole on the disc for precise spacing.
- Swedes have a high requirement for boron and are susceptible to boron deficiency. Some growers can have issues with internal browning due to boron deficiency. It is advisable to apply boron to soil before sowing and subsequently by foliar feeding after five to six true leaves.
- Swedes have a low requirement for nitrogen so apply no more than 120 kg/ha. Ensuring that nitrogen levels are low is very important in reducing malformed roots with open brown cracks.

- Swedes are one of the lowest input crops with the least risk of failure and can leave a very good return if suitable markets are available. Similar to red and white cabbage, they can be harvested when labour units are not required for other crops and can be barn stored in bulk bins until required.

## 3.24 Organic pepper production area and cultivars

The total organic pepper production area for growers in the MOPS project was 0.02 ha in 2019 and 2020. Figure 24 shows a breakdown of the 2020 pepper production area by cultivar. Three MOPS growers produced pepper crops in 2019, four growers in 2020 in counties Galway, Kilkenny, Laois, and Wexford. Direct selling (box delivery, farmers markets, farmgate) is a key route to market. Examples of pepper cropping programmes for MOPS growers are shown in Table 24.

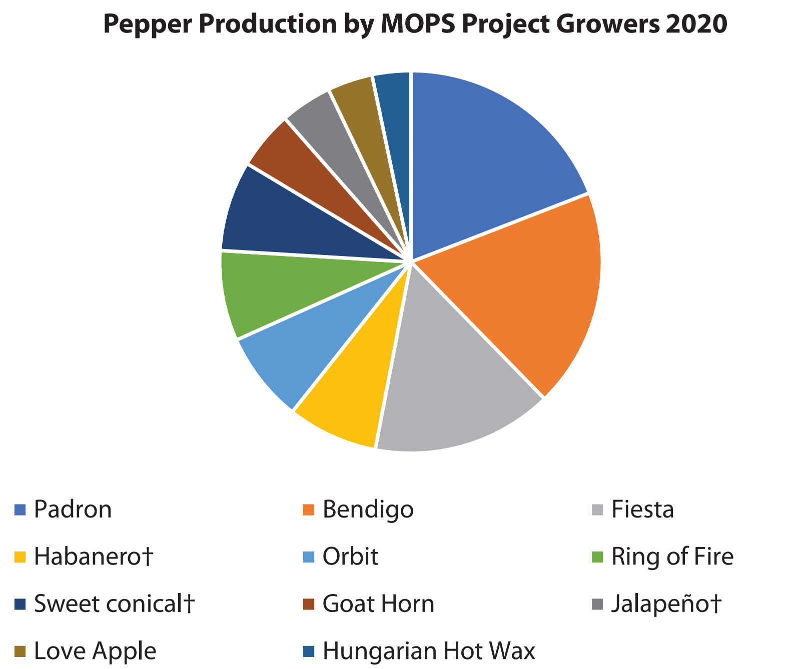



*Figure 24 Pepper production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.24.1 Cropping programmes

**Table 24 Example pepper cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Sprinter | Early Mar | Mid May | 60 × 45 | 50 + | 3.7 plants | Late Jul + |
| Teseo | Early Mar | Mid May | 60 × 45 | 50 + | 3.7 plants | Late Jul + |
| Xaro | Early Mar | Mid May | 60 × 45 | 50 + | 3.7 plants | Late Jul + |
| Hungarian Wax | Early Mar | Mid May | 60 × 45 | 50 + | 3.7 plants | Late Jul + |
| Ring of Fire | Early Mar | Mid May | 60 × 45 | 50 + | 3.7 plants | Late Jul + |
| Orbit | Early Mar | Mid May | 60 × 45 | 55 + | 3.7 plants | Late Jul + |
| **Cropping programme 2** | | | | | | |
| Arwen | Early Mar | Mid May | 60 × 60 | 80 + | 1.7 plants | Early Aug + |
| Ramiro | Early Mar | Mid May | 60 × 60 | 100 + | 1.7 plants | Late Aug + |
| Buda | Early Mar | Mid May | 60 × 60 | 90 + | 1.7 plants | Mid Aug + |
| **Cropping programme 3** | | | | | | |
| Bendigo | Early Mar | Mid May | 90 × 45 | 80 + | 2.5 plants | Late Jul + |
| Fiesta | Early Mar | Mid May | 90 × 45 | 80 + | 2.5 plants | Late Jul + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| Orbit | Early Mar | Mid May | 90 × 45 | 80 + | 2.5 plants | Late Jul + |
| Sweet conical | Early Mar | Mid May | 90 × 45 | 80 + | 2.5 plants | Late Jul + |
| Habanero | Early Mar | Mid May | 90 × 45 | 65 + | 2.5 plants | Mid Jul + |
| Ring of Fire | Early Mar | Mid May | 90 × 45 | 65 + | 2.5 plants | Mid Jul + |
| **Cropping programme 4** | | | | | | |
| Slim Jim | Early Mar | Mid May | 60 × 40 | 80 + | 4.1 plants | Late Aug + |
| Sweet | Early Mar | Mid May | 60 × 40 | 80 + | 4.1 plants | Late Aug + |
| Corno di Toro | Early Mar | Mid May | 60 × 40 | 80 + | 4.1 plants | Late Aug + |
| xaro | Early Mar | Mid May | 60 × 40 | 80 + | 4.1 plants | Late Aug + |
| Zazu | Early Mar | Mid May | 60 × 40 | 80 + | 4.1 plants | Late Aug + |

### 3.24.2 Crop yields
The production of peppers was 693 kg in 2019, and 309.2 kg (-55%) and 36 units in 2020.

## 3.25 Organic garlic production area and cultivars

The total organic garlic production area for growers in the MOPS project was 0.03 ha in 2019 and 0.04 ha in 2020. Figure 25 provides a breakdown of the garlic production area by cultivar. Three MOPS growers produced garlic crops in 2019, four growers in 2020 in counties Kildare, Laois and Wexford. Direct selling (box delivery, farmers markets, farmgate) is a key route to market. Examples of garlic cropping programmes for MOPS growers are shown in Table 25.

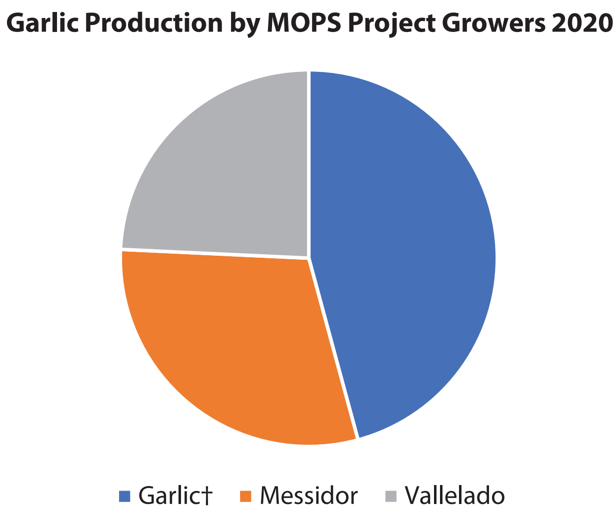



***Figure 25 Garlic production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.25.1 Cropping programmes
**Table 25 Example garlic cropping programmes for MOPS project growers.**

| Cultivar | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | |
| Messidrome | Oct-Nov | 20 × 20 | 190 + | 25 cloves | Mid May |
| Vallelado | Nov | 20 × 20 | 210 + | 25 cloves | Early Jun |
| Messidrome | Mid Nov | 20 × 20 | 160 + | 25 cloves | Late Apr + |
| Vallelado | Mid Nov | 20 × 20 | 170 + | 25 cloves | Mid May + |

| Cultivar | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|
| **Cropping programme 2** | | | | | |
| Vallelado | Late Oct | 55 × 10 | 160 + | 18 cloves | Late May + |
| Purple Wight | Late Oct | 55 × 10 | 170 + | 18 cloves | Early Jun + |
| Elephant garlic | Late Oct | 55 × 10 | 160 + | 18 cloves | Late May + |
| Vallelado | Mid Nov | 55 × 10 | 160 + | 18 cloves | Late May + |
| **Cropping programme 3** | | | | | |
| Music | Late Nov | 38 × 12 | 180 + | 12.8 cloves | Late May + |
| Music | Mid Dec | 38 × 12 | 180 + | 12.8 cloves | Early Jun + |
| Music | Early Jan | 38 × 12 | 180 + | 12.8 cloves | Late Jun + |
| Music | Mid Jan | 38 × 12 | 180 + | 12.8 cloves | Mid Jul + |
| Music | Early Feb | 38 × 12 | 180 + | 12.8 cloves | Late Jul + |
| **Cropping programme 4** | | | | | |
| Vallelado | Early Nov | 30 × 15 | 180 + | 22 cloves | Mid Apr + |
| Messidor | Early Nov | 30 × 15 | 190 + | 22 cloves | May + |
| Vallelado | Early Nov | 30 × 15 | 190 + | 22 cloves | May + |

### 3.25.2 Crop yields

The production of garlic was 640 units in 2019 and 447 units (-30%) in 2020.

## 3.26 Organic parsley production area and cultivars

The total organic parsley leaf production area for growers in the MOPS project was 0.03 ha in 2019 and 0.04 ha in 2020. Figure 26 shows a breakdown of the parsley production area by cultivar. Six MOPS growers produced parsley crops in 2019, eight growers in 2020 in counties Cork, Galway, Kildare, Kilkenny, Laois, Wexford and Wicklow. Direct selling (box delivery, farmers markets, farmgate) is a key route to market. Examples of parsley cropping programmes for MOPS growers are shown in Table 26.

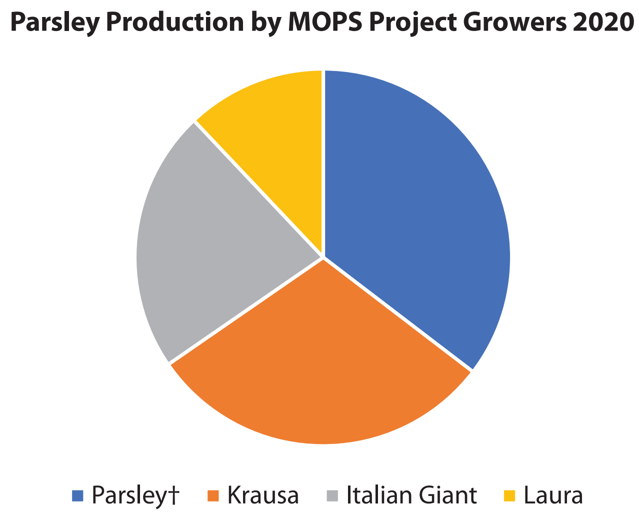



***Figure 26 Parsley production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.***

### 3.26.1 Cropping programmes

**Table 26 Example parsley cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Krausa | Mid Feb | Mid Apr | 30 × 20 | 70 + | 17 plants | Early Jul + |
| Krausa | Mid Mar | Late May | 30 × 20 | 65 + | 17 plants | Early Aug + |
| Petra | Mid Apr | Early Jul | 30 × 30 | 120 + | 11 plants | Early Nov + |
| **Cropping programme 2** | | | | | | |
| Curly | Purchase plants | Late Apr | 30 × 20 | 70 + | 16.5 plants | Mid Jul + |
| Italian Giant | Purchase plants | Late Apr | 30 × 20 | 70 + | 16.5 plants | Mid Jul + |
| **Cropping programme 3** | | | | | | |
| Krausa | Late Mar | Late May | 20 × 20 | 65 + | 25 plants | Late Jul + |
| Krausa | Late Apr | Late Jun | 20 × 20 | 75 + | 25 plants | Late Aug + |
| Krausa | Late May | Late Jul | 20 × 20 | 75 + | 25 plants | Late Sep + |
| Krausa | Purchase plants | Mid Apr | 35 × 22 | 75 + | 13 plants | Early Jul + |
| Krausa | Purchase plants | Late Jun | 35 × 22 | 75 + | 13 plants | Early Sep + |
| Krausa | Purchase plants | Mid Jul | 20 × 20 | 120 + | 25 plants | Dec + |
| **Cropping programme 4** | | | | | | |
| Italian Giant | Mid Jan | Early Apr | 30 × 20 | 60 + | 25 plants | Early Jun |
| Italian Giant | Mid Feb | Early May | 30 × 20 | 50 + | 25 plants | Early Jul |
| Italian Giant | Mid Mar | Early Jun | 30 × 20 | 50 + | 25 plants | Late Jul |
| Italian Giant | Early May | Mid Jul | 30 × 20 | 60 + | 25 plants | Mid Sep |
| Italian Giant | Early Jul | Mid Sep | 30 × 20 | 75 + | 25 plants | Mid Dec |

### 3.26.2 Crop yields

The production of parsley was 215.4 kg in 2019 and 231.5 kg (+7%) in 2020.

## 3.27 Organic celeriac production area and cultivars

The total organic celeriac production area for growers in the MOPS project was 0.06 ha in 2019 and 0.12 ha in 2020. Figure 27 shows a breakdown of the celeriac production area by cultivar. Three MOPS growers produced celeriac crops in 2019, and the same number of growers again in 2020 in counties Galway, Wexford and Wicklow. Direct selling (box delivery, farmers markets, farmgate) is a key route to market. Examples of celeriac cropping programmes for MOPS growers are shown in Table 27.

