A Guide to Vegetable Growing

Teagasc
Agriculture and Food Development Authority

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Vegetable Growing

The selection of fresh vegetables now available in shops and supermarkets is greater than ever before. But there's a huge amount of satisfaction to be had from growing part of the food we eat. A well-managed garden or allotment is an asset to any family and vegetable growing can rapidly develop into an absorbing hobby.

The quantities of vegetables to grow will naturally depend on circumstances. It can be as simple as growing a pot of parsley on your back doorstep or you can make it as big and fancy as you like. If there's only a small area available preference should be given to items where freshness is especially valuable such as lettuce, herbs, spinach, parsley, peas and beans. If there's more ground add brassicas, onions, carrots, beetroot, rhubarb and early potatoes to the mix. It will also add interest to try out some new or unfamiliar kinds each year.

Helpful Hints

(1) Vegetables can be grown on most soils (light, medium or heavy) provided they are well drained. Choose an open though not exposed site, where plants can receive maximum sunlight.

(2) Crops are grown on the flat, in drills (ridges) or on raised beds (also known as deep beds). Choose the system that suits you best. Or maybe a combination of all three.

(3) Site perennial vegetables, such as asparagus, rhubarb, seakale, horse radish and other crops which remain in one place for a number of years to one side so that they do not interfere with the cultivation of annual crops.

(4) Grow the early maturing crops together so that when they are harvested the ground may be planted with late crops. For example, early potatoes, scallions, lettuce, spinach and radish could be followed by savoy cabbage, winter cauliflower or late celery.

(5) Vegetables are normally either sown directly where they are to mature (known as direct drilling) or else the seed is sown into a nursery bed or modules (multi-celled tray) and later on the young plants (transplants) are planted out into

their final quarters. Carrots, parsnips, scallions, beetroot, swedes, spinach, radish, peas and beans are usually direct drilled, while most brassicas, lettuce, celery and courgettes are transplanted. Leeks, onions and sweetcorn are examples of crops that can either be drilled or planted.

(6) A common mistake is to sow seed too thickly. As the seeds germinate and the young plants come through they should not crowd each other. Thinning out plants to their final distance should be done when they are still quite small. The depth to which seed should be sown will vary depending on the size of the seed. See Table 2 in the Appendix for details.

(7) Seeds are expensive to buy and if not all used up should be carefully stored for sowing the following season. Keep seed in a cool dry place. Packets should be put in a sealed container and kept in a cool room or refrigerator.

(8) Transplanted crops are usually sown under protection (plastic tunnel, glasshouse or garden frame) into a container of some sort. These containers could be a seed tray, small pot or a multi-celled tray called a module. Some of the brassicas and leeks can also be direct drilled into a seed bed outdoors and later on transplanted out as bare root plants.

(9) A garden frame (or cold frame) is a marvellous addition to any vegetable garden. It's a simple box like structure with a plastic or glass top that allows you to warm the soil in early spring. If you don't possess a glasshouse you can use frames to propagate transplants or to grow early season crops.

(10) As there are few effective insecticides available it's essential to physically protect your crops from pest attack using fleece, nets or barriers.

(11) Keeping annual records outlining the crops grown, planting distances, varieties, dates of sowing, transplanting or harvesting etc. will add to the owner's store of information year on year.

(12) Vegetable growing can get confusing due to the large number of different types of vegetable that are available and the many different ways of growing them. If you are a beginner you're better off to start small and grow something easy like cabbage, onion sets or beetroot. Look after them well and you'll get a harvest.

What is a vegetable?

Unlike fruit, there is no scientific definition of what a vegetable is. Chambers Dictionary states: "a vegetable is a plant or any of its parts, other than fruits and seeds, that is used for food e.g. roots, tubers, stems and leaves". But that definition causes all sorts of confusion. What about tomatoes, beans and marrows? Are they not strictly speaking, fruit? Tomatoes represent an interesting case. Technically it's a fruit but is considered a vegetable for most culinary uses. And indeed the US Supreme Court in 1893 declared the tomato to be a vegetable at a time when the government were charging an import tariff on vegetables but not on fruit. Their reasoning was that tomatoes were more likely to end up on a dinner plate than being used as a desert. And peas which are seeds is definitely a vegetable. However, consider rhubarb. It passes as a vegetable by the above definition, is usually grown by vegetable growers, is listed under vegetables for statistical purposes but is eaten as a fruit for dessert.

Bud	Brussels sprout
Bulb	Onion, garlic, shallot
Enlarged stem	Kohl rabi, swede, turnip
Fruit	Tomato, pepper, cucumber, courgette, marrow
Immature flower bud	Cauliflower, broccoli, globe artichoke
Immature pod and seed	French bean, runner bean
Leaf	Herbs, chive, lettuce, Swiss chard, spinach, cabbage, kale, Chinese cabbage, parsley
Pseudostem	Leek, salad onion
Petiole	celery
Root	Carrot, parsnip, radish, beetroot, salsify, scorzonera
Seed	Peas, broad beans, sweetcorn
Shoot	Asparagus
Tuber	Jerusalem artichoke, potato, sweet potato

Soils

Soils are crucial to life on earth. They are the bedrock of human civilisation and the source of all we eat. Most of us on this planet hardly give soils a second thought, which is strange, given how vital they to our very survival. So it behoves us to learn something about the makeup of soil and how best to look after it. Sir Albert Howard, one of the pioneers of the organic movement, sums it up beautifully, "the health of the soil, plant and animal is one and indivisible".

The bad news is that you are stuck with the soil that comes with the farm or house you buy. Or allotment you rent. The good news is that vegetables will grow in a wide range of soils provided they are well drained, and even the worst of soils can be improved with the addition of organic matter and drainage if needs be.

So what sort of soil have you got? The only way to find out is to take a spade and dig a hole deep enough to get down to the subsoil; the subsoil will usually be lighter in colour than the topsoil as there is less humus in it. Digging the soil will give an indication if it's compacted or not, how much stone there is and depth of the topsoil. The deeper your topsoil the better - 30 cm would be nice. If you have a trench dug to 45 or 50 cm have a look at the side – is there a network of pores and cracks visible and how deep are the roots? Are earthworms present? Does the soil look solid or crumbly?

There are two key words to understand in relation to soils: texture and structure. Texture is the percentage of sand, silt and clay in a soil. Structure is how these different particles clump together – the architecture of the soil if you will. You cannot change the texture of your soil – what you've been given is what you've got. On the other hand soil structure is a variable and you can influence it. Grassland soils are usually well structured; the same soils under years of continuous tillage can end up poorly structured. Teagasc have some excellent videos and written material on soil quality and structure. Google *Teagasc, soil quality* and carry out what's in *The Soil Structure ABC*.

Gardeners sometimes wonder if it is possible to lighten a heavy soil with the addition of sand or indeed add clay to a sandy soil. It is very difficult to alter

Example of a well-structured soil with good rooting depth. There is not always a colour difference between topsoil and subsoil.

the texture of a soil other than on a very small scale. Better to accept the soil you have and learn how to manage it.

Soil is a mixture of mineral particles that are arbitrarily divided into three size ranges: sand, silt and clay in order of decreasing size. The different combinations of sand, silt and clay give us different soil texture types. Soil can be sent to a laboratory to find out what type you have but with practice soils of different texture can be recognised by the feel of a moist sample kneaded between your fingers. Sand particles are gritty, silt has a smooth, soapy silky feel, while clay is sticky.

Approximate percentage composition of the main classes of soil

Soil type	Sand	Silt	Clay
Sandy loam	70	20	10
Silt loam	20	65	15
Loam	40	40	20
Clay loam	30	35	35

A clay loam would be termed a heavy soil, a sandy loam a light soil and a loam and silt loam somewhere in between – medium soils. Each have their advantages and disadvantages. A light soil is free draining and warms up earlier in the spring but will be more prone to drought. A heavy soil is better able to hold onto water and nutrients but it's usually later in the season before it can be worked. Clay soils need to be at just the right moisture content to get them to break down easily. Sandy soils are easier to work. A loam has a nice combination of all three elements.

Plant roots, and indeed all soil life, need a balance of air, water and sufficient warmth to grow. Soil temperature is important because there is a minimum temperature for each crop, below which it will not grow. Soils are generally at their lowest temperature in January and February, and must warm up in spring for germination and growth to begin. The specific heat of soil is about 0.2 compared with 1 for water. This means that five times as much heat is required to raise the temperature of a quantity of water, as is required to raise the temperature of an equal weight of soil solids. Thus a soil that holds on to a lot of water is a cold heavy soil. Cold because it is difficult to warm the water, and heavy because of the high water content.

Soil structure

Sand, silt, clay and humus stick together to form aggregates or crumbs – in other words the soil has a structure. And in-between these aggregates are spaces or pores, which surprisingly, occupy between 40-60 per cent of the soil volume. If the soil is sandy and gravelly in texture the pores will be large and free draining; if it's a clay soil then they are smaller and slower to drain. Most soils however, consist of differently sized particles and hence the pores vary

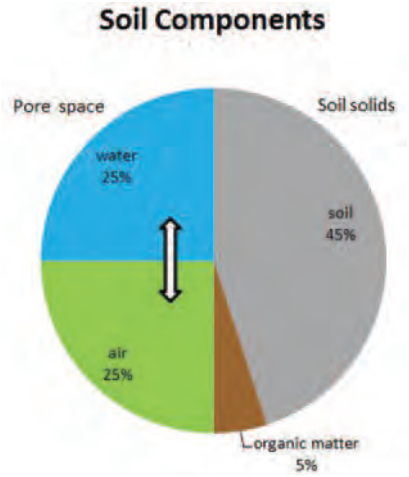
from large to small. This network of variable sized pores is the basis of a well-structured soil and good plant growth. The large pores empty quickly after rain and allow air to enter, while the small ones retain water that may later be taken up by plants. Roots do not readily enter pores unless the pores are of the same or larger diameter than themselves. Crops with thicker roots like peas and beans are therefore more sensitive to soil compaction than brassicas with thinner roots.

Organic matter makes up a small but vital and variable amount in the soil – grassland soils have a higher percentage than tillage soils. It's all to do with the addition or subtraction of soil carbon. The exact content depends on the balance between additions of fresh organic material versus losses due to decomposition, which occurs when microbes oxidise carbon. Hence grassland, which is a permanent crop with lots of fibrous roots, has a high organic matter.

Graceswood soil series is a sandy loam, ideal for carrots.

If the grassland is then ploughed and cropped with vegetables, the organic matter declines rapidly over the first three to four years, then levels off with a new equilibrium established. This decline is mainly due to the lower return of root residues and to the removal of crops. Tillage also aerates the soil and breaks up organic residues, making the carbon more accessible to microbial decomposition.

In general we do not have an issue in this country with low organic matters due to our cool and damp climate. With regular rainfall there is always something growing in the soil, be it crop or weeds. The other side of the coin has to do with temperature; at moderate temperatures plant growth outstrips decomposition and organic matter accumulates; higher temperatures favour the breakdown bugs. There is no ideal amount of soil organic matter. It will vary depending on soil type, crop and climate. Looking at Teagasc soil sample results, a lot of tillage soils fall between 3 and about 8% organic matter, with an average of 6.5%.



The soil has three components: solid material, water and air. The solid part is made up of mineral and organic materials. The mineral element comes from ground down rock, and the organic part comes from dead and decaying plants and animals which is the food source of innumerable living microorganisms and soil animals.

To the human eye soil can look solid and amorphous, but if like Alice in Wonderland, you could shrink yourself down to the size of a nematode you'd see gaps, spaces, and secret passages everywhere. In a 'good soil' 50% of the volume will consist of pore space. During heavy rain the soil pores become totally filled with water. The water then drains out of the larger pores under gravity and ideally after drainage ends, about half of the pore space remains filled with stored water and the other half is air. This ratio obviously varies greatly depending on the weather and plant growth.

Good soil structure and soil health are inextricably entwined. And both are essential for optimum plant growth. Over tilling of the soil or working it when wet can cause soil structure to degrade. And particularly with soils low in organic matter – a key component in soil structural resilience. So how can soils be improved? One of the central planks of soil improvement is the addition of organic matter. This can be rotavated-in crop remains, compost, spent mushroom compost or farmyard manure. These materials increase water retention in light soils and help to keep heavy soils open and improve their workability. Organic matter also plays a large part in the formation and stabilisation of soil aggregates, which in turn improves soil structure.

An active root system can play its part in soil restoration. This indeed could come from a vegetable crop – beneath each square metre of a turnip crop is 24 km of roots! It could also be provided by growing a green cover crop. A cover crop, also known as green manuring, is a crop grown specifically for incorporating into the soil. They have been used for thousands of years to improve soil health and fertility. A common example would be ryegrass and clover.

Compacted soil is another example of a poorly structured soil. It often arises when heavy machinery is driven over wet soils, or if the ground is regularly ploughed to the same depth. The end result is a poorly drained soil which can lead to waterlogging in wet weather. A waterlogged soil has a direct effect on plant growth. Just like leaves, roots respire – they need air in the soil to be able to breath in oxygen and breath out carbon dioxide. So if excess water drives out the air for any considerable period of time, the roots will be severely damaged or killed. If bad compaction is part of your problem the only way to cure it is by deep cultivation.

Wet soil plus machinery equals damaged soil structure.

Physical processes, like freezing and thawing in winter, drying and cracking in the summer, also play a part in restitution of damaged ground.

Managing your soil

A soil management system is essentially about two things – building fertility and good structure. The aim is to produce a stable structure to a good depth, which will allow ready germination of seed and establishment of transplants, along with optimum rooting of the crop.

Traditional cultivations, namely ploughing and harrowing, have served two main purposes down the years – to remove weeds and to produce a suitable tilth for plant growth. Yet a recent trend in agriculture has seen a move away from cultivation to min-till and no-till systems. This is echoed on the allotment by the increasing popularity of 'no-dig' vegetable growing.

No-dig is a simple system of using natural soil processes to build and maintain structure rather than using mechanical methods. It utilises beds, and rather than digging in organic matter a 3-5 cm layer is added annually to nourish the soil. Feeding earthworms and other soil organisms from above, allows a damaged soil structure to recover over time. It is important to remember the role that soil biology plays in the process of soil health. For example when compost is added to the soil it is worked on by soil bacteria and fungi. Bacterial glues formed in the process of breaking down organic matter along with fungal hyphae, help bind soil particles into aggregates.

No-dig encourages earthworm activity which is a key component of the system. In addition to compost, earthworms also ingest a great deal of soil – the two are mixed together and extruded as casts. The net effect of which is to greatly increase nutrient cycling and availability, especially nitrogen. As they tunnel

The farmer's friend.

their way through the soil they create an extensive system of channels which helps aerate the soil and offers important pathways for plant roots to penetrate compacted soil layers. However as stated previously if compaction is severe it will have to be broken up mechanically before you set up your beds.

You can grow vegetables on the flat, in raised beds or on drills. Commercial vegetable production utilises all three with beds and drills being the most widely used. The bed system is probably the best method for amateur use. This way of growing vegetables has been used since the dawn of time. The main purpose of a bed system is to avoid compaction of the soil by unnecessary trampling, as all operations are carried out from the path.

Raised bed. If on a hard surface, minimum depth required is 20 cm and preferably 30 cm or greater.

The traditional width of a bed is 1.2 m or four feet – a human arm can stretch in two feet from either side. A bed can be raised or flat. The term 'raised bed' used here means one with or without artificial sides. A raised bed can require more watering during a dry summer due to exposure of the sides to drying out. However this can be an advantage for winter crops, due to the improved drainage that a raised bed gives; and not forgetting that it warms up earlier in the spring. The fact that all operations are carried out from the path removes the need for widely spaced rows formerly required for access. Instead the crop can be grown at a higher density, and with an even pattern of plant placement, full use can be made of the available land. Paths between beds should be 45-55 cm wide. If you have shallow topsoil you can shovel some of the soil from the path onto the bed.

Overwintered scallions grown on raised beds to improve drainage. Losses in plant stand would occur if grown on the flat on heavy ground.

Thorough drainage of the soil is one of the first requisites for success in vegetable growing. The soil must be well drained so that all surface water may drain quickly into the subsoil within a day or two of falling. As crops are frequently harvested right through the winter growers will often grow their crops on drills or on raised beds to improve drainage.

If you are not following the no-dig system all ground which falls vacant in autumn or winter, should be dug when the weather permits. A good rule of thumb is that if clay sticks to your spade, boots or tractor tyre then the ground is too wet. Ordinary digging should always be done to the full depth of the spade, turning the soil over and burying any trash or small weeds.

Green manures: we have learnt how important it is to maintain a good soil structure. With climate change our winters seem to be getting wetter with

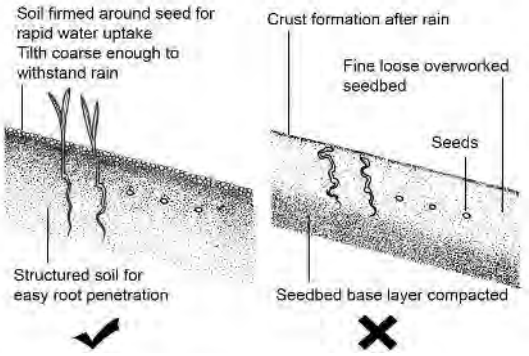
more frequent falls of heavy rain. Soil structure will be done no favours if exposed to this sort of weather especially if it's bare of vegetation. Where there is an appreciable gap between crops sow a green manure. These are fast growing crops that are grown to benefit the soil. They help protect structure by protecting the soil surface, encourage soil biology and aid fertility building. They also reduce leaching losses from the soil and help in weed suppression. Despite what you might think, they don't add much organic matter to the soil.

Green manures occupy the soil from weeks to months and can be sown more or less anytime of the year depending on species and location. One of the features of green manuring is the use of nitrogen fixing species to build up nitrogen reserves for the succeeding crop. Cover crops are normally incorporated back into the soil before they flower or they'll get too woody and set seed. Other cover crops may be incorporated at a much earlier stage depending on the time available. They need to be mown or strimmed a couple of days prior to incorporation. Can be sown on their own or in mixtures.

Crop	Timing	N fixer	Notes
Phacelia	Short term summer	No	Attractive blue flowers that bees love. Quick growing. Sow March to September.
Crimson clover	Short term summer	Yes	Attractive flowers. Annual that dies after setting seed. Can be autumn sown for spring incorporation.
Ryegrass	Summer and winter	No	Westerwolds ryegrass – rapid grower.
Field beans	Winter	Yes	Can be established late in the autumn but ideally in October. Easy to incorporate.
Grazing rye	Winter	No	Reliable cover crop good at soaking up nitrogen. Often used in mixtures.
Vetch (tares)	Winter	Yes	Short term N fixer. Sow August to mid-September. Can also be sown in the spring.
White clover	Long term	Yes	Usually mixed with grass for medium to long term leys. Last sowing date is late August.
Red clover	Long term	Yes	Often mixed with grass for short to medium leys. Can be used on its own for summer green manure. Keep it mown. High N fixer.

The formation of a fine seed bed is of great importance, especially for smaller seeds such as onions and carrots. For a seed to germinate it requires warmth, air and water. First the seed must be in good contact with the soil to absorb soil moisture. This is easier to achieve if the bed is fine rather than cloddy. Second, the soil below the seed must be uncompacted to allow rapid root growth and it should contain a ready supply of nutrients. Finally the soil above the seed should be loose enough to allow the shoot to emerge into the sunlight.

To form a seed bed fork over the ground to a depth of about 10 cm carefully breaking all lumps. The forking down should be done only when the ground is dry enough for the clods to crumble easily. If fertiliser needs to be applied it should be spread during seedbed formation and forked in. Just take care not to overdo it as too high a concentration of nitrogen or potassium fertiliser can inhibit seedling emergence by scorching young roots. This is one of the reasons why we topdress a crop i.e. splitting the application of fertiliser, especially nitrogen, into several applications before and after crop emergence or pre- and post-planting. The final seedbed preparation is carried out by raking to remove small clods and stones and to create an even surface. The aim is to produce a tilth with about 70 per cent of the aggregates ranging in size from a grain of rice to a pea. The diagram below shows the difference between a good and bad seedbed.



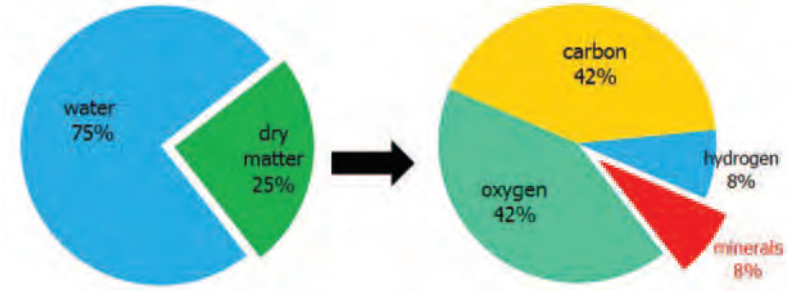
Digging and disturbing the soil stimulates weed seeds to germinate. During the growing season you will need to hoe to remove weeds and this is best carried out when the weeds are small. Hoe only if weeds are present and keep as shallow as possible to prevent damage to roots and prevent bringing wet soil to the surface. One of the advantages of a no-dig system is that you tend to have less issues with weeds.

Plant Nutrition

Plants require a number of things to grow: light, temperature, CO_2, water and minerals, also known as nutrients.

Vegetables are composed mainly of water – most are around 90%. Lettuce is 95% whilst on the drier side you have peas and sweet potato at 75%. If you take away the water what you are left with is termed 'dry matter'. Dry matter is the weight of something when completely dried. When you analyse the dry matter most of it is made up of carbon and oxygen with much smaller amounts of hydrogen and minerals. The carbon and oxygen comes from CO_2 that the leaves breath in and the hydrogen comes from water. Plant roots suck up water and the water molecules (H_2O) are split in two – the hydrogen ends up in the plant and the oxygen atoms recombine to form O_2 which is expelled from the leaf. The water performs another important task – it transports minerals along with it.

Back in the days when we were allowed to have bonfires you were surprised to see what a small amount of ash was left, after the fire went out. The combustion process drives off the water, carbon, oxygen and hydrogen, and all you are left with are the minerals i.e. the ash.



These minerals, or nutrients, consist of major and minor elements. Those nutrients that a plant uses a lot of are called major elements. These are nitrogen (N), phosphorus (P), potash (K), sulphur (S), calcium (Ca) and magnesium (Mg). Minor or trace elements are also essential for plant growth but are only required in tiny amounts. These include boron (B), manganese (Mn), molybdenum (Mo), copper (Cu), zinc (Zn), iron (Fe), chlorine (Cl) and nickel (Ni). These elements are held on clay and humus colloids (tiny particles). The elements actively move in and out of

the water surrounding the colloids – this is referred to as the soil solution. Plant roots obtain their nutrients from the soil solution.

The table below gives you an idea of the average concentrations of mineral nutrients in a plant. You can clearly see that nitrogen is taken up in large quantities whilst molybdenum is required only in tiny amounts. Plus note the clear distinction between major (the first six) and minor elements (all the rest).

Element	Symbol	Mg/kg	%	Relative no. of atoms
Nitrogen	N		1.5	1,000,000
Potassium	K		1.0	250,000
Calcium	Ca		0.5	125,000
Magnesium	Mg		0.2	80,000
Phosphorus	P		0.2	60,000
Sulphur	S		0.1	30,000
Chlorine	Cl	100		3,000
Boron	B	20		2,000
Iron	Fe	100		2,000
Manganese	Mn	50		1,000
Zinc	Zn	20		300
Copper	Cu	6		100
Molybdenum	Mo	0.1		1

Ref: The Plant Nutrition Manual, J Benton Jones

Harvesting vegetable crops removes considerable quantities of nutrients from the soil and hence we have to replace them to maintain good yields. A certain amount of replenishment comes naturally from weathering of minerals and breakdown of organic matter, but the bulk of the replacement has to come from the compost, manure or fertiliser, that we add to supplement what's naturally available. But how do we know how much to add? To work that out we need to know what's in the soil to start with and marry that with the crop to be grown. Normally we only concern ourselves with the three major elements that are used in large quantities: nitrogen, phosphorus and potash.

The only accurate way to find out what nutrients are in your soil is to take a soil sample and post it off to a laboratory for analysis (see Table 3 in the Appendix). It's also possible to purchase 'do it yourself' kits from garden centres which will give you a rough guide to the fertility of your soil. A sample must be representative of the area you're testing, so take about 20 sub samples, mix them up and select about 450g for the test sample. Do not take a sample within three months of applying fertiliser. A basic test will tell you the pH of the soil, how much lime to add if needed, plus the phosphorus (P) and potash (K) level. Nitrogen is not normally tested for as the amount in the soil is very variable – its natural availability depends on biological processes and is also prone to leaching.

The results of the test are expressed in mg per litre (mg/l) of soil which is equal to parts per million. To keep things simple from an advice point of view the results are put into a 1-4 index system, where Index 1 = very small amounts of the nutrient and Index 4 = very large amounts of the nutrient. The general idea is to get your soil into Index 3 – this is the recommended level for optimum nutrition of vegetable crops. This is equivalent to 6-10 mg/l for P and 100-150 mg/l for K; the optimum pH is around 6.5-6.8. You don't have to sample annually – once every 3-5 years is recommended.

The table below sets out the Index levels for P, K and Mg.

Index	Index description	P mg/l	K mg/l	Mg mg/l	Response to fertiliser
1	Very Low	0.0-3.0	0-50	0-25	Definite
2	Low	3.1-6.0	51-100	26-50	Likely
3	Medium	6.1-10.0	101-150	51-100	Unlikely
4	High	> 10	> 150	> 100	None

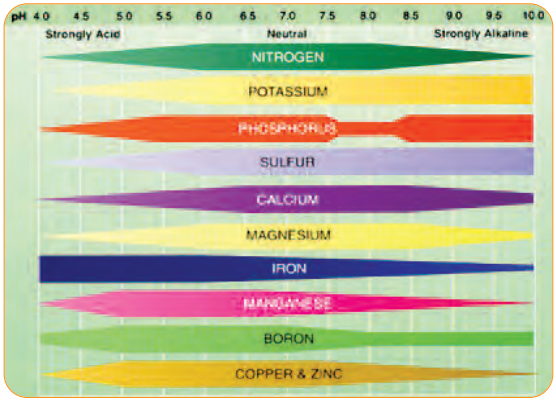
The laboratory will usually make a recommendation based on the results and what crop is to be grown. At Index 1 and 2 relatively large amounts of nutrients are advised to bring the soil up to Index 3. At Index 3 only maintenance amounts are required to replace what's taken out and at Index 4 usually

nothing is advised as the levels are excessive and need to be allowed to drop back to Index 3.

Soil sample results frequently show excessive fertiliser use by vegetable gardeners, so use fertiliser sensibly and take into account that use of organic matter will also add N, P and K to your soil.

Soil pH

The pH of a soil is a *key* component of soil fertility and relates to whether a soil is acid or alkaline. It's measured using a pH scale of 0-14 the mid-point being 7 (neutral), with any reading below indicating acidity and above denoting alkaline conditions. Whilst most vegetables are reasonably tolerant of variations in pH, we ideally try to keep our soil slightly acidic between 6 and 7 to ensure maximum availability of nutrients (see chart). If your soil is very acidic you can get lock-up of certain nutrients like molybdenum whilst other elements such as aluminium and manganese become overly available to the extent of being toxic. At the other end of the scale very alkaline soils can reduce availability of elements like iron, boron and manganese. To check what pH suits what crop see Table 1 in the Appendix.



The natural pH of a soil will depend on the underlying rock formation e.g. limestone based soils tend towards alkalinity whilst those deriving from shale, granite and sandstone tend to be acidic. Over time most soils will naturally become more acidic due to a number of factors but some soils never need liming.

To find out the pH of your ground you can purchase a test kit from a garden outlet but for an accurate pH figure your best bet is to get it analysed in a laboratory.

The amount of lime to apply will depend on your initial pH and the type of soil; heavy clay soils will require more lime than light sandy soils to increase the

pH by the same amount. If you get your soil tested by a laboratory they will tell you exactly how much lime to apply to increase the pH of your soil to a set value – usually somewhere between 6.5-7.0. Typical application rates for a lot of soils will vary between 5-10 t/ha (0.5-1.0 kg per m^2) but do not apply any more than 7.5 t/ha (750g per m^2) at any one time. If your soil is very acidic and requires a lot of lime, spread the application over a couple of years. The form of lime that is normally used is ground limestone. Take note that it takes several months for the lime to react fully with the soil to effect the pH change, so plan ahead and apply in plenty of time. Lime can be applied at any time of the year but preferably apply over ploughed or dug ground in the winter and rotavate or fork it in during the spring. Be careful not to over apply lime as it's far easier to raise the pH than to decrease it.

Apart from correcting acidity lime also improves the structure of the soil, and renders the plant food contained in it more available to the crop. Maintaining the pH between 6 and 7 is essential for many microbiological processes which play an important part in nutrient recycling. It can also have an effect on disease outbreaks. For example in low pH soils brassicas are more liable to attack by club root disease; if the disease is already present the advice would be to lime the ground to pH 7.4 or greater to prevent its reappearance.

To find out the pH of your soil purchase a pH meter. But take note that you shouldn't guess the amount of lime to apply from a pH reading – send your sample to a laboratory to check the pH and buffering capacity of the soil. Buffering capacity is a measure of how much lime it takes to change soil pH.

Liming materials

- Ground limestone ($CaCO_3$ calcium carbonate)
- Dolomitic limestone ($CaMg(CO_3)_2$ calcium and magnesium carbonate)
- Granulated lime ($CaCO_3$ calcium carbonate)
- Burnt lime or Quicklime (CaO calcium oxide)
- Builders lime, slaked lime or hydrated lime ($CaOH_2$ calcium hydroxide)

The commonest liming material used is ground limestone rock. The particles vary in size from dust up to 3.35 mm and the reaction time varies as a consequence. If a soil sample indicates a magnesium reading of less than 50 mg/L then use of dolomitic limestone is advised as it's the most convenient way of applying that

mineral. Granulated lime is very finely ground particles of calcium or magnesium carbonate formed into granules with the addition of a binder which 'cements' the powder that dissolves when applied to the soil and in the presence of moisture. It's a very convenient way for the farmer to apply lime, is quick acting, but is considerably more expensive than using ground limestone. The lime that was produced in the past from lime kilns was burnt lime and the modern version of it is a product called Gromax that's formulated as small chips, is quick acting and can be spread with a fertiliser spreader. If you add water to burnt lime (to 'slake') you come up with builders lime or slaked lime. This is a very quick acting form of lime but is caustic in nature, so handle with care.

Total Neutralising Value (TNV) is an indication of how effective the different liming materials are in neutralising acidity in the soil. The benchmark is pure calcium carbonate which is ranked 100. Ground limestone, which contains a number of impurities, must by law have a minimum TNV of 90. The TNV of quicklime is 178 and 560 kg of quicklime is equivalent to 1 tonne of pure ground limestone. Builders lime has a TNV of 135 and 740 kg is equivalent to 1 tonne of pure ground limestone.

Liming materials react slowly with soil acidity, gradually raising the pH to the desired level over a period of time ranging from a few weeks with the quicker acting forms of lime like builders lime or burnt lime to a year or so before ground limestone completes its job.

Soil SC

SC is something that horticulturists need to know about whereas it rarely bothers our agricultural brethren. SC is a measure of the fertility of the soil and can be indicative of under or over use of fertilisers. SC (also referred to as EC) stands for Specific Conductivity which is used to measure the amount of soluble salts in the soil. If you stir a pinch of table salt (sodium chloride) in a glass of water it will dissolve into its respective ions (charged particles) of sodium (Na^+) and chloride (Cl^-). Likewise, fertilisers that are applied to the soil will go into solution and create ions such as Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, SO_4^{2-}, HCO_3^- etc. These ions are capable of conducting electricity and we can measure this with a conductivity meter. The SI unit of conductivity is siemens per metre (S/m) with results expressed in a variety of sub-units. At Kinsealy we have traditionally used mS/m (milliSiemens

High SC damage on potatoes showing stunting, evident in the middle rows. Row on the extreme right is normal. Crop grown under glass.

per metre) measured at 20°C but SC is more commonly expressed as mS/cm (milliSiemens per centimetre). SC's are easily measured with a handheld meter that that gives a readout in mS/cm – to convert to mS/m, multiply by 100. Conductivity is temperature sensitive but the meter normally contains a sensor that automatically corrects the reading for temperature. The units of electrical conductivity are related as follows.

100 mS/m (milliSiemens per m)	=	**1 mS/cm** (milliSiemens per cm)	=	**1,000 µS/cm** (microSiemens per cm)
		1 dS/m (deciSiemen per m)		

Normally when we apply fertiliser some of it is taken up by plant growth, some is absorbed by the soil and humus and some is leached by excess rainfall. However if fertiliser is applied under glass or plastic it can build up in the soil due to lack of rainfall. If the SC goes too high it will damage plant growth. This is due to plant roots finding it more difficult to extract water from the soil, or it may be

High SC symptoms on glasshouse coriander: stunting, dark green leaves and purpling.

damaged from toxic concentrations of ions within the plant. This excess of nutrients can arise from either fertiliser or from large applications of either manure or compost. Outdoors, rainfall prevents a build-up of fertiliser in the soil but occasionally over enthusiastic topdressing of a crop or manure application can result in damage.

The natural background SC of tillage soils is around 10-20 mS/m. In a glasshouse it's usually higher and for general vegetable production keep the SC between 80-120 or thereabouts. As the SC rises it increasingly restricts plant growth and above 150 damage can be visible on the more susceptible species and certainly above 200 you are heading into the danger zone. Salt tolerance varies within vegetables and stage of growth will also play a part – seedlings are more susceptible than larger plants. Also take note that as the soil dries out the SC rises. Tomatoes are reasonably tolerant – keep the SC around 150 and don't allow it to go above 200 as damage will occur above 250.

Salt tolerance of vegetables	
High	beetroot, kale, asparagus, spinach, courgette, squash
Medium	tomato, broccoli, cabbage, pepper, cauliflower, lettuce, sweetcorn, potato, pea, squash, celery
Low	radish, bean, carrot, onion

If you notice SC damage, irrigating the crop may help to alleviate it. However it's best to check the SC level before a crop goes in and if excessive, flood the area with water to wash out the excess salts. Guideline quantities of water are given in the table below.

Quantities of water required to reduce SC to 80	
SC level	Amount of water L/m^2
>200	120
160	80
120	40

SC is also regularly used in glasshouse production to measure the strength of the feed and to test the growing medium for fertility levels. You may also notice that an SC figure is quoted on bags of compost for commercial growers. For example the 75 litre bags of Seedling Substrate Plus from Bord na Mona quote an SC of 379-513 µS/cm which is equivalent to 37-51 mS/m.

PH and SC meters

PH and SC meters can be purchased if you want to carry out your own measurements. They vary hugely in price and quality and the cheap ones, whilst initially accurate, don't last and aren't worth it. So purchase a mid-priced model and look after it. It's fair to say that the SC meters tend to be more robust than pH meters. It's important to sieve small stones out of the sample to avoid

Testing soils for pH/SC	
1.	Take a representative soil sample.
2.	Air dry the sample.
3.	Sieve the sample using a 2 mm sieve.
4.	To a 10 ml measure of soil add 20 ml of distilled water.
5.	If the sample is moist, to a 20 ml measure of soil add 20 ml of distilled water (only for pH samples).
6.	Mix the sample and leave to stand for 10-20 minutes.
7.	Stir before testing.
8.	Insert the probe, stir once and let the reading stabilize.
9.	Rinse the probe before testing a different sample.

damaging the probe – this is particularly the case with pH meters. The other point to bear in mind is that meters need regular calibrating and distilled water must be used in making up the test samples.

Nitrogen (N)

Nitrogen is a key nutrient for growth and is available naturally in the soil. However we normally supplement soil nitrogen with fertiliser nitrogen and/or by adding organic matter. Vegetables vary in the amount of nitrogen they require. Some of the legumes such as peas and broad beans can fix their own nitrogen and don't require any. The following list groups vegetables into three categories of low, medium and high users of N:

Low: swede, French bean, runner bean, carrot

Medium: broccoli, beetroot, onion, courgette, parsnip, scallion, lettuce

High: leek, spinach, rhubarb, sweetcorn, cauliflower, cabbage, celery, sprouts

The following table gives suggested nitrogen application rates for a range of vegetables using sulphate of ammonia as the nitrogen source:

Crop	g/m²
Pea, broad bean	0
Carrot, radish, swede	20
Parsnip, French bean, runner bean	40
Broccoli, parsley	50
Onion, lettuce, beetroot, courgette, early potato	60
Cabbage, cauliflower, leek, spinach, potato, sweetcorn	70
Celery, Brussels sprouts, rhubarb, leek	90

Some of the N recommendations in this book are expressed in kg/ha. To convert to g/m² use the following formula where the %nutrient is the percentage nitrogen in the fertiliser you are using e.g. 21 if it's sulphate of ammonia.

$$y \text{ kg/ha} = y \times 10 \div \% \text{ nutrient} = \text{g/m}^2$$

The correct amount of nitrogen to apply will depend on a variety of factors such as cropping history and soil type so the suggested amounts may be above or below what is optimum for your situation. In general lighter soils require more nitrogen than heavier soils. If you are using garden compost or farmyard manure these materials are a nitrogen source and the above figures will need to be adjusted downwards. At best a well rotted application of farmyard manure applied in the spring will supply the equivalent of 30 g/m² of sulphate of ammonia.

Nitrogen is normally applied prior to sowing but can be split into 2-3 applications with the higher nitrogen demanding crops. If too much nitrogen is applied at any one time roots can get scorched or seeds may fail to germinate. For example with

Example of excessive nitrogen application on a swede crop resulting in growth cracks.

transplanted brassicas you would apply half pre-planting and the rest about a month later – this is known as topdressing. Celery would get three equal splits – at planting, 3 and 6 weeks later. Be careful when applying nitrogen directly over crop foliage as it can scorch the leaf – if in doubt apply it to the side of the plant. Irrigation may be necessary after application to reduce scorch and to activate the nitrogen.

Phosphorus (P)

This element is important for root development, flowering, seed formation, straw strength in cereals, crop quality and disease resistance. It's also involved in cell division and is the carrier of energy within cells. It's rare to come across phosphorus deficiency in vegetables.

Potash (K)

Potassium is used in a wide range of plant processes and hence a lot of it is needed. It's essential for photosynthesis, starch formation, translocation of sugars and in the development of chlorophyll but the bulk of potassium is in the cell vacuole where it is involved with turgor and water control. It also tends to exert a balancing effect on excessive availability to the plant of nitrogen and phosphorus.

Magnesium (Mg)

Magnesium deficiency in tomato.