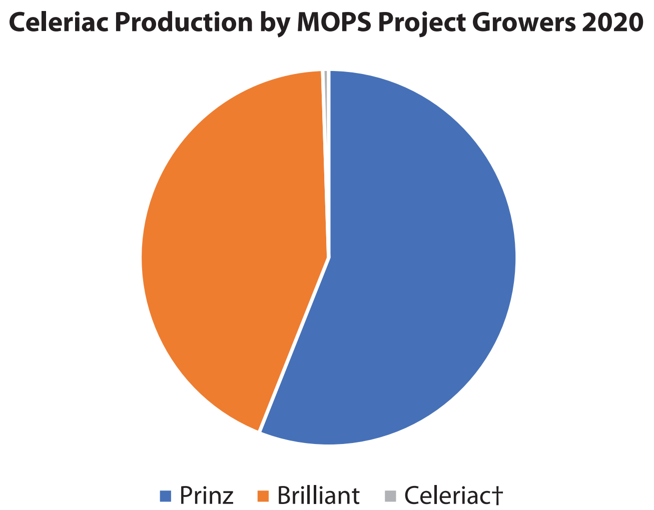



*Figure 27 Celeriac production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.27.1 Cropping programmes

**Table 27 Example celeriac cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Brilliant | Mid Mar | Late May | 55 × 40 | 150 + | 4 plants | Late Oct |
| **Cropping programme 2** | | | | | | |
| Brilliant | Purchase plants | Mid Apr | 80 × 30 | 180 + | 8.3 plants | Oct + |
| Brilliant | Purchase plants | Early May | 80 × 30 | 170 + | 8.3 plants | Nov + |
| Diamant | Purchase plants | Early May | 80 × 30 | 180 + | 8.3 plants | Dec + |
| **Cropping programme 3** | | | | | | |
| Brilliant | Early Mar | Mid May | 70 × 30 | 180 + | 4 Plants | Early Nov + |
| Brilliant | Early Apr | Mid Jun | 70 × 30 | 180 + | 4 Plants | Mid Dec + |

### 3.27.2 Crop yields

The production of celeriac was 2,391 units in 2019 and 3,883 units (+62%) in 2020.

## 3.28 Organic Romanesco production area and cultivars

The total organic Romanesco production area for growers in the MOPS project was 0.16 ha in 2019 and 2020. Figure 28 shows a breakdown of the Romanesco production area by cultivar. Five MOPS growers produced Romanesco crops in 2019, four growers in 2020 in counties Galway, Kildare, Kilkenny and Wexford. Direct selling (box delivery, farmers markets, farmgate) is a key route to market. Examples of Romanesco cropping programmes for MOPS growers are shown in Table 28.

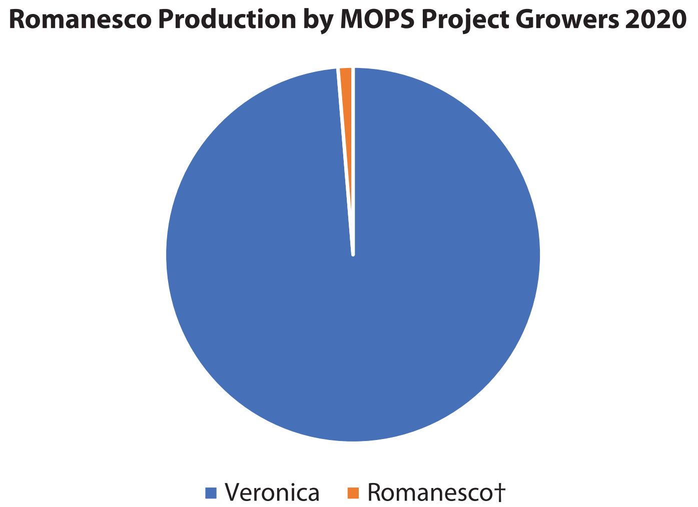



*Figure 28 Romanesco production by MOPS project growers in 2020. Cultivars listed largest to smallest cropping area.*

### 3.28.1 Cropping programmes

**Table 28 Example Romanesco cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Veronica | Purchase plants | Mid May | 75 × 45 | 80 + | 3 plants | Early Aug + |
| Veronica | Purchase plants | Late May | 75 × 45 | 85 + | 3 plants | Late Aug + |
| Veronica | Purchase plants | Mid Jun | 75 × 45 | 90 + | 3 plants | Mid Sep + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| Veronica | Purchase plants | Late Jun | 75 × 45 | 95 + | 3 plants | Late Sep + |
| Veronica | Purchase plants | Early Jul | 75 × 45 | 95 + | 3 plants | Early Oct + |
| **Cropping programme 2** | | | | | | |
| Veronica | Late Feb | Mid Apr | 55 × 45 | 90 + | 4 plants | Mid Jul + |
| Veronica | Mid Mar | Early May | 55 × 45 | 90 + | 4 plants | Early Aug + |
| Veronica | Mid Apr | Late May | 55 × 45 | 85 + | 4 plants | Late Aug + |
| Veronica | Early May | Mid Jun | 55 × 45 | 85 + | 4 plants | Mid Sep + |
| Veronica | Late May | Early Jul | 55 × 45 | 85 + | 4 plants | Late Sep + |
| Veronica | Mid Jun | Late Jul | 55 × 45 | 90 + | 4 plants | Mid Oct + |
| **Cropping programme 3** | | | | | | |
| Veronica | Mid Feb | Mid Apr | 75 × 45 | 90 + | 3 plants | Mid Jul |
| Veronica | Mid Mar | Early May | 75 × 40 | 80 + | 3.3 plants | Early Aug |
| Veronica | Mid Apr | Early Jun | 75 × 40 | 80 + | 3.3 plants | Late Aug + |
| Veronica | Mid May | Early Jul | 75 × 45 | 95 + | 3 plants | Late Sep + |
| **Cropping programme 4** | | | | | | |
| Veronica | Early Apr | Late May | 70 × 35 | 90 + | 4 plants | Late Aug + |
| Veronica | Late Apr | Mid Jun | 70 × 35 | 90 + | 4 plants | Early Sep + |
| Veronica | Early May | Late Jun | 70 × 35 | 90 + | 4 plants | Late Sep + |
| Veronica | Late May | Early Jul | 70 × 35 | 90 + | 4 plants | Early Oct + |

### 3.28.2 Crop yields
The production of Romanesco was 2,201 units in 2019 and 3,233 units (+47%) in 2020.

## 3.29 Organic sweetcorn, Jerusalem artichoke and asparagus production

Amongst the MOPS project growers, crops of sweetcorn, Jerusalem artichoke and asparagus are currently grown on a smaller commercial scale. Examples of sweetcorn, Jerusalem artichoke and asparagus cropping programmes for the MOPS project growers are shown in Tables 29, 30 and 31.

### 3.29.1 Cropping programmes
**Table 29 Example sweetcorn cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Early Bird | Early May | Early Jun | 45 × 30 | 70 + | 7.5 plants | Early Aug + |
| True Platinum | Early May | Mid Jun | 45 × 30 | 75 + | 7.5 plants | Mid Aug + |
| Sweet Nugget | Early May | Mid Jun | 45 × 30 | 75 + | 7.5 plants | Mid Aug + |
| Sweet Nugget | Mid May | Mid Jun | 45 × 30 | 75 + | 7.5 plants | Early Sep + |
| True Platinum | Mid May | Mid Jun | 45 × 30 | 75 + | 7.5 plants | Early Sep + |
| **Cropping programme 2** | | | | | | |
| Early Bird | Mid Apr | Mid May | 70 × 30 | 110 + | 4.7 plants | Early Sep + |
| Swift | Mid Apr | Mid May | 70 × 30 | 120 + | 4.7 plants | Mid Sep + |
| Early Bird | Late Apr | Late May | 70 × 30 | 120 + | 4.7 plants | Late Sep + |
| Swift | Late Apr | Late May | 70 × 30 | 130 + | 4.7 plants | Early Oct + |
| Lark | Late Apr | Late May | 70 × 30 | 120 + | 4.7 plants | Early Oct + |

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 3** | | | | | | |
| Early Bird | Early May | Mid Jun | 55 × 40 | 70 + | 4.5 plants | Mid Aug + |
| Swift | Early May | Mid Jun | 55 × 40 | 75 + | 4.5 plants | Late Aug + |
| Early Bird | Mid May | Late Jun | 55 × 40 | 75 + | 4.5 plants | Mid Sep + |
| Swift | Mid May | Late Jun | 55 × 40 | 80 + | 4.5 plants | Late Sep + |
| **Cropping programme 4** | | | | | | |
| Tramunt | Early Apr | Late May | 45 × 45 | 100 + | 5 Plants | Early Sep + |
| True Gold | Early Apr | Late May | 45 × 45 | 110 + | 5 Plants | Late Sep + |
| Tramunt | Late Apr | Mid Jun | 45 × 45 | 100 + | 5 Plants | Early Oct + |
| True Gold | Late Apr | Mid Jun | 45 × 45 | 110 + | 5 Plants | Late Oct + |

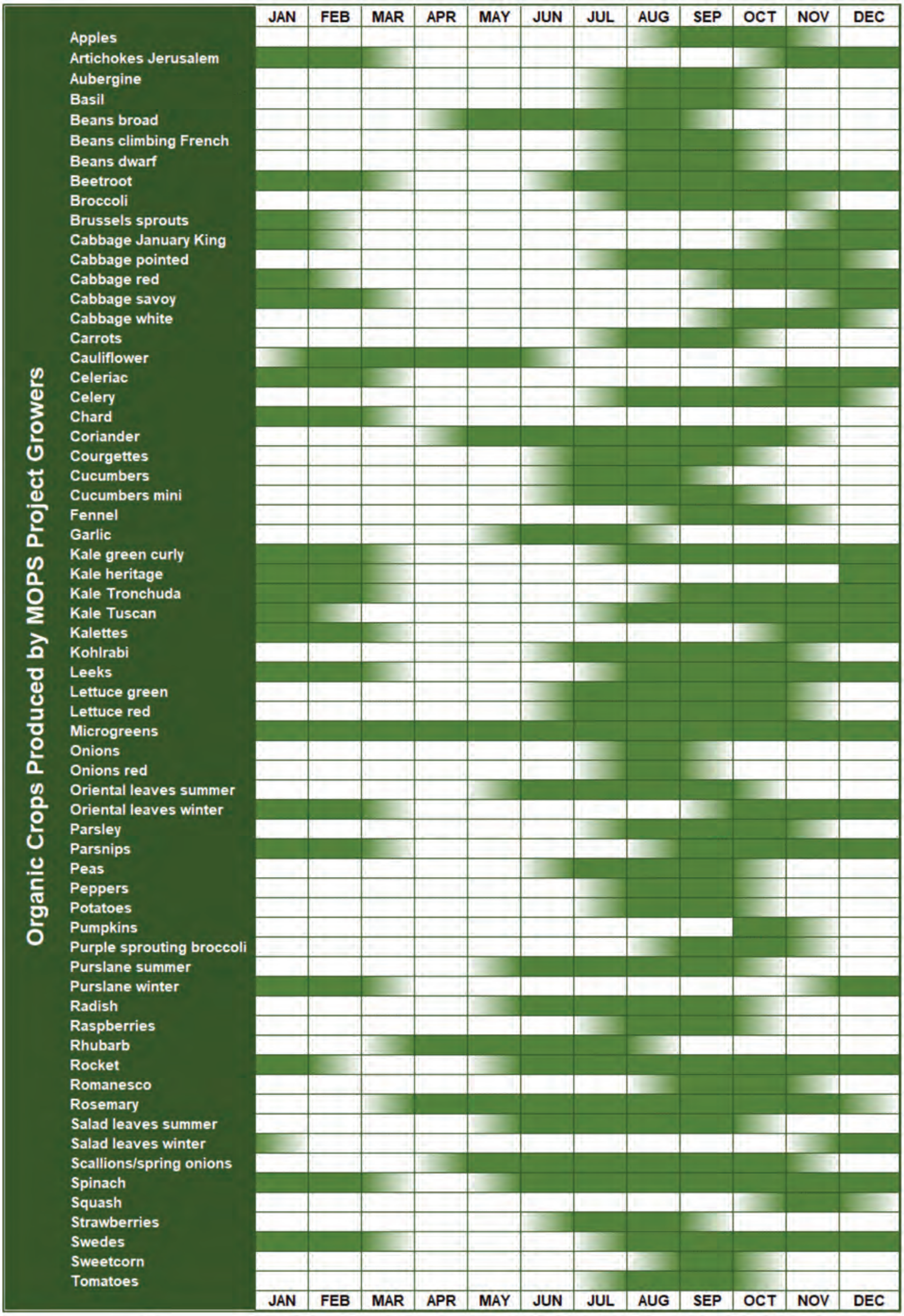
**Table 30 Example Jerusalem artichoke cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Oregon | - | Early Apr | 100 × 100 | 200 + | 1 plant | Mid Nov + |
| Red Fuseau | - | Early Apr | 100 × 100 | 190 + | 1 plant | Mid Nov + |
| **Cropping programme 2** | | | | | | |
| Rema | - | Mid Apr | 75 × 40 | 180 | 3.3 plants | Late Oct + |
| C 9 | - | Mid Apr | 75 × 40 | 170 | 3.3 plants | Mid Oct + |

**Table 31 Example asparagus cropping programmes for MOPS project growers.**

| Cultivar | Sowing | Planting | Spacing (cm) | Days to maturity | Plant density/m² | Expected harvest |
|---|---|---|---|---|---|---|
| **Cropping programme 1** | | | | | | |
| Aspalin | Purchase plants | Early Apr | 100 × 35 | 375 + | 2.8 plants | Mid Apr + |
| Millennium | Purchase plants | Early Apr | 100 × 35 | 380 + | 2.8 plants | Late Apr + |
| Gijnlim | Purchase plants | Early Apr | 100 × 35 | 380 + | 2.8 plants | Late Apr + |
| Cumulus | Purchase plants | Early Apr | 100 × 35 | 380 + | 2.8 plants | Late Apr + |
| **Cropping programme 2** | | | | | | |
| Gijnlim | Purchase plants | Early Apr | 180 × 40 | 390 + | 1.4 plants | Early May + |
| Backlim | Purchase plants | Early Apr | 180 × 40 | 390 + | 1.4 plants | Mid May + |

***Figure 29 overleaf shows the range of organic crops that are produced by the growers participating in the MOPS project during different months of the year.***


Organic Crops Produced by MOPS Project Growers
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Apples
Artichokes Jerusalem
Aubergine
Basil
Beans broad
Beans climbing French
Beans dwarf
Beetroot
Broccoli
Brussels sprouts
Cabbage January King
Cabbage pointed
Cabbage red
Cabbage savoy
Cabbage white
Carrots
Cauliflower
Celeriac
Celery
Chard
Coriander
Courgettes
Cucumbers
Cucumbers mini
Fennel
Garlic
Kale green curly
Kale heritage
Kale Tronchuda
Kale Tuscan
Kalettes
Kohlrabi
Leeks
Lettuce green
Lettuce red
Microgreens
Onions
Onions red
Oriental leaves summer
Oriental leaves winter
Parsley
Parsnips
Peas
Peppers
Potatoes
Pumpkins
Purple sprouting broccoli
Purslane summer
Purslane winter
Radish
Raspberries
Rhubarb
Rocket
Romanesco
Rosemary
Salad leaves summer
Salad leaves winter
Scallions/spring onions
Spinach
Squash
Strawberries
Swedes
Sweetcorn
Tomatoes
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

# 4 - MOPS VIDEOS CROP LISTINGS

Over the course of the three years of the MOPS project a number of videos were made on the participating farms, these videos explore the agronomy of organic crop production. This section highlights some of those videos in parallel with the cropping programmes designed for each farm. All of videos listed here can be found at **www.mopsorganic.ie**

**POTATOES**
Potatoes are an important crop for the organic horticulture sector.
Orla is the most popular variety grown by the MOPS operational group.

**Potatoes #1**
This video captures mechanical potato harvesting in a ten acre field. The variety 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 Emmet Dunne from O' Duinn Organica explains his production process from sowing, weeding, ridging to storage for over winter supply.

**Potatoes #2**
Application of fertilisers to growing potato crops can be difficult especially in field scale production. Emmet Dunne from O' Duinn Organica evaluates the benefits of applying an approved organic fertiliser at the time of sowing your potato crop.

**KALE**
Kale has become an important crop for MOPS growers and is supplied into all retail outlets. Its versatility makes it a popular choice for consumers. The most common varieties with the MOPS growers are Reflex, Black Magic, Oldenbor and the heritage variety Uncle John's.


**Kale #3**
Desmond and Olive Thorpe supply kale to the major multiples and independent stores. Here Desmond outlines his cultivation system for Oldenbor. He also introduces a new crop - Kalettes which are a cross between kale and brussels sprouts.

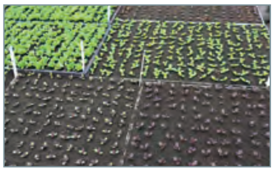
**Kale #4**
Vincent Grace from Riversfield Farm grows both the curly green variety Reflex and a red kale called Redbor. His main markets are direct to consumers and to restaurants. He grows the plants through a bio-degradable mulch to reduce competition with weeds. Crop management techniques to ensure continued supply is discussed.

**Kale #5**
Green Earth Organic farm are trying a new approach with their Kale crop by growing a green manure (Subterranean clover) underneath the plant to supply nitrogen to the kale crop throughout the long growing season.

**LETTUCE & SALAD LEAF PRODUCTION**
Lettuce and salad leaf production are key crops for many of the MOPS growers as they are high value crops that provide a regular income for growers year-round. A wide range of varieties are used depending on grower market requirements such as taste, colour and texture.

**Lettuce & Salad Leaf Production #6**
In this video Vincent Grace from Riversfield Farm discusses winter lettuce production, varieties, crop establishment, irrigation and harvesting. Weed control in the early stages is also highlighted.

**Lettuce & Salad Leaf Production #7**
Gorse Farm discuss the varieties that they use for their winter salad production indoors. They harvest their winter lettuce crops for approximately 6 months. Winter lettuce is hand picked as this extends their growing season. Irrigation for winter production is minimal in order to reduce diseases and ventilation is also monitored. Climate monitors that are used in the MOPS project are also discussed in order to record temperatures and relative humidity in the polytunnel over the winter months.



**Lettuce & Salad Leaf Production #8**
Plant propagation is important for salad production that is not sown directly in situ. In this video Vincent Grace from Riversfield outlines his plant propagation techniques for salads which includes compost, module size, irrigation and disease control.

**Lettuce & Salad Leaf Production #9**
Patrick Frankel discusses polytunnel production of winter salads and the merits of controlled irrigation to reduce potential disease pressure during the coldest months of the year.

**Lettuce & Salad Leaf Production #10**
Salanova is becoming a popular lettuce variety with growers due to its uniformity and quick regrowth potential. Colm Warner from Nurney Farm discusses outdoor lettuce production and the varieties that they use on this farm.

**Lettuce & Salad Leaf Production #11**
Various methods of salad harvesting are used by the MOPS growers from hand picking at certain times of the year, to cutting and also some methods of mechanical harvesting. This video shows large scale field harvesting taking place at Nurney Farm.

**LEEKS**
Leeks are a significant crop for many of the MOPS growers. They are a long season crop with Pluston, Krypton and Triton the most popular varieties used. Leek production increased significantly in the duration of the project.

**Leeks #12**
Green Earth Organics use a transplanter to sow their leeks and in this video they outline their planting, weeding and harvesting system.

**Leeks #13**
Beechlawn Organic Farm grow a large acreage of organic leeks, in this video Padraig Fahy discusses his crop of Krypton leeks including pest and disease management, harvesting and their market specifications.

**CARROTS**
Carrots are a crop that are always in high demand and production area doubled among the MOPS growers from 2019 -2020. Popular varieties remain Romance, Nairobi and Miami.

**Carrots #14**
Nick Cullen discusses the merits of weed control before sowing your carrot crop in order to control annual weeds. Sowing density and pest control such as netting for the carrot root fly is also discussed in this video.

**Carrots #15**
Emmet Dunne from O' Duinn Organica outlines different varieties that he uses for his markets. He discusses how plants coped with heat stress in a particularly warm growing season and the requirements for irrigation to achieve required yields per tonne. Pest and disease, foliage and root development and the importance of stale seed bed production before sowing are also featured.

**BROCCOLI**
Broccoli is an important crop for many of the MOPS growers who supply into the larger retail outlets and also into direct sales channels.

### Broccoli #16

Padriag Fahy from Beechlawn Organic Farm outlines sowing methods and weeding in the early stages of broccoli production. Timely harvesting and monitoring of the crop is essential on field scale level to ensure that crop yields are maximised.

### Broccoli #17

In this video Desmond Thorpe looks at his Parthenon broccoli estimating harvesting as the crop is now between 80-90 days. Market specifications are discussed for pre-pack broccoli for the supermarkets. Shelf-life and crop storage are highlighted. Plant spacings, weed control and disease problems are also mentioned.

### Broccoli #18

Boron deficiency can be problematic for broccoli and other brassicas, this video explores the importance of crop nutrition across a range of brassicas. While in many cases crop quality is not affected it can be problematic especially in some retail outlets.

**CABBAGE**
Savoy cabbage is the most commonly grown cabbage type among the MOPS growers. Demand for Irish grown organic cabbage continues to increase.

### Cabbage #19

In this video Nick Cullen and John Hogan discuss the main Savoy cabbage varieties that he grows. The issue of winter supply and crop regrowth problems are discussed as well as potential crop damage from snow and frost for winter crops.

### Cabbage #20

Red cabbage is widely grown and here Oliver Kelly looks at his crop of winter red cabbage. Market specifications, harvesting and storage of cabbage are featured.

**PARSNIPS**
Parsnips are a good winter crop and very useful for growers who are selling into the larger retail chains and also for growers selling direct to consumers.

### Parsnips #21

Declan Doherty from Green Earth Organics discusses their Javelin parsnips, sowing details, weed control including hand weeding and the use of an inter-row cultivator. This crop followed a green manure fertility ley in the horticulture rotation and the benefits of first crop following a ley are discussed.

### Parsnips #22

This video at Green Earth Organics examines how to estimate parsnip yield in the field in terms of sowing densities and required seeds per acre. The desired parsnips per linear meter is evaluated. Harvesting before regrowth is also highlighted in order to maximise crop returns.

### Parsnips #23

The MOPS agronomist looks at the sowing method, land fertility, distance between rows, estimating how successful the seed rate transferred to parsnip yield, quality and volume. Market specifications and ideal markets for individual parsnip size is also explored in this video.

## SCALLIONS

Supermarket supply and direct sales account for the majority of scallion sales that are grown around the country by the MOPS growers. Indoor and outdoor production is carried out by growers who have an extensive growing season for scallions.

### Scallions #24

Padraig Fahy from Beechlawn Organic Farm discusses sowing time, crop density per meter squared, harvesting and the variety grown on this farm is Parade. The advantages of growing scallions through bio-degradable plastic is also evaluated in an Irish climate. The scallions are grown in conjunction with fennel which is also discussed in this video.

## BEETROOT

Beetroot is a crop favoured by many growers as it is an excellent crop for harvesting and selling over the winter months. Plant density is key to managing successful beetroot crops.

### Beetroot #25

Una ni Bhroin from Beechlawn Organic Farm explains how they manage their Pablo beetroot over the winter in terms of storage and market specifications. They grow their beetroot in three rows on a raised bed which makes winter harvesting easier and it minimises soil compaction.

## SPINACH

The MOPS growers produce a mixture of perpetual and true spinach depending on their market requirements. Indoor and outdoor spinach crops are common in Ireland.

### Spinach #26

Norman Kenny from Nurney Farm discusses field scale baby leaf spinach production. They sow a new crop every week during the summertime. Flame weeding is used prior to sowing and they sow crops as dense as possible in order to compete with weeds. A lot of baby leaf spinach is imported from Europe and Nurney Farm were experimenting with the crop in an attempt to substitute imports with an Irish supply.

### Spinach #27

Janet Power from Gorse Farm explains how they have changed their module size for sowing perpetual spinach Erbette to reduce the amount of compost required. Sowing density and crop management are also discussed in this video.

## TOMATOES

Growers participating in the MOPS project produce a wide range of tomato types and varieties. All are grown indoors with an emphasis on taste, colour and quality as they are a high value crop in all markets.

### Tomatoes #28

Vincent Grace from Riversfield Farm discusses the various cherry tomatoes that he grows each year with Sakura being one of his favourites. Organic growers must grow in the soil as growbags are not permitted under the organic regulations, the benefits that this has on crop particularly flavour is mentioned. Late season ripening of fruit and the removal of crops in order to prepare soil for winter salads is also discussed in this video.

## BRUSSELS SPROUTS

Brussels sprouts are an important winter crop for many organic growers. Plant density, button size and sowing to harvest time are all key components of producing this crop which is in the soil for many months.

### Brussels sprouts #29

Padraig Fahy from Beechlawn Organic Farm grows three varieties of brussels sprouts to extend the growing season. He outlines that he has approximately 15,000 plants per acre. Sowing, weeding, pest control, nutrition and harvesting are all discussed. Aeration and slug control are important aspects of taking care of the crop right up to the main selling period which is December. Removal of buttons at the base is also illustrated in order to maintain quality of the sprouts to achieve a high return.

### Brussels sprouts #30

Padraig Fahy from Beechlawn Organic Farm explains why he reduced the plant spacing for this crop in order to have an ideal size for the right time for market demand in tandem with his MOPS crop plan. Uniformity of button size reduces waste and maximises crop yield.

## CELERY

Celery can be grown both outdoors and indoors to extend the growing season to meet market demand for Irish organic celery.

### Celery #31

Field scale production of celery is discussed at Beechlawn Organic Farm. Victoria is the variety and market specification for direct sales and supermarkets are discussed as well as optimum timing for harvesting.