There are usually plentiful supplies of magnesium in soils and shortages of this element is unusual in most vegetable crops. Magnesium is available in any area with underlying limestone and can come in on prevailing winds enriched with seawater spray (Mg is the third most common element in the sea). Another point to bear in mind is that regular additions of organic matter to the soil will add magnesium. Deficiency can occur on acid or sandy soils but sometimes you get an induced deficiency if the root system comes under pressure from compaction, drought or heavy rainfall. The typical deficiency symptom is interveinal chlorosis; this can occur in broccoli crops close to harvest, but only rarely has any effect on yield. The other crop that you regularly see deficiency symptoms is tomatoes especially if they are grown in some sort of

bag or container. Very occasionally you will see magnesium deficiency in cabbage. If soil analysis indicates a deficiency apply Kieserite (17.5% Mg) at 7-8 bags per ha. Better still use dolomitic limestone when liming as this form of limestone contains magnesium. If you wish to prevent magnesium deficiency symptoms use a 2% foliar spray of Epsom Salts (20 g per litre of water). Epsom salts is magnesium sulphate, $MgSO_4$.

Calcium (Ca)

One of the commonest deficiency symptoms in vegetables of any element, apart from nitrogen, is calcium. It's usually an induced deficiency rather that an actual shortage of calcium in the soil. Calcium is not a very mobile element within the plant and if the transpirational stream in the plant is interrupted, for example in drought or high humidity conditions, a shortage of calcium can occur within the plant and deficiency symptoms appear in the weeks following. The symptoms are called a number of different names depending on the crop: brassicas and lettuce (tipburn), Brussels sprouts (internal browning), celery (blackheart), tomato (blossom end rot), potato (internal rust spot). The most effective way to counter calcium deficiency is make sure that your crops are well supplied with water by irrigating in dry spells. In soil analysis we don't normally test for calcium as it's directly correlated with pH. The higher the pH the more calcium you have. And if your pH is low one adds lime (calcium carbonate) thereby adding calcium.

Black heart in celery.

Sulphur

Sulphur is a constituent of two amino acids, vitamins, enzymes and aromatic oils. Amongst vegetables the legumes, brassicas and alliums have a high requirement for sulphur. Sulphur is very similar to nitrogen in nature. It can be mineralised from organic matter, is available from the air, can be leached, low amounts in light soils and we don't normally test for it because of its variable supply in soil. There was never an issue years ago with sulphur deficiency as there was a lot of aerial deposition (sulphur dioxide) from industrial sources and transport burning coal and fuel oil. After the damage caused by acid rain

in the 1970's and 1980's governments set about reducing sulphur pollution from human activities. We still get aerial deposition but it's far less than it was. Deficiencies are more likely to occur on light soils deficient in organic matter rather than on heavier soils. Sulphur is naturally available in manure and compost, in fertilisers like sulphate of potash, sulphate of ammonia and 7-6-17 and has been added to a lot of compound fertilisers. Sulphur can also be applied as a foliar spray both as a nutrient and a fungicide. Flowers of sulphur can be added to soil to reduce pH. A common application rate for sulphur is 20 kg/ha.

Trace elements

Vegetables don't usually suffer from trace element deficiencies as generally there is sufficient amounts in the soil. But very low or high pH can influence availability of trace elements. Alkaline soils and dry summers are factors that can increase the incidence of boron deficiency in swedes and turnips, a disorder called 'brownheart'. This is a brown discolouration in the centre of the bulb and to prevent it boron should be applied preventatively before the symptoms develop. Boron deficiency can also show up in celery where it's known as 'cat's claw'. And watch out for manganese deficiency on limey soils. On the other hand very low pH soils can induce molybdenum deficiency in brassicas especially cauliflowers causing the formation of narrow, strap shaped leaves known as whiptail. Sometimes you may come across iron deficiency symptoms in module raised plants where they are watered with hard water. This causes the pH of the compost to rise and you end up with an induced iron deficiency. To cure the problem apply some iron sequestrene. One rarely comes across vegetables suffering from either zinc or copper deficiency. Applications of compost or manure will ensure a plentiful supply of trace elements.

As a rough rule of thumb trace element deficiencies tend to show up on the younger leaves as they are not very mobile within the plant. In contrast major element deficiencies, bar Ca and S tend to show up on the older leaves as they are relatively mobile within the plant. For example in a nitrogen deficient plant all available nitrogen goes to support the growing point by transferring nitrogen out of the older leaves.

Boron (B)

By far the commonest crop affected with boron deficiency is swede. Solubility of boron is pH dependent and is much less available at pH's greater than 7. It is

prone to leaching and as such wet winters and light soils can be predisposing factors for deficiency. Organic matter is a major boron reservoir which is released for plant use by microbial mineralization. Boron availability is impaired by long dry spells as it's generally taken up with the transpiration of water, rather than by active ion transport as is the case for the uptake of most other nutrients. Dry conditions may also slow the mineralization of organically held boron. The most susceptible crops are swede, celery, cauliflower, beetroot and spinach. With foliar analysis any reading less than 20 mg/kg is deficient. With soil analysis 0.8-2.0 mg/L B in mineral soils is satisfactory. In peat soils 1.0 mg/L B is potentially deficient. Boron levels in soil can be maintained by 1-3 kg/ha of boron applied as Solubor (17.5% B) or by using some of the liquid based boron products. All of the susceptible crops, and indeed brassicas in general, are always fertilised with a boronated compound. Examples are 8-5-18 and 6-10-18 that have boron added at a concentration of 0.33%. Applying 15 bags per ha supplies the equivalent of 2.5 kg/ha of boron. Boron in excess can be toxic but is rare in occurrence; it has been reported in cereals and under glass in celery.

Molybdenum (Mo)

Molybdenum deficiency in vegetable crops is rare. It can show up in brassicas and spinach on low pH soils (below 5.5) and on onions grown in peat. Of the brassicas cauliflower is the most sensitive causing a symptom called 'whiptail'. Has also been seen in sprouts. It is best prevented by normal liming practices to bring the pH up to 6.5 or thereabouts. In the field spray with 0.6 kg/ha of sodium molybdate or use a proprietary product.

Manganese (Mn)

The availability of manganese is intimately linked to pH. It becomes increasingly unavailable as pH increases and at very low pH's can become available to such an extent that it's toxic to plants. In general there is usually sufficient manganese in the soil and any deficiency that occurs is an induced one – induced by high pH. Manganese deficiency. Is fairly common in peaty soils where pH is greater than 6.5. On mineral soils it is most severe in sensitive crops at pH above 7.0. Can also be induced by drought. The most

Induced Mn deficiency in sweetcorn due to high pH.

susceptible crops are French bean, onion and peas. Manganese deficiency is controlled by foliar applications of manganese sulphate.

Zinc (Zn)
Vegetable crops with the exception of sweetcorn are not susceptible to zinc deficiency. However cereals and maize are prone to zinc deficiency. Peat soils are deficient in most minor elements and peat grown plants often develop zinc deficiency. Apply a foliar application of 5 kg zinc sulphate/1000 L water per ha for prevention.

Copper (Cu)
Vegetables are not prone to copper deficiency in mineral soils. Copper deficiency did show up in reclaimed peat at the AFT vegetable research station in Lullymore Co Kildare in the 1960's. This was especially the case in the early stages of reclamation of peat soils.

Organic matter
Additions of organic matter – usually garden compost or farmyard manure – are beneficial for several reasons. It benefits soil structure, improves water holding capacity and adds in major and minor elements. Compost, which is formed from the decay of plant material, is a useful way for the vegetable grower to recycle precious nutrients and add humus to the soil. Farmyard manure is also a great source of organic matter when available. Spent mushroom compost, available in certain outlets, is pleasant to handle and compares more than favourably with farmyard manure and compost in nutrients.

Organic matter should be dug in or surface applied during the autumn or winter months at a rate of about 5-10 kg per m^2. It can also be applied prior to planting, as for example with potatoes. Organic matter is normally applied in rotation to the high nitrogen demanding crops: transplanted brassicas, celery, leeks, runner beans, courgettes, potatoes and spinach. Final word of warning – don't be tempted to apply copious amounts of organic matter every year to the same ground . Sufficient is plenty.

Fertilisers
Fertilisers are as valuable in the garden as on the farm if used intelligently to supplement moderate dressings of farmyard manure or compost. They supply to the crop the particular nutrient that it most requires. Fertilisers come in two forms – straights and compounds. Straight fertilisers contain just one element, such as nitrogen or potash. Compound fertilisers contain more than one element and usually consist of various mixtures of nitrogen, phosphorus and potash or N-P-K. The advantage of using compounds is that it's a handy way of applying all three major elements to a crop.

The standard notation on a box or bag of fertiliser is to give a percentage figure for nitrogen, phosphorus and potash – or N : P : K – in that order. For example a bag of 7-6-17 contains 7% nitrogen, 6% phosphorus and 17% potash. Take note that UK sourced fertiliser always quote P as P_2O_5 and K as K_2O. In Ireland we use elemental P and K. To convert P_2O_5 and K_2O to P and K multiply by 0.44 and 0.83 respectively. Nitrogen in both countries is quoted in elemental N.

One normally applies fertiliser just before sowing or planting a crop – sprinkle the fertiliser across the ground and lightly rake or fork in. One should apply only as much fertiliser as is required to grow the crop in accordance to the results of a soil sample and the following rates are only a guideline where that information in not available.

Straights
Superphosphate 8% P
Apply 35-50g per m^2 of 8% P at time of sowing or transplanting.

Sulphate of Potash 42% K
Apply 30g per m^2 at sowing or transplanting.

Sulphate of Ammonia 21% N, 24% S
This is the commonest form of nitrogen available to the gardener and is also a useful source of sulphur. Works within about a week of application under warm, showery conditions. With constant use will tend to acidify the soil. Apply at 15-30 g/m^2.

Calcium Ammonium Nitrate (CAN) 27% N
This is the most commonly used straight nitrogen in agriculture. Slightly faster acting than sulphate of ammonia. Apply at 15-30 g/m^2.

Compound Fertilisers

There are various compound artificial manures on sale which incorporate the three main fertilisers i.e. nitrogen, phosphate and potash and sometimes other elements such as sulphur or boron. Granular compound fertilisers such as 10:10:20, 8:5:18+ B or 7:6:17 are ideal for the vegetable garden and do not have to be mixed. They are normally available at agricultural outlets. Apply at a rate of 50-90g per m^2, or preferably in accordance with the results of a soil test. There are other proprietary compounds on the amateur market suitable for vegetables and these should be used according to the manufacturer's instructions. Organic based fertilisers are also available in retail outlets.

For detailed advice on vegetable nutrition google *Teagasc Green Book*.

Liquid Fertiliser

Many proprietary brands of liquid fertilisers are available which when diluted with water according to instructions are valuable for vegetables as a quick acting source of nutrients. However it is a much more expensive way of applying nutrients than using solid fertilisers. Commercial growers frequently apply these products to crops and at times are over used. To quote from a 1978 AFT Research Report on the findings of a three year trial that looked at testing nine different proprietary foliar feeds on a range of vegetable crops: *"The overall picture which has emerged is one of little or no growth response. Indeed, only in carrots in 1977 was there a significant increase in yield and this was obtained with only two products. The results suggest that if soil fertility is high and adequate supplies of trace elements are available, the value of applying any of these products is extremely doubtful even under drought conditions such as occurred in 1976"*. However growers who are selling a green product such as broccoli or cabbage will use foliar sprays that contain N, Mg, Mn and S to green up their crop if it's off-colour for whatever reason as these four elements have a greening effect.

This image shows nitrogen deficiency in parsley. It shows up in the older leaves as a pale green to yellow colour with the younger foliage showing a healthier darker green.

Garden Compost

The word 'compost' can be a confusing one in horticulture. It can either mean a substrate, usually based on peat with added fertiliser, for raising young plants, or it's a natural process that turns waste vegetation into a dark crumbly material called compost. To clarify matters, it probably best to call this latter material, garden compost.

Garden compost is the end result of the decomposition of plant and food waste by an enormous population of micro-organisms and soil animals in a moist, warm, aerobic (aerated) environment. The final product is decomposed organic matter (OM) including humus, that is free of pathogens, weed free and stable; humus, a fraction of organic matter, is a complex biological material that is resistant to further decay. A basic formula for compost is:

$$OM + O_2 + H_2O \xrightarrow{\text{Bugs}} \text{compost} + CO_2 + H_2O + \text{energy (heat)}$$

It's amazing how a large pile of organic waste hugely reduces in volume once it's composted. The explanation for this lies in the formula above. About 50-75% of the initial carbon is oxidised away – goes back into the air from where it came – along with a lot of water. But luckily the minerals are left behind making the finished compost more concentrated in nutrients than the initial raw materials.

There are two phases in the production of compost: the heat production phase and the maturation phase. Once the wastes are gathered into a heap, the moisture content brought to a suitable level and the mass aerated, the microbes multiply rapidly. The readily degradable constituents of the organic wastes – sugars, starches, fats, proteins and hemi-celluloses – go to make new microbes. The materials are oxidised to carbon dioxide and water in the energy liberating reaction. Part of this energy is used for microbe metabolism, the excess is given off as heat. After the initial spike in temperature the heap begins to cool down and after a number of weeks reaches ambient. The end product of the process, humus or compost, is made up of the more resistant parts of the organic wastes – cellulose and lignin, breakdown products, dead and some living micro-organisms – together with products from further complicated chemical reactions between these materials.

And the original organic matter can encompass just about anything that once lived: kitchen scraps including meat, grass and hedge clippings, eggshells, garden waste, leaves, weeds, sawdust, straw, cardboard etc. It's often maintained that adding meat to a heap will attract rats but provided you aerate the pile to allow for a quick breakdown they probably won't be a problem. Not that rats and mice won't occasionally visit but they use a compost heap more as a house than a larder. If they do become a problem use a solid sided bin or lay down rat bait during winter. Weeds can also be added including nasty ones like docks, dandelions and scutch – again – provided you have a hot enough heap that gets turned. Most diseased plants can be added but make exceptions for those ones that are particularly noxious: club root, white rot and sclerotinia. Potato blight can be added provided you cover the infected haulm – it can continue to release spores if just thrown on top of a heap. Addition of up to 10% of a clay soil to the heap can be beneficial as it allows the nutrients to be stabilized and conserved in clay/humus complexes.

Mother nature is very accommodating – if you just create a pile of organic garden waste it will eventually turn into compost. This is known as anaerobic composting – without air – and as a consequence doesn't heat up and takes a longer time to fully compost. This makes perfectly good compost but perhaps a better way is to keep the heap aerated while it's decomposing; oxygen encourages fungi and bacteria to quickly build-up which leads to the production of heat and the rapid break-down of the softer materials. And it's this heat, if held for a few days, that kills off weeds, seeds, pests and diseased plant material. With an anaerobic heap far less heat is generated, the process is slower and there is less chance of killing weed seeds and pathogens; plus release of pungent odours if the heap is turned or moved. However in practice most garden compost heaps go through a combination of aerobic and anaerobic phases.

Temperature begins to build up very quickly in a freshly made heap, peaks at around 70°C after a few days and then cools back down. The following table is a record of temperatures in a compost heap that was turned on day 5.

Day	0	1	2	3	4	5	6	7	8	9	14	21	28
°C	23	60	70	71	68	64	72	64	54	33	28	28	Ambient

Temperatures in and around 60°C held for a few days are required to kill off weed seeds and pathogens. Once the heap has cooled down to ambient it enters

a maturing phase. The initial ingredients of four week old compost that has been turned are unrecognisable and have turned into a dark raw sticky compost. This then needs to be left for several months to mature into a compost that is friable, brown and pleasant to handle. It takes about 3 months to make compost during the warmer months but this can double in the colder months.

Unless you have very large volumes of material then some sort of container or bin is required. The main problem with small-scale compost production is loss of heat, a situation made worse if the compost bin is filled slowly over a period of time. To minimize heat loss you require the walls of your container to be well insulated and topped off with a porous, heat-insulating blanket directly on top of the heap. Overhead protection is also necessary as heavy rain falling onto an exposed heap will cool it down, fill up the air spaces and leach nutrients into the soil.

Four week old compost turned twice.

The usual situation in a household is you have a regular supply of kitchen waste complemented by an irregular supply from the garden. For example you will have lots of grass during the spring and summer and lots of leaves in the autumn; and crop residues from the vegetable plot will vary during the year.

Composting is a microbiological process. Organisms – mainly bacteria and fungi – use decaying matter as their food source. Bacteria and fungi are all around us, in the air and on plant materials, so there is no need to use activators. If these bugs are supplied with water, oxygen and nitrogen they will rapidly multiply.

For aerobic decomposition you need a continuous supply of air. The best place for air entry to a compost heap is from underneath. The air then rises through the material, is warmed and exerts a chimney effect drawing more air after it. This can be achieved by placing a 10 cm deep layer of thick woody prunings on the ground or by inserting a wire mesh cylinder in the base of the heap.

When adding material to the heap it should be blended to give a mix of different materials – wetter materials with drier, greener materials with woody. If there is a lot of sappy green waste e.g. grass it should be mixed with something like straw or partially rotted leaves. Large material e.g. Brussels sprout stems should be chopped up prior to adding to the heap. Small particles have larger surface areas than large ones and therefore reaction or composting rates are faster, provided that the flows of oxygen to, and carbon dioxide from, the micro-organisms in the heap are not impeded. This can well occur if the particles, and hence the air passages between them, are too small. The ideal size range is 12-40 mm screen size.

A lot of the material that you add to a heap contains water. For example grass is about 83% water. But if adding straw it will probably need to be wetted first. The ideal moisture content of compost is around 50%. To check this, take a handful of compost and squeeze; the sample of material should feel moist like a wet sponge, but shouldn't drip excess water.

Carbon-nitrogen ratio

A very common constituent of plants is carbon – it's one of the main building blocks of cellulose and lignin – and represents about 42% of a green plant's dry matter. Nitrogen content of plants is much lower and varies widely, but is a key constituent of growth be it in plants or microbes. The C:N ratio of plant residues can vary from 10-12:1 for vegetable wastes to 500:1 for sawdust. As plants mature, the proportion of protein (contains N) declines, while the proportion of lignin and cellulose (contains carbon) increases, and hence the C:N ratio increases.

C:N ratios of some organic materials

Material	% C	% N	C:N
Vegetable wastes	30	3	10:1
Cabbage	43	3.6	12:1
Young grass clippings	48	4.0	12:1
Farmyard manure	30	2.15	14:1
Grass clippings	58	3.4	17:1
Seaweed	36	1.9	19:1
Potato haulm	38	1.5	25:1
Horse manure	48	1.6	30:1
Tree pruning's	50	1.0	50:1
Straw	56	0.7	80:1
Newspaper	40	0.1	400:1
Sawdust	50	0.1	500:1

Microbes utilise nitrogen to breakdown plant or animal remains – about 1g is required for every 24g of carbon in their 'food'. This has a couple of important consequences. Firstly the ideal ratio of C:N for material added to your heap is around 24:1 – it's not an exact science so let's say from 25-30:1. If it is greatly in excess of that figure (> 40) the breakdown process will slow down as the microbes will need many lifecycles to oxidise away the excess carbon; if such material is added to the soil the bugs will have to scavenge the soil solution to obtain enough nitrogen which will cause plants to suffer from nitrogen deficiency. If the C:N ration is less than 20 there will be too much nitrogen in the material, more than is required by the bugs and the excess is released as ammonia which is lost as a gas to the atmosphere. So you need to obtain a balance between carbon-rich woody materials and nitrogen-rich green sappy plants or animal manures. In general a good mix is about 2 parts high carbon materials to 1 part high nitrogen materials. The C:N ratio of mature compost is about 12:1. This is a stable product that will not deplete the soil of nitrogen when incorporated.

How do know when the compost is ready? Use your senses! When it looks, feels and smells good with a uniform dark colour and earthy aroma.

Here's a summary of the essentials:
carbon rich materials + nitrogen rich materials + moisture + oxygen + time = compost.

Nutritional value of compost
Garden compost contains a complete range of both major and minor nutrients and is a valuable food source for vegetables. The problem is that there can be big variations between different compost samples depending on the source materials and how it was made. Compost made entirely from green waste is less rich than one made from green waste with protein sources (e.g. scraps of meat); a covered heap will contain more nutrients that one that is left open to leaching by rainfall. The only accurate way to find out is to send off a sample for analysis which is not cheap. A laboratory will analyse for total N, P and K plus dry matter percentage. To compare different samples on a like for like basis we usually work out the results at 100% dry weight. The figures below are averaged from different garden compost samples that were sent off for analysis and are expressed in kg/dry tonne. The composting material was general mixed green waste with some meat waste. Most of the nitrogen is organically bound to the humus and is only about 10% available in the season of use whereas the phosphorus and potash are deemed 100% available.

N	P	K
kg/t	kg/t	kg/t
15	2.9	12.9

Can one over apply compost or manure? Listen to the following tale. A gardener rang up Kinsealy and said he was having problems with growing beetroot, carrots and onions in his vegetable patch and thought that his soil was lacking something. So a soil sample was duly sent off. What came back was astonishing: pH 7.5, P 192 ppm, K 505 ppm. Not much lacking there; 8-12 ppm of P will grow the best of crops. On enquiring no fertiliser had been used but copious amounts of compost had been added to the plot over the previous 7-

8 years. It's possible that the over application of compost wasn't helping him. Too much compost or manure will lead to excessive nutrient levels in the soil with the possibility of high EC's and imbalances occurring with trace elements. It is possible to overdo a good thing and above about 5-6% soil organic matter you don't get much added advantage - the curve hits a plateau. Gardeners tend to over apply organic matter whilst commercial growers apply way too little.

Laboratory Results (mg/l)			
pH	P	K	OM%
7.50	192.00	505.00	

Advantages of compost

- Increase organic matter
- Improve aggregate stability
- Improve soil aeration
- Increase water holding capacity
- Increase cation exchange capacity
- Enhance the soil microbial community
- Suppress pests and diseases especially if plant material is composted with animal manures
- Source of nutrients

Rotation

The very first farmers back about 10,000 years ago would have discovered two things about rotation pretty quickly. Firstly, that breaking fresh ground gave them healthy crops; secondly, that if they kept cropping the same bit of ground with the same crops they became unhealthy due to a build up of pests and diseases. And so they would have begun to move – or rotate – their crops around in order to maintain good yields.

The basic idea is that pests and diseases are usually specific to each family group of vegetables and that if you move the groups around you'll minimise the likelihood of an outbreak. But in a sense rotation is a bit of a nonsense for the small plot vegetable grower, as true rotation is something that only a farmer can carry out by moving his crops from *field* to *field*. Take carrot fly for instance. It's capable of flying up to a kilometre from its overwintering site and this year's carrot crop that's 2km away from last year's infected crop is unlikely to be attacked from that source. But the carrots in your allotment that are only a few metres away from the previous year's infected crop will get attacked.

The other problem with small plots is that in the process of growing your vegetables you'll inadvertently move soil from plot to plot via boots, tools and wheelbarrow and in this way soil borne diseases like white rot and clubroot can be spread around.

Hence it's not easy to rotate crops in a small area but the advice would be to practice it in as far as possible. Divide your crops into roughly six groups: brassicas (cabbage, swede, Brussels sprouts, cauliflower, broccoli, kale), legumes (pea, bean), alliums (onion, scallion, leek, garlic), carrot group (carrot, parsnip, parsley, celery), solanums (potato, tomato) and the last group is everything else. The idea is not to grow any one group in the same ground more than 1 year in 4 or 5.

Notwithstanding the last piece of advice, an even simpler system is to divide your plot into three evenly sized areas and split up your vegetables into three groups: leafy crops (includes all the brassicas), peas and beans and root crops. Then follow the sequence in the table below.

	Year 1	Year 2	Year 3
Plot A	Roots	Peas and beans	Leafy crops
Plot B	Peas and beans	Leafy crops	Roots
Plot C	Leafy crops	Roots	Peas and beans

The above rotation would be particularly useful if you are growing organically without access to artificial fertilisers. Leafy crops are high nitrogen crops, roots are low nitrogen crops and peas and beans fix nitrogen and make it available to the following crop. Hence leafy crops follow after the legumes and root crops are placed at the low point in the nitrogen cycle.

The main problems that can stem from poor rotations include club root and white blister in brassicas, white rot and downy mildew in alliums and eelworm in potatoes – all of which are difficult to eradicate once they become established.

Other reasons for rotating crops include evening out what nutrients are absorbed from the soil as crops differ in their requirements and improving soil structure. Varying the crops grown allow for different types of cultivation to take place and this can help to preserve good soil structure. For example the deep cultivations required for a potato crop are different to the more shallow cultivations required for an onion crop.

Weed Control

Weeds are an ever present problem for the vegetable grower. Studies of soil taken from fields cropped commercially with vegetables have shown that it is quite common to find 10,000 seeds per square metre in the top 15 cm of soil, with the figure rising to 75,000 in very weedy fields.

Weeds of tilled ground are usually annuals that have the ability to grow, flower and set seed quickly e.g. chickweed, groundsel and shepherd's purse. They have adapted to survive in cultivated ground and will germinate throughout the year any time the soil is disturbed. They compete with the crop for space, light and nutrients but the effect on the crop can vary. For example, weeds can wipe out a direct drilled onion crop if not dealt with but have far less of an effect on a transplanted crop of cabbage.

Some growers will go to great lengths to remove virtually every weed in the crop with a combination of herbicides and hand pulling. But the effect of weeds on total yield can vary depending on *when* the weeds occur, *where* they occur and on the *type of crop* grown Weeds occurring at the beginning of a crop's life that are subsequently removed or those allowed to develop when it's nearing harvest will have no effect on yield. But between these two periods, the crop is vulnerable to weeds.

Mechanical weed control in a crop of swedes using a grubber.

An interesting experiment took place at the National Vegetable Research Station in Warwickshire where they looked at the effect of weed competition on two crops, beetroot and onions, grown in rows 45 cm apart. In one plot of each vegetable they removed all the weeds, in another they hoed between the rows but left a band of weeds to grow in the rows and in the final plot they left a similar band of weeds but this time between the rows. So the weeds were the same in both weedy plots, differing only in position. When the crops were harvested the onions were fine in the weed free plot but in the other plots were a write-off regardless of whether the weeds were in-row or between the rows. However with the beetroot the results were different. The relative yields were: weed free 100%, weeds intra-row 82%, weeds between the rows 71%.

Essentially what was happening was the larger leaves of the beetroot were able to compete with the weeds better than the slender onion leaves which had very little smothering effect.

	Weed free	Weeds in crop rows	Weeds between crop rows
Beetroot	43.6	36.0	30.9
Weed	0.0	2.6	4.4

What was surprising was that the intra-row weeds had less of an effect on yield than those weeds growing further away from the crop. The reason is that the

weeds closest to the crop are under some suppressing influence whilst those further away grow faster and eventually grow larger.

There are two main ways to control weeds: mechanical and chemical. Mechanical includes everything from hand pulling weeds to the use of a hoe, spade, plough, harrow and a wide range of mechanical weeders. Chemical control involves the use of herbicides.

The development of herbicides has transformed the task of controlling weeds in vegetable crops for the commercial grower. It's hard to see how large scale economic production of crops could take place without the use of chemical weed control.

Herbicides can be divided into various types:

Contact:	Acts directly on the leaf or stem of a plant and destroys all green tissue. Very effective on annual weeds but perennials will re-grow. Contact herbicides are inactivated on contact with the soil so sowing/planting can follow on shortly after spraying. Examples: Spotlight Plus, pelargonic acid
Residual:	Acts when sprayed onto the ground largely staying in the top few centimetres of soil to kill weed seeds in the germination stage for a period of weeks. Requires moisture for activation. Not effective against established weeds. Examples: Stomp Aqua, Emerger
Systemic:	Is taken in through the leaves or roots with the herbicide being translocated throughout the plant killing both roots and shoots. An advantage of systemic herbicides is that both annual and perennial weeds are killed. Examples: glyphosate, 2,4-D
Combination:	Some herbicides are a combination of the above types, e.g. Sencorex used on potatoes has both residual and contact properties.

Another idea to consider to improve the effectiveness of a herbicides or to reduce the amount of hoeing is the creation of a stale seedbed. This is where you prepare the area for sowing or planting several weeks before to allow weed seeds to germinate. Then spray them off using a glyphosate product such as Roundup. As the weeds are only in the seedling stage you can get away with using reduced rates – suggest 1.5 l/ha of 360 g/l product. It's quite safe to sow or plant the day following treatment. Organic growers can achieve the same effect by shallow hoeing or by burning off the weeds.

On a smaller scale the best way to beat weeds is to keep on top of them by constant use of a hoe. The weeds should be eliminated when they are quite small and never allow them go to seed. There is no need for 100% elimination – weeds growing within the crop-row are not a problem with the larger leaved crops. Perennial weeds should be forked out before they become a problem.

Ground was prepared 4 weeks prior to planting, weeds were sprayed off with 1.5 l/ha of Roundup and planted the following day with broccoli. No other weeding had to be done.

An alternative to hoeing is the use of black polythene mulch. Black polythene laid on the ground prevents weed growth, conserves moisture and raises the soil temperature. It is of particular benefit with certain half-hardy vegetables such as courgette, melon, sweetcorn etc. Ideally the surface should be level and pierce the plastic with a sharp knife wherever water ponds to allow rainfall to drain through.

Black polythene mulch weed control on pumpkins.

For weed identification please google *Illustrated Guide to Tillage Weeds*.

Pests and Diseases

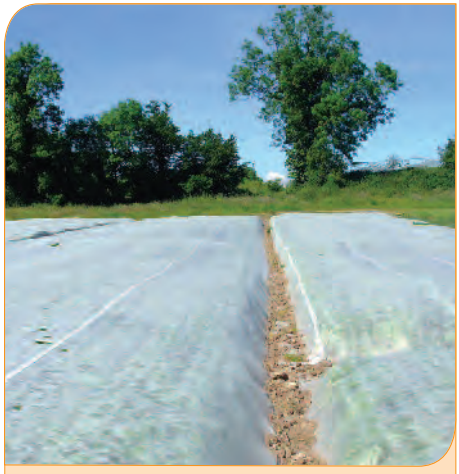
Let's get the bad news out of the way at the beginning. Pests and diseases go hand in hand with growing vegetables and are a natural part of the ecosystem. So we'd better learn to live with them.

It's a sad but inevitable fact of life that the fruits of your labours can be attacked by a wide range of pests. However the good news is that with a little bit of care and attention we can sidestep most of them – provided we know what to expect and take the necessary precautions.

Good control starts with good husbandry. Just like ourselves, if a plant is well looked after, it's far less prone to attack. Thorough preparation of the soil and use of manure or compost will pay handsome dividends in reducing the incidence of pests and diseases.

That said there will always be some pests that inevitably show up in certain crops. Cabbage root fly, carrot fly, caterpillars, slugs and aphids are sure to leave their calling cards at some stage during the season.

An excellent idea to keep the majority of pests off your crops is to cover them with an insect proof cover. You have two choices: fleece or insect netting. Both of these can be placed directly over your crops and anchored at the edges - they will keep the majority of pests out but still allow light and water to pass through. They are put on before the pest arrives and it's taken off when the crop is past the susceptible stage of attack. Fleece is a light woven material and insect netting is a heavy duty plastic; both can be purchased in good garden outlets. Nets are considerably more expensive than fleece but lasts far longer hence probably cheaper in the long run.



Fleece covering a swede crop giving earliness and protection against pests.

For general control of pests, diseases and weeds, you have a choice: pesticides, organic methods or a mixture of both. In a garden situation the organic option is probably the best bet and indeed you may be faced with Hobson's choice in relation to turning organic – the chemical you once used is no longer there in a lot of cases. There are now few insecticides or fungicides available on the amateur market. Commercial growers mostly use pesticides in order to meet supermarket standards and to produce vegetables at an economic price.

Sustainable Use Directive (SUD)

The EU has recently changed the laws concerning the use of pesticides for both amateur and professional users. This set of rules is known as the Sustainable Use Directive or SUD for short. The SUD relates to the sensible use of pesticides and aims to to reduce the risk and impact of pesticide use on people's health and the environment. A big part of the SUD is the onus on professional users to comply with the principals of Integrated Pest Management (IPM). Here's a simple definition from North Dakota State University of IPM: "It's a sustainable approach to managing pests and diseases by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health, and environmental risks." Another aspect of the legislation is that all professional users of pesticides will have to be certified by the Department of Agriculture by 26 November 2015. In future all pesticides will be labelled for either professional or amateur use and amateurs will not be able to either use or purchase professional products.

Identifying pests and diseases

Some pests and diseases are easy to identify. A caterpillar or white blister on a cabbage leaf is easy to identify. But even experienced growers and agronomists can't name everything they meet in the field and have to call upon the services of a specialist to correctly identify a pest or disease. A plant pathologist is the person that deals with diseases and an entomologist can help out with pest identification. If you wish to try your hand at identifying the problem yourself there are a variety of sources available both online and in print. A book that can be recommended is the *Collins Guide to Pest, Diseases and Disorders of Garden Plants* (4th Edition, published 2014). A very useful tool is a binocular microscope that allows one to see things close-up which helps out in pest, disease and weed ID.

PESTS

Aphids

Aphids, also known as greenfly and blackfly, are one of the commonest insect pests of vegetables. A wide range of vegetables are affected though alliums and cucurbits tend to escape. Most aphids are noticed from early summer through to autumn and overwinter as eggs or adults. Warm summers give rise to high numbers of aphids whilst wet weather discourages population build-up.

Aphids are weak fliers but can be carried for many miles on thermals and air currents and this is how they disperse and migrate to infect crops.

There are lots of different species, some with a wide host range but most have just one host or a few related ones. And most of them spend all their lives on the one host but some require two completely separate plant species to complete their life cycle. Here are some examples. The willow-carrot aphid, as its name suggests, has two hosts, willow and carrot. It overwinters as eggs on willow, hatches in the spring, feeds for a while on willow before flying off in May and June in search of certain Umbelliferous plants including carrots. There are two aphids that attack brassicas: mealy cabbage aphid and peach-potato aphid – there are clues in the common names. The mealy cabbage aphid is covered in a waxy like powder and spends all its time on cabbage and other brassicas. The peach-potato aphid has a wider host range than any other species, including peach, potato, brassicas, tomato, beans, lettuce and many ornamentals.

Aphids are usually first noticed in late spring and early summer feeding on young shoots and stems but may also attack flowers and roots. They feed by sucking plant sap and tap into phloem tissue which carries food around the plant. The plant sap contains a lot of soluble sugars but not a lot of the amino acids that an aphid needs for growth and maintenance. Hence they take in way more sugar than they need and end up excreting the excess from their rear end as droplets of sticky honeydew.

Aphids damage plants in a number of different ways – both directly and indirectly. During warm weather their numbers will rapidly build up and can

directly stunt plant growth with their sap sucking but in addition to that their feeding can cause discolouration and distortion of plant leaves. This, along with discarded cast skins (when aphids moult during growth) and honeydew can all conspire to make vegetables very unattractive to the consumer. If all this isn't bad enough the other main area of damage from aphid attack is their ability to transmit virus from plant to plant; potato leaf roll is a good example.

If you look closely at an infested leaf you may notice that some of the aphids have wings and some are wingless. When aphids first arrive on a plant they are winged and subsequently produce wingless individuals. When numbers build on a plant and over crowing occurs, winged individuals are produced that fly off to infest other plants. Most of the aphids you see during the summer are females who have the ability to reproduce asexually, each producing up to 10 live young during a single day. These in turn can start to reproduce within about 10 days – hence the potential for a rapid increase in aphid numbers.

Although aphids have the ability to multiply rapidly there are lots of natural enemies to keep them in check – the best known of which are ladybirds. But lacewing and hover fly larvae also play a part.

There are quite a range of chemicals available to kill aphids – these are known as aphicides. They are either contact or systemic in action with the best ones only available to commercial growers.

Birds

Birds can cause major damage to certain vegetable crops. The two main species involved are pigeons and crows. Pigeons will attack brassicas, lettuce, peas and beans. The worst attacks occur in the May-June period and during the winter months. But if numbers are high and on small plot areas attacks can be all-year-round. Crows can directly attack crops such as potatoes and sweetcorn, take legume seeds out of the ground and cause a general nuisance of themselves by pulling up recently planted modules in pursuit of food. There are numerous scaring devises on the market which may be initially effective but birds invariably get used to them. On one of the brassica trial plots in Kinsealy we had humming tape, CD's on bamboos, a hawk kite and an audio devise to keep pigeons off. After a few weeks of effectiveness they all failed miserably and

the crops had to netted, which worked. The most effective deterrent are bangers especially if backed up by shooting – this approach is frequently used in commercial crops. For small scale areas and increasingly on field scale, vulnerable crops such as brassicas are covered with nets to ward off pigeon damage. It would be remiss not to point out that birds can also be beneficial in eating a range of pests such as leatherjackets and caterpillars.

Cabbage root fly *(Delia radicum)*

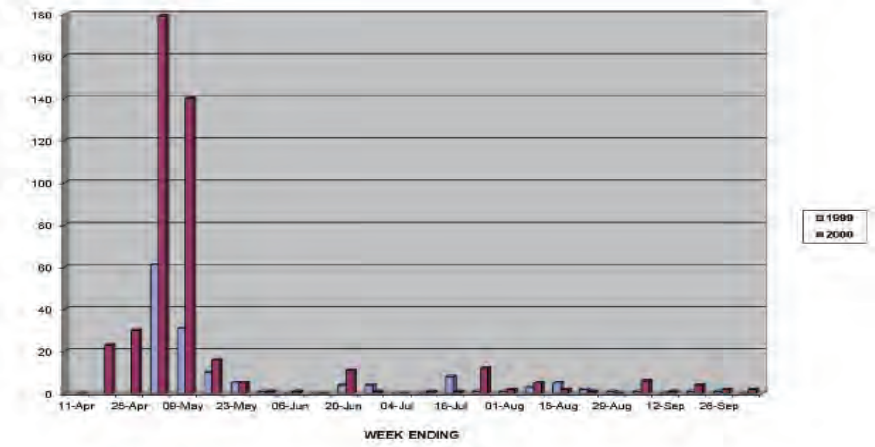
Cabbage root fly is a tough, hardy pest found in every parish of the land and is a major problem of brassicas. The damage it does is unmistakable – young plants wilting and dying off, with white legless maggots on what's left of the roots. Whilst this is a very common pest severity of attack will vary from field to field with worst attacks occurring where brassicas are intensively grown.

The adult fly looks like a small house fly and can be seen sitting on brassica plants if you're observant. The female lays its eggs at the base of the plant which hatch out after 3-7 days into larvae that burrow down into the soil to feed on the roots. The larvae go through several stages over a 3-4 week period to reach a final size of about 7-8 mm before dropping off the root to pupate. Depending on temperature the pupae will hatch out into adult flies after 2-5 weeks or if it's late in the year will overwinter in the soil.