### Indoor Celery Production #32

Padraig Fahy from Beechlawn Organic Farm grows celery indoors to extend the growing season. The variety he grows is Victoria and in this video he explains how he grows, fertilisers, mulches, irrigates and harvests the celery. In a 100 square meters polytunnel he has approximately 2,500 plants which are sold direct to consumers and also into larger and independent retailers.

## ONION

While onions are not a high value crop there is a growing demand for Irish organic onions in all retail markets.

### Onion #33

Nurney Farm grow field scale white and red onions through bio-degradable plastic as most of the alliums find it difficult to compete with weeds due to their inability to grow dense foliage. The onions are harvested and dried in a polytunnel and used throughout the winter for their direct sales channels.

### Onion #34

This video looks at the importance of harvesting and storing onions. Vincent Grace from Riversfield Farm explains how the onions were harvested and left to dry in the field and why this is good for skin setting. Disease control is very important in order to increase storage performance of this crop. The benefits of growing onions from seed compared with sets is also discussed.

## CAULIFLOWER

Over winter cauliflowers can be difficult to grow and require well drained soils as plants remain in the ground for many months and the roots cannot be waterlogged which will limit crop growth.

### Cauliflower #35

Chester and Vogue are the varieties of over-wintering cauliflowers grown by Desmond Thorpe. This video looks at crop architecture, leaf and frame production, weed production and finally the ideal crown size for harvesting.

## COURGETTES

Courgettes are grown outdoors and indoors by the MOPS growers with both glasshouses and polytunnels used for indoor crops. They are a valuable crop for all retail markets.

### Courgette #36

Emmet Dunne from O' Duinn Organica explains his glasshouse production system for courgettes. The variety is Dunja and irrigation, plant supports and weekly harvesting are discussed. Hygiene is very important in a glasshouse in order to prevent disease. Protection of plants in a glasshouse is also mentioned in this video as it not a heated glasshouse so weather conditions and management are important.

## CUCUMBER

Kalunga and Passandra are two of the most popular varieties used by the MOPS growers for indoor production. These varieties yield well and are grown depending on markets as one produces long fruit with the other producing a shorter fruiting crop.

### Cucumber #37

Colm Warner from Nurney Farm discusses glasshouse production of cucumbers. These plants are grown on contract for a retailer. Variety, plant density, retail specifications, irrigation, crop nutrition, and biological pest control are discussed as red spider mite can be problematic in cucumber production.

## PURPLE SPROUTING BROCCOLI

This crop is grown by many of the MOPS growers who are focused on direct selling as it is not available in most of the larger retailers. It is a hardy prolific crop and provides fresh vegetables when many other crops are not in season.

### Purple Sprouting Broccoli #38

Green Earth Organics explain the merits of including purple sprouting broccoli in direct sales as it is a crop that people really enjoy using and it comes in the season when ordinary broccoli is not available. Plants were grown on a raised bed which helps prevent waterlogging throughout the winter months.

### Purple Sprouting Broccoli #39

Rudolph and Red Fire are two of the varieties grown by Riversfield Farm. This crop is available for harvesting from early December onwards. Vincent Grace explains his planting system, crop yield and spacings. Crop architecture is also outlined in this video. He grows 4 varieties to have a saleable crop for market from December to May.

## BEANS

Broad beans and French beans are the most common bean crops supplied by the MOPS growers. French beans are grown outdoors and indoors and climbing and dwarf varieties are used.

### French Beans #40

In this video Liam Ryan from Moyleabbey Farm explains how he achieves continuity of supply for climbing French beans from July through to September. For his direct sales markets he harvests twice a week, spacing here is two rows which suits the bed formation in his polytunnels.

## FENNEL

Fennel is popular with MOPS growers who supply direct sales channels and restaurants and chefs.

### Fennell

See video Scallions #24 as fennel is discussed in conjunction with scallion production at Beechlawn Farm as the crops are grown side by side under bio-degradable plastic.

## PUMPKIN AND SQUASH

Pumpkins are grown for the autumn season to coincide with Halloween however many different varieties are sold throughout the winter months. Restaurants and direct sales are the main retail outlets for the MOPS growers and the target is edible pumpkins and squashes.

### Pumpkins and Squash #41

Liam Ryan from Moyleabbey Farm outlines the various pumpkins and squash that he grows for both display and for cooking. Curing and hardening pumpkins is important to assist them in storage throughout the winter months. Irrigation is also key especially during the early growing season.

### Pumpkins and Squash #42

Patrick Frankel grows Crown Prince which is a more unusual pumpkin variety and he supplies mainly into restaurants. He outlines how the seed is saved from the previous crop and how they are grown, harvested and finally stored in a well ventilated polytunnel to maintain quality.

## SWEDES

Swedes are a useful crop for many growers as they can be supplied into various retail markets for a long duration.

### Swedes #43

Nick Cullen grows Tweed swedes on his farm. He supplies supermarkets and he also sells this crop to other organic growers for their markets. In this video the common issue of boron deficiency is discussed as well as ideal crop sowing dates, nutrition and weeding techniques.

## PEPPERS

Peppers are difficult to grow in Ireland and are ideally suited to early production and also glasshouses. They are sold in a range of markets but can be difficult to yield high volumes unless conditions are absolutely optimal.

### Peppers #44

Sweet pointed peppers and chilli peppers are grown in the glasshouse at Nurney Farm. Colm Warner explains planting dates of the crop transplants, weed control, and irrigation. Sunshine is critical for red pepper production which is mainly what customers prefer. Some of the crop is sold to other growers in the MOPS project to supply their individual markets.

## GARLIC

Most of the garlic produced by the MOPS growers is sold direct to consumers through boxes, farmers markets or via online sales. Many growers save seed to use for future crops. Like all alliums garlic can be difficult to control in terms of disease and harvesting and storage conditions contribute hugely to long term quality of the crop.

### Garlic #45

Emmet Dunne from O' Duinn Organica explains the varieties he planted overwinter in his glasshouse. Weed control is important to allow the crop to establish. Temperature control is also important in this environment and crops are covered with fleece at night to protect from low temperatures and frost.

### Garlic #46

Outdoor garlic production is popular among the MOPS growers and in this video Janet Power from Gorse Farm outlines their no-dig method of garlic production. Seed was saved from last years' crop and cloves were sown in early November.

## PARSLEY

This herb is grown by many of the MOPS growers however it is mostly grown in small quantities and for direct sales or into restaurants.

### Parsley #47

In this video Oliver Kelly outlines his curly and flat leaf parsley crops. Plants were sown in July for the December market. Plants were sown through bio-degradable plastic. Italian giant is the flat leaf variety and Krausa is the curly leaf variety sown on the farm.

## CELERIAC

This crop is not widely grown in Ireland among organic growers as it can be difficult to ensure adequate growth as irrigation and crop nutrition are key aspects of production for this slow growing crop.

### Celeriac #48

The variety of celeriac grown on Oliver Kelly's farm is Brilliant. In this video crop spacing, harvesting and washing the fibrous roots for markets is discussed. One of the dangers of growing celeriac if you grow celery is that it makes celery leaf spot more prolific so care must be taken to keep crops separate and allow for adequate ventilation around each crop.

**ROMANESCO**
This crop is a cross between broccoli and cauliflower and is used by MOPS growers who are selling direct to the consumer or into restaurants.

### Romanesco #49

Declan Doherty from Green Earth Organics explains the benefits of including this flexible crop in your cropping plan as it can store longer and is also a bit more frost hardy than broccoli. Declan also feels that it is easier to grow than cauliflower and it is a more versatile crop for their markets which are direct sales.

**SWEETCORN**
Sweetcorn is grown for specialist markets in Ireland and predominantly sold direct to customers in local markets around the country.

### Sweetcorn #50

Liam Ryan from Moyleabbey Organic Farm plants three separate sowings of sweetcorn throughout the season to extend sales. He grows Swift, Lark and Early Bird and crop performance is very dependent on the season and the weather. It is a short season and crops are covered with nets to protect them from birds and wind damage. Flavour is key to sweetcorn as Liam sells direct to customers. Harvesting usually begins in mid-August.

### Sweetcorn #51

Liam Ryan from Moyleabbey Organic Farm outlines how he plants his sweetcorn on ridges to optimise weed control and airflow. Like most crops weed control in the early stages is crucial and Liam is happy with the ridging system that he uses for this and other crops. The sweetcorn he grows is very popular with his customers at his home farm shop and also the farmers markets.

**JERUSALEM ARTICHOKES**
This crop is grown by a small number of MOPS growers with the majority of the crop produced for speciality retail outlets and for restaurants.

### Jerusalem artichokes #52

In this video Patrick Frankel from Kilbrack Farm outlines how the tubers were planted, spacing and importance of anchoring stems to maintain yield. The crop is harvested in November and senescence takes place slowly in the autumn. Market demand and yield evaluation are also discussed in this video.

# 5 - MOPS project climate/weather monitoring

## 5.1 Weather Monitoring

The MOPS program included a level of environmental monitoring throughout 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. Weather monitoring was undertaken to provide data in delayed mode (not real time) 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 combined air temperature and relative humidity sensors were placed both inside and outside. Data were downloaded at regular project monitor visits and collated centrally where various summary charts were produced, e.g., daily averages. Time series plots were provided at regular intervals as feedback to project meetings and for general interest.

## 5.2 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.

## 5.3 Data collection sites

Figure 1(a) and Table 1 shows the general locations of the growing sites. Figure1(b) displays the locations of the synoptic Met Eireann weather stations where data are freely and openly available for public consumption.

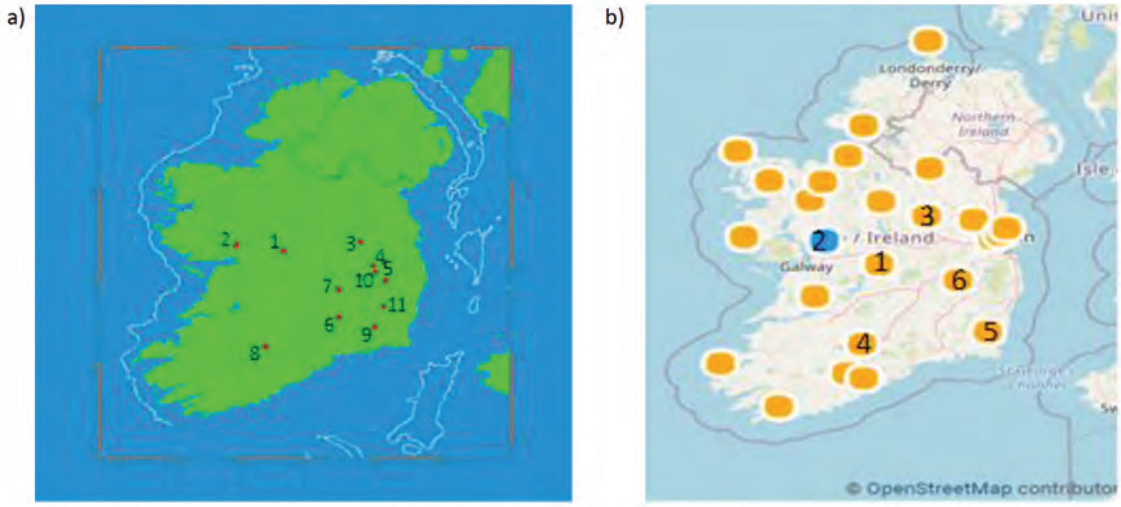


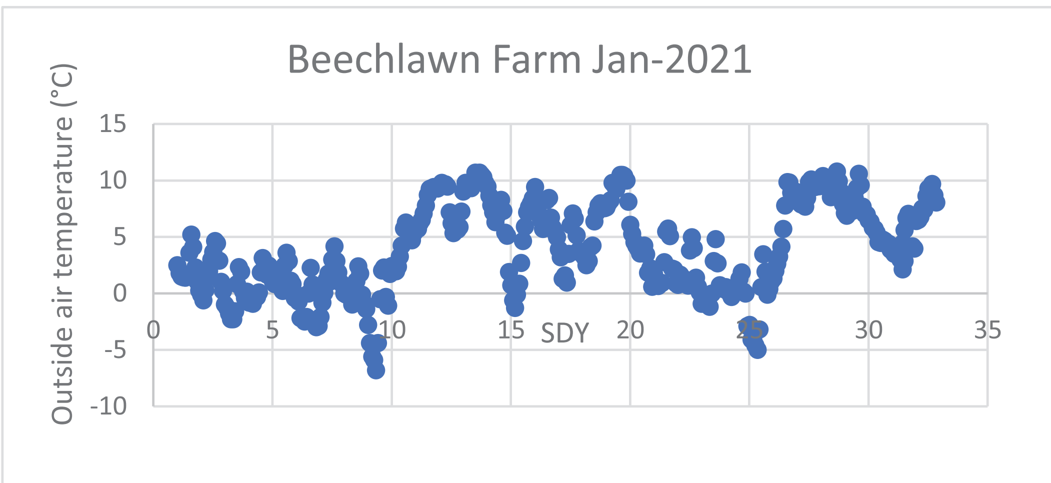

*Figure 1. Location of (a) MOPS growing sites and (b) Met Eireann synoptic weather stations.*

**Table 1.** Growing site locations and National weather monitoring services available from Met Eireann (online available: https://www.met.ie/climate/available-data/monthly-data).