Cabbage root fly larva.

There are 2-3 generations of fly per year. From a damage point of view the first generation is the worst with egg numbers reducing down in the second and third generations. When cabbage root fly start to lay eggs will depend on the weather – it can anywhere from mid-April to mid-May. Experience has shown that initial egg laying coincides with the start of flowering of hedge parsley when about 1 in 20 of its flower heads are showing white. The first generation peaks in May, then there's a valley period around mid-June with little or no egg laying and the second generation appears in late June to early July. There may be a third generation in late August to early September. However, the later generations frequently overlap with the result that adult flies and eggs can be found continuously during July, August and September.

Cabbage Root Fly, Lusk, Co Dublin 1999/2000



As can be seen from the graph the most damaging attacks are on young brassica plants that are put out in the April-May period. But in intensive brassica areas, fly numbers build up and can cause serious damage right through the season. Damage will vary depending on the size of plant attacked. It ranges from complete plant death of young plants, to growth restriction of larger plants and to not noticeable at all if the plant is large enough at the time of attack to withstand it. Later generation flies can lay their eggs on stems and leaves leading to occasional attack on cauliflower curds, broccoli heads and sprout buttons. Direct drilled crops are not susceptible to attack until the two leaf stage. If swedes and turnips manage to evade the first generation they are very susceptible to subsequent generations with the larvae feeding on the outside of the developing bulb.

Control:

- Commercial growers have access to a product called Verimark. This is drenched onto brassica modules just prior to planting out and gives protection against cabbage root fly attack. It's a systemic product which also gives protection against early attacks of flea beetle, aphid, caterpillar and leaf miner. The other product that is available is Tracer but this gives protection only against cabbage root fly.

- Garlic is available for both the commercial and amateur grower. It's available in both liquid and granule formulations and is expensive to purchase. It is effective in that it will kill cabbage root fly eggs but garlic has quite a short persistence and therein lies its problem. Swede growers do use it along with a wetter to control second generation fly but the timing has to be spot on to coincide with egg laying. In practice it has given rather hit and miss results.
- Bionets can be used on brassica crops to physically exclude the pest. What normally is used is a 1.3mm net which is also effective on carrot fly. It's usually just laid on the ground and the crop as it grows pushes it up. It's important that the sides of the net are well secured with soil to prevent entry by the fly. So by covering your brassica plants from mid-April to mid-June, you'll avoid the worst ravages of this pest. Young plants are the most susceptible and if you can get them past this vulnerable stage you can take the covers off, unless you want to protect against other pests such as caterpillar. Numbers are generally low in June but unfortunately there is a second generation to contend with in July and August but it's far less damaging than the first.
- There are no fully effective chemical actives for use on swedes to control second generation attack and for this reason commercial growers have largely switched over to growing their crops under bionet. The nets are put on at sowing time and not removed until after mid-September.
- Delay sowing swedes until the third week of May to avoid the first generation.
- Another physical barrier to consider is fleece which is far cheaper than bionet but will only last for a season or two and works out more expensive in the long run. Bionet can last for up to 10 seasons or more with care.
- For small numbers of plants one can purchase discs that are slipped around the base of the plant. You could also consider making your own from something like foam carpet underlay. These discs work for a number of reasons. They reduce the numbers of eggs laid, act as a shelter for predatory ground beetles that feed on eggs and larvae and help to conserve moisture that encourages rapid plant establishment.
- Nematodes can be purchased that claim to control cabbage root fly.

Carrot fly

Carrot fly barrier with over-hang.

Carrot fly is a major pest of carrot, parsnip, celery and parsley – all members of the same plant family, the Apiaceae. The small larvae of the adult carrot fly mine the roots and can totally destroy a crop. You may be lucky the first time you grow these crops and avoid damage but local populations of the pest can quickly build up. There are normally two generations per year: May to mid-June and late July to September. Celery is worst affected by the first generation while damage in carrots and parsnips normally shows up from September on. Parsley is less prone to being attacked but will suffer with high populations of carrot fly. Coriander, a member of the carrot family, is not prone to attack. The adult fly uses smell, vision and taste to locate its host and most of them will originate from a previously damaged crop within a square kilometre of your crop.

To prevent or reduce an attack from carrot fly try one of the following:

- Cover your crop with fleece or net from late April and leave it on until around mid-September.
- Surround the area with a 60 cm high wall with something like clear plastic. The carrot fly isn't a strong flier and won't be able to find the carrots if they are barricaded off. The picture shows a metre high net barrier with a lip at the top for extra security – it managed to protect a plot 10 m wide.
- Sowing them in a garden frame or polythene tunnel will also probably be effective in warding off the ravages of this pest.
- Sow in mid May to avoid the first generation and with a bit of luck you'll avoid the worst of the problem.
- There's an insecticide on the amateur market which contains lambda-cyhalothrin, the same active that the commercial growers use for carrot fly control. It works by killing the adult fly and must be used preventatively. Use it only when the fly is active. The second generation spray protection programme usually starts around 20 July and would be applied every 2 weeks up to mid-September.

Bean seed fly

Bean seed fly is a localised and occasional pest of beans, spinach, onions, cucurbits, beet, sweetcorn and brassicas. The flies emerge in March and April and the female lays eggs on freshly disturbed ground. They are attracted by decomposing organic matter and plant debris. The eggs hatch after a few days into white larvae, similar to cabbage root fly maggots, and grow to 5-8 mm in length. It's the larvae that do the damage by feeding on buried bean seed, on emerging Alliums and recently planted cucurbits. There are several generations and attacks can occur until early autumn. Commercial growers use seed treatments to combat the pest on susceptible crops. A cultural control method is to delay sowing for about 10 days after cultivating to reduce the risk of attack

Beet leaf miner *(Pegomya hyoscyami)*

Beet Leaf miner.

This pest is also known as the mangold fly or the beet fly. Adult flies emerge from the soil in late April to May and lay their eggs on the underside of beet plants – red beet, spinach beet, sugar beet. The eggs hatch into larvae that tunnel into the leaf feeding between the upper and lower leaf surfaces. They feed for about 2-3 weeks before dropping to the soil to pupate. Normally there are 2-3 generations per year. The visible damage is a blistering of the leaf which later on withers to give a scorched brown appearance. Severe attacks on young plants may check growth but older plants are far less affected.

Caterpillar and cutworm

Caterpillars are familiar to every grower as they are a common pest that attack a wide range of vegetables but are particularly associated with brassicas. Caterpillars are the larvae of butterflies and moths. Butterflies fly during the day and have clubbed antennae whilst most moths fly at night and have feathery or straight antennae. They are pests that occur in the summer and continue into the autumn and in warm years can appear in large numbers. On small areas pick off the caterpillars, otherwise use one of the insecticides available such as pyrethrum or cypermethrin. Take note that butterflies and moths have ability to lay through bionet if the foliage is pressing up against the net. There are quite a variety of caterpillar species that attack brassicas, potatoes, lettuce, spinach, peas and beans. Some of the commoner ones are detailed below.

Small white butterfly (*Pieris rapae*)

Small white caterpillar.

Attack brassicas. Dull velvety green caterpillar with a yellow line down its back. Two to three generations per year from June to late autumn. This species can be potentially damaging to brassicas especially cabbage as it occurs widespread throughout the field and burrows down into the head making it difficult to hit with an insecticide.

Large white butterfly (*Pieris brassicae*)

Large white butterfly caterpillar.

Attack brassicas. Distinctive black and yellow markings on the body of the larva. Two generations per year, summer and autumn with the autumn generation being the largest. Feeds on the upper and lower surface of the leaf, often in large groups. The damage to plants can be severe but few plants are attacked on a field scale so usually not worth spraying. Much more damaging on garden plots and allotments where remedial action needs to be taken.

Diamond back moth (*Plutella xylostella*)

Diamond back moth, adult and larvae.

Everything about this caterpillar is small apart from the damage it does. Attacks brassicas especially cabbage with the worst damage showing up on pointed cabbage. In a bad attack every single cabbage in a field can be damaged. Diamond back is a small green caterpillar (1 cm) that is difficult to see as it mostly feeds on the underside of the leaf. Two to four generations per year from early summer to late autumn. Feeding leaves characteristic 'window panes' on the leaf, and the other diagnostic feature is the caterpillar when disturbed will wriggle and then drop down from the plant remaining suspended by a fine silken thread. Diamond back moth is a migratory species though some adults may overwinter in the milder parts of the country. Native to southern Europe, moths are carried in on high pressure winds during the summer. This pest is hugely destructive of brassica crops in hot countries and occasionally causes problems here in warm dry summers. Two very bad years were 2006 and 2016.

Cabbage moth (*Mamestra brassicae*)
Attacks a wide range of plants including vegetables: brassicas, lettuce, beet, potato, onion and peas. The eggs hatch out as small light green caterpillars but as they become older their colouring varies greatly. They may remain light green, or become brown, dark green or even black on the upper surface. Feeds at first on underside of outer leaves; later may be found in centre of plant. Two generations a year: June to late autumn.

Silver Y moth (*Autographa gamma*)
Attacks a variety of crops including peas, sugar beet, cabbage, lettuce and potatoes. The caterpillars are green with whitish markings, three prolegs and about 3 cm long. When disturbed it curls up tightly in a ball. Damage from this species is often sporadic and coastal in nature as it's a migratory moth. As the name suggests there is a characteristic white Y marking on the wings of the adult.


Silver Y moth.

Cutworm
Cutworms are caterpillars of several species of noctuid moths e.g. turnip moth. They are so called as they inhabit the surface layers of the soil and commonly feed on young seedlings by cutting through them. They attack a wide range of plants including brassicas, root crops, lettuce, celery and leek. They feed just below the surface and at night can feed on foliage. If you notice wilting or collapsed plants check the surrounding soil for brown or greenish brown caterpillars. Because of the range of species one can find cutworms throughout the year but they are not a common pest of vegetables and attacks are sporadic in nature being worst in warm summers. Reducing weed cover can reduce numbers. May occasionally cause problems in glasshouse crops.

Celery fly *(Euleia heraclei)*
Celery fly is also known as celery leaf miner. The first adult flies appear in May and early June and lay their eggs on the lower surface of celery and parsnip leaves. The eggs hatch after a week and the larvae mine the leaves causing large blotchy blisters. If you open up the blister you may be able to find a larva present which when fully grown is 7 mm long. Larvae take about 3 weeks to fully develop after which they pupate either in the leaf or drop down onto the soil to eventually produce a second generation in August. This second generation normally doesn't cause any noticeable damage. The damage is usually first seen on celery crops in June but damage is normally more severe in back gardens and allotments than on commercial crops – but in intensive commercial areas this pest will commonly enough show up.

Leatherjacket (*Tipula padulosa*)
Leatherjackets are the larvae of the crane fly or daddy longlegs that are particularly associated with damage to cereals and grass. They are a natural grassland pest and usually only appear in vegetables if the crop follows grass or grassy stubbles. Continuous tillage obliterates them. Occasionally you will find enormous numbers in a particular field when all the conditions come right for the pest. There is a nematode (*Steinernema feltiae*) available for leather-jacket control in high value crops.

They have an annual lifecycle with eggs being laid by the crane fly from mid-August to the end of September in grassy areas. The young leatherjackets feed on roots and grow in size over the autumn period. Crop damage normally occurs in spring, typically March and April, when the larvae are larger in size (about 25 mm) and nearing maturity. They usually feed just below the surface eating roots and stems and on warm, damp nights come to the surface and feed on seedlings like swedes and lettuce making holes in leaves and small plants can be completely severed. To confirm leatherjacket damage search in the soil adjacent to the damaged plants and look for a soft, dull brown, wrinkled larva that is legless with no apparent head. Come June/July, when fully grown it pupates in the soil for a few weeks before emerging in August as a crane fly to start the cycle all over again.

Eelworm
Also known as nematodes. Eelworm are a common naturally occurring animal in the soil some species of which attack plants.

Root knot eelworm *(Meloidogyne spp.)*
A range of vegetables can be attacked: cucumber, tomato, French bean, lettuce, carrot, parsnip and beetroot. The nematodes invade the root and as they feed the plant cells enlarge and proliferate to form galls. This has been seen a few times on carrots causing forking and distortion of the side roots.

Root knot eelworm.

Potato cyst eelworm

Long ago we had just the one species of potato cyst eelworm - Heterodera rostochiensis. Then they decided they had 2 strains of the same species, pathotypes A and B. Now they have upgraded them to full species, namely, H. rostochiensis and H. pallida. The common names for H. rostochiensis is the yellow potato cyst eelworm or golden nematode and H. pallida is the white potato cyst eelworm. The generic name is now more correctly known as Globodera. We have both species in this country but H. rostochiensis is much more commonly found than pallida. This is significant as certain potato varieties such as Premier are resistant to rostochiensis (aka PCN Ro 1) but not to pallida (aka PCN pallida) but the only way to find out is to test your land.

Flea beetle (*Phyllotreta spp*)

Flea beetle.

Flea beetles are a widespread and occasionally serious pest of all seedling brassicas. There are several members of the genus Phyllotreta that are called flea beetles but all share one thing in common: enlarged hind legs that enable them to jump; and hence the name. This characteristic also enables you to identify them; if you spot one on a plant it will only let you come so close before it hops away to safety. The adults overwinter in hedgerows and emerge in spring. If the weather turns warm during April and May crops of direct drilled turnips and swedes can be severely attacked particularly if the growth of the crop is held up at the cotyledon stage by dry weather. The feeding damage is very characteristic – small puncture holes in the leaf that expand in size as the leaf grows. If the attack is heavy an entire sowing can be lost. The adults will also feed on other brassicas but the damage is less damaging on older plants. A second generation of beetles hatch later in the year to cause more trouble from mid-June to late July.

Pea and bean weevil *(Sitonia lineatus)*

Pea and bean weevil.

This is a very common pest of peas and also attacks broad beans. The damage is very characteristic – semicircular notches eaten out of the leaf by the adult weevil. The adults hibernate in hedgerow bottoms and under plant debris and when spring arrives fly out to feed on peas, beans and other legumes. Eggs are laid in the soil from which larvae emerge. They feed on the root nodules of legumes before pupating. The adults emerge during the summer to complete the lifecycle. This pest, although common, is not particularly damaging unless present in very high numbers – good rotation will prevent this from happening.

Rabbits and hares

Hare damage on cauliflower.

Rabbits and to a much lesser extent hares can cause serious damage to brassicas in the early stages of the crop. Once a crop grows on it's out of the danger zone. On a field scale rabbits tend to graze fairly close to the hedge; damage further out in the field is very likely to be hares. Very often hares will just chop through the plant without eating it. The most effective remedy for rabbits is to fence off the crop from the ditch – expensive but effective.

Rats and mice

When other food sources get scare rats may turn their attention to vegetable crops particularly in wintertime especially if large numbers of rodents are around. The following are susceptible: root crops especially potatoes, brassicas especially Brussels sprouts, sweetcorn and pumpkins. Attacks can often be worse close to ditches and you may also notice that certain varieties fare worse than others in susceptibility. Mice are less of a nuisance but can cause problems in the greenhouse by eating seeds. Carefully applied rodenticides will normally effect a cure but be mindful of the side effects of baits on wildlife; download the *Campaign for Responsible Rodenticide Use* (CRRU Code) for further information.

Slugs

Common to every field and garden these pests can wreak havoc if present in large numbers. Given the amount of shelter available in an average garden they are a bigger problem in small plot areas than in the open field. There are several species including the grey field slug, the black slug and the keeled slug and all are active throughout the year provided temperatures don't go too low. Activity is highest in warm, humid weather. It's impossible to eliminate slugs so an integrated approach, using several different techniques is more successful than relying solely on pellets. The first step is to minimise areas where slugs can shelter – keeping the area around the vegetable plot tidy and controlling weed growth within it can help. Ensure that the remains of previous crops are tidied up and dug in or raked off and removed to the compost heap. Repeated cultivations, especially if carried out using a rotavator can also help in reducing numbers.

Slug pellets are the commonest method of controlling this pest. They are based on one of two chemicals: methaldehyde or ferric phosphate. There is little difference in efficacy between either active. Pellets are usually cereal based to make them attractive to slugs and coloured blue to make them unattractive to birds and other animals. The methaldehyde based pellets immobilises the slug and subsequently dies from desiccation. They can recover if the weather turns wet. Ferric phosphate pellets slowly poisons slugs and once ingested stop feeding. They become less mobile and die within 3-6 days normally underground as dead slugs are not usually visible overground. Use pellets sparingly and bear in mind that they will remain effective for 1-2 weeks depending on weather; they tend not to last in prolonged wet spells. Apply directly after sowing or planting out a susceptible crop. If you want to keep slugs off a small plot area surround it with a 20 cm high zinc coated metal wall.

Other controls:

- Nematodes: expensive but effective method of control. Must be sprayed on in rainy weather and will last for about 6 weeks.
- Traps: use of hollowed out grapefruit or orange, planks or black plastic bags laid on the surface of the soil will attract slugs which can then be subsequently destroyed. Beer traps are also effective in attracting and drowning slugs.
- Predators: encourage frogs, hedgehogs and ground beetles into the garden to help keep slug populations under control.

- Barriers: there are a variety of barrier materials sold to keep slugs away from desirable plants – of varying usefulness it must be said.
- Go out in the late evening or early morning and dispose of any slug or snail you come across.

Slugs will eat a variety of vegetables but not all. They prefer soft rather than fibrous material. However if choice of food is limiting they will graze on less palatable crops. The worst losses can occur at the seedling stage when complete crop rows can disappear. They mostly feed at night but if weather conditions are humid enough they continue during daylight hours as well. Having found a desirable food, slugs remember its location and return to it from their resting areas for subsequent feeds. The following table lists the susceptibility of various crops to slugs under three categories. To explain what intermediate means, take carrot for example. Slugs will eat seedling carrots, won't touch the more mature foliage but will eat the root when it forms. Commercial carrot growers don't need to apply pellets unless they are covering the crop with straw for overwintering but in a garden situation it may be necessary. Similarly with onions, the commercial crops are not treated but in a garden situation with possible high slug numbers and different species, alliums may be attacked.

Susceptible	Brassicas, lettuce, celery, rhubarb, potato, sweetcorn, French bean, asparagus, tomato
Intermediate	Spinach, peas, broad bean, onion, scallion, carrot, parsnip, leek, beetroot
Resistant	Courgette, artichoke, herbs (except basil), garlic

Thrips, Onion *(Thrips tabaci)*

The occurrence of thrips on a range of crops has increased in recent years. Onion thrips attack a wide range of crops including onions, leeks and brassicas. The crop most associated with onion thrip is leek but this is a relatively recent phenomenon, only showing up in the past few years. Thrips are tiny winged or wingless insects rarely more than 3mm long and in the case of

Thrip damage.

onion thrip about 1mm long. This makes them difficult to see. If you want to see what thrips look like shake a dandelion flower over a sheet of white paper – but wait until summer time to allow the populations to build up. They are difficult to find on leeks – they tend to hide in the leaf sheaths, so pull them apart gently and have a magnifying glass to hand. Larvae and adults both feed on plants sucking out plant sap which produces the characteristic white markings on the leaf which arises from air entering the empty epidermal cells. Attacks are worst in warm dry summers.

Thrips, pea *(Kakothrips pisivorus)*
The adults emerge from the soil in May and June and lay eggs in pea flowers. They hatch out into young wingless thrips which feed on the developing pod to leave the pods misshapen with characteristic silvery markings. These markings can also be seen on the leaves. The main outbreaks occur in June and July. Worst attacks occur in hot dry weather which are often ended by a wet spell.

Weevil, ground *(Barynotus obscurus)*
This is a new pest that was first reported attacking southern coastal crops of carrots and parsnips around 2009. It is a native species that normally inhabits grassland. It's the larval stage that does the damage by feeding quite extensively on the roots, particularly on the lower portions. Early crops under plastic seem to more prone to attack than later sowings. Tight rotations also seems to be a factor in the pest's appearance. It is unclear quite why this pest has started to attack these crops given that it's a native species.

Wireworm
The natural home of wireworms is grassland and they normally only become a problem when old grassland is ploughed up for vegetables. Wireworm are the larvae of click beetles so named from their peculiar ability to flick themselves into the air when lying on their backs. Unlike leatherjackets, wireworms take 4-5 years to mature eventually reaching a length of around 25mm. Wireworms are aptly named: they are orangey-brown in colour, tough skinned, and with three short pairs of legs just behind their small dark brown head. When grassland is ploughed down wireworms will turn to arable crops for food although damage in the first year may be lessened as wireworms continue to feed on the roots of the old sod. Damage may occur for 3 years following

ploughing. Wireworm damage is most associated with potatoes with other vegetables seldom being attacked bar swede which the odd time attracts attention. Damage in potato manifests itself as narrow tunnels bored into the tuber leaving small round holes on the surface. Although this damage does not affect yield, it causes a serious reduction in quality and provides access for slugs, millipedes etc. It is important to note that most permanent pasture only has low populations of wireworm and where problems do occur it's where high numbers have built up in a particular field. Wireworms can also be associated with arable situations if weeds and grasses are allowed to establish. Only a very occasional pest of vegetables.

Control:

- Thorough cultivation and good weed control will quickly reduce initial populations
- Wireworms are attacked by various birds particularly rooks
- Lift potatoes early as wireworm damage tends to steadily increase from about mid-August onwards

DISEASES

A wide range of diseases attack vegetables and we have a climate that is tailor-made for the spread of disease. So we need to understand the nature of disease, be able to recognise the common ones and find out how best to deal with them.

Plant diseases are caused by fungi, bacteria or viruses. But it's important to realise that fungi and bacteria are also enormously beneficial – human life would be impossible without them. They carry out a myriad of essential life processes including nitrogen fixation and sorting out your compost heap.

There are many different species of fungi including mushrooms, mildews, moulds and yeasts. They are made up of thin thread like structures called hyphae and a visible mass of hyphae is called a mycelium. They propagate themselves by producing spores that are spread by wind and rain splash. There are two

types of fungi: parasites and saprophytes; but one thing they have in common is the inability to manufacture their own food – unlike plants. Saprophytic fungi live off dead material and are commonly found in the soil and on rotting plant and animal material. Parasitic fungi are the ones that attack plants but in general don't kill them. The hyphae penetrate between the cells, secreting enzymes to break down the tissues and absorb the digested molecules.

Bacteria are tiny single celled organisms which increase in number by dividing in two. The majority of plant disease is caused by fungal pathogens but bacteria can occasionally cause problems such as blights, leaf spots and soft rots. Unlike fungi bacteria do not produce spores and hence don't get spread around by the wind. Plant pathogenic bacteria can exist on leaf surfaces without causing any problems; but if for any reason they multiply to sufficient numbers they are able to enter the plant through wounds or natural openings such as stomata or hydathodes. Once inside the plant they multiply and cause disease. Bacteria spread from plant to plant by rain or irrigation splash and are also readily transported around by contact e.g. machines, tools, trays, clothing or hands. A number of bacterial diseases are seedborne, e.g. Xanthomonas in Brassicas – if the seed is sown the disease can show up later in the growing crop. Plant pathogenic bacteria do not survive in the soil unless on partly decomposed plant material – the exception is *Streptomyces scabies* which causes common scab in potatoes and other root crops. Bacterial diseases in vegetable crops have become more common in recent years due to wetter summers – it's a pathogen that develops in spells of wet weather. Examples of bacterial diseases are bacterial leaf spot on Brassicas, halo blight on beans and blackleg on potatoes.

Viruses are tiny, non-cellular structures that can only be seen with an electron microscope. They can attack a wide range of vegetables but not frequently. Most need a vector to transmit from plant to plant – aphids would be the commonest example of a vector. Examples of viruses are beet yellows virus, celery mosaic virus and virus x in potatoes.

White mould *(Sclerotinia sclerotiorum, S. minor)*
Sclerotinia has a very wide host range. It can show upon cabbage, carrots, beans, lettuce, celery and parsley; for a full list see the table below.

Asparagus	Broccoli	Carrot	Celery
Chicory	Cabbage	Cucumber	French bean
Lettuce	Swede	Turnip	Tomato
Parsley	Mustard	Pea	Runner bean
Potato	Radish	Endive	Cauliflower

It's a disease that tends to build up in intensive production and can become problematic under glass and plastic. What makes it problematic is that it produces resting structures called sclerotia – these are small dark hardened masses of fungal mycelium that allow the organism to survive unfavourable conditions. They can infect plants by two methods:

- Via mycelia growing directly from the sclerotia
- Via ascospores produced from cup-shaped apothecia that form at soil level as an out-growth from the sclerotia

The spores usually germinate on wounded, dead or dying tissue but can directly infect healthy tissue if the atmosphere is moist enough. A wet rot subsequently develops along with the production of white fluffy mycelial growth that go on to develop black sclerotia. You can tell the difference between the species by the size of the sclerotia – those of S. minor are noticeably smaller, usually up to 2-4 mm in diameter and more numerous on plant tissue. Sclerotinia minor does not produce apothecia and infects the plant from mycelia that grows from the sclerotia. This species particularly infects lettuce, chicory, endive and carrots.

Control:
- Good rotations
- Regular use of Contans can reduce infection levels. This is a fungus *(Coniothyrium minitans)* that is a natural pathogen of Sclerotinia
- Use of Signum fungicidal sprays are effective

Mint rust *(Puccinia menthae)*
Mint rust is probably the most important foliar disease of mint, capable of causing reductions in both yield and quality. The most obvious indication of this problem is the presence of the rust pathogen itself.

Affected leaves are pale and distorted with rusty coloured pustules appearing on the stem and leaves. Later in the summer the pustules turn brown in colour. A systemic infection of shoots in the spring can occur if overwintering rhizomes are infected by teliospores in soil – this allows the fungus to survive the winter.

Control:

- Burning off old foliage in autumn with a flame gun may control the disease but not if it has penetrated the rhizome
- The disease may not infect all the rhizome, so propagation from some pieces, especially the youngest, may yield disease-free plants
- Hot water treatment may cure the problem: immediately prior to autumn planting, wash plants thoroughly, immerse the rhizomes for 10 minutes in water kept at 44°C , then cool in cold water
- High N and low K levels are said to encourage rusts in general
- Use resistant cultivars

Allium Diseases

Crops: onion, salad onion, shallot, garlic, leek, chives

Cladosporium leaf blotch *(Cladosporium allii-cepae)*
This leaf spotting disease was first identified on overwintered bulb onions in May 1978 in Co Cork. With a bad outbreak it can be a damaging disease but the newer varieties are more resistant and nowadays would be regarded as a minor leaf disease of onions.

Cladosporium causes small, grey-yellow, depressed lesions, which become elliptical in shape. As the lesion ages it becomes brown to olive-brown in colour. These will eventually coalesce causing the leaves to wither and die.

Leaf blotch on scallion leaves with characteristic eye shaped lesions.

The pathogen is not seed-borne with the principle source of infection being air-borne conidia. These either transfer from a neighbouring crop or arise from debris in the soil. Peak times for spore liberation are in the autumn and spring. The spores require high humidity to infect host leaves with the resulting lesions continuing to develop throughout the crop's life. The pathogens prefer cool temperatures (9-12°C) and high humidity to infect and sporulate. For these reasons overwintered onion and scallion crops can be most at danger of infection, particularly in the spring.

Control:

- Plough down infected debris as soon as the crop is harvested

Downy mildew *(Peronospora destructor)*

Downy mildew can be troublesome in bulb onions, being particularly serious where crops are grown under cool, moist conditions. The pathogen can infect most types of onion, chives, shallots, leek and garlic, with the last two crops being much less susceptible.

The disease normally starts at isolated sites within a field from where it spreads to surrounding plants. Older leaves show elongated patches (3-30 cm in length) that are paler than the surrounding tissue and in time turn light brown in colour. The under-surface of the lesions may be covered with a greyish violet downy growth, which may be particularly prevalent during periods of high moisture. Affected leaves gradually become pale green and later yellow, with disease parts folding over and collapsing.

The pathogen over-winters in volunteers and soil as oospores and as mycelium in infected bulbs. The pathogen produces both asexual sporangia and sexual oospores, both of which can infect young plants being blown or water-splashed up from the soil respectively. To achieve infection the fungus requires cool temperatures (<22°C) and the presence of rain or dew on the leaf surface. Dry weather will halt development of the disease. After landing on a leaf surface, spores can remain viable for up to 3 days, depending upon environmental conditions. In the absence of control measure the disease can completely destroy a crop during the course of 4 infection cycles.

Control:

- Plant disease free onion sets
- Four year rotation will help reduce soil inoculum
- Open windy site is preferable to a sheltered one

Onion neck rot *(Botrytis allii)*

If you find your onions going soft in store then the most likely cause is neck rot. This common storage disease – more common certainly with amateur growers – can originate in the sets or seed you buy. Both are possible carriers of Botrytis spores that may systemically infect the developing crop. Few if any symptoms appear during the growing season; but with infected sets one can get yellow leaves showing up in the crop. At the end of the season when the foliage begins to senesce the fungus sporulates and can infect the neck of the onion where the crop is topped or through breaks in the foliage when the tops bend over. The mycelium of the fungus then grows down into the bulb. After several weeks in storage a water soaked or light brown decay will appear on the neck of the onion along with grey sporulation. At a later stage small black resting bodies or sclerotia will develop on the surface of the bulb. The disease further develops to spread throughout the bulb which eventually rots. To reduce the chances of getting this disease buy your sets or

Neck rot showing up after planting infected sets which will spread the disease to healthy plants.

seeds from a reputable outlet - heat treated sets should be free of the disease. The other thing to do is to ensure that the necks of the onion are completely dry before storing the bulbs. Take note that any sclerotia that reach the soil can also act as an infection source and can survive for two years on the buried debris.

Control:

- Use disease free seed and sets
- Good rotations
- Rapid and thorough drying of onion necks in storage

Onion leaf blight *(Botrytis squamosa)*

This leaf spotting disease is most commonly associated with salad onions but can also attack the foliage of bulb onions. The source of the infection is airborne spores that originate from neighbouring crops, debris from previously infected crops or from sclerotia in the soil. The initial symptoms are the formation of small white elliptical spots surrounded by a green halo. With time these spots coalesce and lead to total bleaching of the foliage and general collapse of the plant. Don't confuse the initial symptoms of the disease with hail damage on the leaf which can look very similar. Twirl the leaf between your fingers and if the damage is one sided it's weather damage and if the spotting is all around it's Botrytis. Leaf spot often breaks out after a spell of warm muggy weather and the disease can rapidly spread across an entire field.

Control:

- Good rotations
- Separation of overwintering and spring crops
- Avoid excessive use of nitrogen fertilisers
- Use of preventative fungicides

Rust *(Puccinia allii)*

Rust will attack onions, leeks, garlic and chives but its worst effects are seen on leeks and garlic. The disease is aptly named and easy to identify: elongated rust coloured pustules appear on the leaves of the infected plants. The disease is spread by windborne spores and does not carry over in the soil; it can only do so on green tissue. Hence initial infection of a crop is usually from a

neighbouring diseased crop – this known as a green bridge. So if you are in an isolated part of the country and are only growing for example a single maincrop of leeks you are less lightly to encounter rust. However in the more intensive commercial areas and on allotments rust is the commonest disease on both leeks and garlic. It appears that leek rust will not infect onion and chive and visa-versa. The rust you commonly see on groundsel is completely different to rusts that attack alliums and one will not attack the other.

Rust is a common pathogen on intensively grown leeks and garlic.

Rust is most active between 12-21°C but can infect leeks down to 7°C. Cold frosty weather will tend to knock the fungus back. For spores to germinate successfully a minimum leaf wetness period of 4 hours is required and spells of wet weather encourages outbreaks. It's normally seen from July onwards and leek crops are most at risk of infection from August to October.

Control:

- Removal of crop debris
- Siting of the crop – the disease will spread downwind for several hundred metres
- Rotation – not so important as the disease is not soil borne
- Choose a variety that is less susceptible
- Apply fungicides before any disease is seen

White rot *(Sclerotium cepivorum)*

White rot is a devastating disease of Alliums with bulb onions, salad onions and garlic being particularly affected; leeks less so and perhaps chives are resistant. It's a serious disease as there are no fully effective control measures and white rot can remain in the soil for many years. The first symptom you'll notice is a premature yellowing of the foliage in patches in the crop. If an infected plant is pulled up there will be a white mycelium growing on the root

White rot: one of the most intractable of Allium diseases.

and base of the plant which with time will develop small, black, pin-head sized resting bodies called sclerotia. These can be seen with the naked eye if you look carefully. The sclerotia germinate in response to sulphur type compounds that come from developing Allium roots. The optimum temperature for the development of the sclerotia is 14-18°C with little response below 9°C; hence autumn sown or planted crops may experience less damage from the disease. Secondary infection can occur by mycelial growth from plant to plant if the roots are in close proximity as is the case with salad onions. Early infection causes bulbs to completely rot in the field whilst later infections cause the collapse of bulbs in store.

The puzzling thing about white rot is that onions can be grown on the same patch of land for years without ever seeing the disease and can make an appearance very early on in fresh ground. This variation all depends on whether sclerotia are present in the soil or not. They can be very easily transported from infected to clean ground in soil via implements, footwear or by crops e.g. potato tubers, and once in the ground can last for over 100 years. Also take note that onion seed is not a carrier but sets can be. Poor rotation is then the prime reason why white rot develops in a field after the initial infection. It you persist with growing Alliums in affected ground the disease just get steadily worse. For these reasons white rot is most commonly found in intensive vegetable growing areas and in cottage gardens and allotments.

Various attempts have been made to find a chemical cure with little enough success. Basimid (soil sterilant) at 570 kg/ha gave up to 70% control in trials but cannot be relied upon to give complete or lasting control. Tebuconazole, the constituent of Folicur has given partial control in UK trials applied either as a spray or as a seed dressing. We also have an off-label for the use of Signum. The bottom line is: forget about chemicals and select clean ground for your Allium crops.

Control:

- Select fields with no history of the disease
- Where practical gather up the infected bulbs to reduce disease loading in the field and if possible grass the field down
- In a garden situation create a raised bed with fresh soil free of disease, forget about rotation, and grow your Allium crops there; just make sure that you don't reinfect the soil by good hygiene
- Purchase sets and garlic bulbs from a reliable supplier

White tip *(Phytophthora porri)*
This is a common leaf disease of leeks in the more intensive growing areas of the country. Early infection causes the tips of leaves to turn yellow. These will later either become crisp and bleached or decay and die. The infection progresses down the leaf from the tip with the tissue becoming water-soaked in advance of the lesion. Severe infection can cause rotting of the leaves at ground level with lower levels of disease causing wilting at harvest. The pathogen over winters as resting spores (oospores) in infected debris remaining in the soil. On germination these produce sporangia that are carried by the wind to new crops. The disease will first appear in the field during August or early September with symptoms continuing to progress until harvest. Worst in wet weather. As the disease is soil borne ensure at least a 3 year break between successive crops of Alliums.

Control:

- Good rotations
- Removal of infected plants will reduce inoculum
- Metalaxyl or dimethomorph fungicides will aid control

Beet Diseases

Crops: beetroot, perpetual spinach (leaf beet), Swiss chard, spinach

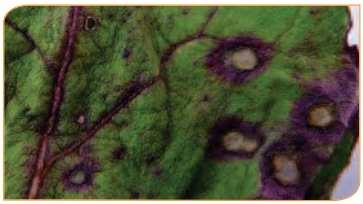
Ramularia leaf spot *(Ramularia beticola)*
This is a common leaf spotting disease of sugar beet, fodder beet and beetroot, but can also attack perpetual spinach and Swiss chard. The symptoms are pale brown round or irregularly shaped spots. Although the disease can be present in the seedling stage it seldom becomes serious until later in the season as crops

approach maturity. Outbreaks are worst in cool wet seasons. The fungus can persist in the soil for more than two years. Sources of infection include buried roots, overwintered crops and soil. The pathogen may also be seed borne.

Control:

- Bury crop residues
- Use a broad spectrum fungicide such as Score or Dithane

Cercospora leaf spot *(Cercospora beticola)*



This leaf spotting disease of the beet family traditionally was less common than that caused by Ramularia as it requires warmer temperatures to thrive. But it seems to be on the increase. The spots which are small usually retain their circular shape and are surrounded by a reddish purple margin – a feature than helps to distinguish it from Ramularia leaf spot. Spores are wind and rain dispersed but dry periods, of up to 6 hours during the day, enhance infection compared with continuous wetness. Sclerotia are formed in the infected leaves and the disease can survive for up to two years in soil. Initial infection sources encompass infected seed, weed hosts (fat hen, orache) and infected crop residues.

Control:

- Use disease free seed
- Bury infected crop residues
- Use fungicides like Score or Dithane

Brassicas Diseases

Crops: Brussels sprouts, cabbage, broccoli, cauliflower, kale, swede, turnip, radish, kohlrabi, rocket, mustard, cress, Chinese cabbage, pak choi, mizuna, horseradish

Fungal diseases

Black leg / Canker (*Phoma lingam*)

This is the same organism that causes dry rot in swedes and turnips but inflicts

somewhat different symptoms on other brassicas. It typically causes a canker or constriction at the base of a brassica plant causing the stem to blacken and the roots to decay. This will cause a stunting and yellowing of the plants which may keel over at the end stage. The disease tends to occur randomly in the field. If it attacks young plants the stem can be constricted to such an extent that it breaks in two. The sources of infection are the same as those detailed under Dry Rot.

Control:

- Clean seed or use dressed seed
- Good rotations
- Keep the crop away from oilseed rape

Club root (*Plasmodiophora brassicae*)

One of the first things that will alert you to club root is the foliage of a brassica plant going limp on a warm day; and if you pull up the plant you will see the characteristic misshapen roots that confirm the suspicion. It's one of the worst diseases to attack brassicas as once it gets into the ground it's there for 20 years or more and there's no cure for the disease. Virtually all the brassicas succumb to the disease but kale is fairly resistant to it. Some of the brassica weeds such as charlock can also carry it.

Club root resting spores are stimulated to germinate once a brassica crop is established and gain entry to their hosts via the root hairs. Once inside the plant the pathogen cause the formation of tumours or galls on the roots, which cause initial wilting symptoms followed by death of the plant. The initial infection can come from any of a number of sources. Infected soil can be spread by farm machinery or footware or it may come from transplants either bare root or modular. The pathogen can be transported in drainage water; all water sources (bore, mains, streams, rivers) can become infected and clubroot is easily spread by irrigating from these sources. It can also be spread in manure from farm animals fed with infected plant material. Lack of proper rotations and growing brassicas too frequently in the same ground is one of the chief causes of clubroot. It's a common disease in the more intensive brassica growing areas of the country and the worst outbreaks occur during warm, wet summers. The

optimum temperature is 18-26°C which may help to explain why spring harvested brassicas sometimes escape.

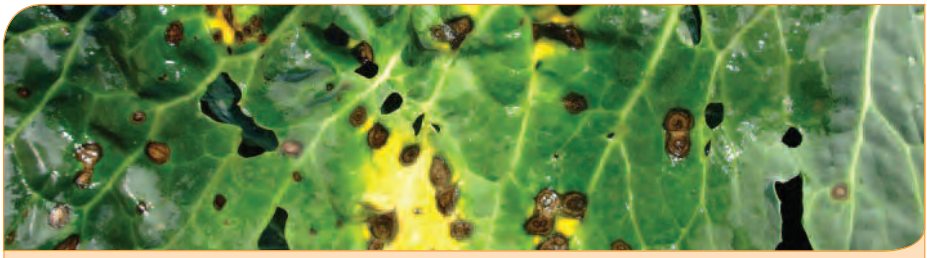
When club root first makes its appearance on a farm, the infected plants should be immediately removed and destroyed. The field or plot that it's found in should then be grassed down to prevent further spread around the farm. But that's a bit of advice that is seldom followed. But you should be aware that if the infected roots are allowed to develop and subsequently rot, millions of resting spores will be released into the soil.

It's a disease that's intimately associated with pH – worst at low pH's and absent from very high pH's. Despite growing brassicas intensively for many decades at Kinsealy there is no club root because the soil is naturally high in lime (pH 7.6-8.0). It's a similar situation in the sandy fields around Rush Co Dublin where's there's no clubroot despite brassicas been grown in the area for generations. The soil is derived from windblown sea sand which has a naturally high pH. If you do have club root, maintain long rotations of 6-7 years between brassicas to keep the inoculum at low levels and if possible stay away from infected field altogether with susceptible crops. The other alternative is to lime the ground to a pH of about 7.4 or above – high pH's don't kill the organism but prevent it from germinating. However there have been cases in the UK where club root can still occur despite liming the ground. In cases where a brassica crop is to be planted in a field with low levels of club root then the preventative use of Perlka (calcium cyanamide) can help. Use 400-500 kg/ha rotavated in one week prior to planting, followed by another 400-500 kg/ha 2-3 weeks post planting preferably earthed up. Must apply to dry crop foliage otherwise scorch will occur. Contains about 20% N so take that into account when calculating nitrogen application. Perlka is not suitable for swedes.

Control:

- Tight rotation is a major cause of club root so practice long rotations
- Lime ground to pH 7.4 or greater
- Remove and destroy infected material before the clubs break down
- Infected material should not be fed to stock
- Use resistant cultivars – increasingly available
- Use of Perlka may help as a preventative but is expensive

Dark leaf spot (*Alternaria brassicae, A. brassicicola*)
This leaf spotting disease can attack all brassicas and also causes a head rot on cauliflowers and broccoli. The disease looks like ring spot and could be confused with it but it's not as common. The initial spots are small 1-2 mm black spots that later enlarge to circular, tan to brown spots 5-25 mm in diameter. The black spores are visible using a binocular microscope. Symptoms are more commonly seen on the older leaves. Can also cause problems with storage cabbage as the fungus will continue to develop under low temperatures. Alternaria can be seed borne but the initial infection is more likely to be wind borne from a neighbouring crop of infected oilseed rape (especially when being harvested) or other brassica. Infection may also arise from infected brassica weeds.



Alternaria. Both Alternaria and ring spot look rather similar. Alternaria spots tend to be more circular.

Control:

- Practice good rotation
- Stay away from oilseed rape
- Destroy diseased crop residues after harvest
- Use seed dressings

Downy mildew (*Peronospora parasitica*)
Downy mildew is common on all brassicas except Chinese cabbage and white turnips. The fungus is most damaging when it causes early infection of seedling cotyledons – particularly broccoli and cauliflower – with a substantial proportion of plants being killed outright. It will also affect larger plants of a variety of brassicas and occasionally will occur systemically within a plant, notably in broccoli and cauliflower flowering stems. It can also be important on radish as it causes black lesions on the fleshy root and may also develop internally.

Symptoms: upper surfaces of affected cotyledons and leaves show yellowing, usually confined to areas between veins. On the underside of leaves, superficial greyish-white granular fungal growth develops, that looks for all the world like big trees under a x10 magnification. It can survive in the soil and on crop residues as oospores.

Cool (10-15°C) moist conditions favour the development of this disease and under glass or polythene can rapidly spread through seedling brassicas. Outdoors, similar conditions favour it and typically will develop on broccoli crops in the autumn. Will also affect cabbage and cauliflower but less so on sprouts. It commonly infects swedes and can be troublesome especially in the early growth stages (3-6 leaf stage) but generally the crop grows out of it.

Control:

- In protected structures ensure good ventilation
- Irrigate brassica seedlings early in the day to allow them to dry before nightfall
- Use of phosphite foliar feeds on brassica seedlings may bolster plant defences but must be used before any signs of the disease appear
- Practice good hygiene within the greenhouse
- Use of metalaxyl or propamocarb based fungicides

Dry rot (*Phoma lingam*)
Dry rot is a disease that attacks the bulb of swedes and turnips, commonly seen in patches throughout the crop especially during the autumn and winter.

The worst cases are where swedes follow a crop of swedes that were affected with dry rot in the previous year. Phoma lingam also causes black leg (or stem canker) in other brassicas and oilseed rape.

The fungus can be seed borne but a far more common source of infection is from airborne ascospores. These are produced from infected plant debris remaining on the

Lesions can appear on the top or side of the bulb.

soil. These plant remains could be from any canker-infected brassica but oilseed rape is an important source of inoculum. In the latter case airborne spores which are produced on the stubbles, are discharged in large numbers from September to April during periods of wet weather. They can be carried long distances by wind – over 1000 m – to infect neighbouring swede crops. Infected debris can survive for several years but disease risk diminishes with time. And hence the need for good rotations with other brassica crops to minimise risk of carry-over.

The disease manifests itself on the bulb as pale elongated greenish lesions commonly found on the crown of the plant, which gradually extend, deepen, and turn brown to become a transverse crack. Minute dark structures (pycnidia) that contain spores are produced at the edges of the sunken area. Eventually a dry brown rot develops, and in cases of secondary bacterial infection, turns into a wet rot. Although dry rot can be initiated from leaf inoculum, it can also arise from direct airborne infection.

Once infection takes place it will spread during wet weather when spores ooze out of the pycnidia and are dispersed by rain splash and wind. It follows that wet summers followed by mild wet autumns will favour the spread of this disease. Dew or wetness that persists for long periods can also allow the fungus to multiply. Small fields enclosed by hedges will help such conditions to develop.

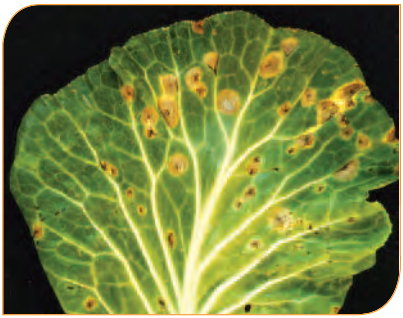
Control:

- Maintain long rotations between crops
- Site the crop away from oilseed rape
- Swede varieties vary in their susceptibility; Magres is susceptible with Helenor being less so
- For at-risk crops apply fungicides during August to October

Ring spot *(Mycosphaerella brassicicola)*

This is one the commonest diseases in brassicas, important on winter cauliflower, cabbage, kale and sprouts with swedes much less susceptible except in the wetter parts of the country. It's worst in wet seasons and is associated with intensive brassicas production areas. It starts off as small dark spots 3-5 mm in diameter which eventually enlarge to 2-3 cm. Leaf spots are restricted

by veins so can appear angular in shape – this is a distinguishing feature in comparison to Alternaria leaf spot. Later on tiny black fruiting bodies appear in concentric rings. Badly affected leaves turn yellow and wither prematurely. The chief sources of infection are spores that blow in from a nearby crop or from plant debris on the soil.



Control:

- Maintain long rotations between crops
- Site the crop away from oilseed rape
- For at-risk crops apply fungicides from August to October

White blister *(Albugo candida)*

The characteristic chalky white pustules on the leaves of brassicas make this disease an easy one to identify. The disease attacks most brassicas bar swedes. It's a common disease in the more intensive brassicas growing areas of the country typically showing up in early autumn; and an awkward disease if it appears in the vegetable garden. Awkward because it will tend to persist in the soil from resting bodies known as oospores and also as there are no chemical controls available on the amateur market. It doesn't tend to reduce yield but does disfigure the plant. Its worst effects are on sprouts where a bad attack on the buttons will render a crop unmarketable. The initial infection can arise from the oospores and subsequent infection within the crop from airborne spores that arise from the pustules. Whilst the spores need water to develop this disease can be prevalent in dry weather as the spores only require a short period of leaf wetness to germinate. The ideal temperature for infection in 20°C. White blister can also attack shepherd's purse but that strain of the disease will not attack vegetable brassicas.

White blister.

Control:

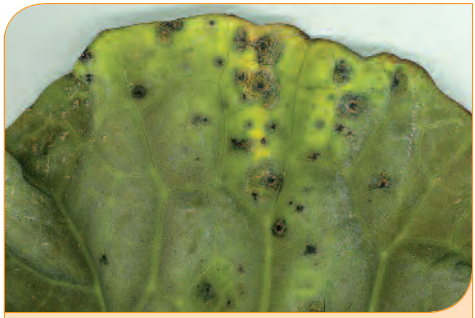
- Good rotations
- On small areas remove affected leaves before the pustules break
- Use a metalaxyl based fungicide.

White mould *(Sclerotinia sclerotiorum, S. minor)*
With the exception of oilseed rape Sclerotinia is only a very minor disease of brassicas. It can however show up in crops like cabbage on very intensively worked ground with too tight rotations. And usually only a small percentage of the plants are affected.

White spot (*Pseudocercosporella capsellae*)
This is a minor foliar leaf spotting disease of swedes, turnips, Chinese cabbage and oilseed rape. Years ago it used to be a serious disease of turnips and swedes along the western seaboard in high rainfall areas. The disease starts off as small circular spots (2-5 mm in diameter), grey-green in colour that later turns light tan to white and the spots enlarge to over a centimetre. It's encouraged by wet weather and the wind borne spores are splash spread by rain. White spot doesn't persist in the soil and survives on wild and volunteer brassicas.

Bacterial diseases

Bacterial leaf spot (*Pseudomonas syringae pv. maculicola*)
A leaf spotting disease that has started to show up in recent years is bacterial leaf spot. This may be due the advent of warmer, wetter summers experienced in past decade. It shows up on cabbage but has been reported in other countries on cauliflower, Brussels sprouts, radish and turnip. The symptoms are small black lesions on the leaf that could be mistaken for the early stage of



Bacterial leaf spot.

Alternaria or ring spot. The cause is bacteria that get water splashed onto the leaf from infected debris. It may also cause problems at the propagation stage where the symptoms can resemble downy mildew. This pathogen is associated with spells of very wet weather.

Black rot (*Xanthomonas campestris pv. campestris*)
This is a bacterial disease that causes serious losses in brassicas worldwide especially in countries with warm, humid climates. In Ireland it mainly attacks cabbage and cauliflower. Symptoms are V-shaped yellow coloured areas at the leaf margins which later turns brown and dry up. Black veins can sometimes be seen within these brown areas and this is a useful diagnostic feature.

Initial infection mainly arises from infected debris or seed. The bacteria transfer to the cotyledons as they emerge from the infected seed coat. They spread in water splash between closely spaced seedlings and invade young leaves via hydathodes and then spread throughout the plant in the vascular tissue. Hydathodes are glands at the edge of the leaf that secrete water. This initial infection may not exhibit visible symptoms until the crop is planted out in the field. Infection may also arise from infected plant debris or from infected cruciferous crops and weeds. Once symptoms develop in the field the disease can rapidly spread through rain splash particularly during spells of warm humid weather. A bad outbreak of black rot can render a crop unsalable. There is a strong varietal component in the expression of Xanthomonas e.g. in cabbage Tundra is particularly susceptible.

Control:

- Plough in crop remains straight after harvest and leave at least two years before the next brassica crop
- Use a reliable source of seed
- There are no useful chemical control measures but the use of Amistar or Signum may help to limit the spread of the disease

Carrot family Diseases

Crops: carrot, parsnip, celery, celeriac, parsley, coriander, fennel

Alternaria *(Alternaria dauci)*
Common foliar disease of carrots that is always worse in wet weather. Early symptoms are greenish-brown water soaked angular spots that later become dark brown to black that may develop a greenish fringe. Widespread infection in a field shows up with foliage that looks scorched and blighted in appearance. The disease is seed borne and whilst it can't survive in the soil it can on crop debris.

Control:
- Use disease free seed
- Use fungicides preventatively
- Do not follow an infected crop with a second crop of carrots

Violet root rot *(Helicobasidium brebissonii)*
This pathogen can infect a wide range of hosts including carrot, parsnip, parsley, sugar beet, potato and lettuce but is most commonly found on carrots. The disease may first be seen in late summer or early autumn occurring in patches within the field. The lesions are small at first consisting of hyphae and spores giving a purplish-black colouration. These lesions continue to develop through the autumn eventually covering the root. The infected area will remain firm but take on a leathery appearance.

The sclerotia formed either on the roots or in a hyphal mass in the soil are left in the soil at harvest. These may remain viable for several years; it has been known to reappear after a 10 to 20 year absence of root crops. The fungus can also survive on weed hosts. Infection in carrots can occur anywhere on the root surface, with older roots being more susceptible. The spread of the disease is slow during the spring and early summer but speeds up later in the season. Soil conditions can have an effect on the severity of disease with the heaviest infection occurring on poorly drained, acidic soils.

Control:

- Long rotations
- Increase the pH to around 7
- Remove infected crop material

Celery leaf spot *(Septoria apiicola)*

Celery leaf spot.

This is the most important disease of celery which can also attack celeriac. Weather conditions that favour potato blight also favour the spread of this disease and the worst outbreaks occur during wet seasons. The symptoms are a dark brown spotting of the leaves and stem; small black pycnidia develop in the blighted areas and under humid conditions spores ooze out that can be rain splashed onto neighbouring plants. The other common name for this disease is late blight and as the name implies the first symptoms are not usually seen until the crop is well developed and approaching maturity. The pathogen is very often seedborne but the initial infection can also come from infected debris so don't follow one crop with another.

Control:

- Rotation
- Separate early and late crops
- Use treated seed
- Apply fungicides preventatively

Parsley leaf spot *(Septoria petroselini)*

It is a reasonably common foliage disease of both flat and curly parsley. The disease appears as small, tan leaf spots with black dots across the surface indicating the presence of black spores. The leaf spots are surrounded with a pronounced dark red-brown margin. As the disease progresses the foliar tissue turns yellow and leaves eventually die. The disease can be seed borne and spores may survive and remain infectious on dead or dried leaf material. Wet leaf surfaces are required for spores to emerge. Rain, dew, overhead irrigation, workers and equipment in fields of wet foliage can transmit the spores to healthy plants. Mild temperatures

and high humidity are conducive to disease. Optimum temperatures for infection are 20-25°C with high humidity (e.g. period of leaf wetness with morning dew). Disease symptoms appear 14-21 days after infection.

Control:

- Buy good quality seed
- Flat-leaf parsley varieties are generally more susceptible to the disease than curly-leaf types
- Spray with Signum

Parsnip canker

Parsnip canker is a common cause of crop wastage in both early and main season crops. In Ireland all the main varieties can be infected especially White Spear and Javelin. Canker development is linked to the presence of specific pathogens and our understanding of these is improving. There are several different types of canker lesions referred to as black, brown or orange-brown canker. The different crown cankers are often difficult to distinguish and are frequently referred to as black cankers or black spot. The fungi responsible include the following:

Black/Brown canker

Itersonilia pastinacea – affected tissue is dark brown or black, often with a purple tinge. Lesions may remain fairly shallow, but are frequently invaded by secondary soft rot. The disease is associated with high rainfall together with seed or foliage infection followed by transmission to the roots. This pathogen has been regularly identified at Kinsealy from roots with suspect canker lesions.

Mycocentrospora acerina – shows very similar characteristics to Itersonilia although the lesions are tinged with purple and often surrounded by a water soaked or red band. They can also be flaky in appearance. This fungus does not always require root damage to establish an infection, but commonly infects lesions such as from common scab.

Phoma comlanata – this is the major cause of large cankers, careful examination will often reveal a scattering of small black-brown fruiting bodies on the lesion surface. Attacks are favoured by any form of root damage such as skin splitting, common scab or pest attack.

Orange canker often referred to as 'cavity spot'
Fusarium species – Several species of Fusarium have been isolated from canker lesions. It is not known which are the most important.

Pythium species – Lesions appear on the shanks of the roots, starting as an orange / brownish shadow. As the damage develops the skin cracks and splits along the length of the lesion. This problem occurs spasmodically, often in low lying areas or those with imperfect drainage with adjacent fields being unaffected.

Sources of infection: Infected seed can allow the transmission of diseases such as Itersonilia. Field infection can also occur from airborne spores arising from old crop debris and soil. Leaf spotting can develop on the leaves which in turn can infect the roots. Cankers are often associated with extended periods of rainfall.

Control:
- Practice good rotations
- Use clean seed and seed dressings
- Use varieties that are less prone to the disease
- Control leaf spot by fungicides
- Do not have crops over mature for over wintering

Pythium root rot *(Pythium spp.)*
Celery seedlings are particularly prone to pythium root rots either early-on as damping off or later-on affecting the roots of young transplants. Poor emergence and collapse of seedlings may be the first signs of damping off in celery. Commercial plant raisers will always use a fungicide straight after sowing to prevent it. Celery transplants that are held too long before planting can often develop brown roots which can be symptomatic of pythium attack. If celery is grown too intensively in an area, transplants can be attacked from soil borne innoculum. The plants become stunted, leaves turn yellow, develop brown roots with an overall lack of thrive.

Control:
- Use sterilised module trays and clean compost
- Drench trays with Proplant fungicide
- Use good rotations for outdoor crops

White mould/Pink rot *(Sclerotinia sclerotiorum)*
This disease is occasionally seen attacking carrot and parsley when it's called white mould or celery when it's called pink mould. With carrot its most important as a storage disease and sometimes will not be apparent until sclerotia develop on the roots post-harvest – typically under warm humid conditions. The disease on parsley is most commonly seen on protected crops when the stems closest to the ground show symptoms of white cottony growth with subsequent death of the stem. In celery the disease is called pink rot. Seedlings in modules can be infected from ascospores and in field planted celery Sclerotinia infects the base of the plant causing a soft, brown lesion which has a pink coloured border.

Legume Diseases

Crops: beans, peas

Ascochyta blight *(Mycosphaerella pinodes)*
This disease causes lesions on leaves, stems an pods. Lesions initially appear as small, irregularly shaped flecks that are dark brown in colour. If conditions favour the disease the lesions can coalesce and cause significant blighting of the leaves and pods, particularly when the crop begins to senesce. Although the original source of the pathogen may be from seed it can overwinter on crop debris and in the soil.

Control:
- Use disease free seed
- Good crop rotation

Chocolate spot (Botrytis fabae, B. cinerea)
This common disease of broad beans is primarily caused by B. fabae with B. cinerea also implicated with some of the attacks. The disease first manifests itself as a brown spotting of the leaves and in a wet year the spots coalesce blackening the leaves which can lead to total destruction of the foliage. The pods are also attacked. Although infection can be seed borne initial infections mostly arise from airborne spores. These can arise from infected volunteer plants or from debris. B. cinerea is a common pathogen that attacks a wide range of plants.

The optimum temperature is from 15-20°C but Botrytis will happily operate down to 4°C. Although free water is not required for spore germination it does require high humidity (85-100% RH) to develop. And after initial infection subsequent spread can be rapid.

Control:

- Increase plant spacing or crop location to improve air flow
- Ensure adequate supplies of potash
- Early crops will often have yielded before the worst of the disease takes hold

Rust *(Uromyces vicia-fabae)*
Occasionally attacks broad beans. It starts off on the bottom leaves as small chlorotic leaf spots that later develops into typical brown rusty pustules. Tends to get worse as the crop matures.

White mould *(Sclerotinia sclerotiorum, S. minor)*
Can attack a range of legume crops including peas, plus French, Runner and broad beans. The initial symptoms are small water soaked areas usually at the base of the stem that later develops into brown lesions and white cottony growths developing over time.

Lettuce family Diseases

Lettuce Fusarium wilt *(Fusarium oxysporum f. sp. lactucae)*
This deadly disease was first noticed in a glasshouse lettuce crop in Rush Co Dublin in 2016. There are many strains of Fusarium that inhabit the soil, most are harmless, but some cause wilt disease in a range of plants including lettuce. However it's important to remember that they are strain specific – lettuce wilt will only attack lettuce. The initial symptoms are a yellowing of the bottom leaves. As it develops the basal leaves turn brown and the plant wilts particularly in bright weather. The surest way to identify the disease is to cut down through the stem and check for any slight discolouration in the xylem tissue that later develops into a red-brown colour. The disease is soil borne and does not spread by windblown spores. This means that it is spread by soil contamination of fresh

ground and once the ground is affected it is difficult to get rid of it. The growth of the fungus is greatly favoured by warm temperatures with the optimum soil temperature being 24-28°C but can be active down to 10°. This implies that it is a disease more of glasshouse crops than outdoor and will be worst in protected summer crops. This is a difficult and persistent disease so try to avoid getting it if at all possible.

Control:

- There are no fungicides available. Disease inoculum can be reduced but not eliminated by soil sterilisation
- If disease is found bag the infected plants and surrounding soil and remove from the nursery
- Cease growing lettuce in the affected house/tunnel and avoid moving contaminated soil to unaffected areas
- Long rotations will help to reduce disease loading in the soil but not to the extent of eliminating it
- The solution to this disease will be in the development of resistant varieties some of which are commercially available

Lettuce downy mildew *(Bremia lactucae)*

This is the most important foliar disease of lettuce. It is first noticed on the lower leaves as pale, angular areas bounded by the leaf veins. Masses of white spores form on the lower leaf surface. Cool, humid conditions are required for Bremia to sporulate and infect lettuce. There are several different strains of lettuce downy mildew which are known as races, and plant breeders are always trying to keep one step ahead of the disease by building in resistance to their varieties. So you will read in the catalogues that a certain variety is resistant to races 16-33 or whatever.

Control:

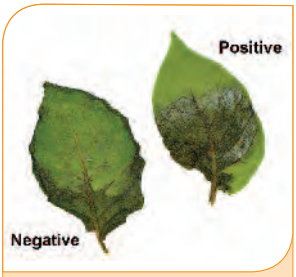
- Remove infected plant debris and maintain as long a rotation as possible
- Manage watering and ventilation so as to minimise humidity in protected structures
- Choose resistant varieties

Potato family Diseases

Crops: potato, tomato, pepper, aubergine

Target spot /early potato blight (Alternaria solani)
This leaf spot disease of potatoes was first reported in Missouri in 1885. It's an occasional leaf spotting disease occurring more frequently on senescing leaves. Despite it's name it more often occurs late in the season. Dark brown spots concentrically zoned appear on the leaves often bounded by a leaf vein to give an angular appearance. The fungus persists on debris in the soil. May also tomatoes under glass.

Potato blight *(Phytophthora infestans)*
This is the most important disease affecting potatoes that arrives every year, with the severity of the outbreak depending on the weather. The initial source of the infection is invariably from infected tubers that have overwintered as volunteers left in the soil, or discarded in a heap. These sprout in the spring and develop blight, acting as a source of infection for new crops. Home-saved tubers from an infected crop may also develop the disease when planted. The airborne spores can travel long distances. Early infections often appear just on the stem – this is known as stem blight. Later in the season the leaves get attacked and if the disease is not controlled at this stage spores will get washed into the soil and infect the tubers.



Potato blight test.

Blight is encouraged by warm, muggy weather and rainfall. Optimum temperatures for the disease are 18-22°C with an optimum humidity of 95%. Blight normally makes an appearance during July and August but can occur much earlier especially in the early potato growing areas such as Cork and Wexford. The table below shows date of outbreak of blight on unsprayed Kerr's Pink potatoes from past Oak Park experience.

Area	Earliest Date	Average Date
North west	Early June	Mid July
West	Early June	Late July
West midlands	Early June	Late July
South east	Late May	Late July
East midlands	Late June	Early August
South	Late April	Mid June

The table below gives a ranking to a number of different varieties in relation to blight resistance in both foliage and tuber, where 1 equals lowest disease resistance and 9 equals highest disease resistance.

Table: BLIGHT RESISTANCE

Variety	Foliage	Tuber
Duke of York	2	2
Home Guard	2	2
Sharpe's Express	2	2
British Queen	3	3
King Edward	3	4
Kerr's Pink	4	4
Maris Peer	4	4
Setanta	5	3
Maris Piper	4	5
Coleen	3	6
Record	4	6
Sante	4	6
Rooster	4	6
Orla	4	8
Cara	7	7
Sarpo Mira	7	9
Carolus	9	9

Control:

Tuber blight.

- If you plant earlies or second earlies you have a good chance of harvesting before the blight season gets into full swing.
- Choose a variety with good blight resistance characteristics. To help you pick the right ones see the table above. Sarpo Mira, though not totally resistant to blight, is head and shoulders above the rest of them and with this variety you can get away with little or no blight spraying. Other varieties to consider are: Bionica, Toluca, Carolus and Athlete. If you choose varieties like Orla or Setanta with good tuber blight resistance you can get away with reduced number of sprays.
- Listen out for blight warnings on the radio and tv and spray with a fungicide at regular intervals from June-July onward.
- Learn to recognise blight symptoms on both the leaf and stem and remove diseased tissue as soon as it's spotted – this will reduce the chances of the disease spreading further within your crop. A simple trick if you want to be 100% sure that a lesion on a leaf is blight is to pop it in a plastic bag overnight with a few drops of water. Next morning you'll clearly see a white mycelium has developed on the underside of the leaf if the result is positive and no growth if it's negative.
- If blight gets a hold in your crop and the tubers are of sufficient size, cut down and remove the tops to prevent the spores being washed down by the rain to infect the tubers. Do not dig the crop for a minimum of two weeks to allow spores on the soil surface to die off.

Black leg (*Erwinia carotovora*)

This is a common bacterial disease of potatoes particularly on the variety British Queen and particularly in wet seasons. Black leg arises almost entirely from infected tubers and the symptoms may appear at any time of the growing season depending on when the pathogen becomes active. Very early invasion of the shoots may kill the young plant before it has had time to emerge, so that black leg is one possible cause of gappiness in potato crops. Usually however the disease is first noticed any time between emergence and the stage at which the plants begin to meet across the rows. The symptoms are a yellowing of the foliage with upcurled leaves and if you pull up an infected plant the base of the

stem is often black. What is happening is that the bacteria move through the vascular tissue and block water transport to the foliage. The bacteria can also infect the developing new tubers via the stolons and in wet conditions subsequently develops into a wet rot. If conditions are dry the rot is confined to the heel end of the tuber. The other way that a tuber can get infected is via the lenticels in wet soils and once inside the bacteria rapidly multiply and the tuber turns into mush; alternatively the infection remains latent, the tuber looks perfectly sound and may be selected at a later stage for planting. When the disease is initially spotted there will be usually both diseased and healthy stalks on the one plant but as the season progresses the whole plant will eventually succumb. However as a rule the disease does not become epidemic in the field as the disease does not spread easily from plant to plant. But the main problem area with this disease can occur later on in store. When the crop is harvested the bacteria from the rotted tubers can infect healthy tubers particularly if they are lifted in the wet and made worse if the tubers are damaged on lifting; other tubers may look ok on lifting but are partially infected. Both of these cases can go on to develop soft rots in store or cause wet spots in bags if they are bagged directly from the field.

Control:

- Don't save seed from a badly infected crop
- Using good quality certified seed will reduce the problem but not necessarily eliminate it
- Burn off affected crops as early as possible and leave for 3-4 weeks before lifting
- When lifting and storing minimise damage as a cut surface will allow an entry point for the organism
- Avoid lifting crops in the wet
- Sell off an infected crop as soon as you can
- Make sure to dry the crop well going into store as rapid drying will kill off the bacteria

Stem canker/ Black scurf *(Rhizoctonia solani)*

This disease has two common names which reflect two commonly seen symptoms: a canker on the stem and black particles on the skin that are easily removed with your finger nail. This is one of the diseases that can cause blanks in your crop – the other being black leg. The disease can come from two sources:

infected seed or from the soil where Rhizoctonia is commonly found. It is more prevalent on light soils, particularly during dry cold springs if unsprouted seed is present. The tips of the young sprouts are attacked underground becoming blackened causing side shoots to develop which may in turn be attacked and killed. This can lead to delayed emergence or in a severe attack to non-emergence. Where shoots do emerge they can have cankers on the below ground portion of the stem which interferes with water uptake which manifests as a rolling and wilting of the upper leaves. Later in the season a white mould can develop at the base of the stems. This is a disease that tends to build if potatoes are grown too frequently in the one area.

Control:

- Use clean tubers
- Plant sprouted seed and avoid deep planting
- Practice long rotations

Disorders

Disorders are things that go wrong with plants that are not caused by a pest or disease. They can be caused by a host of environmental factors e.g. weather extremes, faulty nutrition or poor cultural practices.

Forking in carrots and parsnips

It's not entirely known what causes forking in root crops but there are a number of theories. Something damages the tip of the radical early on and the developing root subsequently forks. However we're still not sure what that 'something' is that causes the damage. It could be eelworm but there are times when you get the problem despite a nematicide been used. Some growers associate crops drilled close to ley with the disorder and maybe there's a eelworm link here. It may be a disease like Rhizoctonia or Pythium attacking the tap root at an early stage that later causes the root to fork. We're not sure that there's any link between drought stress and forking but Linuron wash-down is a recognised cause as it will damage the root. There was a case where a grower who rolled some of his recently sown carrot fields to conserve moisture discovered forking in his crop subsequently – the crop must have just struck when rolled and the radical was damaged in the process. There is no link between

variety and forking. In work carried out at Oak Park on sugar beet a reduction in forking was noticed after subsoiling – the suggestion being that compaction along with associated perched water tables may contribute to forking. Gardening books often lay the blame for the disorder on use of farmyard manure but *if* this is the case then the answer is simple – don't use manure or compost prior to drilling root crops. Parsnips are more prone to fanging than carrots.

Strangles

Strangles in iceberg.

This is a condition with young plants where the stem is constricted at soil level and in a bad case the top breaks away from the root. High surface soil temperatures during hot weather especially on crusted mineral soils or on peat soils can cause it. Windy weather can exacerbate the situation. There were cases of iceberg lettuce developing strangles when transplanted out in windy weather and young carrots grown in peat developed it after several hot days. It has been observed on sugar beet, iceberg lettuce, carrots and swede.

Internal rust spot in potato

If you find discrete rusty brown flecks or spots randomly distributed throughout the tuber the likelihood is that it's internal rust spot. No one is quite sure what the cause is, but it's probably bound up with calcium deficiency and that in turn is bound up with dry periods during the growing season. Calcium is not very mobile within the plant and if a dry spell occurs, then uptake is interrupted and deficiency symptoms can result - internal rust spot. So it follows that this disorder is worst on light ground and in dry years. High levels of free living nematodes may also be implicated, in that they feed on potato roots thereby impairing uptake of calcium. Symptoms develop during the season and can continue to develop during storage. Varieties vary in their susceptibility: Maris Piper is moderately susceptible, Golden Wonder is very susceptible. Although calcium deficiency is strongly associated with the development of this disorder, most soils have a plentiful supply but the tubers are running short of this element during hot weather and dry spells. So to minimise the risk irrigate your crops during dry spells.

Internal rust spot in potato.

Blindness in broccoli

This is where the growing point of the plant doesn't develop which occasionally turns up in early broccoli. It is caused by a combination of poor light and cold temperatures during propagation with January and February sowings. It isn't normally noticed until after you have planted the crop and at that stage it's too late to do anything. To counter it ensure a minimum propagation temperature of 3-5°C. Varieties vary in their susceptibility to this condition.

Heat scorch on strawberry – can occur in protected crops that have been under-watered in hot sunny weather. Symptom is a marginal scorch on the leaf.

Oedema

Oedema on potatoes grown in a tunnel.

This water blistering disorder crops up from time to time with certain indoor and outdoor plants. Symptoms appear as bumps or as a raised crusty appearance usually on the underside of older leaves. It happens when plants take up more water than they can transpire, pressure builds within the plant and bursts out through the epidermis. This occurs under conditions of damp or wet soil with high humidity around the leaves. Often occurs when you get warm days followed by cool nights. Has been seen in potatoes and brassica vegetables like cabbage, cauliflower and broccoli.

Hormone Weedkiller in farmyard manure

Aminopyralid damage.

Hormone weed killers used in cereals can end up contaminating farmyard manure. This in turn can damage crops that the FYM has been used on. The most susceptible crops belong to the Solanaceae family, mainly potato and tomato. If you get distortion of the foliage following application of FYM suspect the latter as the cause of the damage. A grassland herbicide containing aminopyralid has also caused damage to vegetable crops, usually potatoes. It can occur in the following situations: with crops planted or sown after grass that was treated with aminopyralid the previous season; when using slurry or manure from stock that were fed with hay or silage from grassland treated with aminopyralid prior to cutting.

Bruising in potatoes

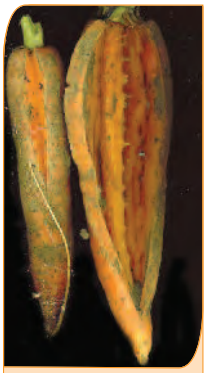
Bruising in Coleen potato.

Mechanical damage when lifting or handling potatoes can show up as bruising. It is characterised by greyish-blue and black patches in the flesh with no external symptoms. High dry matter varieties are more prone to this disorder. Lifting potatoes in dry soil conditions especially if stones are present may cause bruising. Lifting or grading potatoes in cold conditions exacerbates

the condition. Rough handling at any stage between farm and outlet can cause bruising. Growing potatoes in potash deficient soils can make a tuber more susceptible to damage.

Splitting in carrots

There are two expressions of this disorder. A crack down the side of a root and where the root is completely split open. The side cracking can be exacerbated when harvesting but the splitting wide open occurs in situ. Carrot tissue fracture is caused by cell wall breakage which in turn is determined by cell wall toughness. It usually happens when heavy rain follows a dry spell and a surge of growth occurs where roots take in a great deal of water and become turgid. Varieties vary in susceptibility.



Cracking in carrots.

Weather

Weather is one of the major drivers of growth in vegetables. The interplay of frost, rain, wind and sun all conspire to thwart or aid our ambitions to grow good crops. That ideal summer combination of sunshine and showers is one to hope for but seldom happens. The reality is that we get periods of wet or dry, cold or warmth which in turn gives periods of poor, middling or good growth. But in general over the course of a year the weather tends to even itself out. A worrying trend in recent years has been an increase in extremes of weather. This may be related to climate change but whatever the cause it does not make the task of growing vegetables any easier.

When it comes to planned sowing and planting dates the calendar may well have to be ditched if the weather turns too wet or too cold. Experienced growers will tell you that a crop that is 'mucked in' in unfavourable conditions will often be passed out by a crop planted later on in good conditions. So be patient, and delay that sowing or planting until soil conditions or soil temperature come right, even if it means waiting a week or two. You also need to adapt sowing or planting dates you might read in a book to the part of the country you live in – Antrim is a lot different weather-wise to Kerry.

Temperature is one of the main factors driving or limiting the growth of vegetables. Growth occurs at temperatures above 6°C and doubles for every 10°C increase in temperature within the range normally encountered. Which is why we use protection to increase growth rates e.g. we propagate seedlings and grow vegetables in a frame, polythene tunnel or glasshouse.

Hardiness

The vegetables we grow in Ireland originate from many different parts of the world and as such vary in hardiness. There are two categories of hardiness: hardy and half-hardy. Hardy vegetables are those that survive the normal Irish winter and can be harvested during the coldest months. Half-hardy vegetables are those that are damaged by frost and are grown and harvested during the warmer months. So when it comes to sowing or planting these types we need to be mindful of late spring frosts and complete the harvest before winter closes in. Some vegetables such as beetroot lie in-between the two categories as they will survive outdoors in a mild winter – let's call them 'almost hardy'.

During 2010 we experienced a return to frosty conditions that hadn't been experienced for many years. Air temperatures greater than -15°C were recorded at several meteorological stations. The temperature you see on tv weather maps is air temperature which is measured at a height of 1.25 m. But a more meaningful figure for vegetable crops is the grass minimum (Gmin) which is measured at ground level – also known as ground frost. The grass min can be anything up to 5-6°C [Image 7] [Image 7A] lower than air temperature. If you wish to check grass min temperatures you can find them on the Met Eireann website under Latest Weather Reports > Yesterday's Weather, Gmin. You will also find grass min temperatures under Climate > Daily Data. The photographs show frost damage to sprout buttons and damage to the core of storage cabbage.

At temperatures below 0°C frost occurs and ice forms within the plant. The damage that subsequently occurs will vary from none to total tissue destruction depending on the hardiness of the plant and the degree of frost. Other factors can also affect the outcome: older tissue is more prone to frost damage than younger tissue and a rapid rate of thaw can exacerbate the situation.

One sometimes sees the instruction on a seed packet or bag of seed potatoes to sow or plant out after the last frost. So how do you know when the date of the last frost will be? The short answer is, you don't. However past weather records and personal experience can help us in picking a date that hopefully will be correct. The table below shows the average and extreme dates of last spring and first autumn air frosts, 1971-2000.

Station	Last		First	
	Mean	Extreme	Mean	Extreme
Valentia Obv	26 March	29 Apr	25 Nov	16 Oct
Claremorris	28 Apr	20 May	25 Oct	8 Sep
Kilkenny	29 Apr	30 May	13 Oct	10 Sep
Clones	26 Apr	31 May	30 Oct	8 Sep

The last date of the last ground frost can be considerable later that the date of the last air frost and has the potential to damage half-hardy crops in the ground at that stage. The table below gives the average and extreme dates of last spring and first autumn ground frosts at the specified stations.

Station	Last		First	
	Mean	Extreme	Mean	Extreme
Valentia Obv	4 May	15 June	18 Oct	31 Aug
Claremorris	28 May	28 Jun	11 Sep	3 July
Kilkenny	17 June	30 Jun	7 Aug	1 Jul
Clones	9 May	29 Jun	24 Aug	3 Jul

The following table is an attempt to rank vegetables in order of hardiness. Take note that relative hardiness can depend on the growth stage. In the case of rhubarb the dormant stools seem to be totally frost resistant but the young

shoots produced in spring can be prone to damage. Swedes are pretty hardy in the mature stage but can bolt due to cold weather if sown too early. The experience of 2010 has shown that with the exception of parsnips virtually all vegetables will develop frost damage if temperatures go low enough. You are heading into the danger zone with Gmin temperatures of -10°C or greater.