| Site | MOPS growing site | Latitude, longitude | Adjacent Met Eireann monitoring station | |
|---|---|---|---|---|
| 1 | Beechlawn Organic Farm | 53.318238 , -8.224681 | 2 | Athenry |
| 2 | Green Earth Organics | 53.390563 , -8.976953 | 2 | Athenry |
| 3 | Nurney Farm | 53.388107 , -6.990220 | 3 | Mullingar |
| 4 | Moyleabbey Organic Farm | 53.042783 , -6.791531 | 6 | Oak Park |
| 9 | Thorpe's Organic Farm | 52.413760 , -6.858238 | 5 | Johnstown castle |
| 6 | Riversfield Organic Farm | 52.533990 , -7.399630 | 4 | Moore Park |
| 7 | O'Duinn Organacha | 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 | Nick Cullen | 53.121350 , -6.825900 | 6 | Oak Park |
| 5 | Oliver Kelly | 52.941700 , -6.643290 | 6 | Oak Park |

Data from the sites were readily recovered from the data files and were reported back to the project group for consideration, albeit after the fact. For example, Figures 2(a) and 2(b), for Beechlawn Organic Farm in Ballinasloe, Co Galway show a snap-shot of air temperature observations and the rainfall (by month) measured during the study period.

a)



b)

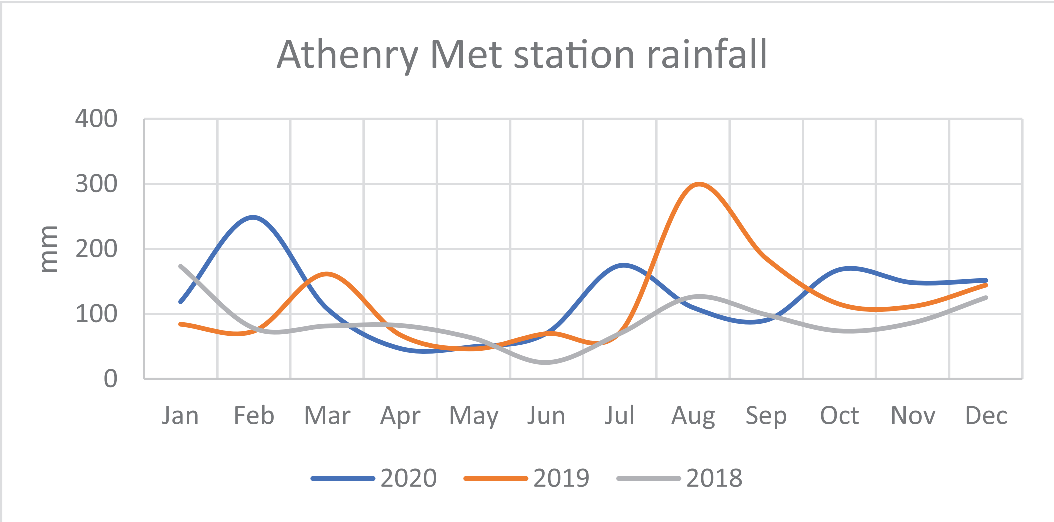



***Figure 2 (a) Lowest daily air temperatures recorded in the month of January 2021, (b) Total annual rainfall (by month) from Athenry Met Station for the periods 2020, 2019 and 2018 (data taken from www.met.ie).***

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 Eireann network.

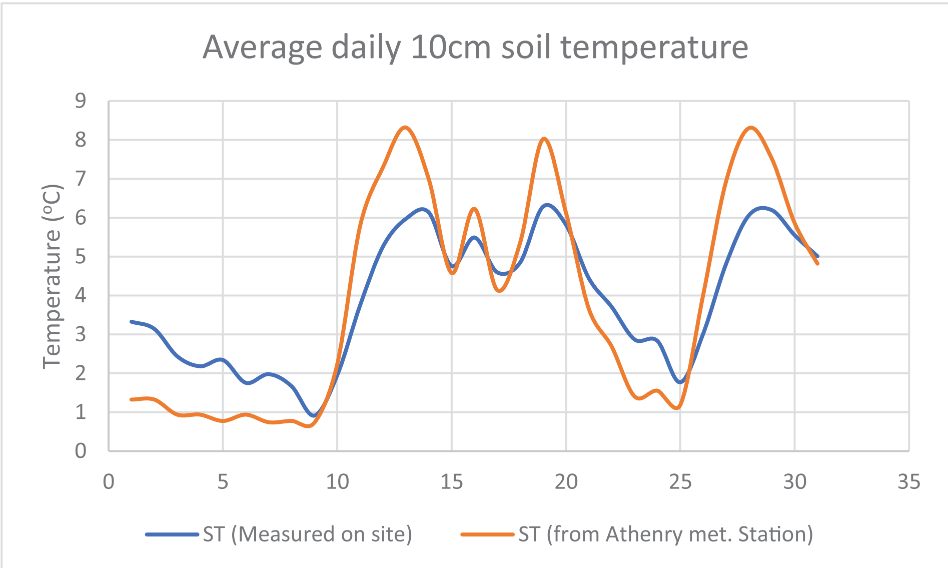



***Figure 3 Comparison of local (Beechlawn Farm) measured soil temperature (blue line) and soil temperature measured at a nearby weather station (orange line) during January 2021 (data from www.met.ie).***

Data displayed in Figure 3 show a time series comparison of daily soil temperature averages for January 2021 at Beechlawn farm and the Athenry Met Station @40km away. 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 (R2 =0.263). 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 a useful record and *monitoring tool to growers.*

# 6 MOPS project technical note: using organic materials in organic agriculture and horticulture production in Ireland

## 6.1 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
- sample analysis results including those from organic materials that were sampled from participant MOPS project growers

***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].

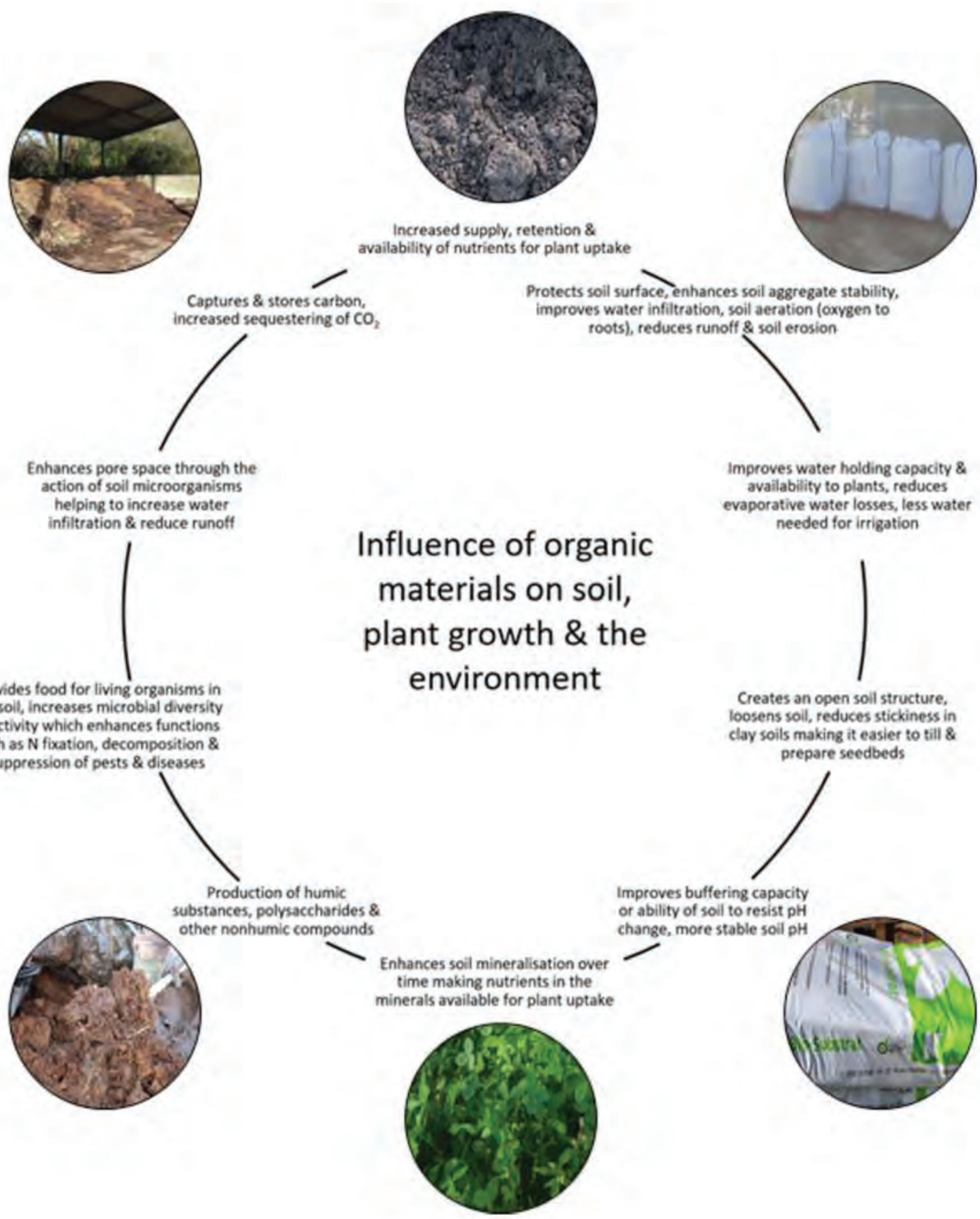



***Figure 2 Important ways in which organic materials influence soil properties, plant growth and the environment*.**

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.

## 6.2 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

Section 6.10 Additional information and references in this technical note provides links to further details on the above legislation, regulations, standards and guidelines.

Note: the new organic Regulation (EU) 218/84820 repealing Regulation (EC) No 834/20078 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 1 January 2022.

## 6.3 Sampling organic materials for nutrient analysis

**6.3.1 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

**6.3.2 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

**6.3.3 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*

## 6.4 Interpretation of nutrient analysis results and calculations

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

**6.4.1 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/m3 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/m3
- total nutrients or available (extractable) nutrients
- as nutrient element (N, P, K, Ca, Mg, S) or nutrient oxide (P2O5, K2O, CaO, MgO, SO3)

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.

**6.4.2 Conversion calculations for nutrients**

Nutrient content results in laboratory analysis reports may be expressed in oxidised form or elemental form. For example, P2O5 and K2O 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 |
|---|---|
| P2O5 × 0.436 = P | P × 2.292 = $P_2O_5$ |
| K2O × 0.83 = K | K × 1.205 = $K_2O$ |
| CaO × 0.715 = Ca | Ca × 1.399 = CaO |
| MgO × 0.603 = Mg | Mg × 1.658 = MgO |
| SO3 × 0.40 = S | S × 2.50 = $SO_3$ |
| Na2O × 0.742 = Na | Na × 1.348 = $Na_2O$ |

**6.4.3 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 |

**6.4.4 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 $\times \frac{\%\ \text{DM}}{100}$ |
| To convert g/100 g nutrient in DM to kg/t FW: | g/100 g nutrient $\times \frac{\%\ \text{DM}}{10}$ |
| To convert % nutrient in DM to kg/t FW: | % nutrient $\times \frac{\%\ \text{DM}}{10}$ |

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

**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).*

### 6.4.5 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: $\frac{\text{mg/kg nutrient}}{1{,}000} \times \frac{\text{\% DM}}{100}$

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

**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 | |

### 6.4.6 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., P2O5 and K2O) 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 % P2O5 | 9 % × 0.436 = 3.924 % | 0.03924 × 25 kg = 0.981 kg of P |
| 0 % K2O | 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 % P2O5 | 1.2 × 0.436 = 0.524 | 0.00524 × 25 kg = 0.131 kg of P |
| 3 % K2O | 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 % $K_2O$.***

**6.4.7 Example laboratory analysis results and using organic materials**

Table 7 provides an 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** |

## 6.5 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.**

| Parameter | Mean | kg/t FW<br>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 | Mean | kg/t FW<br>Minimum | Maximum |
|---|---|---|---|
| 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 | - |

## 6.6 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 |

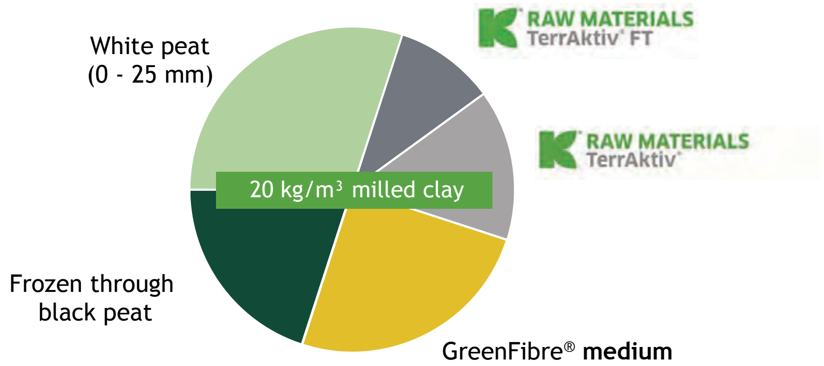
SUBSTRATES Easy Growing

1913 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 |

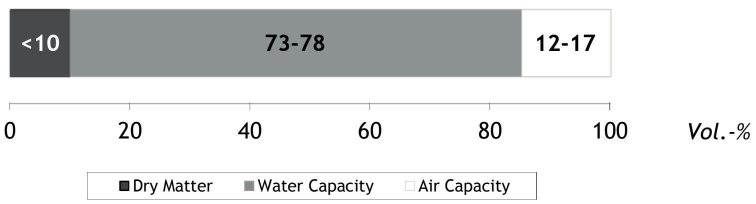
| Fertiliser | kg/m³ |
|---|---|
| Horn shaves | 4.0 |
| + extra trace element fertiliser | |

**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<br>Shrubs<br>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.