Hardy	Almost hardy	Half-hardy
Parsnip	Winter cauliflower	French bean
Rhubarb	Perpetual spinach	Runner bean
Kale	Carrot	Courgette
Garlic	Storage cabbage	Marrow
Cabbage	Beetroot	Pumpkin
Leek	Scallion	Celery
Swede	Parsley	Potato
Brussels sprouts	Onion (overwintered)	Sweetcorn
Broad bean		Broccoli
		Lettuce

Bolting

A lot of vegetables are biennials; that is they grow vegetatively in the first year and flower and set seed in the second. Examples include most brassicas, celery, beetroot, onions, leeks, carrots and parsnips. Sometimes if they are planted or sown too early they can get a cold check and start to flower in year one – this is known as bolting.

Biennials require a period of cold to initiate flower buds – this takes place naturally during the winter and is a process known as vernalisation. However they are insensitive to cold in the seedling or young plant stage – this is the juvenile stage. The optimum temperature for vernalisation is usually within a degree or two of 4°C – at lower temperatures growth processes stop and at higher temperatures – above about 12°C – there is no stimulus to flower.

It's interesting to note that if a warm day follows a cold night it tends to cancel out the vernalising effect of the lower temperature but if cool days follow a succession of cold nights then a crop is set along the path to flowering. As a rough guide it only takes about 6 weeks of cold weather to initiate flowering – but the effect takes a while to show. A crop that bolts in early summer will have encountered a cold spell sometime during the previous spring.
So for a crop to bolt it has to have to be of a certain age and endure a period of cold. The cold conditions are a combination of temperature and time and can arise from a fairly low temperature for a long time or a low temperature for a shorter time – but it takes more than a few frosty nights to trigger the reaction.

The table below shows the differences with the swede variety Magres in sowing dates and whether the crop is covered or not. The covering material was perforated polythene which would have been removed in May. The trial was sown into modules under glass in January and planted out at the end of March and also direct drilled outdoors in March. You can see the effects of cold spring weather on both of the uncovered crops, and the elimination of bolting by covering.

Kinsealy Research Centre Trials, 1996

Treatment	t/ha	Bolting %	Harvest date
Jan sown, 308 cell + cover	40.0	0	28/6
Jan sown, 308 cell	22.3	83	3/7
Mar sown outdoors + cover	16.6	0	3/7
Mar sown outdoors	6.3	98	17/7

Variety can play a part and plant breeders do their best to develop bolt resistant cultivars. Beetroot is a crop that can run to seed if sown before April but if you choose a variety such as Bolthardy that's been selected for its cold tolerance, it can be sown in March. Breeders are also working hard to select out resistant strains of coriander which is also prone to bolting.

Daylength can also influence time of flowering. Annual vegetables such as radish, spinach and lettuce are triggered into flowering by the length of the day. Under normal circumstances a lettuce will only bolt after hearting. It is

responding to the long days of summer in doing this, and at the height of the summer there may be only a few days between the heart being formed and the formation of a flowering shoot. But if the crop suffers a stress – for example if the weather turns hot and dry and the crop is left unirrigated – then the lettuce may well go straight to the flowering stage without forming a head. The same holds true for radish and spinach.

Varieties

With hundreds of varieties available to the vegetable gardener it can be puzzling to decide which ones to choose. While some of the varieties that are available in the garden catalogues have been around for many years, plant breeders are continuously trying to produce new and improved varieties of all crops. Varieties can be divided into two types – hybrids (designated F1) and open pollinated or standard varieties. Hybrids are becoming increasingly common in amateur catalogues due to their widespread use in commercial growing. They offer a number of advantages over open pollinated varieties, chiefly increased vigour and uniformity, though the latter is not always advantageous to the gardener. The downside of hybrid seed is that it costs more than standard seed. The best advice is to try out different varieties and see which ones suit your conditions best. The RHS test out vegetable varieties and give the best of them an Award of Garden Merit commendation. You will find the complete list on their website.

Plant Spacing

Different vegetables require different amounts of room to grow. And hence we space them accordingly. But it can get confusing when no one seems to agree what the optimum spacing should be! One can look up five different books and get five different spacing for the same vegetable.

But why do we space our vegetables the way we do and what are the end results for the spacings we choose? There are two parameters by which we can define spacing: population and pattern. For example if we were to plant a single cabbage plant in a hectare of fertile ground the *population* would be one per ha. We would grow a fine big cabbage but the overall yield would be

pretty dismal. Say we were to plant two per hectare but put both plants into the one hole – we'd end up with two poor plants. So the *pattern* is how we space out our population. If we choose a different pattern and space them well apart, we'd end up with two very large heads.

And so as we keep increasing the population and keep them evenly spaced, the overall yield per hectare goes up in a step by step incremental fashion. As we pack yet more plants into our plot we notice at a certain stage that while the overall yield continues to increase, the individual size of the heads begins to decrease due to the competitive effects of ever closer spacing. We eventually reach a point where the yield is at a maximum with a certain plant population. This holds true for all crops.

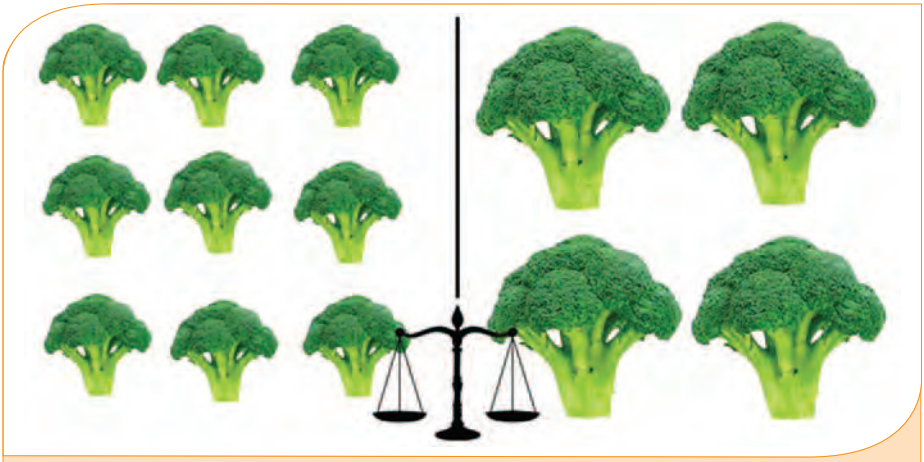
But what happens if we continue to put more plants into our plot? It all depends on the crop. With a crop like beetroot the yield will plummet quite rapidly as a beetroot requires a certain minimum framework of leaves to form a harvestable head. At very high populations all you will produce is leaves. However with a crop like carrots as the plant population is increased the overall yield is maintained but the size of the individual roots reduce. This can be useful as it allows us to control the size of carrot whilst maintaining maximum yield.

So as you can see spacing has a very direct effect on total yield and on the individual size of the vegetable. There is another effect – timing of harvest. If we are looking for earliness in a crop or indeed sowing late in the season, the spacing we choose will have an effect on those outcomes. The wider you space the earlier the crop and the better chance we have of harvesting a late crop.

As you will have gathered by now spacing is a very useful tool for the vegetable grower.

Getting back to pattern, you would think the best system would be to space your plants as evenly as possible but the standard advice is to grow most crops in rows, where everything can look unnecessarily crowded. To find the reason for this we have to go back to the agricultural revolution and Jethro Tull who invented the seed drill and mechanical hoe. For these inventions to work, crops necessarily had to be grown in rows. And so we use rows in the vegetable garden to make it easier to control the weeds.

Growing in rows does not necessarily have a detrimental effect on yield. Broccoli is remarkably unaffected by row spacing up to a distance of 60 cm. So spacings of 60x10 cm, 40x15 cm and 30x20 cm will all yield approximately the same – in this example the population per m^2 is the same but the pattern varies. With parsnips if the ratio of the between-row spacing to the within-row spacing does not exceed 2.5:1 yield is not reduced. For a population of 22 per m2 the maximum row spacing would be 34x13.6 cm but perhaps using a ratio of 2:1 is simpler which would work out at 30x15 cm - both spacings will give you approximately the same population. Lettuce and celery are examples of perfectly round crops that works best at even spacings length by breath, or better still in a diamond pattern.



Four or nine plants per square metre will yield the same overall weight but individual head size will vary.

When it comes to root crops simply allocating each plant an even amount of circular space is not enough to ensure an even sized crop. This is because those plants which emerge first remain ahead of the others and take up more space than they are entitled to. As a result, they are bigger than they should be and their neighbours are smaller. Hence it becomes important to get a rapid and even emergence of the seed to improve uniformity. Commercial growers are able to purchase primed seed, a pre-germination process carried out by the seed company, that helps with evenness of emergence.

If you are growing a number of different crops on a larger scale and have mechanisation it makes sense to choose just the one drill or row size for all the crops. You will see all sorts of spacings mentioned but it's much of a muchness – if the drills or rows are wider the plant spacings will be tighter within the drill or row, and visa-versa.

As mentioned don't get too hung up about the spacings mentioned in this book, or in any other for that matter. They are only suggestions and spacings will vary according to your growing system – beds, drills or on the flat – and even to the width of your hoe. They will also vary in accordance to what size you want your particular vegetable to be. For example closer spacing in the drill will reduce the individual head size of broccoli. Or you might choose slightly wider spacings for an early or late crop. If you see a reference to 30x15 cm in the book, this means a 30 cm row spacing and 15 cm in-row spacing.

Soil Moisture and Irrigation

If you put a sponge in a sink of water it becomes saturated – both small and large pores are full of water. If you then place the sponge on the drainer all the water flows out of the large pores under force of gravity. The water eventually stops flowing out but there's still plenty of water left in the sponge – in the smaller pores. Next, pick up the sponge and squeeze as hard as you can to remove the water from the smaller pores. To all intents and purposes there's no water left in the sponge. But wait. Touch the sponge against your face – it still feels damp.

The above analogy is a way of explaining the various states of water in soil. After a spell of prolonged rain all the pores fill up with water – we call this a

saturated soil. When the rain stops the soil begins to drain. After a day or two all the water has drained out of the larger pores – this is gravity at work. A soil with this amount of water left is at field capacity. If it remains dry two things then begin to happen – the water on the soil surface evaporates and the weeds or crop in the ground extract water from the soil and transpire it out through their leaves. As a consequence the soil begins to dry which in turn leads to a soil moisture deficit (SMD). SMD is the term used to measure how dry the soil is and is measured in mm. For example a SMD of 15 mm means that it will take 15 mm of rainfall to bring the soil back to field capacity. That's equivalent to applying 15 litres of water per square metre.

Growth of young plants is affected at about 30mm SMG but all plants will be affected as the SMD rises to 50 mm and higher. Under prolonged drought conditions all the available water gets used up and crops die – this is known as the permanent wilting point. At this juncture there is a very small amount of water left in the soil but plants are unable to extract as it's held too tightly. Crops dying of drought is rare in Ireland but in the summer of 2018 there were several cases of brassica modules failing to establish and died. You can find out the current soil moisture deficit on the Met Eireann website under *Forecasts > Agricultural Data Graphs*.

Plants take up water through their roots and it is lost from their leaves through small pores or stomata. The loss of water from the plant is a physical process and is determined by the amount of sunshine, temperature, relative humidity and amount of wind. However a plant is able to restrict its water loss when there is a shortage of soil moisture or when the rate of loss is extremely high. During hot summer days a vegetable crop that fully covers the ground and which has a plentiful supply of soil moisture will lose upwards of 5 litres of water per square metre of crop per day. Conversely, under cloudier, cooler conditions of spring and autumn the water loss may be as low as 0.5-1.5 litres per day.

Despite the general impression that it rains a lot in this country, in most years there are dry spells during the growing season which affect plant growth. In response growers will irrigate their crops to maintain continuity and to improve quality and yields.

The need for irrigation depends on soil type, crop, location and weather. Weather concerns the amount of rainfall received during the growing season versus evapotranspiration. Evapotranspiration is the combination of evaporation (loss of water from surfaces) and transpiration (loss of water from plants) – measured in mm. These figures can be got from the Met Eireann website under *Climate* > *Monthly Data*. The table below compares Valentia and Dublin Airport for monthly rainfall versus evapotranspiration.

Dublin Airport	May	June	July	August
Average rainfall – mm	59.5	66.7	56.2	73.3
Average evapotranspiration – mm	71.6	82.3	82.5	69.0
Valentia	**May**	**June**	**July**	**August**
Average rainfall – mm	93.5	95.3	99.0	114.9
Average evapotranspiration – mm	72.7	78.2	74.3	64.0

As you can see from the above figures we lose more moisture on average than we gain in Co Dublin for the months of May to July, while it's the opposite in Co Kerry. So you are far more likely to have to irrigate in Dublin than Kerry. But of course these are only average figures and the actual rainfall figures may be quite a bit different in any one year.

Soils play a vital part in water availability. Gardeners will be aware that a light sandy soil holds less water than a heavy clay soil, but less will appreciate the role of soil structure. A deeply dug, well-structured soil will allow for a bigger root system that is better able to tap the available water supply. And the best way to improve soil structure is by digging in compost or manure. Apart from building structure another advantage of organic matter is its ability to absorb moisture. A

1% increase in soil organic matter allows a soil to hold onto an extra 170,000 litres of water per hectare; that's equivalent to 17 mm of rain.

In the height of the summer a crop at full canopy can lose up to 2-3 litres of water per square metre per day. As a general rule it's best not to water a little and often as you will lose a high percentage of it through evaporation. And with the exception of seedlings and transplants it's not worth while giving any less than 10 litres per square metre at any one time and greater than 25 is excessive.

In an ideal world we would irrigate every time our crops need water but time constraints and hose pipe bans may well conspire to limit how much water we can apply. Fortunately research has shown us the critical times of a crop's life cycle when response to irrigation is greatest. All crops will be responsive at crop establishment – either at sowing or transplanting. If sowing in dry weather run a little water along the open drill before sowing. Other stages that have been identified are:

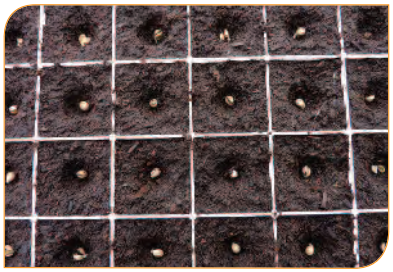
Cabbage, cauliflower, broccoli: 2-3 weeks before expected harvest.
Potato: when the tubers are marble sized (flowering stage).
Peas and beans: at flowering and during pod swelling.
Celery, lettuce, courgette: these crops (especially celery) require frequent watering – suggest weekly.
Carrot, parsnip, beetroot: apply 16-22 litres per m^2 every 2 weeks.
Onion: during the early plant growth stage up to bulb initiation (mid-May to early July). Onions are most responsive to irrigation from bulb initiation to egg stage (early August).

Crops vary in their requirements for water. For example in commercial practice celery is always irrigated while swedes are virtually never irrigated. Apart from celery other crops that are frequently irrigated are lettuce, potatoes, scallions, early cauliflowers, onions, courgettes and spinach. The most drought resistant vegetables are courgette, pumpkin and sweet corn.

1 inch of rainfall = irrigation equivalent of 250,000 L/ha = 25 L/m^2
1 mm of rainfall = 1 L/m^2

Propagation: Transplants or Direct Drilling

The vast majority of vegetables are raised from seed. The seed is either sown directly into the ground where it is to mature (known as direct drilling) or else it's raised as a transplant and planted out. The three main ways to produce a transplant are: bare root plants, blocks and modules. A module is a multi-celled plastic tray. Traditionally seed was sown in indoor or outdoor plant beds to produce a bare root transplant. But this method of plant raising has been largely superseded by modular raised plants particularly on commercial units. However leeks are still planted as bare roots as well as in modules and plant beds still offer an alternative to modules for the smaller grower and allotment holder. Peat blocks, made by a specialised block making machine, are now confined just to lettuce and celery propagation.



Root crops such as carrot, parsnip, swede and beetroot are direct drilled along with crops that are normally sown at high populations like scallions, radish, spinach, peas and beans. Planted crops include brassicas, lettuce, celery and courgettes. And crops such as leeks, onions and sweetcorn can be either direct drilled or planted.

The primary reason for transplanting is the more economical use of space and time. For the more widely spaced vegetables it makes more sense to propagate expensive seed under cover and plant out at exactly the plant population you require; it also allows for a quicker turn around of the ground and makes weed control that bit easier. The development of half hardy crops like courgettes and French beans can be speeded up if they are initially raised under protection and will give you greater yields by season's end in comparison to drilling.

Modular Plant.

The main disadvantage to transplanting is the check to growth that occurs mainly from damaged roots, and the grower or gardener is conscious of doing everything in his

or her power to ensure that transplants establish quickly and grow on with minimal check. The development of modular propagation has greatly reduced root damage and improved speed of establishment.

Crops like carrots and parsnips that have a tap root and are grown at high densities are of necessity direct drilled. Swedes are generally direct drilled but the early crop is sometimes transplanted but growers will tell you that the root shape is always poorer with the transplanted crop as against the drilled crop.

Seed to germinate requires oxygen, moisture and a certain minimum temperature. One can divide vegetables into 3 groups in relation to minimum soil temperature requirements for germination:

- 5°C: brassicas, lettuce, pea, broad bean
- 7°C: carrot, parsnip, beetroot, onion, scallion, leek
- 10-12°C: French bean, runner bean, courgette, sweetcorn, tomato

These are minimum temperatures – they will germinate more quickly at higher temperatures. For every vegetable there is an optimum soil temperature for germination, and at that temperature the maximum number of seeds will germinate and in less time than at any other temperature. A good guideline figure that suits the majority of vegetables is 20°C. But take note that there are upper temperature limits for certain crops. Butterhead lettuce will not germinate at temperatures above 25°C, leeks and onions will not germinate well above 21-24°C and celery germinates best between 10-19°C – much higher and it won't come through. Be careful of covering seed trays with glass or polythene – during hot sunny weather if the temperature of the compost goes above 35-40°C you will end up killing the seed. Consider using newspaper or a polystyrene sheet over the glass in these situations.

Hot box with soil warming cables to germinate seeds.

You can buy a soil thermometer to check the temperature of your soil if you're

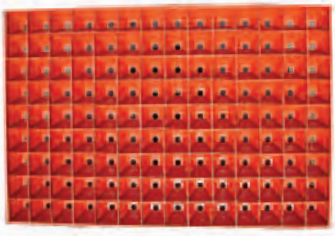
interested. It's probably best to measure the soil when it's at its lowest which is usually around nine or ten o'clock in the morning and the standard dept of measurement is 10 cm. Taking a series of daily temperatures and averaging them will give you a more reliable figure in comparison to what the temperature is on any one day. Alternatively you can log onto the Met Eireann website and click on *Latest Weather* > *Agricultural Data* and there you'll see averaged weekly soil temperatures for a range of locations – pick the one that is nearest to you. Say you want to grow a crop of French beans and wonder how early can you sow them? We know that the minimum temperature required is 10-12°C and if we study the average soil temperatures for Dublin Airport you can see that May is the month to pick – perhaps towards the middle of the month for this particular area.

Mean soil temperatures (10 cm) at Oak Park Carlow

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3.7	3.7	5.4	8.1	12.0	15.5	16.9	15.9	13.0	9.3	6.0	4.2

Seed is sown at a dept that relates to the diameter of the seed – see Table 2 in the Appendix for details. You normally cover seed to make sure that it stays moist for the requisite period of time after rainfall or irrigation but some seed like celery or certain varieties of lettuce require light to germinate and is normally sown on the surface of the compost.

SOWING UNDER PROTECTION – MODULES



126 Module Tray.

The use of modules originated in the United States in the mid 1960's, spread to Britain by the early 1980's and growers here first began to use them around the mid 1980's. They have transformed the commercial production of several crops particularly brassicas. The advantage of using modules over bare root transplants include:

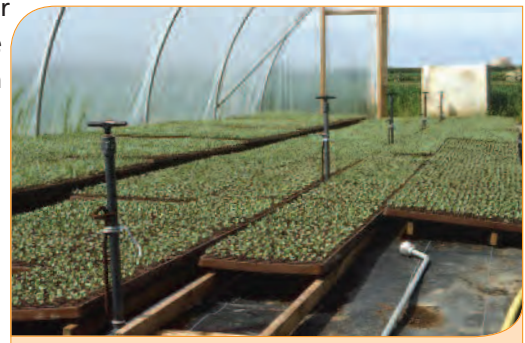
- ease of handling
- ability to control early growth
- mechanisation of plant propagation and planting

- faster transplanting
- better crop establishment especially in dry weather

Modular production is a complete plant propagation system that is now fully mechanised. It's a multi-step process:

- ➢ trays are filled with peat compost
- ➢ seed sown and covered with compost
- ➢ trays are stacked, covered with polythene and placed in a germination area
- ➢ after chitting trays are laid out under protection
- ➢ crop is grown on
- ➢ trays are taken outside to harden off.

A seed that has chitted is where the radicle (root) has just broken through the seed coat signifying the visible start of germination.



Modular propagation system using GPG 308 trays, on wooden rails sitting on Mypex, sprinkler irrigation system plus hand lance.

A key feature of modular propagation is the ability of the propagator to control the growth of the plant. This is done in two ways: air pruning of the roots and through targeted liquid feeding. Plants laid out in the growing house must be isolated from the ground by standing the trays on wooded laths, pots or similar. They must be high enough off the ground to allow air to circulate. This stops root growth at the base of the tray and so prevents rooting into the ground. The second element of growth control is the use of N and K liquid feeds to speed up or slow down growth.

The compost used is normally a peat based product specially formulated for seedling production. It is limed and fertilised with both major and minor

nutrients and has a structure that allows for good porosity with an optimum balance between air and water. There are a number of composts on the market for the professional grower: Bord na Mona Seedling Substrate Plus, Westland Professional Grower, Shamrock Seed and Modular, Bullrush Modular Substrate.

Module trays come in a variety of shapes and sizes. In commercial practice the standard size is 60 x 40 cm with the cells varying by number and volume. They are usually designated by the number of cells in a tray. By far the commonest trays in use are the 308 and 345.

Cell number	Cell volume (ml)	Cells per m^2	Crop
126	55	525	Beans, courgettes
216	30	900	Brassicas, early production
308	13	1283	Brassicas
336	19	1399	Brassicas
345	15	1437	Brassicas
600	10	2500	Leeks

The cost of raising a tray of plants is fixed regardless of the percentage of cells that contain a plant. So it is essential that only the best seed is used with high vigour and germination rates. With brassicas one would be expecting a minimum germination rate of 95% with commercial grade seed.

Filling and seeding of the trays can be done by hand or machine. If filling by hand trays should be spread out in a block formation on a level concrete floor with the compost levelled across them. Sowing by hand is feasible on a small scale but is a very monotonous job to carry out. A variety of machines have been developed to speed up the operation from simple plate seeders to highly automated vacuum versions. Seeders can be set up to single seed the cells e.g. brassicas or to multi-seed e.g. onions.

After sowing the trays can be laid out in the growing area and allowed to germinate. Alternatively they can be stacked, wrapped with polythene and placed in a germination room. This is an area where a constant temperature of

20-21°C can be held and would be useful early in the season to germinate crops. It's important to remove trays of all crops, except onions and leeks, to the light before emergence, or the seedlings will etiolate. Trays of onions or leeks can be left in the germination room after emergence for up to one week without harmful effects, as long as trays are not stacked on top of each other.

Leeks in a 336 module.

Watering is a key factor in successful plant raising. Over watering will cause leaching of nutrients especially nitrogen and potash. Under watering will cause plant flagging and stunting. Both extremes will result in unacceptable variation within trays. To get used to what quantities of water are required, check the underside of the tray after watering to guard against run-through of water and pull up the odd plant to check that the peat is uniformly wet. Accurate watering by hand is possible with experience but if a big area has to be covered then investment in an overhead system is desirable. This can be an overhead sprinkler system or gantry which is a spray boom that passes over the crop. Whatever system you employ evenness of watering is an important component in delivery of an even end product. The frequency of watering will depend on the weather and time of year and can vary from once a fortnight to twice a day. Water when the crop shows signs of drying out and water to cell capacity.

The compost will usually have enough phosphorus and trace elements to last the life of the crop but liquid feeding with nitrogen and potash will generally be required. Liquid feed is simply fertiliser dissolved in water and is normally applied when watering using a dilutor or on a smaller scale with a watering can. Potassium nitrate and urea were traditionally used to make up a stock solution which is a concentrated feed solution. This is applied at a dilution rate

of 1:100 or 1:200 e.g. 1 part stock solution to 99 parts water. As the purchase of potassium nitrate requires a licence it is more convenient for growers to obtain a proprietary feed that contains NK or NPK plus trace elements. For example Solufeed sell 1:1:1 or 1:0:2 feeds in addition to a lot of others. Incidentally, those numbers refer to the ratio of N:P:K and not the percentage nutrient e.g. 1:0:2 has 17% N, 0% P, 34%K.

Liquid Feed	Comments
High N 200 mg/L N 200 mg/L K	To produce fast growth or to re-activate plants held with low N
Normal 100 mg/L N 200 mg/L K	Stand feed given 2-3 times per week will give sturdy growth
Low N 50 mg/L N 150 mg/L K	Given every watering will produce slow, sturdy growth. Given once a week will hold plants

How to make up liquid feeds

There are two ways of preparing a liquid feed. You can make up the feed in a bulk tank to pump out through the irrigation system or to fill a watering can from it. The second way is to make up a stock solution, typically 100 times the concentration of the final feed which is then passed through a dilutor to achieve the desired concentration.

Example 1

Let's make up a feed containing 100 mg/l N and 200 mg/l K using potassium nitrate (13% N, 38% K) and urea (46% N); and we want to make 100 L of stock solution for dilution at 1:100.

To calculate the weight of fertiliser needed to provide a given concentration of a nutrient use the following formula.

$$\text{Kg of fertiliser} = \frac{\text{nutrient conc (mg/l) x dilution x vol of stock solution (L)}}{\text{\% nutrient in fertiliser x 10,000}}$$

We'll work out the 200 mg/L of potash first.

$$\text{Amount of potassium nitrate required} = \frac{200 \times 100 \times 100}{38 \times 10{,}000} = 5.26 \text{ kg}$$

The potassium nitrate also provides some N in the feed. To calculate the concentration of a nutrient in a feed supplied by a given amount of fertiliser, use the following formula.

$$\text{Nutrient conc (mg/l)} = \frac{\text{Wt of fertiliser (kg) x \% nutrient in fertiliser x 10,000}}{\text{Dilution x volume of stock solution L}}$$

We now input the 5.26 kg into the above formula.

$$\text{Concentration of N (kg/l)} = \frac{5.26 \times 13 \times 10{,}000}{100 \times 100} = 68 \text{ mg/l}$$

We need 100mg/l N, we already have 68 mg/l supplied by the potassium nitrate, so we require an additional 32 mg/l N from the urea.

$$\text{Amount of urea required} = \frac{32 \times 100 \times 100}{46 \times 10{,}000} = 0.69 \text{ kg}$$

Using these formulae, we can calculate stock solutions for any feed we want once we know the nutrient content of the fertilisers. The rates can be adjusted either by making an adjustment to the strength of the stock tank solution, or by adjusting the dosing pump so that it pumps at say,1:50 to deliver a higher concentration feed, or 1:200 to deliver a lower concentration feed.

Conversion factors

P_2O_5	→	P	x 0.44
K_2O	→	K	x 0.83
MgO	→	Mg	x 0.6
SO_3	→	S	x 0.4

Mg/L = parts per million (ppm)

Example 2

Say we purchase Phostrogen 14-10-27 and want to work out how many mg/l or parts per million (ppm) of N, P and K we are applying at the recommended dilution rate. The first thing we need to do is to change the UK notation for P and K from 10% P_2O_5 to elemental P and 27% K_2O to elemental K. Nitrogen is already in elemental form.

So 10 x 0.44 = 4.4 and 27 x 0.83 = 22.4. Hence the corrected formula is Phostrogen 14-4.4-22.4. The directions require you to add one scoop (10g) to 4.5 litres of water. Let's work out how many parts per million of potash is in the water, taking into account that the dilution rate is 1:1.

$$\text{Concentration of K (ppm)} = \frac{0.01 \times 22.4 \times 10{,}000}{1 \times 4.5} = 22.5 \text{ ml}$$

And it's a similar calculation for N and P.

To simplify the maths if you are using grams of fertiliser and a watering can and you want to find out the nutrient concentration, use the next equation.

$$\text{Nutrient conc (mg/l)} = \frac{\text{Wt of fertiliser (g)} \times \text{\% nutrient in fertiliser} \times 10}{\text{Amount of water used (L)}}$$

To work out the nitrogen ppm using the above formula.

$$\text{Concentration of N (ppm)} = \frac{10 \times 14 \times 10}{4.5} = 311 \text{ ppm N}$$

Example 3

We want to make up 9L of liquid feed containing 150 ppm N using a proprietary brand of liquid tomato feed that contains 6% total nitrogen.

$$\text{g of fertiliser} = \frac{\text{nutrient concentration (mg/L)} \times \text{amount of water (L)}}{\text{\% nutrient in fertiliser} \times 10}$$

Use the above formula to work out the number of mls required. A ml is one gram in weight.

$$\text{Amount of liquid fertiliser required} = \frac{150 \times 9}{6 \times 10} = 498 \text{ ppm K}$$

Example 4

Make up a high nitrogen feed containing 300 ppm N, using sulphate of ammonia (21% N) in 100 litres of water. Use the formula in example 3.

$$\text{Amount of sulphate of ammonia required} = \frac{300 \times 100}{21 \times 10} = 143\text{g}$$

Hardening off

You may get a check to growth if plants raised under protection are planted straight out into their final quarters. This is because there can be a big difference in climatic conditions between the glasshouse and outdoors. To overcome this we 'harden off' our young plants to acclimatise them prior to planting out. Commercial propagators will lay the trays out in a sheltered area beside the glasshouse for a number of days before they are sent to the grower. You could also place your plants in a frame and give increasing amounts of air to harden off. However as the season progresses there is less need for hardening off e.g. modular brassicas are put straight into the field from the tunnel or glasshouse.

The most usual way to ensure continuity of supply is to stagger your sowings or plantings. To make things a bit easier for the small producer with modular raised brassicas, make one big sowing and plant out what you require when the plants are fit. Put the remainder of the plants into a plastic bag and keep them in a fridge and plant out at weekly intervals. Plants may be kept in the fridge for up to 3 weeks.

SOWING OUTDOORS

If you don't have a greenhouse, tunnel or frames, you can raise your plants in a nursery bed outdoors. Outdoor seed beds can be used for raising brassicas, leeks and lettuce.

Prepare your soil well as it needs to be in a fine condition for sowing seeds. If lime is needed it should be applied during the previous winter. If a soil sample result is not available the following fertilisers should be forked in: 50g per m^2 of superphosphate, 30g per m^2 sulphate of potash and 15g per m^2 of sulphate of ammonia. Seed is usually sown in rows known as drills.

When sowing brassicas a seed bed plant population of 400 per m^2 is recommended. A spacing of 10x2.5 cm would achieve this. If a 10 cm drill width is too narrow, then suggest using 15x2.5 cm which will give a plant population of 266 per m^2. Do not go below an in-row spacing of 2.5 cm – this is equivalent to 40 plants per metre run. No thinning is required. Plant out when the plants have reached the 3-5 true leaf stage. Water before lifting if the soil is dry.

Kinking of stem (hockey stick) of a sprout plant raised outdoors. Kinking seems to be due to anything that makes the plant grow too quickly, too etiolated: heat, fertilizer, lack of light but can be varietal; some varieties seem to suffer regularly and others do not.

If slugs and snails are troublesome slug pellets should be used. Cover outdoor beds with netting to keep cats and dogs away.

It takes anywhere from 5 to 8 weeks from sowing to transplanting brassicas depending on the time of year. Under protection it typically takes 6 weeks to produce a transplant.

PLANTING

When transplants are large enough to handle they are ready to plant out e.g. brassicas and lettuce will be at the 3-4 leaf stage, leeks will be at pencil thickness. Quite a good indicator for container grown plants re timing in planting out, is root colour – white roots that hold onto the compost and you've got the timing right; if brown then you may be some days late. This is not a hard and fast rule, just an indicator. Commercial growers use planting machines to plant out modules and block plants but gardeners are not so lucky where a trowel, garden line and some backache is the order of the day. Water your plants before you plant out. Using a garden line lay out your plants at the

Bare root cauliflower in a plant propagation bed.

Basrijs 4 row leek planter planting bare roots.

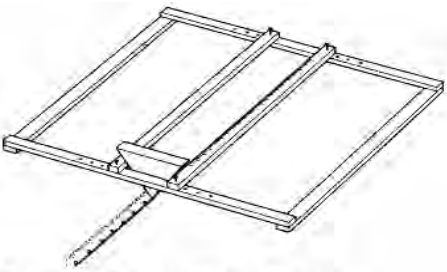
recommended spacing. A marked metre rule or similar is a useful gadget to have to get the spacings right. Regarding planting depth you usually plant at the same level as the plant is in the container, but there are exceptions. Brassicas do not mind their stems being covered so plant up to the first leaves to ensure they are well anchored. It's a similar story for tomatoes – plant them deep enough to support the plant covering a few inches of the stem above the original compost level. It's the opposite with lettuce. Plant the module or block slightly proud of the soil surface to reduce the chance of Botrytis or basal rots setting in. And with such an arrangement harvesting is facilitated as lettuce has a flat base. If celery is planted too deep you end with a V shaped base rather than a nice flat cut from level soil planting. We plant leeks deeply to encourage the base of the stem to whiten – giving you a milder flavour than the greener portion of the stem that's above ground. A leek has its growing point hidden away in the middle of the base of the plant, so doesn't mind being buried. When planting is complete apply slug pellets and netting if appropriate.

DIRECT DRILLED CROPS

Use of seep hose to germinate seed.

If sowing outdoors it is important that you prepare the ground well by forking and raking to produce a fine tilth. For direct drilled crops it's critical to sow your seeds at an even depth that leads to even emergence, as you want to end up with a uniformly sized crop. It's not easy to make a drill by hand that has an even depth all the way along its length. Seed that is deeply buried will emerge later in comparison to more shallowly sown seed – and this difference is maintained right through to harvest. To get over this you can make a wooden sowing frame to help you control the depth of sowing.

Once seed is sown the soil should be firmed in around the seed using the back of a rake to tamp down the rows. Seed requires water to germinate, supplied from either rainfall or irrigation. A problem that can arise with outdoor sowings, especially on poorly structured soils, is soil capping if the rainfall or irrigation following sowing is very heavy. This is where the very fine particles are washed into the spaces between the larger particles and the soil is said to have slumped. If it then dries out, a hard surface crust develops, which can physically prevent the germinating seed from emerging. One way around this problem is to water the bottom of the drill before sowing your seed. If the soil does cap keep the soil damp with frequent light applications of water to allow the crop to emerge. Always use a watering can with a fine rose when watering seed or seedlings.



Sowing frame to control dept of sowing

Even emergence means an even end product.

Vegetable Storage

Some vegetables won't store, go over quickly and have to be eaten fresh. Examples include butterhead lettuce, scallions and spinach. They can be kept in a fridge for a week or two but after that will need to be consumed. Onions and garlic on the other hand are natural storage organs with papery outer skins protecting the fleshy inner scales from physical damage and drying out. Another example is haricot beans where the beans are allowed to mature on the plant to dry off the individual seeds which can then be stored in jars.

A lot of our winter vegetables – mainly brassicas, leeks and root crops – are best stored where they are growing, in the ground. The weather is cold enough from November to March to restrict growth and development – think of it as natural refrigeration. However we need to be mindful of severe frosts causing damage. Winter brassicas are normally not protected but in colder parts of the country it may be worthwhile to earth up root crops with soil. Better still would be to cover them with a layer of straw, bracken or leaves.

Crops grown for winter consumption need to be planted or sown early enough to allow them reach the desirable size before growth ceases but late enough so as to prevent them getting too large and in the case of root crops too woody and tough. For example a good time to drill carrots for overwintering would be from mid-May to mid-June.

Building a clamp was the old way of storing root crops through the winter but is not much used nowadays. A clamp was where the crop was harvested in late autumn, put in a pile outdoors and covered by straw and clay. The idea was that the covering would keep the temperature of the roots from going too high or low and maintain them at a high humidity. If you do want to try one out pick the coolest part of the garden and make a long stack of roots about a metre wide and high, cover with 15 cm of straw and top that off with 15 cm of soil. Dig the soil from around the sides of the clamp so as to provide a degree of drainage. Keep an eye out for rats to prevent or minimise spoilage.

Potatoes are a root crop that needs to be lifted and stored by the end of October at the latest. They require to be stored in a cool, dark, frost-fee shed. If light gets at the tubers they develop poisonous alkaloids in the surface of the tuber as they turn green in colour. Paper sacks that the commercial crop is sold in, would be useful for storing the home saved crop as they allow it to breath and prevents light damage. Potatoes are susceptible to frost but the main problem for the gardener is keeping the temperature low enough; 4°C is an ideal storage temperature but hard to achieve. The higher the temperature the greater the risk of storage rots and sprouting. The tubers will eventually sprout if held for longer than their natural storage period but will sprout prematurely if the storage temperature is too high. If this happens go through the crop and remove the sprouts – this will give you a few extra weeks storage. The question

is sometimes asked about leaving potatoes in the drills over-winter and whilst it is possible provided they are sufficiently insulated, it's not recommended as you may well end up with increased levels of slug attack and rodent damage.

Onions are available all year round in the shops with most of the supply coming from refrigerated stores where they are stored at 0-2°C and 70-75% relative humidity. These conditions are difficult to replicate at home but do you best to store onions and garlic as cold as you can and as dry as you can. Onions will store for several months at ambient temperatures in an unheated building – a north facing unused bedroom could be used. The key point to remember is that dormancy in onions or garlic will quickly be broken by water or moisture on the bulb hence the reason to keep them dry and also the reason for not storing them in any sort of plastic bag.

Successful onion storage begins at sowing time by choosing a variety that has good storage qualities. Onions from sets will not store as well as those from seed. The best of the seed varieties (e.g. Hyfort F1) will store until March or April before sprouting becomes a problem.

Equally important is ensuring that the crop is harvested correctly. When the tops fall over on the plants in August or September, sprout inhibitors are produced in the leaves that are translocated down to the bulb and it's for this reason that the leaves must be dried on the bulb. When most of the tops have fallen over lift the crop and dry off, ideally in a glasshouse. It's essential to seal the neck of the bulb by ensuring that the leaves are completely dry before removing them. The bulbs can be tied into 'onion ropes' or put into a net bag and hung up. Alternatively they can be put into stackable slatted wooden trays going to a maximum of two deep in the tray. The main idea is to have a flow of air around the bulbs to remove the moisture that's continually produced by respiration.

Finally just to say that the invention of refrigeration has revolutionised vegetable storage. With freezers now commonplace in most homes, this is becoming a increasingly popular way to store home grown veg and also a handy way of dealing with the inevitable gluts.

Asparagus

Asparagus is a perennial vegetable that's grown for its edible young shoots (spears) that appear in late spring. A well drained site is essential for this crop. As asparagus will remain in the same place for as long as 20 years the site should be carefully dug over as deeply as possible taking care to remove all perennial weeds such as scutch-grass, docks, etc. Plenty of farmyard manure or bulky organic material should be well mixed with the soil during digging.

Asparagus is grown from seed or from one-year old crowns planted in March. Either way the plants must be allowed to establish for 2 years before taking your first harvest in year 3.

Sow seed in modules in January at 16-18°C under glass. Plant out in late May to early June in a staggered double row at a spacing of 45x30 cm, leaving 90 cm between rows. Plant in a 10 cm deep depression and as the plants grow gradually level off the bed by the end of the first season's growth.

The easier alternative is to buy in 1 year old crowns and plant in March taking care to space out the roots in all directions and covering with soil to a depth of 10 cm.

A light cut can be taken in the second year but the best advice is not to take the first harvest until the third year and don't cut beyond May 23. The harvest period in subsequent years can extend over a 6-8 week period from mid-April to mid-June. Cut the stems about 2.5 cm below ground level when the spears are 13-18 cm tall.

When the foliage has turned yellow in the autumn cut it down to within 2.5 cm of soil level. Top-dressings of farmyard manure should be given each autumn and supplemented in spring with a dressing of artificial.

Varieties: Backlim F1, Gijnlim F1, Millenium F1
Diseases: rust, wilt
Pests: slugs

Beans, Broad

Sow	Harvest
October – November	Late May – June
February – Mid June	June – October

Broad or fava beans are a hardy leguminous crop that can be sown in the autumn or spring. There are three main types – Seville, Longpods and Winsors and can be further divided on the basis of seed colour – green or white. Seville (e.g. Aquadulce) are the hardiest suitable for overwintering. Longpods have eight seeds per pod while Winsors have four seeds in shorter, wider pods. A fourth type is the Dwarf or Fan-podded (e.g. The Sutton) which are bushy, short plants that mature quickly.

The very earliest crop can be sown from mid-October to November, weather permitting. Plants don't need to be any more than 5 cm high going into the winter. The two varieties recommended for overwintering are Aquadulce and The Sutton. Most of the varieties grow about 1.3 m tall but The Sutton is smaller at around 80 cm and is free standing. The spring sown crop is drilled any time from February to mid-June.

The seed should be sown 5 cm deep in staggered double lines, 23 cm apart each way. If more than one double-row is to be grown allow 60-75 cm between them. Where you want to add organic matter to the soil, open a trench 30 cm deep and wide and add a layer of well-rotted manure or compost to the base and mix with the soil to leave a trench 5 cm deep. Sow your beans and cover over with the remaining soil. If growing on a bed aim for 18-19 plants per square metre – that's about 23 cm square.

Broad beans do not require staking unless they are a very tall variety or if your site is exposed. To support the crop erect posts at either end of the drill and tighten a double row of twine between them.

They take around 3 to 4 months to crop and last for about a month. For succession sow every month. Pick the pods when quite young – before the scar on the pod

turns black; if left too long the beans will be tough to eat. If black bean aphids attack pinching out the tops of the plants will remove most of them. Otherwise spray them. At the end of the harvest cut the stems down at base level to leave the roots in the ground to allow the nitrogen containing root nodules to rot down for the next crop.

Varieties: Express, Imperial Green Longpod, Aquadulce, Jubilee Hysor, The Sutton
Pests: black bean aphid, pea and bean weevil, crows
Diseases: chocolate spot (Botrytis), downy mildew, rust, Ascochyta

Beans, Dwarf, French or Kidney

Sow	Harvest
May – June	July – October

This versatile vegetable can be harvested as immature green pods (green beans), left grow on to a half ripe stage where the pods can be shelled like peas (flageolet) or let mature completely to dried beans (haricot). There are two forms: bush and climbing.

NB: take note that beans at the flageolet stage (especially if they are a bit overmature) can be poisonous if eaten raw. Cooking renders them completely safe to consume.

French Beans are sensitive to cold temperatures and exposure, so chose a warm, sheltered spot for them. They require a minimum soil temperature of 10-12°C for germination. In early districts the first sowing may be made early in May and in late districts about the third week of that month. Further sowings can be made to the end of June. Open lines 5 cm deep and 45 cm apart. Place the seeds 5-10 cm apart in the drill.

Borlotti beans are a flageolet type that if left to mature on the plant will become a haricot bean. Most other varieties are green bean types.

An early sowing may be made around mid-April in a glasshouse by single seeding 5 cm pots for transplanting out in May when the plants are about 8 cm tall. This early planting should be covered by fleece to protect against late frosts or cold wind. French beans take about 9-10 weeks from sowing to mature. Pick every two to three days to keep the plants productive and to maintain quality by preventing seed development. Outdoor crops can be harvested from July to October.

Commercial crops of French beans are always produced under glass using climbing varieties. Climbing varieties are more productive than bush varieties and especially so when grown under protection. For indoor production start off the plants in 5 cm pots and plant out after about 3 weeks when 8 cm high. Plant in double rows 60 cm apart, with 25-30 cm spacing between the plants in the row. Allow 1.5 m for the paths between the double rows. The crop is grown up twines supported on overhead wires 2 m from the ground. The stem should be allowed to grow along the wire for a metre before being stopped. It takes about 8 weeks for the first pods to be ready for harvest.

Bush varieties: The Prince, Nomad, Delinel, Borlotto Firetongue
Climbing varieties: Cobra, Emerite, Borlotto Firetongue
Pests: black bean aphid, slugs
Diseases: halo blight, root rot

Beans, Runner

Sow	Harvest
May – June	July – October

More popular in the UK than Ireland – in the supermarkets in any case – this is another example of a half hardy vegetable which cannot be sown too early. The runner bean is not only a nutritious vegetable, but also an ornamental plant for growing against a fence or wall, or to form a screen for an unsightly corner. It is a climbing plant that will twist itself around a string or a pole.

A minimum soil temperature of 11-12°C is required which will be achieved sometime in May. The seed is

usually sown from mid-May to the end of June in double rows. Could get away with sowing a late crop in favourable areas in early July. Sturdy supports are required, such as 2.5 m bamboo canes, one per plant, that are arranged in a tent like fashion secured at the top with a horizontal bar. The seeds are sown 5 cm deep, 20 cm apart, in rows 45 cm apart. Alternatively make a wigwam out of 6 or 7 poles with a plant per pole. One sowing is usually sufficient. The alternative method of propagation is to single seed 8 cm pots under protection in late April to early May, harden off, and plant out in late May to early June.

Twist the young shoots around the cane to encourage them to climb. When they reach the top of the support, pinch out the top of the plant to prevent it becoming top-heavy. From the flowering stage on make sure to water your plants in dry periods as this will help the flowers to set. Runner beans are self-pollinating but need the help of bees and bumble bees to set the flowers. The flower structure is so designed that it needs a bee to 'trip' the flowers to get the pollen to land on the stigma. French beans have no such problems and set their own seed quite readily without the need for bees, as the pollen is deposited directly onto the surface of the stigma within the flower. This helps to explain why the newer varieties from French/Runner bean crosses such as Moonlight (white flowered) and Firestorm (red flowered) have improved pod set. Hestia which has very attractive flowers is a dwarf variety suitable for growing in a flower pot. Regular picking of the crop will also encourage more pods to develop. Runner beans will crop from mid-July to mid-October.

Varieties: Scarlet Emperor, Moonlight, Firestorm, Red Rum, White Lady, Hestia
Pests: black bean aphid, slugs
Diseases: halo blight, root rot

Beetroot

Sow	Harvest
April – July	July – March

This is an easy crop to grow and will succeed on most soils. There are two types – long and the more popular round or globe shaped. What you get in the seed packet are 'clusters' or dried seed heads that may contain up to 3 seeds, unless you have purchased a monogerm variety that's been bred to produce one seed per cluster.

A Guide to Brassicas

Crop	Sow seed	Plant out	Row Width cm	Plant Width cm	For use	Varieties	Comments
Spring cabbage pointed	Third week July	Mid-Sept – early October	40	25	March (Greens) April-May (Hearted)	Duncan Winter Special, Excel Pyramid F1	When spring growth starts apply a side dressing of Sulphate of ammonia or CAN at 30g/m^2
Spring greens	August (direct drill)		40	15	January – March (unhearted)	Wintergreen	Sow in situ
Early summer cabbage pointed	February (Frame or modules)	April	40	30	June – July	Caramba F1 Pyramid F1 Hispi F1 Greyhound Dutchman F1 Caraflex F1	York varieties are less prone to bolting from early sowing than round head
Summer Cabbage pointed	March – May (open ground)	May – June	40	30	July – September	Caramba F1 Caraflex F1 Dutchman F1	Watch out for aphids and caterpillar in the summer period
Autumn cabbage pointed	May – June	July – August	40	30	September – November	Pyramid F1 Caraflex F1 Dutchman F1	Fertiliser side dressing as above in July.
	June	July	40	30	November – December	Monarchy	Late season York
Round cabbage	February March April – May August	April April – May May – July Sept – Oct	40	30	Mid June – July July – August August – Oct End April – May	Charmant F1 Derby Day Elisa F1 Kilaton F1 Tundra F1 Sennen F1	

A Guide to Brassicas – continued

Crop	Sow seed	Plant out	Row Width cm	Plant Width cm	For use	Varieties	Comments
Savoy cabbage	End April Early-mid May	June July	60	35	November – December January – March	Cordessa F1 Tarvoy	Follow early potatoes
Summer cauliflower	Mid October (frame) March/ April	March May to early June	60 60	45 50	June – July August	Nautilus F1 Nessie F1 Gipsy F1	Water well after planting to avoid buttoning
Autumn cauliflower	Late April/ June	June – July 20	60	60	September – November	Nessie F1 Skywalker F1 Belot F1	
Winter cauliflower	May/ early June	July	75 70	75 70	January – February March – June	Miracle F1 Medallion F1 Aalsmeer	January – February production only for coastal districts
Broccoli Calabrese	Mid-February – early June	Mid-April – early August	30 45	15 30	July - November	Aquiles F1 Ironman F1 Parthenon, Green Magic F1	Broccoli does not require a lot of N
Kale	April – May	June - July	60	45	Nov – April	Bornic F1 Reflex f1	
Sprouting broccoli	April – May May	May – July July	60 60	45 60	July- October February - May	Summer Purple, Rudolf, Red Arrow	New varieties increase season of harvest

Seed may be sown from April to the end of July to crop from July to March. For earlier sowing in March use one of the bolt resistant varieties such as Bolthardy. Cover that sowing with fleece to get it to crop in early June.

The drills should be 25 cm apart and the seed sown every 4 cm about 2.5 cm deep. Start lifting the roots as they are needed when around 5 cm in diameter – this gives the remaining crop more space to develop. The crop is not fully frost hardy, so unless you are in a mild area, it is advisable to cover them with 15 cm of straw sometime in November. Alternatively cover with a double layer of fleece.

Two plants from one 'seed'.

Varieties: Boltardy, Detroit 2, Burpee's Golden, Pablo F1, Red Ace F1, Cylindra, Chioggia
Pests: mangold fly (leaf miner), black bean aphid, beet flea beetle
Diseases: leaf spot (Ramularia, Cercospora), scab

Brassicas

If you wanted to pick out the three most important plant food groups for humans they would be cereals, legumes and brassicas. Brassica crops worldwide provide the greatest diversity of products used by man derived from a single genus, Brassica. Collectively brassicas deliver leaf, flower and root vegetables: cabbage, cauliflower, broccoli, Brussels sprouts, sprouting broccoli, kale, collards, swede, turnip, kohlrabi, pak choi, Chinese cabbage, mizuna and mustard. Other members of the brassica family add in seakale, watercress, cress, rocket and horse radish.

Wild cabbage growing on the Cliffs of Dover in chalk soil. It's difficult to conceive that this loose-leaved plant has given rise to so many distinctively different brassicas.

Most of our common brassicas are derived from wild cabbage (Brassica oleraceae) which grows wild in coastal locations in southern Britain, north western Europe and along the Mediterranean. Two things to note about the photograph – to withstand sea breezes the wild cabbage has had to develop a waxy leaf to prevent scorch; it's growing on chalk (calcium carbonate) so likes limey soils. Brassicas are considered to be calcicoles or calcium loving plants. Perhaps this is why we quite often see calcium deficiency showing up in the cabbage tribe.

Brassicas are well suited to Irish soils and climate and dominate the rankings of the top five vegetables grown: cabbage, carrot, broccoli, cauliflower and swede. With the exception of swedes and turnips which are drilled, brassicas are normally sown in modules under protection and planted out. Cabbage, cauliflower and swedes are available all year round, Brussels sprouts in the autumn and winter and broccoli in the summer and autumn.

Broccoli (calabrese)

Sow	Plant	Harvest
February – June	Late March – end July	June – November

This popular vegetable which hails from the Mediterranean only began to be grown in Ireland for the fresh market from about 1980. During the 1970's it was grown in the midlands for the processing market. The name of this vegetable can cause confusion: it may also be called calabrese or green broccoli and is not to be confused with its near relation, sprouting broccoli. Stemming from its southern origin it's one of the less hardy brassicas that we grow; we harvest it during the summer and autumn and import our winter and spring requirements from Spain.

The main harvest comes from a large centre head, but once that is removed you can get a second harvest from side shoot production depending on variety. The commercial grower will take just the main head going through the crop in two to three harvests but the gardener can utilise side shoots to extend the harvest period over several weeks.

The crop is normally sown in modules and planted out. Bare root transplants may

induce buttoning (production of a small premature head). It could also be direct drilled and thinned out to the required spacing. The early sowing is made in February for planting out in late March. This early planting should be covered with fleece to lessen the chances of bolting and to give the plants a head start. Remove the fleece about 3 weeks before harvest or sooner if desired. Alternative sowing dates for early broccoli are the last week in September and overwintering the plants under glass or sowing in January under heat; but these early crops are only for mild areas and must be fleeced otherwise they'll bolt. Crops planted from the second week of April onward do not require fleecing. Commercial growers will plant on a weekly basis through the season to ensure continuity. The late planting, by say August 7, can be chancy if the autumn is cold and frosts arrive early. A broccoli crop will normally mature in 65-85 days of planting depending on variety and date.

Broccoli is grown at a number of different spacings depending on the size of the centre head required but the overall yield doesn't vary from plant populations of 5 to 100 plants per m^2. For 500g heads use 60x40 cm (4/m^2) for maincrop and 60x45 cm (3.7/m^2) for early and late crops. For smaller heads try 45x30 cm (7.4/m^2) or 30x15 cm (22.2/m^2). For side shoot production use the wider spacings – suppressed at closer spacings.

Broccoli has quite a low demand for nitrogen in comparison to other leafy brassicas. The table below shows the results of a Teagasc trial applying increasing amounts of nitrogen to a crop of broccoli grown on a light and heavy soil.

Table: Effect of N rate on marketable yield (kg/plot) of green broccoli for summer and autumn production, 2002-2003.

	Heavy soil		Light soil	
Kg N/ha	Summer	Autumn	Summer	Autumn
0	14.1	15.0	5.0	9.2
30	20.3	17.2	7.0	7.9
60	21.6	17.0	8.1	8.8
90	18.3	16.9	7.9	8.9
120	24.5	16.3	10.5	9.7
150	25.6	16.0	9.9	8.2
180	27.9	17.8	10.9	8.8
210	26.5	17.6	10.3	9.3

For summer production a strong response to applied N was found. A minimum of 120 kg/ha was required to produce the optimum response on both heavy and light soil types. For autumn production there was no marketable yield response to applied N on a heavy loam soil. Results on a light sandy loam were not consistent and the optimum requirement varied from 0 kg to 60 kg/ha. Wet rot incidence was significantly higher with increased nitrogen rate.

For small plot production an application of manure or compost should suffice expecially for crops maturing in the September to October period. Otherwise apply 20-30g per square metre of sulphate of ammonia at planting and repeat a month after planting.

Broccoli can be a temperamental crop. During hot weather you may find some of the beads on heads that are close to harvest opening up and turning yellow; this can also happen after harvest. Certain varieties are more prone to this problem than others but is worst where the heads are slightly over mature so harvest on time. Depending on variety heads can also discolour if the weather turns sunny and may also discolour in very wet summers. Parthenon is the best variety to withstand a variety of weather conditions.

Tenderstem broccoli is a cross between broccoli and Chinese broccoli (Kaai laan) developed originally by the seeds company Sakata. The centre head is harvested first and after that the side shoots develop.

Varieties: Aquiles F1, Ironman F1, Steel F1, Parthenon F1, Green Magic F1
Pests: cabbage root fly, aphid, caterpillar, slugs, birds
Diseases: downy mildew, wet rot, white blister

Broccoli, Sprouting

Sow	Plant	Harvest
April – June	May – July	July – May

This is a hardy crop that was grown to fill in when there wasn't much else around in the vegetable garden in the spring time. However new varieties have been developed that allow for a greatly extended season of production. Depending on the variety chosen sprouting broccoli can be harvested from July to May.

For late summer to autumn production through to spring sow from April to June and transplant from May to July. For the over wintered crop it is essential to protect your plants from pigeon damage by netting or black thread. The plants may need to be staked as they are tall growing.

Come harvest time a centre head develops and side shoots or spears grow out from the main stem below the centre head. Both the centre head and side shoots should be harvested before the tiny purple flowers open out to a yellow colour. A succession of pickings can be made as long as side shoots continue to develop.

Pests cabbage root fly, aphid, caterpillar, slugs, birds
Diseases: ring spot, Alternaria, downy mildew, white blister

Brussels sprouts

Sow	Plant	Harvest
Late February (frame)	Mid – Late April	August – September
Mid – Late March	Early May	September – October
Early April	Mid May	October – November
Mid April	Late May	November – December
Late April	Early June	December – March

Plant breeders have done a number of favours for this much maligned vegetable – the season now stretches from September to March, the sprouts are easier to pick and better flavoured, plus the development of hybrids has rendered blown sprouts a thing of the past. However sprouts can be a difficult enough crop for the amateur to grow for a few reasons. The crop – including the bit you eat – can be prone to a variety of pests and diseases which the professional grower can counter by using a range of chemicals that are not available to gardeners.

Sprout varieties can be roughly divided into early, mid-season and late, spanning the months mid-August to October, October to December and December to March. They need a long season of growth and start off with being propagated as bare root transplants or in modules. The previous table is a guide to sowing and planting dates.

The main sowing period is March – April with the bulk of the planting taking place in May and up to the end of the first week in June. You can plant later in June but yields will reduce.

Succession in sprouts derives from using different planting dates combined with different varieties. One possible suggestion to use Maximus or Helemus planted in mid-May for October to December period followed by Doric or Petrus in early June for December to February; but there are lots of other varieties and timings to pick from.

Sprouts develop naturally from the base of the stem to the top and most gardeners will harvest them on a 'cut and come again' basis. However commercial crops are sometimes stopped by removing the growing point to allow the sprouts to mature evenly for machine harvest. This is done when the bottom sprouts are a centimetre in diameter. You might consider using this technique if you were growing a crop for freezing but in general stopping confers no benefit to the gardener.

Plant spacing for sprouts varies from 2.8 to 3.7 per m^2. Populations greater than 3.7 incurs the law of diminishing returns. Increasing your plant population results in:

- increased stem length
- reduced sprout size on the stem
- increased stem length
- delayed maturity
- increased uniformity of sprout development on the stem

In relation to these characteristics overall plant population has been found to be more important than the spatial arrangement of the plants. The old traditional spacing for sprouts was 90x90 cm which is too wide for the hybrid varieties that are currently in use. For regular picking over of sprouts suggest using 60x60 cm or 60x50 or 45 cm for a tighter spacing. If you are growing for freezing try out a spacing of 50x50 cm, stop the crop and carry out a once-over harvest.

Sprouts have a high nitrogen requirement as you need to get height into the plant for optimum yields. Apply 30g per m^2 of sulphate of ammonia at planting, repeat a month later and again in July.

Start picking your sprouts when the bottom ones are between 2-4 cm in diameter. The sprouts you buy in the shops are normally sold in two separate size grades: 22-30 mm and 30-38 mm. The interval between picks is from 3-5 weeks and a single variety can crop for up to 4-5 months. A single plant will yield 60-70 sprouts or about a kilogram in weight.

Aphids can be a problem with this crop if they are allowed to establish within the buttons. They tend to start to build up in July with large populations developing by early autumn. As there are no effective aphicides available to the amateur market the plants should be covered with fleece from July to October. Slugs can also be troublesome as they will climb up the plant to feed on the sprouts. Apply 3 applications of pellets during the summer to autumn period. The main diseases on sprouts are ring spot and white blister.

All the best varieties are hybrids.

Varieties: Abacus F1, Maximus F1, Helemus F1, Brendan F1, Doric F1, Petrus F1, Exodus F1, Neptuno F1, Crispus F1
Pests: cabbage root fly, aphid, caterpillar, slugs, birds
Diseases: ring spot, Alternaria, white blister, light leaf spot

Cabbage

Cabbage along with cauliflower is a crop that can be harvested all year round. Although consumption of cabbage has declined over the years it still is a major crop in Ireland.

Cabbage has been selected and bred for centuries which helps to explain the confusingly large number of types and varieties and indeed the plethora of sowing and planting dates. The different types include: round headed (ballhead), pointed (York), Savoy (winter maturing), red cabbage, white cabbage (for coleslaw) and winter cabbage (Tundra type). York cabbage can be grown 12 months of the year but during the winter months it is harvested as 'greens', which is unhearted heads of cabbage. Duchy was the standard commercial York variety for June to November production but has been superseded by Dutchman, a variety very similar to Duchy. Both are good to eat. Savoy cabbage was traditionally a winter vegetable but summer varieties have also been developed. White cabbage, also known as Dutch cabbage or storage cabbage is mainly grown for coleslaw and is produced from summer through to winter. This type of cabbage is prone to frost and is brought into store in November, although some growers will take a chance and field harvest it over the winter. Round headed cabbage for general consumption have been developed for summer and autumn production – there are many varieties. However a variety called Sennen F1 has been developed for overwintering – it's planted in October and matures in May.

Cabbage is planted at a variety of spacings depending on variety and size of head required. Suggested spacings are given in the Table entitled "A Guide to Brassicas". The narrower the spacing the smaller the head and visa-versa. For example storage cabbage can be spaced at 50x50 cm to produce 1 kg heads.

Cabbage requires generous feeding but the quantity and the kind of fertiliser varies with the season. A boronated compound like 8-5-18 +B is used for the base dressing as all the brassicas have a requirement for boron. Cabbage has quite a high requirement for nitrogen with summer and autumn crops

receiving somewhere in the region of 70-80 g/m^2 of sulphate of ammonia. This is split between the base and top dressings with the top dressing applied about a month after transplanting. Autumn planted cabbages which have to withstand the rigours of winter are given little nitrogen but relatively high potash in the base dressing. Compound fertilisers such as 0:7:30 or 0:10:20 are suitable for autumn planted crops. With the advent of fine weather in the spring nitrogen is given as light top-dressings. As soon as growth commences in spring give 40-50 g/m^2 of calcium ammonium nitrate (CAN) or sulphate of ammonia and repeat three weeks later.

The main pests of cabbage are cabbage root fly, aphids and caterpillar. Pigeons can be a nuisance especially in early summer and also over the winter. The main diseases are leaf spots caused by either ring spot or Alternaria.

Pests: cabbage root fly, aphid, caterpillar, pigeons, slugs
Diseases: ring spot, Alternaria, white blister, downy mildew, Botrytis, clubroot

Cauliflower

It is possible to have cauliflowers in season during most of the year but take note that production in the January-February period is usually only possible in mild coastal locations. Careful selection of varieties and sowing and transplanting dates will go a long way towards successional cropping. Weather conditions will influence harvesting dates.

A general rule of thumb is that plant spacing increases as the season progresses. This is because a larger plant size is required to produce a head of cauliflower in the depths of winter than an early crop in June.

Early summer cauliflower for cutting during June and early July are sown either in cold frames in mid-October or under glass in January. They are planted out in

warm well-manured ground in March as soon as weather conditions allow, at a spacing of 60x45 cm. This crop is particularly susceptible to buttoning, which is where a small curd (edible white portion) forms prematurely caused by a check to growth. The crop must be kept growing to produce a big frame so make sure to water during dry spells.

Summer cauliflower for cutting from mid-July to August can be sown in March-April for May planting.

Autumn cauliflower is the easiest to grow and gives the biggest yield. Seed should be sown from late April to June for transplanting from June to about 20 July. The plants should be planted out at 60 cm square 5-7 weeks after sowing. It is a mistake to leave them too long in the seed-bed or modules as this may lead to buttoning.

Winter cauliflower may be had in succession from December to May by planting a number of varieties. Development of the heads is greatly influenced by the prevailing weather – mild spells may cause rapid maturing while cold, wet weather with little sun will delay development. Hence, it may be difficult to accurately time the harvesting of this vegetable. Crops that mature in the January to February period can only be grown in the milder coastal areas of the country. Commercial crops of winter cauliflower traditionally follow early potatoes.

Where winter cauliflower follows an early potato crop, 90g per m^2 of a compound vegetable fertiliser should be given. Nitrogen top-dressings in the early spring are necessary for the late maturing kinds (February-May).

Pests: cabbage root fly, aphid, caterpillar, pigeons, slugs
Diseases: ring spot, Alternaria, white blister, downy mildew, clubroot

Carrots

Sow	Harvest
February – July	June – April

Carrots can be grown on a range of soils from heavy to light but the majority of the commercial crops are grown on light to medium soils. A sandy loam would be ideal.

They can be produced outdoors from June to April with the earliest crops being produced using polythene covers and the very late crop from under black plastic and straw. The best place to store carrots for winter and spring use is in the ground where they are grown. However they are quite susceptible to frost so spread some soil over the tops in November or cover with a double layer of fleece. In the colder areas of the country cover the beds with 25-30 cm of loose straw. If commercial growers want to keep the crop to March and April they lay down a sheet of black plastic covered with straw in October-November – the straw keeps out the frost and the plastic keeps out the light to prevent re-growth in the spring. Apply slug pellets prior to strawing down to prevent damage to the roots. The use of leaves would be a suitable alternative to straw.

Stony soils produce misshapen roots. Commercial growers de-stone their soils to prevent this and to reduce damage when lifting.

There are several different types (root shapes) of carrots such as Amsterdam and Nantes and plant breeders have used them to produce hybrids, which is now the dominant type on the supermarket shelf. Nairobi is the main

variety grown commercially and will grow well on a wide range of soils. Its other advantage is that it will hold well once it becomes fully sized.

Excellent sample of evenly sized Nairobi carrots.

The early crop is sown in February/ March for June/July production. The main crop is normally sown from mid-April to May. A late sowing of an early variety can be made in June to give you a tender tasting crop in about 12 weeks. Seed may be sown in lines 15 cm apart on the flat at a depth of 1-2 cm. Carrots are difficult to sow by hand but try to sow thinly so as to avoid thinning; otherwise thin the resultant seedlings to 5-7 cm apart. One can get pelleted carrot seed which although more expensive is easier to sow evenly by hand.

Varieties
Early: Laguna F1, Mokum F1, Trevor F1
Maincrop: Nairobi F1, Ulyses F1, Kingston F1, Romance F1
Pests: carrot fly, aphid, slugs
Diseases: scab, Alternaria, cavity spot, Sclerotinia

Celeriac

Sow	Plant	Harvest
March	May	October – April

This vegetable is closely allied to celery and is grown for its swollen stem base produced above and below ground which has an appreciable taste of celery. It's similar to celery in that it has to be propagated under protection and planted out; it's different in that it grows much more slowly and is reasonably hardy, being harvested from open ground over the winter.

Propagation is very similar to celery. Seeds need to be sown under glass in March in heat and pricked out in pots or modules. Single sowing pelleted seed into modules would be ideal for the purpose. Propagation time is about 10 weeks.

If you plant too early the crop may bolt and if you leave it too late it will not have enough time to mature fully. So aim to plant in May or at the latest, early June. Shallow plant and space the crop to give a plant density of 5.5-7 per m2. So work out your spacing accordingly or choose 50x35, 40x40 or the popular 45x30 cm.

Fertiliser for celeriac would be the same as for celery but requiring far less nitrogen. Suggest 70-90 kg/ha would be sufficient.

Celeriac responds well to irrigation so don't leave the crop short during dry spells. Regular and even water applications will ensure that roots are not hollow. Side shoots may develop during the course of the season and these should be removed along with some of the oldest leaves. It will initially seem to be growing slowly but will put on a lot of weight in the last few weeks of growth.

It is a crop that does not seem to be greatly affected with pests or diseases but watch out for slug damage on transplants.

Varieties: Brilliant, Rowena, Giant Prague, Prinz, Monet F1
Pests: slugs, carrot fly, celery fly
Diseases: celery leaf spot

Celery

	Sow	Plant	Harvest
Early	Early February	Mid – Late April	August – September
Main	March – April	May – June	August – September
Late	May	July	October – November

There are three types of celery – green, self-blanching (SB) and trench. The old fashioned trench celery is no longer favoured having being replaced by the easier to grow self-blanching and green varieties. Virtually all of the commercial crop is now green celery. Trench celery was grown in rows to allow for earthing

up but the self-blanching and green varieties are always grown on beds. In order to get self-blanching celery to blanch correctly it needs to be grown in a block at close spacing. Blanching is the development of a light colour by the process of excluding light.

Green celery, variety Plato.

The main inputs in growing celery is nitrogen and water. A high level of fertility is necessary as you need to aim at maintaining continuous growth in order to grow succulent sticks of celery. A heavy dressing of farmyard manure or compost is recommended and supplemented with fertiliser.

Celery needs to be propagated and grown on under glass or polythene before being planted out. The early crop has to be propagated under heat otherwise it will bolt. It's sown in February for planting out from around mid-April. The maincrop is sown in March – April and transplanted out in May – June; a late crop can be planted up to July 20 for harvest in November and December but this crop is a bit of a gamble as it can be damaged by early frosts.

To reduce the risk of bolting with the earlier sowings maintain a day/night temperature of 17°C and venting at 21°C. In practice lower and higher min/max temperatures (10-25°C) can be tolerated without inducing a bolting reaction.

The traditional way of raising celery is to sow the seed on top of moist compost and keep covered with polythene or glass until germinated in about 2 weeks. Grow on until large enough to handle (1 true leaf) and prick out into trays at 3 cm square spacing. They could also be pricked singly into modules. It takes 4-5 weeks from sowing to pricking off and a further 4-5 weeks from pricking off to planting out.

Propagation temperature for celery is 15-20°C. Be wary of higher temperatures (25°C +) as germination percentage will slump. It may be necessary to use Styrofoam sheets to cover germinating seed during warm weather. Young celery seedlings are also liable to heat damage when under glass in sunny weather – shading material may have to be employed.

With advancements in seed technology all commercial celery is now propagated using quick-pills. A quick-pill is a pre-germinated coated seed that makes propagation of celery much easier and quicker as it eliminates the pricking out stage. The pill is single-sown directly into a peat block or module by machine or by hand. The pill is lightly covered by compost and grown on for around 6-8 weeks until fit for planting.

Celery is normally planted on the flat in beds, typically four rows across a bed, 28-30 cm square in a diamond shape. A dressing of sulphate of ammonia at 30g per m^2 may be given pre-planting and topdress at about the 4 and 6 week stage with another 30g per m^2.

Irrigate after planting and after topdressing to establish the plants and to wash the fertiliser in. Copious watering should also be given during dry weather.

Apply slug pellets along the rows just before the crop close in as slugs can move up into the developing celery head and consequently be difficult to remove. Ensure that pellets don't lodge in crown of the plant as they will still be there at harvest time.

Blackheart can occasionally cause problems with celery. It's a blackening of the centre leaves at the base of the plant caused by a lack of calcium. It more usually is an induced deficiency brought on by a lack of moisture at the roots. To counter it ensure that the crop doesn't run short of water and irrigate well during dry spells. It would also be advisable to use calcium nitrate (15% N) as your topdressing material as it supplies calcium as well as nitrogen. If signs of blackheart appear, spray the plants with calcium nitrate at 10-20 kg/1000 L per ha so that the hearts get a thorough soaking. Repeat at 10-14 day intervals until near harvest.

Celery is sensitive to boron deficiency which causes a disorder known as 'cat's claw'. Apply 2.2 kg/ha of boron or use a boronated compound such as 8-5-18 +B.

Varieties: Galaxy (SB), Loretta F1 (SB), Victoria F1 (green), Tango (green), Plato (green)
Pests: carrot fly, aphid, slugs, celery fly
Diseases: celery leaf spot (Septoria), Pythium root rot, pink rot
Disorder: black heart (calcium deficiency)

Chicory

Chicory can be grown on any light fertile soil provided the site is deeply worked and heavily manured. Farmyard manure, potash and phosphates should be incorporated in the soil during the autumn in preparation for seed sowing towards the end of May or early June. Seed is sown in lines 30 cm apart and 1 cm deep; the plants are later thinned to 20 cm apart.

By October the roots will be fully grown and may be lifted for blanching. Those not needed at once should be heeled in temporarily.

Forcing is done by introducing medium-sized roots of about 2.5 cm in diameter into the forcing shed or glasshouse. The roots are cut to a uniform length of 20 cm and placed in an upright position in rows 5 cm apart and 2.5 cm apart in the rows. After watering they are covered with light soil, sand, or peat to a depth of 17 cm so as to blanch the subsequent growth. If a suitable house is not available a forcing bed may be prepared out of doors by erecting boards 23 cm wide along its sides. The prepared roots are placed in position and after watering are covered with suitable blanching material. Fermenting stable manure, if available, may then be placed on top to speed up growth but if such material cannot be obtained the bed should be covered with glass lights, corrugated iron or other protective material. Some new varieties are now available which can be forced without covering with soil.

Varieties: Witloof, Normato, Mitado, Tardivo.

Courgettes

Sow	Plant	Harvest
Mid April – Early May	Late May – Early June	July – October

Courgettes or zucchini are immature marrows which are harvested when about 15-24 cm long. They originate from the Americas and are a half hardy crop that is damaged by frost. Because of this the crop is normally raised under glass or polythene and then planted out when the cold threat has diminished.

To span the season from July to September two sowings and plantings are normally carried out. In milder parts of the country the first sowing can take

place in mid-April under protection. Sow the seeds singly 15 mm deep into an 8 cm pot or large module. Heat (18°C) is desirable but not altogether necessary to get the seeds to chit (germinate). Grow on at ambient temperatures but frost protection must be provided because frosted plants will be badly checked. If frost threatens cover the plants with fleece. Be a little careful with the watering as courgettes don't react well to waterlogged compost. It takes about 4 weeks from sowing to planting out at the 2 true leaf stage.

The first sowing is planted out around the third week of May and will need the protection of a cloche or low polythene tunnel. The second sowing is made in early May, planted out in early June and is left uncovered. It takes about 6-7 weeks from planting to first harvest. Courgettes can also be sown directly into the ground in June, using 2 seeds per station and thinning to one.

Space the plants at 1x1 m or 90x90 cm spacing or if you require a wider row spacing use 1x1.4 m.

Cucurbit pollination

Courgettes, marrows, cucumbers, melons, gherkins and pumpkins are all members of the Cucurbit family. They have separate male and female flowers on the same plant; you will see a small underdeveloped fruit at the base of the female flower. Early in the season you may notice that the flowers are initially all male but later on settle into a pattern of producing both types. This is because the proportion of female flowers tend to increase as the days grow longer – it's a day length effect. The all-male flowers is a lingering carryover from the shorter days of early summer. Courgette flowers open in the morning and close in the afternoon. Honey bees and bumble bees are the main pollinators but even without pollinators about half of the courgettes will develop due to parthenocarpy – fruit that sets in the absence of pollination. However for maximum yield you need pollinators and these will be encouraged by growing wild flower strips within or close to the crop.

Harvesting normally starts in early July from the covered crop and continues to the end of September. The first few fruits to form can be poorly pollinated and distorted in shape – if this is the case just remove them and discard. Courgettes grow fastest in warm muggy conditions and can mature rapidly. Pick every 2/3 days. Care needs to be exercised when picking as the fruit are easily damaged. Protect your hands and arms when harvesting to prevent skin irritation from the leaves of the plant. Average yield would be 3-4 fruit per plant per week.

Watch out for slug damage to recently planted courgettes. The main pest and disease problem is powdery mildew that frequently attacks in late summer. If you get a bad outbreak it can reduce yields.

Varieties: Cora F1, Tosca F1, Tuscany F1, Firenze F1, El Greco F1
Pests: aphid, slugs (at planting only)
Diseases: powdery mildew, Botrytis

Garlic

Sow	Harvest
October – November	June – July
February – March	July – August

Garlic, a member of the onion family, is grown from cloves, not from seed. These are planted in the autumn or spring and subsequently develop into bulbs that are formed underground. There are two types: hardneck and softneck. Hardnecks develop a stiff centre stalk from the flowering spike which is called a scape. Bulbs from this type are frequently purple or pink in colour with fatter but fewer cloves. The softnecks are usually white in colour and store well. We import most of our garlic from China and Spain.

Clove of Garlic.

The best crops are grown on light to medium, free draining soils. On heavier soils grow the crop on a raised bed to improve drainage especially for the over-wintered crops.

You can use ordinary shop garlic but as there are many clones of garlic you may find you get better results with named varieties purchased in a garden outlet. In addition shop garlic is often treated with a growth regulator that will give poor sprouting when planted out. Garlic needs exposure to cold temperatures (0-2°C for 1-2 months) to initiate bulbing – this can happen during storage or post planting.

Garlic is a hardy vegetable that is either over-wintered or planted in early spring. Plant in October-mid December for June/July harvest or in February-March for July/August harvest. The bulb must be broken up into cloves for planting, discarding the very small and keeping those of 1 cm diameter and upwards. In general large cloves will produce the largest bulbs.

Garlic is responsive to plant density with overall yield increasing at higher densities but with a decrease in individual bulb size. A density of around 20-30 per m^2 is about right for good sized bulbs. A spacing of 20 x 20 cm is equivalent to 25 per m^2. Plant the cloves with the basal plate facing downwards, 5-7 cm deep.

Garlic is a moderate nitrogen demander – similar to bulb onions. Apply one-third of the nitrogen at planting, one-third when growth begins in the spring and the final third about a month later. If spring planted apply half at planting and the other half about 4-6 weeks later but not later than early May. The crop is also responsive to potash.