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***Figure 4 Example of producer compost analysis results.***

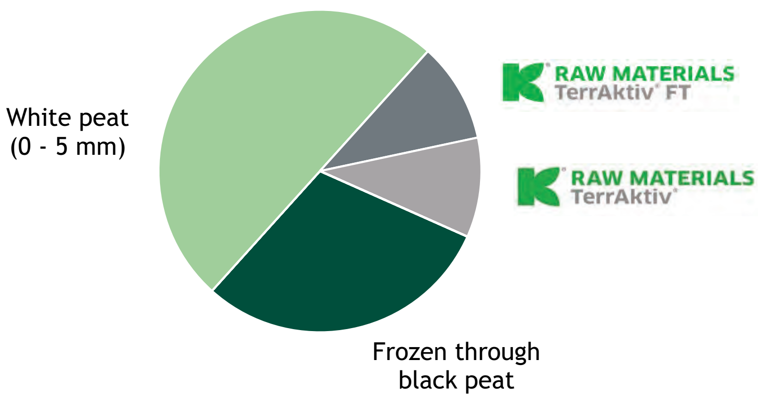
SUBSTRATES Easy Growing

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 |

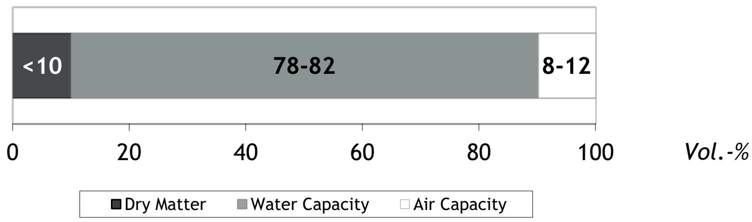
| Fertiliser | kg/m³ |
|---|---|
| Horn shaves | 2.0 |
| + extra trace element fertiliser | |

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

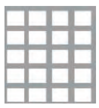
| | |
|---|---|
| Nitrogen (mg N/l): | 300 - 400 |
| Mineralised N (mg N/l)* | 50 - 80 |
| Phosphorus (mg $P_2O_5$/l): | 200 - 300 |
| Potassium (mg $K_2O$/l): | 300 - 500 |
| Magnesium (mg Mg/l): | 100 - 200 |

* available on delivery

## Physical Data:
(according to EN 13 041)




## Trays:



## Additional Comments:

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.

## Plants:

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<br>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.<br>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.<br>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.***

## 6.7 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.

### 6.7.1 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/m$^3$ FW<br>Whole (slurry) digestate | kg/t FW<br>Whole digestate | kg/t FW<br>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 |

## 6.8 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 (NH4+) | 1.71 | - | 0.59 |
| Nitrate Nitrogen (NO3-) | 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 |

## 6.9 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 (NH4+) | 1.65 | 0.82 | 1.36 | 9.36 |
| Nitrate Nitrogen (NO3-) | 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%

## 6.10 Additional information and references

Further useful information can be found in the following sources, Tables 15, 16, 17 and 18, and the reference list.

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 15 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 m3 | 220 gallons | |
| 4.5 m3 | 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 m3/ha | 90 gallons/acre | |
| 11 m3/ha | 1,000 gallons/acre | |
| 1 kg/m3 | 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 16 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/m3 | 1.6 | 0.6 | 1.7 | 0.3 | 0.2 |
| Cattle slurry | 6 | Kg/m3 | 2.6 | 1.2 | 2.5 | 0.7 | 0.6 |
| Cattle slurry | 10 | Kg/m3 | 3.6 | 1.8 | 3.4 | 1 | 0.9 |
| Dirty water | 0.5 | Kg/m3 | 0.5 | 0.1 | 1 | 0.1 | 0.1 |
| Pig slurry liquid | 2 | Kg/m3 | 3 | 0.8 | 1.8 | 0.4 | 0.4 |
| Pig slurry liquid | 4 | Kg/m3 | 3.6 | 1.5 | 2.2 | 0.7 | 0.7 |
| Pig slurry liquid | 6 | Kg/m3 | 4.4 | 2.2 | 2.6 | 1 | 1 |
| Pig slurry separated liquid portion | 3 | Kg/m3 | 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/m3 | 4.8 | 1.1 | 2.4 | 0.7 | 0.2 |
| Digestate food-based separated liquid | 3.8 | Kg/m3 | 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/m3 | 3.6 | 1.7 | 4.4 | 0.8 | 0.6 |
| Digestate farm-sourced separated liquid | 3 | Kg/m3 | 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 17 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/m3 | 2 (0.7) | 0.6 | 3.3 |
| Pig (4 % DM) | Kg/m3 | 2.1 (2.1) | 0.8 | 1.9 |
| Soiled water | Kg/m3 | 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/m3 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 18 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.

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*The EIP-AGRI programme was launched by the EU Commission in 2012 to move towards smart, sustainable and inclusive growth in the agricultural sector. It was envisaged as a coming together of expertise in academic institutions, researchers and farmers to form partnerships working from the bottom up to solve issues in the agricultural sector. As a result, the Department of Agriculture, Food and the Marine have funded a variety of projects nationally under the EIP programme.*

*Maximising Organic Production Systems (MOPS) is one such project, which was successful as part of the first EIP open call in 2017, and it works with eleven certified organic horticulture farms of varying sizes and cropping capacity. Research and development in organic farming production methods is almost non-existent in Ireland, therefore the lead project partner the Irish Organic Association included a Green Manure Trial in the MOPS project. The following report is based on the trial.*

# 7 Field Trials on the Role of Short-term Green Manures in Organic Vegetable Production in Ireland

## INTRODUCTION

**Green manures**
"Green manures" are crops specifically sown to be incorporated into the soil to improve soil structure and fertility. 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" (Table 1).

**Types of green manure**
There are three main types of green manure: long-term, 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 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.

## Effects of green manures

**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.

**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 (low-pH) 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$^{o}$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.

**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.

**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.

**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 of these more fibrous plants 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 include no cash crops.

**Table 1. Characteristics of green manure plants for Irish conditions**

| 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 |

| Plant | N effect[1] | Weed effect[2] | Sowing date | Sowing rate (kg/ha) | Green manure type[3] | Comments |
|---|---|---|---|---|---|---|
| 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 soils, alkaline soils |
| Red clover | NF | | March-May, | 15-25 | LT | Herbaceous perennial, erect or Augusthabit, topped at 30cm. Deep roots, improves soil structure. |
| Sweet clover | NF | | March-May, or August | 15-30 | STS STW | Biennial, erect habit (not good weed suppression). High biomass. Tap root, breaks "pans". |
| Lucerne | NF | | March-May, or August | 20-30 | LT | Herbaceous perennial. Needs alkaline soil (>pH6.3). Slow to establish, slow to suppress weeds |
| Vetch | NF | WSWA | 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 | NHNL | 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. Buckwheat seed is expensive. |

| Plant | N effect[1] | Weed effect[2] | Sowing date | Sowing rate (kg/ha) | Green manure type[3] | Comments |
|---|---|---|---|---|---|---|
| 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 | NHNL | WSWA | 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 | NHNL | WS (early) | March-April or August - late September | 30 | LT | Short-lived perennial. Rapid early growth, good early weed suppression. Needs regular topping. |
| Mustard | NLNH | 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 – 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 | NHNL | 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. |

| Plant | N effect[1] | Weed effect[2] | Sowing date | Sowing rate (kg/ha) | Green manure type[3] | Comments |
|---|---|---|---|---|---|---|
| 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. |

**Key**
*[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.*

## 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.

## 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 because of the risk of building up levels of soil-borne specialist brassica pests and pathogens, preventing the use of some of the widely used green manure crops, such as mustard and fodder radish.

## 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.

## Trial site

The trials were carried out over three years (June 2018 - May 2021) on the organic mixed farm of Des Thorpe at Lacken, Enniscorthy, Co. Wexford. The soil on the site, which had been under grass for silage for a number of years, was a sandy loam, pH 5.9, and the nutrient analysis is shown in Table 2. Granular fertilisers were applied on 15/09/2018 by hand to to raise the levels of K (sulphate of potash, 5 kg/plot) and P (rock phosphate, 5 kg/plot) to Index 2.

**Table 2. Soil analysis of 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 | - |

The 3000–4000 $m^2$ site for each year's trials 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).

***Fig. 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 3), with four replicate plots of each. 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 as the cash crop and 16 with onion 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 32 winter green manure plots (Table 2), with broccoli and red oakleaf lettuce as the two cash crops

**Table 3. Composition of the green manure seed mixes (Fruit Hill Farms, Bantry, Co. Cork)**

| Green manure (kg/ha) | Composition | Ratio | Seeding rate |
|---|---|---|---|
| Summer | Control* | - | - |
| | Buckwheat/phacelia | 60: 40 | 32 |
| | Rye/ phacelia | 60: 40 | 67 |
| | Persian clover/Egyptian clover/ Westerwold's ryegrass | 30: 30: 40 | 28.5 |
| Winter | Control* | - | - |
| | Vetch/crimson clover/ Westerwold's ryegrass (Landsberger) | 30: 30: 40 | 65 |
| | Rye/vetch | 60: 40 | 160 |
| | 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

## RESULTS

**Restrictions**
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.

**Green manure establishment (2018-9)**

**Soil nutrient analysis (2018)**
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 4), 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.

**Table 4. Effect of 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 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. 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 4). Each of the three green manures (but not the control plots) exhibited higher soil organic matter 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 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 (Mr Thorpe) 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.

**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 5).

**Table 5. Effect of winter green manures on macronutrient contents (%) in leaves of red oakleaf lettuce**

| 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 |

*Any two samples within a row with a common letter are not significantly different.*

**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. 2). 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).

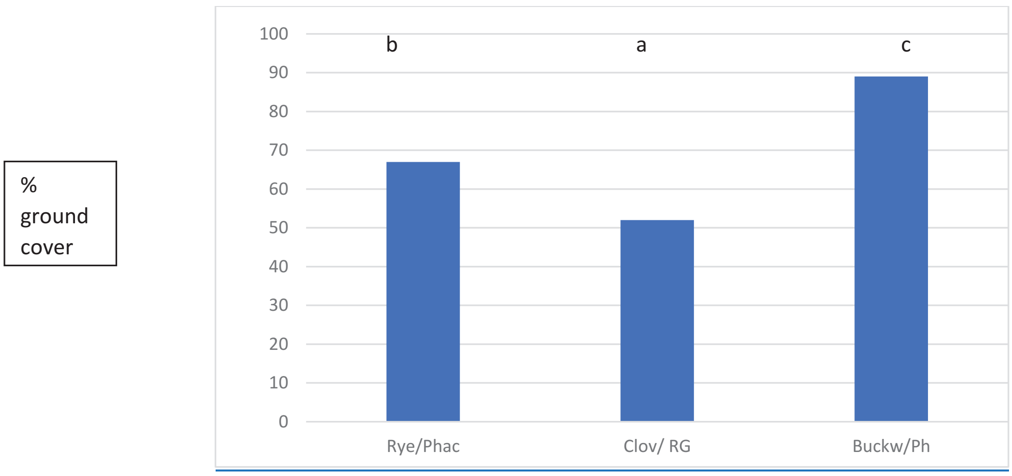


***Fig. 2. Percentage ground cover of the three summer green manure crops after 2 months.***
*Any two samples with a common letter are not significantly different (P>0.05).*

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, where no significant difference in establishment between the three winter green manures was determined (Table 6) 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 6. Winter green manure establishment (percentage soil cover)**

| 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 |

*Any two samples within a row with a common letter are not significantly different.*

**Weed management (2018-2020)**
The main weed species in the trial site were the annuals corn spurrey, fumitory and charlock (from the seed bank) and the perennials dock and perennial ryegrass.

***Corn spurrey***

***Fumitory***

***Charlock***

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.3), and a significant negative relationship between green manure % cover and % weed cover. The green manures caused significant reductions in the population sizes of the three annual weeds but had no significant effect on % cover of the perennial weeds.

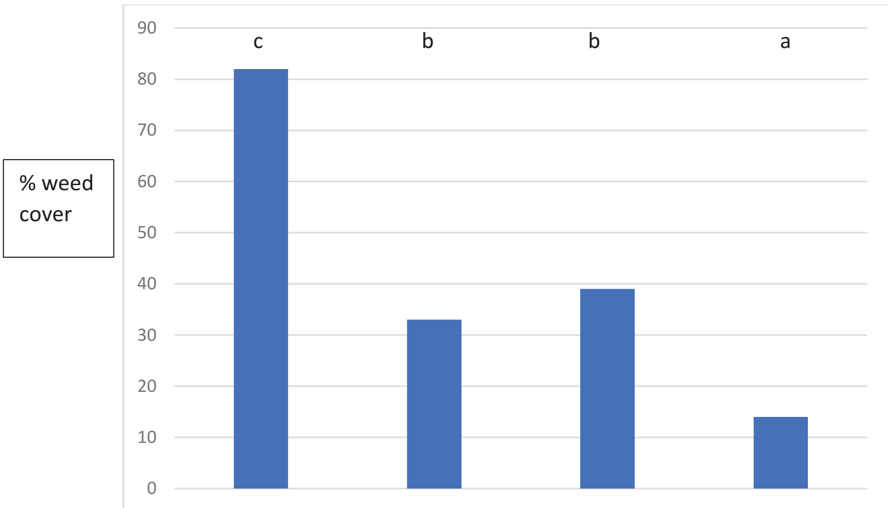


***Fig. 3. Percentage weed cover in the green manure plots after 2 months.***
*Any two samples with a common letter are not significantly different (P>0.05).*

After incorporation of each of the three summer green manures and transplantation of the onion or 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 7), 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 7. Effect of incorporated summer green manures on weed cover**

| | 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 |

*Any two samples within a row with a common letter were not significantly different*

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 8), 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 8. Effect of winter green manure treatments on the frequency of dock (*Rumex* sp.) plants (mean number per plot) (21/05)**

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

*Any two samples within a row with a common letter are not significantly different*

**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 ground beetles, 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. 4). Phacelia is usually regarded as a green manure which supports high populations of beneficial insects.

***Common Ground Beetle***

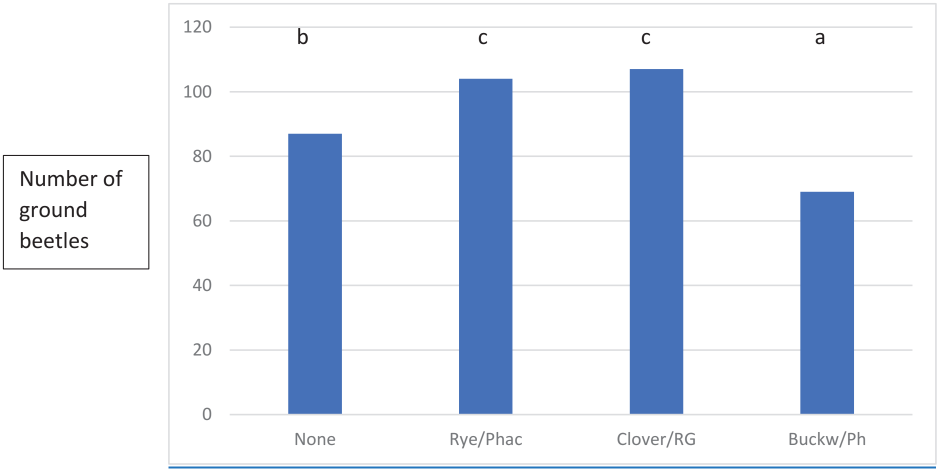


***Fig. 4. Number of ground beetles trapped in summer green manure crops after 2 months in 2018.***
*Any two samples with a common letter are not significantly different (P>0.05)*

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. 5).

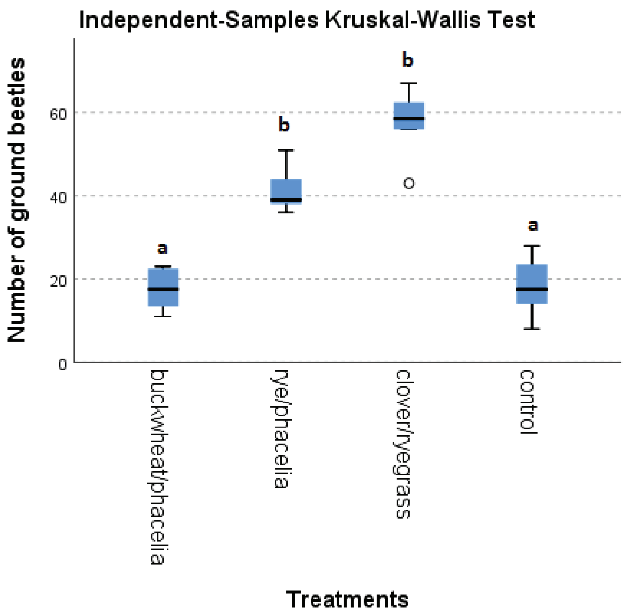


***Fig 5. Numbers of ground beetles in summer green manure and control plots in 2019.***
*Any two samples with a shared letter are not significantly different (P>0.05)*

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 9). 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 9. Numbers of ground beetles in winter green manures in 2018**

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

*Any two samples within a row with a common letter are not significantly different*

**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. 6). The average intensity of colour over the plate reflects the density of bacteria in the soil (Fig. 7), while Principal Component Analysis of the results (Fig. 8) reflects the functional diversity of the bacteria in each soil sample.

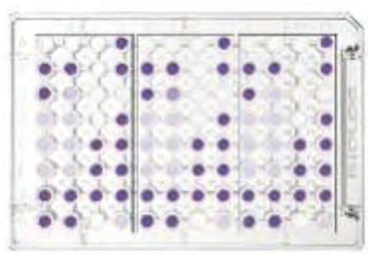

***Fig. 6. A developed Eco-Biolog plate: the deeper the colour in a particular well, the more bacteria in the soil could use the particular C source in that well.***

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. 7). Note that the y-axis (vertical axis) of Fig. 7 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 ($9 \times 10^6$), species from plant families (Polygonaceae and Boraginaceae) not commonly found in grassland. The clover/ryegrass mix supported the highest bacterial density ($7 \times 10^8$), 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.

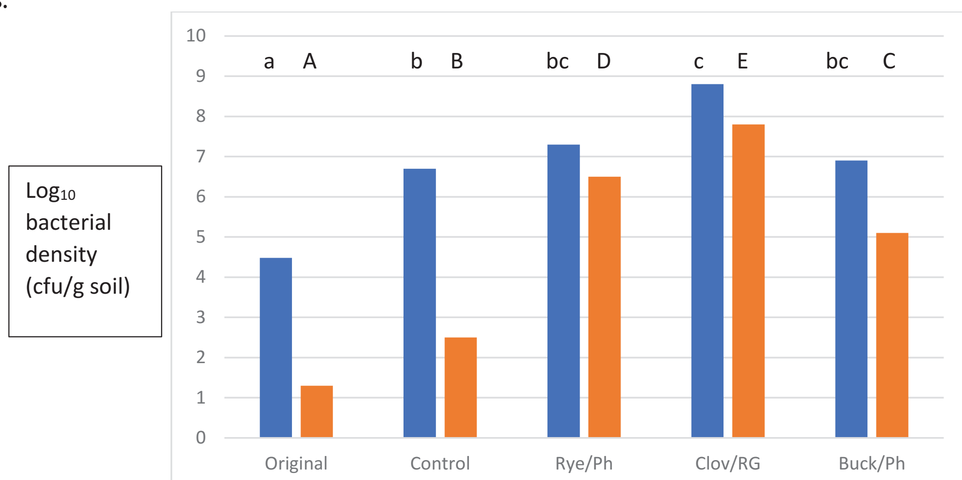


***Fig. 7. Effect of different soil sources on log total bacterial density (cfu/g soil; blue) and log total pseudomonad density (cfu/g soil; orange).***

*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 (Fig. 8), whereas the phacelia/rye and, in particular, the clover/ryegrass plots gave quite distinct diversity signatures, reflecting the results from the bacterial densities (Fig. 8).

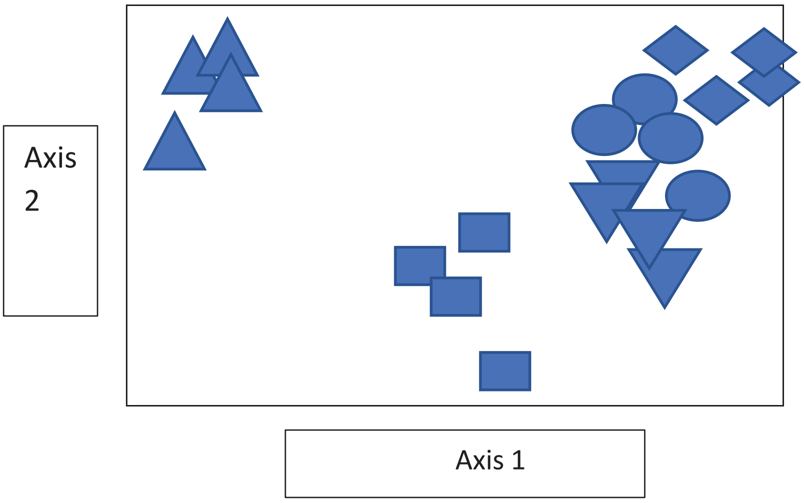


***Fig. 8. Principal Component Analysis of Biolog data.***
*Diamonds: original pasture land; circles: buckwheat/phacelia; inverted triangles: control; squares: phacelia/rye; triangles: clover/ryegrass*

The 2019 investigation 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) 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 10).

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 10). 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 10. Effect of green manures (before and after incorporation) on soil bacterial population numbers (AWCD) and diversity (Richness, Shannon Index) from Eco-Biolog plates.**

| 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 |

*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)*

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 10), PCA revealed that differences remained in the ability of the bacterial populations under different green manures to metabolise different organic compounds in the soil (Fig. 9).

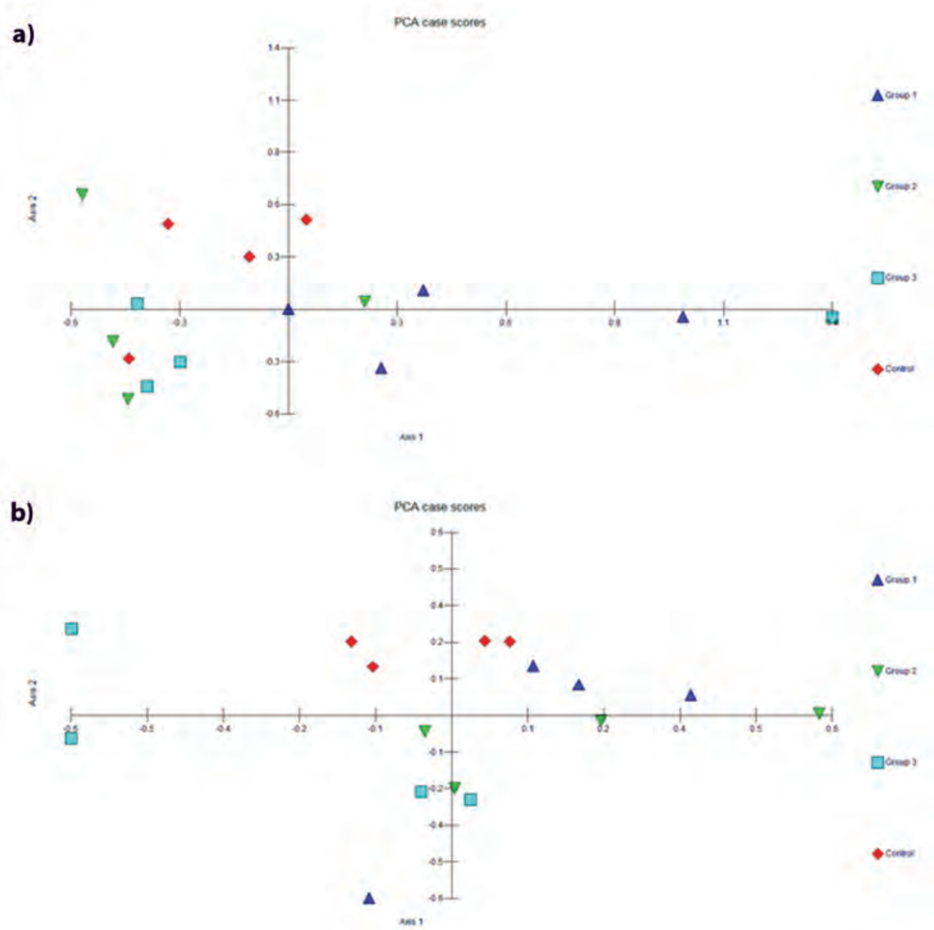


***Fig. 9. Principal Component Analysis of Biolog-ECO data from the different green manure plots before (a) and after incorporation (b).*** *Red: control; dark blue: buckwheat/phacelia; green: rye/phacelia; light blue: clover/ryegrass*

The four examples of each green manure in Fig. 8 represent the four replicate plots. Although the replicates of the same green manure are scattered, trends are visible. Before incorporation (Fig. 8a), 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. 8b), 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.

**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 11). 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 12).

**Table 11. Effect of incorporated summer green manures on crop plant development (2019)**

| 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 |

*Any two samples within a row with a common letter were not significantly different.*

**Table 12. Effect of incorporated summer green manures on mean cabbage head fresh weight (g) (2019)**

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

*Any two samples within a row with a common letter were not significantly different.*

The onion crops after each of the summer green manures were significantly heavier than in the control plots (Fig. 10).