The crop is sensitive to dry soil conditions and needs to be irrigated during dry spells. The most critical stage for irrigation is during bulbing – May to July. A lack of water will result in reduced yields and earlier maturity.
If any flower stems are produced, just snap them off to allow the plant concentrate all its energy into the developing bulbs.

If any flower stems are produced, just snap them off to allow the plant concentrate all its energy into the developing bulbs. These are known as scapes and are delicious in a stir-fry.

Harvest the crop when 10% of the tops have fallen over or when the foliage just starts to turn yellow. If you notice that some of the bulbs have split open

you are harvesting too late. Carefully lift the bulbs, tie together in bunches of 10 and hang in light, airy, place to dry; or else lay them on wire mesh in a glasshouse. After about 4-5 weeks they should be sufficiently dry. Trim the roots and cut the tops to about 2 cm. Clean the bulbs by removing some of the outer skins without exposing the cloves. The art of drying garlic is to achieve tight, full cloves in the bulb with the leaves around the bulb and the stem completely dry but not brittle.

Store in a cool dry place – can last up to ten or eleven months. For maximum storage store at 0-4°C and at a humidity of 60-70% RH.

Varieties: Arno, Cristo, Germidour, Purple Wight, Solent Wight, Vallelado
Pest and Diseases: as for onions but the main problem is rust

Kale

Sow	Plant	Harvest
January – June	March – July	June – April

Kale is one of the hardiest and also one of the most nutritious of vegetables and except for juicing has never taken off in the popularity stakes. The leaves are the edible part and these can be harvested individually from the bottom of the stem up, or the complete head can be harvested in one go.

Although it's produced commercially from June to April, it's still regarded as a traditional winter crop available from November through to March. To cover the June to April period five or six plantings will be required at approximately monthly intervals from March to the end of July for the late crop; this will entail sowing the crop in modules from January to June. Plant density for kale is in the order of 3.7-4.5 per m^2. So use a spacing of 60x45 cm for early and late crops and 60x37 cm for the main crop.

There are three broad types – green curly leaved, red leaved and Italian black leaved.

Varieties: Bornick F1, Firbor F1, Reflex F1, Red Russian, Nero di Toscana
Pests: aphid, caterpillar, birds
Diseases: ring spot, white blister, largely resistant to club root

Kohlrabi

Sow	Harvest
March – July	June – October

This underrated brassica vegetable is far more popular on the continent than in these parts. It originated in northern Europe in the fifteenth century and its name comes from two German words: kohl meaning cabbage and rabi meaning turnip. The turnip-like globe of kohlrabi is actually the swollen base of the stem, not the root. There are green and purple versions.

Kohlrabi can be either direct drilled or sown into modules and planted out. Sow from April to July in rows 30 cm apart with 20 cm in-row spacing. If sown too early there is a risk of bolting and if going earlier into March sow in modules under protection and plant out later. Sow every 3 weeks for succession. It's a quick growing crop – ready for harvest about 2 months after sowing during the summer months; so keep the crop moving along during dry spells by watering it. Harvest the crop when the bulb is between golf and tennis ball size.

Varieties: Domino, Kongo, Superschmelz
Pests: as for brassicas
Diseases: as for brassicas

Leek

Sow	Plant	Harvest
January – February	April – May	July – September
March	May – June	September – December
April	June	November – March
Late April – early May	July	March – May

Leeks are a reasonably hardy vegetable and a valuable substitute for onions from August to April, with the very earliest and latest stretching the crop from the third week in July into May. How late the season goes depends on when they bolt which in turns depends on variety and weather. The beauty of leeks is that they will hold for several months in the ground, which means that a couple of plantings will cover a long period.

Bare root transplants.

The edible bit is the shank, the lower part of which is usually blanched white by excluding the light. Traditionally this is done by dropping the young plant into a 15-18 cm deep, 5 cm wide hole. If a greater length of blanch is required then the leeks are clayed up as they grow. However all commercial leeks are deep planted with a specialised planter using mainly bare root plants.

The crop can be direct drilled or planted. Leeks sown directly suffer from the same problem as direct drilled onions – require irrigation and suffer competition from weeds. So it's easier to transplant the crop by sowing into modules or by using bare root plants. Leek seedlings are slow to grow and take about 8-12 weeks to produce a plant big enough to plant out – one about 15-25 cm tall.

Modules can be sown with anything from 1-4 seeds per cell. If multi-seeded the plants are planted out as one and not split up. Seed can also be sown in a seed tray at a spacing of about 2.5x2.5 cm. Because of the length of the propagation period the plants will need some liquid feed to keep them going. For bare root plants sow

in drills 15 cm apart using a seed rate of 80 per metre run. Do not thin. A seedbed can be in a glasshouse, tunnel, frame or outdoors. With either system the seedlings as they get bigger can be trimmed back to give you a better balanced plant.

The early crop is sown in January or early February under glass for planting out in April. The main crop is sown in March under protection or in an outdoor seed bed in April for planting in May and June. The late crop can be sown from late April to early May for transplanting in late June to the third week of July.

Leeks growing in alluvial soil in Belgium.

To facilitate handling and planting, the leaves and roots of the pulled plants are normally trimmed to leave a plant about 20-25 cm long. Leeks will readily regrow new roots and shoots from the base plate so don't be afraid to trim them back. Planting density for leeks varies from 20-40 per square metre. Closer spacing will give you smaller leeks without loss of yield. Standard spacing is rows 30 cm apart with 15 cm between the plants; or try 20x20 cm. Multi seeded modules are spaced 30x30 cm. Planting is done with a dibber making a hole about 15-18 cm deep. For success with this method the soil has to be at the right moisture content – it won't work if the soil is too wet or too dry. A single plant is dropped into the hole and watered in to settle soil around the roots. The holes will fill in gradually as the season progresses. Alternatively plant with a trowel 10-15 cm deep.

Leeks are responsive to nitrogen and bulk up a lot between September and December. So apply compost or manure to the ground prior to planting and if necessary augment with a nitrogen source 2-3 times during the season up to the end of September. If using sulphate of ammonia suggest using 60-100g per square metre, equivalent to 130-210 kg/ha N. Apply about half the amount at planting, another 30% a month later and the remainder about a month after that if required.

To aid establishment irrigate straight after planting in dry weather. It is interesting to note that during the wet summer of 2012 the one crop that didn't mind the rain was leeks, so don't leave them short of water if the weather is dry.

If you want a longer blanch then earth up the plants during the season. Gently draw soil around the stem when the plants are well developed 2-3 times during the season. But don't allow soil to fall between the leaves. Such an operation also aids weed control.

Apart from thrips, pests are not an issue with leeks. The main disease is rust which can commonly attack leeks. Rust won't kill the leek but can slow its growth. Unfortunately none of the varieties are resistant but they do vary in susceptibility. If the variety you are growing comes down badly with the disease try a different one the following year.

The quality of leek varieties have improved no end over the last number of years, and the development of hybrids has helped in this respect. Virtually all the commercial growers use hybrids as they are very uniform and easier to clean. But hybrid seed is considerably more expensive than open pollinated varieties so choosing an OP is a good garden option.

Varieties: Zermatt, Pancho, Krypton F1, Pluston F1, Porbella, Triton F1
Pests: thrips
Diseases: rust, white tip (Phytophthora), white rot, Fusarium foot rot

Legumes

Legumes are members of the Fabaceae family (formerly Leguminosae). They include the peas and beans both of which have long been recognised as hugely important to mankind. Important for two reasons – they are a source of protein in the human diet and most of them have an ability to fix nitrogen from the air. Hence they have been in cultivation since near the dawn of modern agriculture 10,000 years ago.

Nitrogen fixation occurs when nitrogen fixing bacteria colonise the roots of clover, peas and beans resulting in the formation of nodules. Here the bacteria convert nitrogen gas in the soil air into nitrogen compounds utilisable by the host plant in exchange for carbohydrates supplied to the bacteria. And when the nodules break down they release their nitrogen for other crops.

Peas and broad beans are nodulated by a bacterium called *Rhizobium leguminosarum*. This species is very common in European soils as it nodulates the vetches which are wild relatives of peas and beans. On the other hand French and runner beans originated in South America have no compatible bacteria in European soils and have difficulty in fixing nitrogen. However it has been found that they can nodulate on certain soils. To check for active nodules, dig up some roots to look for nodules; if present cut them open and a pink colour (due to iron compounds) means they are fixing nitrogen, no pink means they are inactive. The other thing that causes a lack of fixation is high soil nitrogen – legumes will use soil nitrogen (from fertiliser or organic matter) in preference to fixed nitrogen as the latter takes a lot more energy. To improve nodulation on French and runner beans, it's possible to buy inoculants to mix with the seed prior to sowing.

Legumes		N fixing	Pollination	Germination	Origin
Pea	Annual	Yes	Self-pollinating	Hypogeal	Europe
Broad bean	Annual	Yes	Bees	Hypogeal	Europe
French bean	Annual	Little	Self-pollination	Epigeal	S America
Runner bean	Perennial	Little	Bees	Hypogeal	S America

Lettuce

There are many different varieties of lettuce but there are two basic types: those that are leafy and those that form heads. Butterhead, iceberg and cos are examples of head forming lettuce. Lollo Rossa and oakleaf are just two representatives of leafy lettuces that exhibit a range of shapes and colours.

Once mature, lettuce will not hold well; for succession make subsequent sowings when seedlings of the previous sowing have just emerged. Alternatively one can buy a packet of seed with a mixture of varieties with differing maturity dates.

Lettuce is normally a transplanted crop but some of the leafy types can be direct drilled. It can be sown in a seed bed or tray and transplanted as bare-root plants but will establish better from modules. Take care when planting lettuce to ensure that the module is planted level or slightly proud of the surface of the soil – deep planting may induce basal rots in the young plant.

Lettuce is normally a transplanted crop but some of the leafy types can be direct drilled. It can be sown in a seed bed or tray and transplanted as bare-root plants but will establish better from modules. Take care when planting lettuce to ensure that the module or block is planted slightly proud of the surface of the soil to reduce the incidence of Botrytis or bottom rot.

Iceberg lettuce is a crisp lettuce that is grown outside and not under glass. Sow in blocks or modules from February to the third week in July. Ideal temperature for germination is approximately 15-21°C. Take note that at temperatures greater than 27°C, high temperature dormancy can occur. It takes from 3-5 weeks from sowing to transplanting. Plant out from April to early August at a spacing of 35 x 30 cm. The crop will mature in 7-10 weeks from planting.
Varieties: Gondar, Robinson, Sioux, Saladin

Cos is a type of lettuce that produces upright oblong plants with a crisp inner heart. The Little Gem variety is one of the earliest to mature in a more compact frame. Seed may be sown from March to mid July in drills 23 cm apart and thin out the seedlings to 23 cm apart.
Varieties: Little Gem, Little Gem Maureen, Pinokkio

Butterhead lettuce can be produced from June to October from sowings made from March to mid-August. Space the crop at 30 cm square. Because lettuce is a perfectly circular crop, some savings in space can be made by planting in a triangular pattern - circles of 30 cm will fit into 30 cm rows and 27 cm in-row spacing.
Varieties: Cassandra, Roxy, Diana

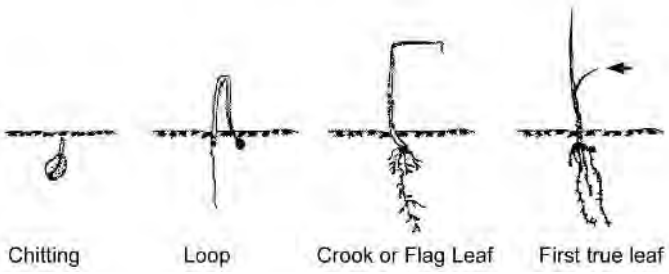
Lettuce needs to be kept growing so water during dry spells and a rich, moisture retentive soil will help in this regard. Farmyard manure or compost may be used to enrich the soil and improve its moisture retaining capacity.

Pests: aphids, root aphid, slugs, caterpillars, pigeons
Diseases: downy mildew, botrytis, bottom rot, ring spot, sclerotinia

Onion family

The Alliaceae or onion family is a very important food group that has been in cultivation for thousands of years. Members include onions, scallions, shallots, garlic, chives and leeks.

Most vegetables are dicots meaning that they have two seed leaves or cotyledons. But the onion family and sweetcorn are monocots possessing just one seed leaf. The diagram below shows the seedling growth stages of an Allium.



Chitting is the visible start of the germination process after the seed has imbibed water. The seed coat breaks and produces an initial root followed shortly by the cotyledon. The solitary seed leaf or cotyledon arches up through the ground in the shape of a loop and then gradually straightens itself out to reach the crook or flag leaf stage. Shortly after the crook stage you'll notice a second leaf coming through – this is the first true leaf (arrowed), which looks identical to the cotyledon. As more true leaves are developed the cotyledon begins to wither and fade away. It takes about a month from sowing to the first true leaf stage.

The initial emergence and growth of an onion crop can be slow due to low temperatures. As the days lengthen and the weather gets warmer new leaves are produced and the plant gets bigger. But at a certain stage leaf production stops and the plant switches over to bulbing. This is where the leaf bases begin to swell into fleshy scale leaves that go to form the familiar bulb. The environmental trigger for this change in development is day length. For spring sown varieties this equates to a day length of 16 hours which occurs in June. It

follows then that the more leaves we have before the switch-over takes place the bigger your bulb will be. And this is the reason why we need to sow our crop in early spring or by starting them off in modules under glass. And it is also the reason why sets are so handy – they establish and grow away quickly.

Sets are very small onion bulbs that are produced by late sowing and close spacing. By sowing late only a few leaves are formed before the switch-over to bulbing takes place and hence small bulbs are produced. These are then stored over-winter for planting in the following year.

Bulbing in the field becomes obvious when you notice the base of the onion beginning to swell during July and warm temperatures at this time greatly helps the process.

Harvesting windrowed onions in Co Dublin.

Onions, shallots and garlic all share the same ripening process. When the tops start to topple over, it's a sign that the crop is maturing and getting close to harvest. With the exception of garlic leave them for 2 weeks to complete the process and then lift with a fork. To store them successfully the crop has to be dried. If the weather is warm and dry the drying can take place outside; get the crop up off the ground onto something like suspended chicken wire to allow air to circulate and cover with plastic if rain threatens. But better still, bring them into a glasshouse or plastic tunnel and spread on staging for 2-3 weeks until the necks are completely dry. Any thick necked onions can be set aside for immediate use. Twist off the foliage and store the bulbs in trays, net bags or tie into onion ropes for hanging from rafters.

When applying nitrogen to onions it is normally split 50:50. With direct drilled onions apply half at sowing and the other half at the first true leaf stage. With sets and planted onions apply the first split at planting and the second about a month later. The latest date for nitrogen application is mid June.

Pests: thrips (mainly leek), bean seed fly (scallion)
Diseases: downy mildew (onion), rust (mainly leek), Botrytis leaf spot (onion), Botrytis neck rot (onion), white rot, white tip (leek), Cladosporium leaf spot (onion)

Onion, Potato

The potato onion is an old type of onion now seldom grown as it offers no advantage over other types of onion. You would only grow it for interest's sake. It is similar in growth to shallots where you get several small bulbs from one planted.

The potato onion bulbs should be planted in well manured ground from mid-February to mid-March. Plant in rows 30 cm apart and 20 cm between the plants in the rows.

Cover the bulbs to rather more than half their depth. Early in August, as the bulbs are ripening, they should be pulled up and left on the surface to dry. When thoroughly dry, they should be stored in a cool dry place. Reserve a quantity of the smaller, well-ripened bulbs for planting in the following spring. Planting stock of this type of onion is not commonly available.

Onion, Seed

Sow	Harvest
February – March	September

We can grow onions perfectly well in Ireland but the problem for the commercial grower is to get a couple of dry, fine weeks in September to harvest the crop. Drilled onions need a long season to provide yield and good bulbing development for harvesting in early autumn. But the advantage of seed onions over sets is they will store for longer, can have less problems with disease and there's a greater choice of varieties.

Direct drilled onions.

Sow the crop from mid-February to mid-March with the very latest date being the first week in April. For late sown crops apply irrigation if the weather is dry to get the crop off to a flying start.

Bull Necks
The formation of an unusually thick neck on an onion is called a 'bull neck'. It is difficult to dry these sorts of onion and as a consequence don't store well. The most common reason for this disorder is too much nitrogen either from too much manure or fertiliser, especially if topdressed too late. It tends to be worse in a wet year. It may also be related to a poor bulbing response brought on by low light levels and high rainfall. Late sown crops, late varieties and sets are the most prone. Use bull neck onions immediately and don't bother to store.

Most commercial crops are spaced to give a plant density of about 55 per m^2 – this gives a high percentage of bulbs in the pre-pack size grade of 50-70 mm. Plant populations can vary from 25 to about 85 per square metre depending on the size grade required. In respect of size, the greater the density the smaller the bulb, and visa-versa. So space your crop accordingly to your own specifications but don't go beyond 30 cm row widths. Some sample spacings are shown in the accompanying box using 25 cm rows as standard.

Spacing cm	Density per m^2
25 x 5	80
25 x 6	67
25 x 7	57
25 x 8	50
25 x 10	40
25 x 12	33
25 x 15	27

As onions are a slow crop to develop from seed and complete poorly with weeds it is imperative that you keep the crop well weeded throughout the season.

As an alternative to direct drilling, you can propagate your onions in modules under protection for planting out at a later stage. This method is well suited to the gardener who prefers to use seed to sets. Sow 5-6 seeds per cell between late January to mid-February and germinate on a warm bench if possible. Once

germinated the modules can be grown-on in a glasshouse or polythene tunnel. Plant out in early to mid-April at a spacing of 30x30 cm. The individual plants look far too close together but you'll be surprised at how they are able to elbow each other out of the way as the season progresses.

The number of seed/seedlings per cell has a major influence on the eventual size of onions produced. A seeding rate of 5 per cell will produce a lot of onions in the 60-80 mm size grade; if you up the rate to 8 or 9 per cell you will get a high proportion of 40-60 mm grade.

Varieties: Golden Bear F1, Hyton F1, Hygro F1, Hyfort F1, Vision F1, Red Baron, Hypark F1

Onion, Sets

Sow	Harvest
Early October	July
March – April	August

The easiest way to grow onions is by planting sets. These are small immature bulbs specially produced for planting. The advantage of sets over seed is they are quicker to establish and hence more accommodating in relation to time of planting, easier to weed and mature earlier. Plant in March to mid April but the season can extend from February to the end of April at a push. Ensure that late planted sets are watered if the weather is dry to make sure they get off to a rapid start. Spacing for sets is identical to spacing for seed onions so consult that section. However a common spacing is rows 23 cm apart with sets 10 cm along the row (43 per m^2). Use a trowel to plant sets about 2.5 cm deep rather than just pushing them into the soil, as they may push up out of the ground when the roots start to grow. If you plant them just covered with soil it will stop birds from rooting them up.

Sets can also be planted in the autumn for an over-wintered crop maturing in July. Plant in the first week of October.

Sets for the commercial market are sold in four size grades: 10-14 mm, 14-17 mm, 17-21 mm and 21-23 mm. The very smallest grade can lack vigour and the very largest grade can be more prone to bolting. The ideal size is 14-21 mm.

Set onions normally mature in August. Onions from sets do not store as long as onions from seed. They will store satisfactorily until about January, after which time they start to sprout.

Varieties:
Spring: Stuttgarter Riesen, Sturon, Setton, Hercules F1, Centurion F1, Red Baron
Autumn: Shakespeare, Troy

Grow your own sets
Just for the fun of it try growing your own sets. You are looking to grow a set somewhere between 14 to 21 mm in diameter, so correct spacing of the seed is critical. Ideally grow them in a glasshouse or polythene tunnel. If grown outdoors you will need to bring the seed trays indoors at the end of July to dry them off.

Variety: Sturon
Sow: second week May in a seed tray or suitably sized module
Spacing: 3x3 cm

Grow until the end of July and then stop watering to dry off the plants. In early September top and tail the dried sets with a scissors and store in a cardboard box placed in a cool dry place for winter storage.

Onion, Shallots

A shallot is a small onion, that when planted grows to give a small cluster of bulbs at harvest time – they will multiply up about 8-10 fold.

Shallots are quite hardy and can be planted in February or March 15 cm apart, in lines 30 cm apart. Plant with a trowel, leaving just the tips of the bulbs visible. When the leaves topple over and begin to die back sometime during July or

August, the clumps should be pulled up and left on the surface to dry. When thoroughly dry, they can be broken up and stored in a cool dry place. All the bulbs should not be used in autumn or winter; a quantity of the smaller, well-ripened ones should be kept back for planting in the following spring.

Shallots can also be raised from seed, with each giving rise to a single shallot. Sow in March or April in drills 10 cm apart with seeds spaced 4 cm apart in the drill; you require about 250 seeds per m^2.

Varieties: Golden Gourmet, Matador F1

Onion, Salad

Sow	Harvest
Mid August – mid September	May – June
March – June	July – October

Salad onions or scallions are a direct drilled onion crop sown quite thickly and harvested immature when they are about pencil thickness for use in salads. They are produced from outdoor production from May to October and imports from Mexico and Egypt supply the winter to early spring period.

Sow from March to June for cropping from July to October and the over wintered crop is sown during the last two weeks in August to mid-September for cropping from May to June. The early spring sowings can be covered with fleece to ensure a late June harvest.

Space the rows 15 cm apart sowing 40 seeds per metre run, and increase that to 50 for the overwintered crop to compensate for winter losses. The summer crop takes from 12-17 weeks from sowing to harvest depending on time of year. Sow every 2-3 weeks for succession.

Another approach to sowing scallions is to sow 10 seeds in a module cell and when large enough plant them out at a spacing of 25x20 cm. This means that when fit to pull you can harvest a bunch of scallions at a time.

There are two types of onion sown as salad onion. The old standard Allium cepa White Lisbon has been in cultivation since the late 1800's and is an excellent garden variety. There is a selection of it called White Lisbon Winter Hardy that is more suited to overwintering but more prone to bulbing in the spring. The newer Allium fistulosum or Japanese bunching onion has a more upright growth habit to White Lisbon, freer from bulbing but not suited to over winter production. Also not quite as good to eat.

Four row air drill sowing onions.

Varieties:
Allium cepa: White Lisbon, White Lisbon Winter Hardy, Lilia, Ramrod
Allium fistulosum: Savel, Green Banner, Ishikura
Allium cepa x fistulosum: Guardsman

Parsnips

Sow	Harvest
March – May	August – April

Parsnips are a root crop that will grow in a wide range of soils, more tolerant of heavy soils than carrots, and can be harvested from August through until March. Sowings are direct drilled from March to May. The March sowing can be covered with fleece for a mid July harvest.

Prior to sowing the surface should be forked over to a depth of about 10 cm and raked free of stones and clods. The seed should be sown in drills 30 cm apart and 15 cm apart in the drill, sowing 2-3 seeds per station. This spacing equals a plant population of 22 per sq m giving you a medium sized root. For larger roots go up to 30x20 cm. They will take from 2-4 weeks to germinate depending on the weather. Thin to one plant per station. Parsnips are one of

the hardiest of vegetables and can be left in the ground during the winter, digging them as required.

Varieties: Cobham Improved, Gladiator F1, Javelin F1, Countess F1, Palace F1
Pests: carrot fly
Diseases: canker, various leaf spotting diseases

Peas

Season	Sow	Harvest
Early	March	June – July
Main	April – May	July – August
Late	June – mid July	August – October

Peas are one of the most ancient and nutritious vegetables. There are three main types: shelled peas, mange tout and sugar snap. The traditional pea is the shelled type where you extract the peas and discard the pod; the more modern types are the mange tout and sugar snap where both peas and pod are eaten. The difference between the latter two lies in the development of the individual pea – the mange tout is underdeveloped in a flat pod, whilst the sugar snap has a developed pea in a thicker pod. The shelled peas can be divided into two types – round and wrinkled seeded – in the dried form. The round are hardier and used for early and late crops and wrinkled are less hardy and generally sweeter.

Sowing peas in a flat bottomed trench.

Sow from March to June, every two to three weeks for succession if required, in flat bottomed drills 5 cm deep, 15 cm wide, spacing the seeds roughly every 5 cm apart. Allow 90 cm between the rows. Could also be sown on a bed at a density of 50 per m^2 (seeds sown about 14 cm apart). Extra early crops of peas may be had by sowing first early varieties in pots placed in frames, early in

February and planting them out in April. Takes 7-15 weeks from sowing to harvest depending on sowing date.

On poor soil, where it is necessary to apply manure at the time of sowing, a trench should be opened 30 cm wide, and of the same depth, in which a layer of well-rotted manure should be placed, dug in and mixed with the soil from the trench. No nitrogen is required as pea roots develop nodules on their roots that fix nitrogen from the soil air.

Generally peas require some sort of support for the leaf tendrils to hold on to and for ease of harvest but the newer varieties are shorter than the older and easier to support. This is particularly the case with the semi-leafless varieties. Traditionally tree branches (especially Elm) were cut in winter and used to stake the pea crop. Nowadays it's more likely that plastic pea netting or sheep fencing will be used. Whatever you choose it's important that the support be placed to the peas before the stems bend, i.e. before they have reached a height of 10cm. Having said all that peas can be grown without staking but it's messier.

Varieties
Earlies: Early Onward, Meteor, Kelvedon Wonder
Maincrop: Hurst Green Shaft, Onward, Terrain
Mangetout: Oregon Sugar Pod, Snow Wind, Edula
Sugar Snap: Sugar Ann, Sugar Bon, Cascadia, Sugar Heart
Pests: pea and bean weevil, pea aphid, thrips, birds
Diseases: powdery mildew, root rot, leaf and pod spot, downy mildew

Potatoes

Season	Plant	Harvest
Early	March	June – July
Second Early	March – April	July – August
Main	April	September – October

Potatoes are a half hardy crop that originate from South America and first reached these shores around 1586. Being half hardy means that frost can cause problems. It can kill off newly emerged shoots from an early planted crop or damage tubers (potatoes) if the harvest is left too late.

The crop is grown from tubers; you can use your own but it's probably best to buy fresh seed annually that is certified free of disease. Seed about the size of a hen's egg is ideal. These should be planted whole, but in the event of larger seed being used, they may be cut into two sets. The tubers can be directly planted into the soil but it's advantageous to sprout them first as they will emerge more quickly and mature earlier. Buy your certified seed in February or March and place them upright in a tray placed in a light, cool, frost free place. After a month or so the tubers will have developed short (about 12 mm long), sturdy, dark green sprouts.

Potatoes can be divided into 3 types in order of harvest: Early (June), Second Early (July-August) and Maincrop (September-October).

The usual time for planting potatoes is March and April. Don't be tempted to go too early – ideally soil temperatures should around 7°C for three days before planting. Check the Met Eireann website first for the weekly agricultural report for your area – *Forecasts* > *Agricultural Data Report*. If you are inland where frost might be an issue don't plant before mid-March.

Early potatoes are planted in March. If well sprouted potatoes planted at this time they should be ready for use during June and July. Main crops are planted in April to early May.

Potatoes are traditionally grown in ridges or drills. Why? The edible portion of a potato is not a root but a stem tuber. Branch stems that grow underground

Potato tuber formation.

develop from axillary buds of the basal leaves, and towards their tips they swell to form tubers. This explains why we earth up the growing potato plant to cover those axillary buds, which will in due course grow out as underground stems and end up as a crop of potatoes.

Space the drills 70 cm apart for early and second early varieties and 75 cm for maincrop. Using a garden line to guide you, dig out a shallow trench with a shovel, and spread compost/manure (if you have it) and fertiliser along the base. Space the tubers out 25 cm apart in the row for earlies and 30 cm for maincrop. Open up a second drill parallel to the first and cover in the first trench with the soil from the second as you go along. Continue across the plot until you are finished to leave the ground roughly level.

The crop will require to be earthed up as it grows during the early part of the season. As mentioned, potatoes are prone to frost damage and if the shoots are showing and frost is forecast cover the exposed shoots with soil from between the rows. Ridge them up again when the emerged shoots are about 20 cm high. You need a soil covering over the top of the tuber of 10-12 cm for earlies and 15-17 cm for main crop. If necessary first loosen the soil between the rows with a hoe and then use a shovel to earth up.

If you are growing on beds potatoes can be planted on the flat. Dig over the bed, rake it level and plant the tubers using a trowel. Space them 30x30 cm at a depth to give a soil covering suggested above. If spacing them at this distance use smaller seed with 2-3 shoots per tuber. When planted on the flat there is no need to earth up unless planted shallower than recommended.

What makes for a good potato crop? A fertile soil with a full leaf canopy by the end of May to mid-June; and the development of a deep extensive root system which is important for water uptake. And keep potato blight at bay.

Slugs: if you find you crop riddled with holes along with hollowed out cavities the chances are that slugs are the culprit. The problem tends to be field or plot specific – it's a problem in certain fields but not in others. Slug attack tends to worse in wet years on heavy soils and varieties vary in their susceptibility. Varieties like Kerr's Pink, Maris Piper and Rooster are vulnerable; Golden Wonder, Nicola and Pentland Dell are among the least susceptible varieties. Two slug species are implicated: the keeled slug and the garden slug. The

problem with trying to counter the keeled slug is that it lives mostly underground and only comes to the surface to mate. Because of this applying slug pellets may be of limited use. Slugs will feed on tubers from late summer into the autumn; and essentially the longer you leave the tubers in the ground the greater the damage. For example in a trial they discovered that Maris Piper lifted on August 8th suffered 10% damage, lifted on October 3rd 30% damage and lifted in early November 45% were damaged. The following suggestions may help:

- Grow early or second early varieties as they are harvested early and hence less susceptible to slugs.
- For main crops apply two applications of slug pellets in mid-July and August. Alternatively use four half-rate applications.
- Consider the use of Nemaslug in early August; this is a species of eelworm that actively seeks out slugs and kills them. But it's not cheap and not 100% effective.
- Avoid growing susceptible varieties.
- If you do notice slug damage towards the end of the season lift the crop promptly as the damage will only get worse the longer the crop is in the ground.
- Do not get alarmed if you notice slug damage to the potato leaves as there is little if any connection between foliar and tuber damage; different species involved in both.

Harvest the earlies and second earlies direct from the drill when they are big enough and as you require them. The main crop haulm will naturally die back in the autumn allowing the crop to be lifted in October. If you wish you can cut the haulm off 3 weeks prior to lifting. Yields can be very variable but you get about 1-2 kg of tubers per plant. Store the crop in a dark, frost free shed.

Varieties:
Early: Home Guard, Duke of York, Coleen, Sharpe's Express
Second Early: British Queen, Maris Peer, Charlotte
Maincrop: Orla, Kerr's Pink, Rooster, Record, Pink Fir Apple, Cara, Setanta, Sante, Carolus, Sarpo Mira, Sarpo Axona (Axona is better flavoured than Mira)
For online information on varieties consult the AHDB Potato Variety Database.
Pests: slugs, aphids, wireworm, eelworm
Diseases: potato blight, black leg, pink rot, soft rot, dry rot

Pumpkin and Squash

Sow	Plant	Harvest
April – May	Mid May – Early June	September – October

Members of the genus Cucurbita come in a confusing range of colours, shapes and sizes. And to add to the confusion the common names of pumpkin and squash can be attributed to several different species of Cucurbita (but mostly *C. pepo*). But to keep it simple pumpkins are a type of winter squash and the other type you'll see mentioned is summer squash. Summer squash is a quick growing type utilized when immature as a table vegetable, whilst winter squash matures in the autumn, develops a thick skin, and can be stored over the winter (hence the name) in a cool frost free shed. Curcurbita species also encompass marrow and courgette.

Pumpkins are traditionally grown for Halloween for decorative purposes but pumpkins and squashes can be both edible and/or ornamental. They are vigorous annual plants that grow in a trailing and sprawling fashion, but some of the varieties have a more compact bush type of growth.

The squash family require a rich well drained soil and preferably one that hasn't grown squash for 3-4 years. Squash is reasonably tolerant of soil acidity growing down to pH 5.5. The crop only requires moderate amounts of nitrogen – about 40-140 kg/ha – depending on initial soil fertility.

With their origin mainly in Central America and Mexico they are all half hardy. Hence the crop is normally propagated under cover and planted out after the last frosts. Sow the seeds singly into large modules, 5 cm blocks or 7-8 cm pots at a temperature of around 20°C in late April or early May. Provide frost protection if necessary during the propagation stage. They could also be direct drilled when soil temperatures reach 11-12°C sometime in May, preferably through black plastic to improve soil temperatures and weed control.

Depending on location, plant out after 3-4 weeks from mid-May to early June. Plant two rows on a 1.4m bed, spacing the plants 85-90 cm apart, or from 1x1 m to 1.5x0.75 m on the flat.

Weed control can be awkward with this crop as it grows everywhere so best bet is to plant through black plastic which will keep down the weeds and keeps in the moisture. Alternatively use a combination of a stale seed bed, inter-row cultivations and hand weeding.

The only pests of note are slugs and then only at the planting out stage. However, disease is more problematic. The commonest is powdery mildew, which manifests itself as a white powdery coating on the leaves from mid-summer onward. A late attack is of no great importance but an early one will slow plant growth and induce premature senescence. A tank mix of Microthiol Sulphur and SB Invigorator can be effective as can potassium bicarbonate at 5g per litre applied weekly. Pumpkins are susceptible to rots which can occur either pre- or post-harvest. It is not fully understood why they rot. There may be a connection with a powdery mildew attack; Phoma has also been implicated. Pumpkins are not very good at curing damage to their skin and this can allow entry of fungal and bacterial organisms that may initiate rot; so harvest and handle with care. Watch nitrogen levels in the soil – excessive amounts will increase the degree of rots.

Harvesting usually takes place in September when the foliage has died back and the fruit has turned colour. Whenever possible the pumpkins and squashes should be allowed to fully ripen on the vine – the fruit will have a hollow ring when tapped – but harvest before the first frosts. The fruit are normally cut and windrowed in the field for a period to allow curing to take place, prior to collection into wooden bins and initial storage under glass or plastic. When removing pumpkins from the plant snap

Ornamental gourds.

the stem at the knuckle to leave a handle 10-15 cm in length – if too short there's a greater likelihood of disease rotting organisms gaining entry. Curing allows the stem to seal and the skin to harden. In a poor summer the crop can be slow to turn colour and if a small bit of colour only is present curing can take place indoors in a well-ventilated glasshouse, tunnel or shed – ideal temperature is 25°C for about 2 weeks.

The storage life of winter squash ranges from 2 to 6 months depending on the cultivar. Most cultivars of winter squash store longer than pumpkin cultivars. Store at 7-13°C and at 60 to 75% relative humidity.

Pumpkin yield: 1-2 per plant; 1.5 is a good average.

Varieties:
Pumpkin: Baby Bear, Rocket F1, Paint Ball F1, Summer Ball F1, Mars F1
Winter Squash: Hunter F1, Harrier F1, Crown Prince F1, Turk's Turban
Summer Squash: Summer Mix F1
Pests: slugs, rats
Diseases: powdery mildew, rots, scab

Radish

Radish which comes in a number of different shapes and sizes is divided into two main types: summer and winter. Summer radishes are quick growing maturing in 4-8 weeks and are used in salads. Winter radish is ready in 8-10 weeks and is much larger than its summer cousin; it can be eaten raw in salads or cooked like turnip or swede.

Sow summer radish from March to August and winter varieties from July to August. The summer crop can be thinly sown to aim for a final spacing of 15x3 cm. Allow more room for the winter crop – 15x15 cm. Summer radish can be harvested when quite small – about 2 cm in diameter. They can go woody quite quickly so only sow in small batches and every two weeks if succession is required.

The summer crop needs to be grown quickly so make sure to keep it well watered in dry spells.

Varieties:
Summer types: Cherry Belle, French Breakfast, Sparkler, Rudi
Winter types: China Rose
Pests: flea beetle, slugs, cabbage root fly
Diseases: downy mildew, Rhizoctonia root rot

Rhubarb

This is an extremely useful early vegetable and a good plantation may remain in production for many years.

Rhubarb requires a deeply worked free draining soil well manured and free of weeds. Farmyard manure is beneficial and should be applied in the autumn prior to planting or the ground may be fertile enough after a previously heavily manured crop such as potatoes; fertiliser requirements can be made up by subsequent topdressings.

Planting material may be obtained by dividing up two to three year old stools into a number of portions, each portion or set as it is called, should have at least one bud and a fair portion of a root system. Plants raised from seed are likely to be variable and are best avoided.

Plant anytime during the winter up to March if weather and soil conditions are suitable. Sets should be planted about 1 metre apart each way and sufficiently deep that the crowns are level with the surrounding soil. When growth starts a dressing of 30g sulphate of ammonia per m^2 should be given to help build up the root system. It's best not to pull the stems the first season after planting to allow for good establishment. When the leaves have died down in the autumn farmyard manure should be put around the crowns without covering them.

The rhubarb harvest normally starts in February in mild areas in the south and in March further north in the country. During the pulling season an occasional application of liquid manure or sulphate of ammonia will help to promote a

further flush of leaves. Take around a third to one half of the stems per stool at any one harvest leaving the rest to allow regrowth of new shoots. When pulling the sticks, put your hand down near the base of the stem and ease it out of the ground. Finish pulling in August or September to allow the plant to rebuild its reserves for the following year's crop. A simple method of forcing rhubarb for an early supply is to invert a tub over the crown at the end of January.

It may happen that some of the stools occasionally throw up flowering shoots. These should be removed to stop the plant from expending its energy into flower and seed production. Most commonly seen in the season following a wet summer.

Varieties: Timperely Early, Victoria
Pests: slugs
Diseases: leaf spot (Ramularia), crown rot (Erwinia), downy mildew

Seakale

Seakale may be propagated either from seed sown in late March or early April, or by means of root cuttings. Planting roots can also be purchased from horticultural seedsmen. When planting out permanently remove all buds except one, and place the rooted plants in lines 60 cm apart allowing 38 cm between the plants in the lines.

Plants are then encouraged to grow luxuriantly until the following January when preparations for blanching should begin. The crowns can be covered with special earthenware pots, or alternatively, with flue liners covered on top with tiles or slates. Fermenting manure, if placed round these coverings, will provide gentle warmth and force the crop.

Very good blanched seakale can be obtained by heaping fine cinder ashes, sand, sawdust or dry peat moss over the crowns. Blanching can also be done in certain well-drained soils by covering the crowns with earth from alleyways.

When blanching is finished and the crop harvested, the materials used for blanching should be removed and the plants encouraged to grow vigorously and naturally through the summer, removing flower heads as they appear. In spring a dressing of a balanced fish meal or meat-and-bone meal fertiliser plus sulphate of potash should be given.

Spinach

Sow	Harvest
March – September	January – December

Black bean aphid on spinach.