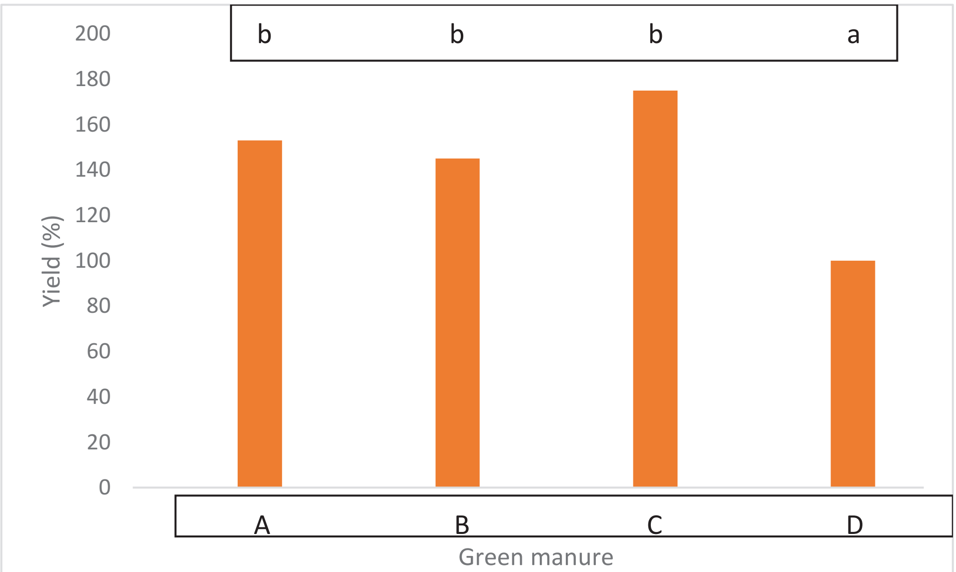


***Fig. 10. Effect of summer green manure incorporation on onion yield, as % of control (D).***
*A: rye/phacelia; B: buckwheat/phacelia; C: clover/ryegrass; D: control.*
*Any two bars with a common lowercase letter are not significantly different.*

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 13). 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 13. Effects of incorporated summer green manures on crop development (leaf number/plant) of onion and cabbage cash crops in 2020**

| | 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 |

*Any two samples within a row with a shared letter are not significantly different (P>0.05), using the Tukey test.*

In Years 1 (2018–2019) and 2 (2019–2020), the pointed cabbage (cv. Duncan $F_1$) was planted after summer green manure incorporation (Fig. 1). The yields were similar between the three years (Table 14), 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 14).

**Table 14. Effects of summer green manures on yield of pointed cabbage in 2019–2021.**

| 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 | 100a | 100a |

**Yield expressed as % of control*

*Any two treatments within a year with a common letter are not significantly different*

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. 11).

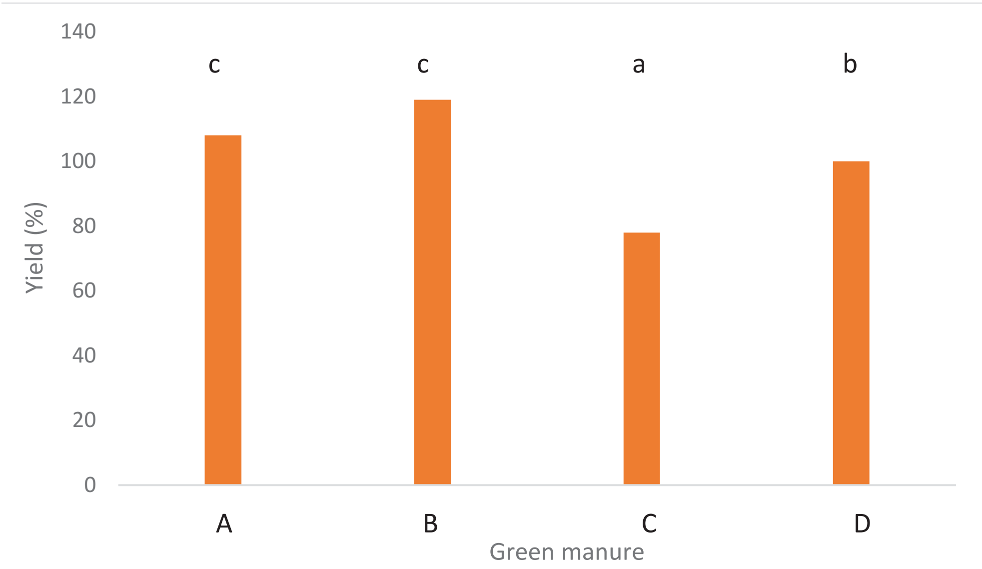


***Fig. 11. Effect of winter green manure incorporation on red oakleaf lettuce yield in 2019, as % of control (D).***
*A: vetch/clover/ryegrass; B: clover/oats/rye; C: rye/vetch; D: control.*
*Any two bars with a common lowercase letter are not significantly different.*

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 direct sowing 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 15). 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 15. 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. 12), 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.

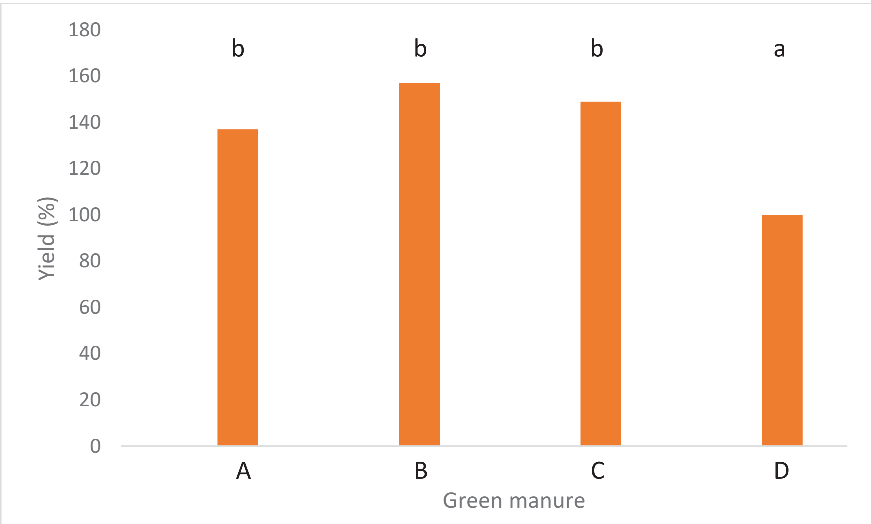


***Fig. 12. Effect of winter green manure incorporation on broccoli yield in 2019, as % of control (D).***
*A: vetch/clover/ryegrass; B: clover/oats/rye; C: rye/vetch; D: control.*
*Any two bars with a common lowercase letter are not significantly different.*

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 16 and 17). 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 16).

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 16).

**Table 16. Effects of winter green manures on yield of broccoli in 2019 and 2020.**

| 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*

*Any two treatments within a year with a common letter are not significantly different*

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 2020. 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 17). There was clear evidence of green manure-specific effects on cash crop yield in 2020 and 2021, with rye/vetch green manure causing the least yield-stimulation of broccoli but the greatest stimulation of lettuce yield, after extending the delay between green manure incorporation and cash crop transplantation.

**Table 17. Effects of winter green manures on yield of red oakleaf lettuce in 2019–2020.**

| 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 | 122 b |
| Control | 100 | 101 a | 100 a |

**Yield expressed as % of control*

*Any two treatments within a year with a common letter are not significantly different*

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. 2) 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. 13–15).

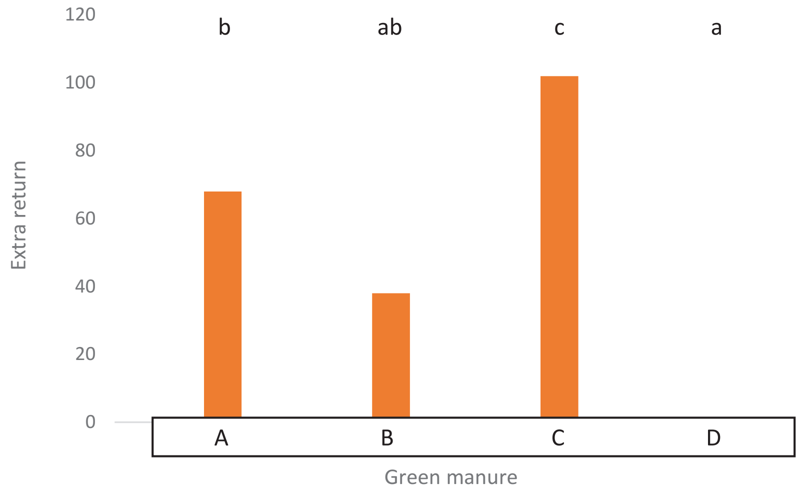


***Fig. 13. Net additional income (€/50 m²) from onions grown after summer green manure in 2019, with control (D) being zero****. A: rye/phacelia; B: buckwheat/phacelia; C: clover/ryegrass; D: control. Any two bars with a common lowercase letter are not significantly different.*

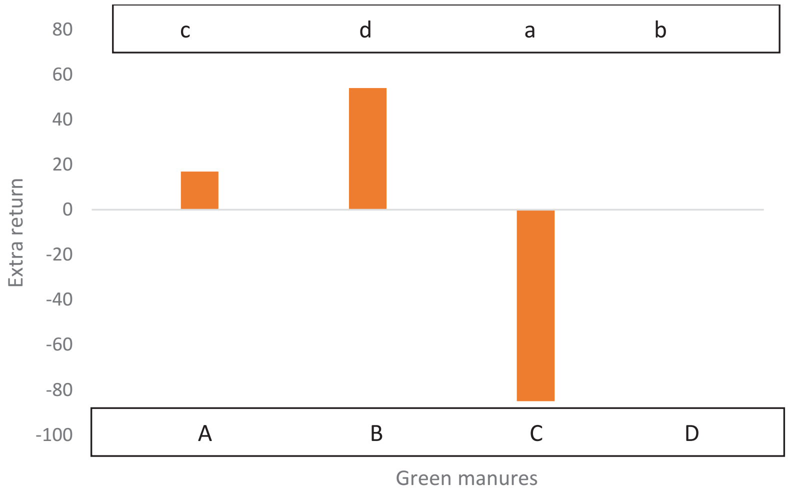


***Fig. 14. Net additional income (€/50 m²) from red oakleaf lettuce grown after winter green manure in 2019, with control (D) being zero****. A: rye/phacelia; B: buckwheat/phacelia; C: clover/ryegrass; D: control. Any two bars with a common lowercase letter are not significantly different.*

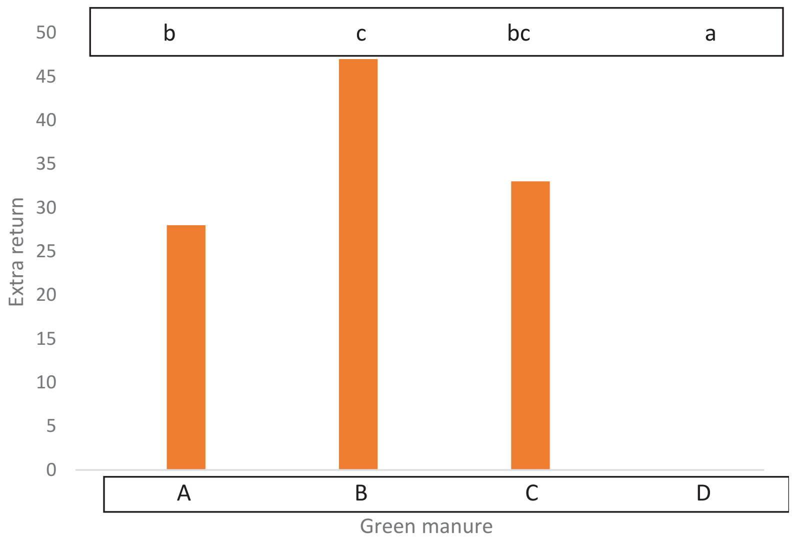


***Fig. 15. Net additional income (€/50 m²) from broccoli grown after winter green manure in 2019, with control (D) being zero.*** *A: rye/phacelia; B: buckwheat/phacelia; C: clover/ryegrass; D: control. Any two bars with a common lowercase letter are not significantly different.*

The cost-benefit analyses showed that all cash crops bar the lettuce crop after the rye/vetch winter green manure resulted in a significant increase in returns over and above the costs associated with setting up the green manures (Figs.13–15). 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 50 $m^2$ (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 50 $m^2$ lower than in the control.

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.

## SUMMARY

**In the summer green manure:**

- 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>control
- Onion yield: clover/ryegrass>rye/phacelia>buckwheat/phacelia>control

**In the winter green manure:**

- 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_

## 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 70.0 mm (2018), 120.2 mm (2019), 83.1 mm (2020) and 99.4 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 ("refugium") increased biodiversity throughout the growing season and provided a corridor for species movement from the headlands (data not shown). The strip could be topped to prevent flowering or allowed to flower, further increasing biodiversity. 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. The initial results, however, are promising and suggest that green manures can readily and profitably be incorporated into Irish organic vegetable production.

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