For years spinach was a less than popular garden vegetable until rescued by the arrival of baby leaf spinach on the supermarket shelf. Baby leaf is the exact same as standard spinach just harvested at a small plant stage. It likes rich ground and is one of those crops that will benefit from the addition of compost or manure to the soil.

Spinach is one of the most sensitive plants to long days. Just one summer's day of 13 hours will induce flowering (bolting) in certain varieties. Hence traditionally the best time for spinach production was autumn, winter and spring, along with the oft repeated advice that summer sowings should be made little and often. However modern varieties have been bred to be much more bolt resistant.

Sow in 30 cm rows eventually thinning to 5-15 cm apart. Ensure the variety you pick is sown at the correct time. Correct variety notwithstanding, dry hot weather can trigger bolting so shade will help and water during dry spells. For milder areas late sowings made in August and September will yield from October to April.

Downy mildew can be an issue with this crop, and the best defence against it is to look for varieties with the greatest degree of inbuilt resistance. You may see that a certain variety is resistant to a certain number of races of downy mildew e.g. races 1-11, and the higher the number the better. If the variety you are using comes down with mildew try a different variety next time round.

Baby leaf spinach is sown from March to first week September and takes from 3-7 weeks to yield depending on time of year. Sow at a density of 500-700 seeds per sq m in rows 7.5 cm apart.

Varieties: Amazon F1, Medania F1, Rubino F1, Helios F1
Pests: black bean aphid, bean seed fly, caterpillar
Diseases: downy mildew

Spinach, Perpetual

Sow	Harvest
April – August	January – December

Perpetual spinach is neither perpetual nor spinach. It's a biennial plant that goes to seed the year after it's sown, but will give an almost year round supply of leaves – February is a difficult month and plants are beginning to bolt in April and May. Also known as spinach beet or leaf beet this old style vegetable looks and tastes much like spinach but in fact is a member of the beet family. It has never been bred to any extent and is usually available from the seedsman simply as perpetual spinach or as a named selection. Years ago growers in Rush always kept a few plants aside for home saved seed.

It is sown from April to mid-August. Will bolt if sown too early but unlike spinach is resistant to summer bolting. Direct drill the seed 3 cm apart in 40 cm rows. Will get 2-3 cuts per sowing. For single plants sow much wider and thin to 25-30 cm apart. The March sown crop will begin to crop in mid-June. The commercial crop is totally cut away with a second cut taken three weeks later after topdressing with nitrogen. On a garden scale the individual outside leaves can be taken from low down on the plant. The late crop in mid-August will come in late September-October and repeat harvests can be obtained from November through to May with the caveats already mentioned. The other possibility is to produce under protection (glass or polythene) from October to June. The pests and diseases listed below also attack Swiss chard.

Pests: leatherjacket, flea beetle, leaf miner, aphid, slugs
Diseases: leaf spot, downy mildew, powdery mildew, rust

Swiss chard

Sow	Harvest
March – August	January – December

Swiss Chard or leaf beet is very closely related to perpetual spinach and beetroot and is in the same family as spinach. It is a hardy and versatile leafy vegetable that also looks very decorative. It's similar to spinach but a single sowing will last longer and is less likely to bolt. The original Swiss chard of green leaves and broad white stalks has now being joined by all sorts of colourful types.

Chard is cultivated like perpetual spinach. Sow from March to July at a spacing of 30x20 cm. Two sowings will generally suffice – April and July. The latter sowing will overwinter to crop again in the spring. Harvest the outer leaves by twisting them off working towards the centre. Overwintered plants will go to seed in late spring.

Varieties: Swiss Chard White Silver, Rainbow Chard, Rhubarb Chard, Swiss Chard Bright Yellow

Swiss chard.

Swede

	Sow	Harvest
Early crop	March (under protection)	July on
Early maincrop	April	August on
Maincrop	May	September on
Late maincrop	June	November on

Swedes are a traditional winter vegetable, that's now available all year round in the shops. It's a hardy vegetable well able to withstand most frosts but can bolt if sown too early.

Swedes will grow on a wide range of soils and have a low nitrogen requirement. It's a crop suited to slow steady growth but if conditions are too rich they will grow too fast, split, and develop soft rots. A warm wet August combined with an over fertilised crop are the classic condition for cracks and splits to develop. So it's best not to apply any compost or manure prior to sowing the crop and watch the nitrogen. They are also tolerant of relatively low pH (see Table 1 in the Appendix).

The crop is normally direct drilled but early crops can be sown under protection in modules and planted out. Single seed the cells and plant out a month later in April using a wide spacing (30 cm) and cover with fleece if extra earliness is required. The direct drilled crop is sown from April to mid-June with the main crop sown in May. At a push one can sow to the end of June. Drill 2 cm deep. In comparison to turnips swedes are quite a slow crop to develop but will stay fit for harvest for many months. It takes about 15 weeks for the first ones to come fit. Late sown crops in June will allow the crop go out to spring harvest with reduced woodiness developing in the roots. At the tail end of the harvesting period the crop will send up flowering shoots in April – by keeping these topped the season can be extended by a few weeks.

Crop density usually varies from 10-16 plants per m^2 with around 13 per m^2 fairly typical for a commercial crop that requires a 0.8-1 kg head weight. Early

swedes are about 500g. You can experiment with different spacings depending on your requirements but try 40x20 cm that equals 12.5 per m^2. For early or late crops increase the spacing a bit to 40x25 or 40x30 cm.

Swedes are prone to a disorder called 'Brown Heart' which is caused by a deficiency of boron, that can be particularly prevalent on high pH soils. If you come across the problem apply 2-4 g per 10 m^2 of Borax at the 4 leaf stage to prevent its occurrence in subsequent seasons. Commercial growers spray routinely for this common problem along with using a boronated compound.

There are two pests that can cause trouble. If you notice pin-prick holes in the leaves when the plant is small, particularly during a spell of fine weather, it's probably flea beetle. If you spot white maggots feeding on the roots it's more than likely to be those of cabbage root fly. In both cases the best way to avoid them is to use crop covers, either fleece or bionet. Most of the commercial crop is now covered with insect nets. Egg laying by cabbage root fly begins at the two leaf stage of the crop so get on the nets before then and leave them on until the end of September. If you delay your sowing to late May you'll avoid the first generation of cabbage root fly, which is always significantly worse than the second generation which occurs from July to September. Swedes are also prone to downy mildew but is normally not a problem as the crop will grow out of it. In warm dry summers powdery mildew can make an appearance and if desired can be controlled with sulphur sprays.

Magres which was introduced in 1980 is the standard commercial swede variety. It's a very versatile high dry matter variety. This means that it's hardy in most winters but also renders it tough to chop in the kitchen when it reaches maturity. Magres is prone to downy mildew but is resistant to powdery mildew. Marion and Invitation have good resistance against clubroot and powdery mildew. Helenor has an attractive dark purple colour with a sweet taste. Gowrie is a low dry matter Scottish variety that exhibits vigour, good resistance to downy mildew and is suitable as an early variety; prone to frost. Hybrid varieties are a new development in swedes and the best of them is Tweed which is a vigorous variety well suited to less fertile soils and produces uniform globe shaped roots.

Varieties: Brora, Helenor, Marion, Ruby, Magres, Gowrie, Invitation, Tweed F1
Pests: cabbage root fly, flea beetle, aphid, caterpillar
Diseases: powdery mildew, downy mildew, crater spot, dry rot (Phoma), club root

Swede crop covered with a 1.3 mm net to keep out cabbage root fly. A 0.8 mm net will in addition keep out flea beetle and reduce aphid attack.

Sweetcorn

	Sow	Plant	Harvest
Early	April (glass) April (plastic mulch)	May	August August
Main	May (glass) May	Early June	September – October September – October
Late	Late May – Early June		October – November

Sweetcorn developed thousands of years ago as a natural variant of maize which is a native of Central America, probably Mexico. It was brought to Europe by Columbus and subsequently spread worldwide to become one of the most important food crops for mankind. Sweetcorn differs only in a single gene from maize which slows down the conversion of sugar to starch. This produces kernels with a high sugar content and pleasant texture in contrast to the starchy grains of maize. It now only exists in cultivation and as such could be called a man-made crop.

This vegetable was transformed for the commercial grower by the development of supersweet varieties in the mid 1980's. These varieties possess sh2 genes which causes them to convert much less of their sugar to starch to produce kernels about 30% sweeter

than the standard ones (known as normal sugar), but more importantly hold their sweetness for longer. The old varieties, once ripened, quickly converted their sugars into starch and had to be used immediately. Another type you may come across in catalogues is the 'extra-tender sweet' variety which is a sweeter and less chewy version of the supersweets.

Sweetcorn is one of the half-hardy vegetables and is better suited to the warmer eastern and southern parts of the country. But the development of new varieties has rendered the crop less susceptible to the vagaries of an Irish summer. That said it will always do better in a warm summer and select a warm sheltered site if possible. It is doubtful whether commercial production of this crop would be financially viable except in the most favourable parts of the country.

Most of the varieties available are hybrids. The supersweet and extra-tender varieties can be grown together but must be separated from the normal sugar varieties plus the whites and multi-coloured types. All varieties must be isolated from forage maize by at least 75m as the starchy character of maize is dominant to the sweet character of sweetcorn. If you're growing sweetcorn in one of the colder areas of the country you'd be advised to stick with using just the early varieties such as Earlibird or Northern Xtra Sweet.

Maize is grown commercially in Ireland for silage production and a lot of the crop is direct drilled through a strip of biodegradable clear plastic. The plastic increases the soil temperature by about 2-4°C which generates better growth especially for earlier sown crops. Maize requires a temperature of 10-12°C to germinate and doesn't thrive at air temperatures of less than 10°C.

Unusually for a vegetable crop it's a member of the grass family (Poaceae) and as such is wind pollinated. For this reason sweetcorn is sown or planted in blocks to allow the pollen produced by the male tassels produced at the top of the plant to fertilise the female flowers known as cobs.

Sweetcorn can be either direct drilled or transplanted. It's not a crop that takes to transplanting well from bare roots so always propagate the seed in pots or modules. Sow 2.5 cm deep in large modules or pots under glass in mid-April to early May and plant out when the seedlings are 10 cm tall, sometime in May. Don't delay too long in getting the plants out – it only takes 3-4 weeks under glass to have a plant fit enough to plant out. Plant in a block formation at a spacing of 45x45 cm or 45x40 cm for a higher

density – plant population for sweetcorn can vary from 4.8-6 plants per m^2. Alternatively direct drill the crop outdoors in May to the first week in June. In warmer parts of the country and if drilled under clear plastic an early crop could be sown in April. The earlier drillings can with advantage be covered with fleece until well established, particularly if the weather is on the cool side. If not covered by fleece or plastic crops probably shouldn't be drilled until mid-May. For succession under plastic suggest direct drilling in mid-April, early May and mid-May.

Sweetcorn is quite a nitrogen demanding crop. Up to 70 g/m^2 of sulphate of ammonia can be used split half at sowing or planting and the other half a month later.

Sweetcorn can be harvested from August through to October. The silks which hang from the developing cobs turn brown shortly after pollination and to a dry dark brown when the cob is close to harvest about 30 days later. The final test of ripeness is to push a fingernail into one of the grains – if the liquid runs clear it's unripe; if it's milky it's ready to harvest. You will normally harvest 2 cobs per plant. The top cob matures first followed by the one further down the plant. The supersweet varieties will last satisfactorily in a fridge up to a week.

Varieties
Normal sugar: Sundance F1
Supersweet: Northern Xtra Sweet F1, Earlibird F1, Mainstay F1, Seville F1
Extra-tender: Lark F1, Lapwing F1, Wagtail F1
Pests: aphid
Diseases: rust

Sweet Potato

Sweet potato, despite its name is not related to the potato but is a member of the bindweed family; and as its name suggests, it's a good deal sweeter than the ordinary potato.

The sweet potato was probably domesticated in Mexico but possibly in South America, some 8,000 years ago. Much later, after Columbus discovered the New World in 1492, European sailors introduced the sweet potato to Africa and then Asia. Interestingly, the sweet potato was being grown in Oceania before Columbus, but the routes of introduction are still debated.

As it's a semi-tropical plant it must be planted under protection, either glass or plastic. Grows best at 21-26°C.

Sweet potato is grown from slips or rooted cuttings (plug plants) which can be purchased. To produce your own slips get a tuber and stick it in peat in a warm glasshouse and it should produce 10-15 cm sprouts in 4 or 5 weeks. Take a cutting and put it into a small pot covered with a plastic bag – burying it 2-3 nodes deep. Grow in a warm place for about 3 weeks until established. It will root from the cut stem area and also from the nodes.

Plant on a shallow mound at 30x75 cm spacings under protection in late May to early June. Density is 4.5 per square meter. Takes 100 to 120 days to maturity. Pest and disease not generally problematic but keep an eye out for aphids. Slugs can graze the tubers and red spider mite can feature along with sclerotinia if either of these two are present in the glasshouse or polytunnel.

In early autumn when you notice the crop beginning to turn yellow and die back, harvest the tubers. You can leave them to get bigger but they need to be lifted before the first frosts.

Varieties: Evangelina (orange), Beauregarde (orange), Bonita (white)
Pests: aphid, slugs

Tomato

	Sow	Plant	Harvest
Glass	February	April	June - October
Plastic	March	May	July - October
Outdoor	April	June	August - October

Tomatoes are a half hardy vegetable that give the best results when grown in a glasshouse or polythene tunnel. That said, if you have a sheltered warm spot in your garden or allotment, you can try growing them outdoors. There are two types – bush (or determinate) and cordon (or indeterminate). The bush varieties require little

staking but don't yield as well as the more traditional cordon types which require both staking and side shooting. Bush types are possibly more suited for containers or pots and would recommend the cordon type for the vegetable garden.

Outdoor tomatoes are raised under protection and planted out in June when all frosts are gone. You can propagate your own plants or more conveniently buy them in at planting time. Sow 1-2 seeds in a 8 cm pot sometime in April, about 8 weeks before your chosen planting date sometime in June.

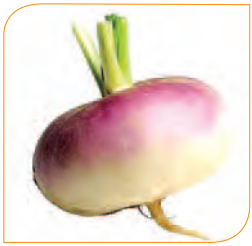
You require a plant density of about 4 per m^2 so space them at 50x50 cm and put a 1.2 m stake beside each plant. As the plants grow they will have to be tied into the stake and the little side shoots that develop in the leaf axils need to be removed by snapping them off when they are about 3 cm long.

Tomatoes are heavy feeders so they would be a good crop to receive manure or compost and when watering apply a liquid feed as standard. Pinch out the growing point in August two leaves above the last flower truss – this is to get the plant to put all its energy into developing and ripening the fruit before the first frosts of autumn.

Varieties: Gardener's Delight (cherry), Sungold (cherry), Sweet Apertif (cherry), Alicante (round), Ailsa Craig (round), Ferline (beefsteak)
Pests: caterpillar, slugs
Diseases: potato blight
Disorder: blossom end rot (calcium deficiency)

Turnip

Turnips are a quick growing crop maturing in as little as 6 weeks from sowing. They come in a variety of shapes – flat, round or long – and in a variety of colours – purple, green or white. It's a versatile crop that can be harvested when small and eaten raw or left to grow in size and cooked; the tops can also be harvested like spring greens from a late summer sowing.



A small sowing should be made about every three to four weeks from March to August in drills 30 cm apart and 2 cm deep. Sow thinly and gradually thin out to 5-15 cm apart. Start harvesting when they are golf ball sized for salads or grow on to tennis ball size for cooking.

The main problems will stem from attack by cabbage root fly, flea beetle and slugs. Your best bet is to cover the crop with fleece for the first two and a small amount of pellets to keep slugs at bay. As with any quick maturing crop water the crop during dry spells.

Varieties: Oasis, Purple Top Milan, Goldenball, Green Globe, Sweetbell F1
Pests: Flea beetle, cabbage root fly, slugs
Diseases: downy mildew

Herbs

There is a very wide selection of these useful flavouring plants and only the enthusiast grows all of them. Room should be made in every garden for few of the more commonly used kinds. Choose a warm, sunny site for your herb garden.

Thyme: Sow seed in April and thin or transplant to 15 cm apart. Will last for several years.

Mint: Plant in October or March in a cool, rich soil. Cut down the tops in autumn and cover with 5 cm of manure or compost.

Sage: Grow from seeds in April or cuttings in July or August. Plant 40 cm apart in a dry position. Each spring prune back the branches to ensure a supply of fresh growth.

Chives: Clumps may be bought from seedsmen and planted in early spring. Leaves are cut during summer as required.

Coriander: This annual plant is grown for both its leaves and seeds. Direct drill from March to July for harvesting from May to October. For May harvest sow

under protection or in a garden frame. Sow every 3 weeks for succession. This crop is prone to bolting so keep well watered to prevent checks to growth. This plant hails from the Mediterranean and doesn't thrive outdoors in cool, wet summers. Coriander is surprisingly cold hardy once established.

Parsley: There are two types of this popular herb: curly and flat leaved. The flat version is the more flavoursome of the two. The seed should be sown in March/ April, in lines 45 cm apart and thinned to 10 cm apart. A sowing may also be made in June/ July for winter and spring use. Parsley can also be raised in modules and planted out. It's a biennial plant and several cuttings can be taken from a single sowing before the plants go to seed in May or June.

Tender and out of season vegetables

Dutch lights, polythene tunnels or polythene mulch will be found of great assistance in raising out of season and frost tender vegetables.

Dutch light frames – Dutch lights consist of a single frame of 600g glass measuring 142 x 73 cm slipped into grooves on the long sides of a light wooden frame. These lights can be used to cover a frame with 60 cm back wall and 45 cm front wall. The frame may be heated by electric cables or crops may be grown without heat.

Polythene Tunnels – These are of two main types:-
(1)Low tunnels which have replaced cloches. A roll of 150 gauge polythene is supported by wire hoops and secured by twine. These tunnels are very useful for low growing crops or for providing shelter in the early stages of a crop's development.
(2)Walk in tunnels – these are a low cost alternative to glasshouses. Polythene (600 gauge) is drawn tight over galvanised metal tubing forming a semicircular shape. These tunnels can be used for raising plants or growing more tender or out of season vegetables including tomatoes, cucumbers, melons, aubergines and sweet peppers.

Black Polythene mulches – If black polythene is laid on the ground and secured at the edges, many tender crops grow better than if planted into the open ground. The best system of culture is to raise the plants indoors or in a heated

frame or glasshouse and to plant through holes in the polythene mulch when all danger of frost is gone. Tomatoes, gherkins, marrows and sweet corn benefit especially from these mulches.

Cropping Programmes – Under any of the above systems careful planning and management are needed if the protected area is to be utilised to full advantage. Suitable varieties should be used and dates of sowing and transplanting carefully studied. Many variations in cropping programmes can be employed. Early sowings of carrots in January will mature in May and can be followed by tomatoes, cucumbers, peppers or aubergines which in turn can be followed by lettuce. Alternatively lettuce can be succeeded by celery planted in late July for harvesting in early December.

APPENDIX

Table 1: Guide to pH values below which crop growth is affected

Crop	Soil pH	Crop	Soil pH
Asparagus	5.9	Mint	6.6
Bean	6.0	Mustard	5.4
Beetroot	5.9	Onions	5.7
Broccoli	6.0	Parsley	5.2
Brussels sprouts	5.7	Peas	5.9
Cabbage	5.4	Potato	5.0
Carrot	5.7	Rhubarb	5.4
Cauliflower	5.6	Spinach	5.8
Celery	6.3	Sweetcorn	5.5
Chicory	5.2	Swede	5.4
Leeks	5.8	Tomato, outdoor	5.2
Lettuce	6.1	Turnip	5.4

The above picture shows a swede plant growing in a mineral soil at a pH of 4.9. Notice the cupping of the leaves with a pale outer rim to the leaves that are characteristic symptoms of manganese toxicity.

Table 2: Guide to depth of sowing

12-20 mm	20-25 mm	25-38 mm	38-50 mm
Beetroot	Broccoli	Pea	Broad bean
Carrot	B. sprouts	Sweet corn	French bean
Leek	Cabbage		Runner bean
Lettuce	Cauliflower		
Onion	Cucumber		
Parsley	Marrow		
Parsnip	Radish		
Spinach	Swede		
	Tomato		
	Turnip		

Table 3: Soil sample laboratories

Any local Teagasc office will accept samples **www.teagasc.ie**
Southern Scientific Services Dunrine, Killarney, Co Kerry Tel: 066 - 976 3588
F.B.A. Laboratories Ltd Carrageen Industrial Estate, Cappoquin, Co Waterford Tel: 058 - 52861
EURO Environmental Services Unit 35, Boyne Business Park, Drogheda, Co Louth Tel: 041 - 9845 440
IAS Laboratories Unit 4, Bagenalstown Business Park, Bagenalstown, Co Carlow Tel: 059 - 9721 022
Dairygold Feed Laboratory Lombardstown, Mallow, Co Cork Tel: 022 - 47275

What's in a name?

The common name of a vegetable can vary depending on the part of the world you live in. Swedes are frequently called turnips in Ireland, neeps in Scotland and rutabaga in northern America. French beans have very little connection with France other than it was a crop popularised by the French Canadians in that part of the world. And it has a confusing list of other common names: kidney; bush; pole; snap; string; green; wax; haricot; flageolet. But Brussels sprouts do indeed come from Brussels having originated in and around that area in the middle ages.

Many years ago the term 'broccoli' referred to winter cauliflower which was grown long before we grew the present day broccoli in these latitudes. Broccoli is also called calabrese which refers to that part of Italy called Calabria. This crop was initially grown in the 1970's for processing in Banagher Co Offaly and whilst initially referred to as calabrese, nowadays most growers call the crop broccoli. Broccoli has also been called green broccoli to distinguish it from purple or white sprouting broccoli – these are all forms of *Brassica oleraceae* var *italica* which originated in the eastern Mediterranean including the Calabrian area of southern Italy.

York cabbage is a distinctly Irish term and refers to a pointed cabbage; growers will refer to 'spring York' or 'summer York' meaning any pointed variety of cabbage maturing at those times of year. Where does the name come from? According to Mike Day of NIAB York was a very old pointed variety probably introduced into England before 1763 and presumably linked with the city of York; it was phased out because it was very loose. And the name must have been kept on in Ireland as a generic term for pointed varieties in general.

Mention the term 'Early London' and a Rush grower will immediately think of early cauliflower. The name comes from a variety of early cauliflower that was grown in the Rush area many years ago – the variety is long gone but the name lives on as a generic term for the first of the new season's crop. Traditionally the crop was sown under glass around mid-October, planted out as bare roots in early March and would crop from the third week of May on. Early London's are no longer grown having been taken over by module plants.

Table 4: Seed companies

Suttons Seeds Woodview Road Paignton Devon TQ4 7NG	Thompson & Morgan Poplar Lane Ipswich IP8 3BU
Europrise Blakes Cross Lusk Co Dublin	Mr Fothergill's Kentford Suffolk CB8 7QB
Kings Seeds Monks Farm Kelvedon Colchester Essex, CO5 9PG	Moles Seeds Turkey Cock Lane Stanway Colchester Essex, CO3 8PD
Gold Crop Rush Co Dublin	Dobies Long Road Paignton Devon TQ4 7SX
Irish Seed Savers Association Capparoe Scarriff Co Clare	Tamar Organics Cartha Martha Farm Rezare, Launceston Cornwall, PL15 9NX
M.G. Seed Company (Moles Seeds) Sutherland Ratoath Co Meath 087 - 262 3133	Klaus Laitenberger Alderwood Eden Point Rossinver Co Leitrim

Vegetable aphids (greenfly)

Crop	Species	Occurrence
Beans Spinach	Black bean aphid *Aphis fabae*	Common
Brassicas	Mealy cabbage aphid *Brevicoryne brassicae*	Common
	Peach-potato aphid *Myzus persicae*	Frequent
Carrots/Celery/Parsley	Willow-carrot aphid *Cavariella aegopodii*	Common
	Carrot root aphid *Pemphigus phenax*	Uncommon
Lettuce	Potato aphid *Macrosiphum euphorbiae*	Common
	Peach-potato aphid *Myzus persicae*	Common
	Lettuce aphid *Nasonovia ribisnigri*	Frequent
	Lettuce root aphid *Pemphigus bursarius*	Uncommon
Peas	Pea aphid *Acyrthosiphon pisum*	Common
Potato	Potato aphid *Macrosiphum euphorbiae*	Common
	Peach-potato aphid *Myzus persicae*	Common
	Glasshouse-potato aphid *Aulacorthum solani*	
Sweetcorn	Cherry bird aphid *Rhopalosiphum padi*	Common

Table 5: Latin names of vegetables

ALLIACEAE		
Allium cepa	Var ascalonicum	Shallot
	Var cepa	Onion, salad onion
Allium fistulosum		Japanese bunching onion
Allium porrum		Leek
Allium sativum		Garlic
Allium schoenoprasum		Chives
APIACEAE	Formerly Umbelliferae	
Apium graveolens	Var dulce	Celery
	Var rapaceum	Celeriac
Coriandrum sativum		Coriander
Daucus carota		Carrot
Foeniculum vulgare	Var azoricum	Florence fennel
Pastinaceae sativa		Parsnip
Petroselinum crispum		Parsley
ASTERACEAE	Formerly Compositae	
Cichorium endivia		Endive
Cichorium intybus		Chicory/Radicchio
Cynara scolymus		Globe Artichoke
Helianthus tuberosus		Jerusalem Artichoke
Lactuca sativa		Lettuce
BRASSICACEAE	Formerly Cruciferae	
Armoracia rusticana		Horseradish
Brassica napus	Var napobrassica	Swede
	Var napus	Oilseed rape
Brassica oleraceae	Var acephala	Kale
	Var botrytis	Cauliflower
	Var capitata	Cabbage
	Var gemmifera	Brussels sprouts
	Var gongylodes	Kohlrabi
	Var italica	Broccoli/calabrese

Table 5: Latin names of vegetables *continued*

Brassica rapa	Var chinensis	Pak choi
	Var nipposinica	Mizuna
	Var pekinensis	Chinese cabbage
	Var rapa	Turnip
Eruca versicaria	Subspecies sativa	Rocket
Nasturtium officinale		Water cress
Raphanus sativus		Radish
Rorippa x sterilis		Garden cress
CHENOPIACEAE		
Beta vulgaris	Subspecies cicla	Leaf beet, Swiss chard
	Subspecies vulgaris	Beetroot
Spinacia oleraceae		Spinach
CUCURBITACEAE		
Cucumis melo		Melon
Cucumis sativus		Cucumber, Gherkin
Cucurbita pepo		Marrow, Courgette
FABACEAE	Formerly Leguminosae	
Phaseolus coccineus		Scarlet runner bean
Phaseolus vulgaris		French bean
Pisum sativum		Pea
Vicia faba	Var major	Broad bean
POACEAE		
Zea mays	Var saccarata	Sweet corn
POLYGONACEAE		
Rheum x cultorum		Rhubarb
SOLANACEAE		
Capsicum annum		Sweet pepper
Capsicum frutescens		Chilli pepper
Lycopersicon esculentum		Tomato
Solanum melongena		Aubergine
Solanum tuberosum		Potato

Vegetable production guide

Crop	Season	Sow	Plant	Spacing cm	Harvest
Bean broad	Early Main	Oct – Nov Feb – May		23x23 60 rows	Early June on June – Sep
Bean French		Mid May – June		45x8	July – October
Bean runner		Mid May – June		60x20	Aug – Sep
Beetroot		Apr – July		25x4	July – March
Carrots	Early Main Late	Feb – March April – May June		15x7 15x5 15x5	July – Aug Sep – March
Celery	Early Main Late	March April May	May June July	30x30 30x30 30x30	Aug – Sep Sep – Oct Nov – Dec
Courgettes	Main Late	April – May June	May – June June – July	80x80 90x75	July – Sep Sep – Oct
Garlic	Early Main		Oct – Nov Feb – Mar	20x20 20x20	May – June July – Aug
Leeks	Early Main Late	Jan – Feb March April	April May – June June – July	30x20 30x15 30x20	Aug – Sep Oct – Feb March – Apr
Onion	Shallot Sets Seed	 Feb-March	Feb – Mar Feb – Apr Early Oct	30x15 25x10 25x10 25x7	July – Aug August July Aug – Sep

Vegetable production guide *continued*

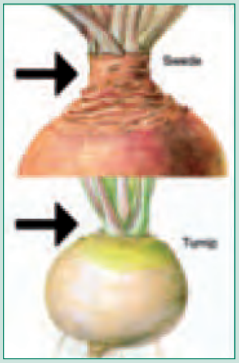
Crop	Season	Sow	Plant	Spacing cm	Harvest
Parsnips	Early Main	March April – May		30x15	July on Aug – March
Parsley	Early Main	September March – July		45x5	May June on
Peas	Early Main Late	March April – May June		90 rows	June – July July – Aug Sep – Oct
Potatoes	Early Main		March April	70x25 75x30	June – July Aug – Oct
Radish		March – Aug		15x3	May – Oct
Rhubarb			Winter time	1x1 m	March – Aug
Scallions	Early Main	August (last 2 weeks) Feb – June	Sow 20-30 seeds per 30 cm	25 cm rows	April – May June – Oct
Spinach	Early Main	September Mid Mar - July		30x15 30x15	March – April June – Oct
Swede	Early Main Late	March (fleece) April – May June		40x23 40x20	July Aug – March October on
Sweetcorn	Early Main Late	April (glass) May Early June	May	45x40 45x45 45x45	August September Sep – Oct
Turnip		April – Aug		30x15	June – Nov

History of the Swede

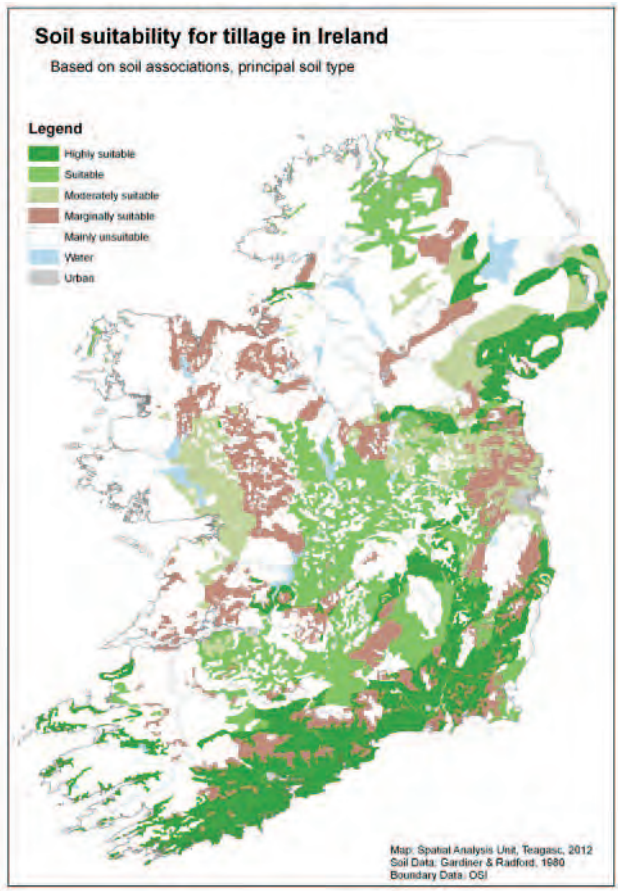
The swede is a comparatively recent vegetable whose origin is uncertain but possibly originated in Finland. It arose from a cross between *Brassica rapa* (turnip) and *B. oleraceae* (possibly kohlrabi) and was first recorded by a Swiss botanist Caspar Bauhin in 1620.

The swede spread to other countries including Holland and Sweden where it became popular as stock feed and as a winter vegetable for humans. There is a record for its introduction into Scotland in 1781-1782 and a mention in the Gardeners' Chronicle of its introduction into England in 1790. It presumably arrived in Ireland sometime after.

The name 'swede' derives from the time that Sweden began to export their crop to Britain – it's a shortened version of 'Swedish turnip', turnip being very similar in looks to swede. Sweden also exported the crop to North America from whence came the American name for swede, rutabaga, which comes from the old Swedish word *rotabagge*, meaning "root ram".



What's the difference between a turnip and a swede? Both are formed from the hypocotyl (that bit of the stem just below the seed leaves) swelling up into the familiar 'root', but in the swede the top and bottom of the bulb are derived more from stem and root tissue, respectively, than is turnip. This leads to leaf scars giving a swollen neck around the top of the swede and the presence of adventitious roots on the bottom of the bulb.



The top tillage counties are Wexford, Cork, Meath, Kildare, Tipperary and Louth – concentrated in the south, east and northeast of the country. Why? Two main reasons. If you look at the map above you will see that the most suitable tillage soils in the country are located to the right of a line drawn from Cork to Louth - indicated by the dark green colour. The second reason is rainfall. Annual rainfall in Ireland varies from 700 mm in the east to over 2000 mm in the west and most of the tillage is carried out in regions where rainfall is about 1000 mm or less. We get away with tillage crops on less than stellar heavy Dublin soils because it's one of the driest areas of the country. Tillage occupies about 6% of the agricultural area. Vegetable production is concentrated in Leinster and the top three counties are Dublin, Meath and Wexford.

Tales of old

There was a farming family who grew vegetables in the Rathmines area of Dublin back in the late nineteenth century. As Rathmines grew and developed their farm was bought for housing. The farmer didn't want to have to go through the ordeal again so decided to move out to the heart of the countryside and settled in Crumlin where he grew potatoes and vegetables. When Crumlin was developed in the 1930's the farm was again bought out for housing and this time the farmer's son decided this wasn't ever going to happen again and decided to move to the hills. He relocated his farm to Fortunestown Co Dublin. The family's luck again ran out with the building boom that engulfed the rural village of Tallaght in the 1970's. They were last seen heading for Maynooth.

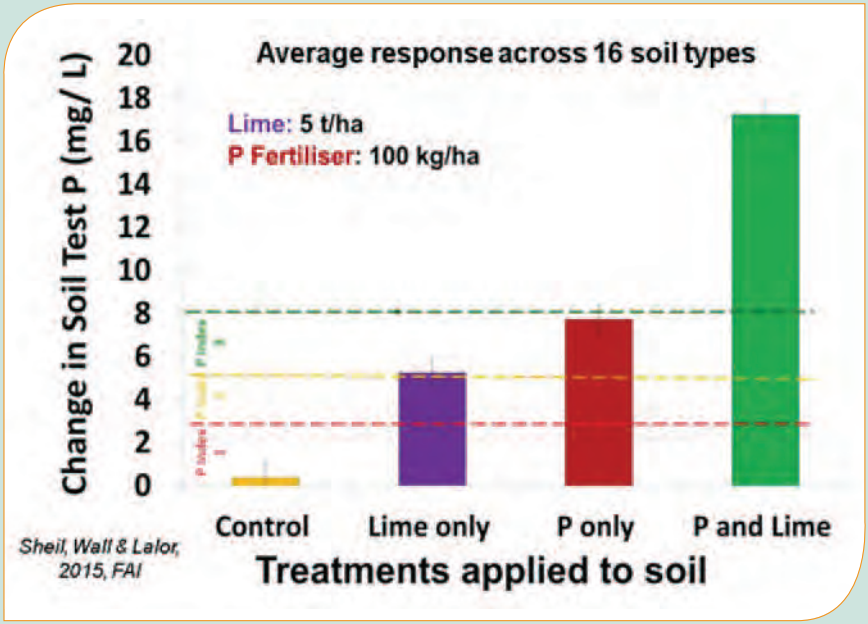
Willie Flanagan, better known by his nickname 'The Bird Flanagan' was a well-known Dublin character and market gardener. He was born in 1867 at Walkinstown House which was located close to the present day SuperValu on the Walkinstown Road. The family had built up a sizeable business in the Walkinstown and Drimnagh area growing vegetables for the denizens of Dublin. A story was told of the The Bird driving his largely female workforce back to their lodgings in the inner city at top speed over cobblestones and humpbacked bridges in horses and carts. On reaching Neary's pub in Chatham Street he tipped the ladies out onto the street. No doubt at this stage they were screaming blue murder at him, but by way of compensation Willie bought them into the ale house and stood his staff a well-earned round of drinks.

Load of loose Rush cauliflowers from the Flynn farm ready to leave for the Dublin Market around the mid-1960's.

There is an interesting look back at the Dublin Wholesale Market from the RTE archives of 1962. It features Joe McDermot from Donabate bringing in his cabbage and potatoes to the Dublin Market and highlights the problems of the times, namely zero quality control. If they had too little of it then we have too much of it now.

https://www.rte.ie/archives/2013/1111/486007-dublins-victorian-fruit-and-vegetable-market-1962/

Influence of pH on P availability



Getting the pH right and some nice warm showers can transform nutrient availability for your crops. It might sound like an odd combination but it works. Teagasc Johnstown Castle did a simple experiment that showed the benefits of lime in increasing phosphorus availability. They got pots of acid soil (pH 5.5) that had very low available P (0.8 ppm). The researchers added in lime (5.5 t/ha equivalent) to some of the pots, P fertiliser (100 kg/ha) to others and both P and lime to the last ones. They left the pots for a year and then retested for phosphorus. The results were surprising. The application of lime alone increased available P to 5.8 ppm, the fertiliser addition increased it to 8.1 ppm and the combination of the two yielded 17.7. This last result is a combination of the lime increasing availability from P reserves along with the added fertiliser. And getting your soil to a pH of about 6.5 increases not just the availability of P but all the other elements as well. So where do the showers fit in? Rainfall makes everything work – the nitrogen gets into the plant along with all the other nutrients including trace elements. As a grower once said, "A good night's rain sorts out a lot of deficiencies".

Tillage weeds listed by family

Apiaceae:	Fool's parsley
Asteraceae:	Creeping thistle, spear thistle, colt's foot, corn marigold, groundsel, mayweed, scentless mayweed, smooth sowthistle, prickly sowthistle, perennial sowthistle, nipplewort
Boraginaceae	For-get-me-not
Brassicaceae:	Charlock, shepherd's purse, swine cress, hedge mustard
Caryophyllaceae:	Chickweed, corn spurrey, mouse-ear chickweed
Chenopodiaceae:	Fat hen, orache
Euphorbiaceae:	Sun spurge
Lamiaceae:	Hemp-nettle, deadnettle, marsh woundwort
Onagraceae	Willowherb
Papavaraceae:	Common poppy, fumitory
Poaceae:	Annual meadow grass, scutch, wild oats
Polygonaceae:	Black bindweed, knotgrass, redshank
Rubiaceae:	Cleavers
Scrophulariaceae:	Common field speedwell, ivy leaved speedwell
Solanaceae:	Black nightshade
Urticaceae:	Annual nettle
Violaceae:	Field pansy

Top 20 commonest weeds in field vegetable crops

1. Chickweed
2. Shepherd's Purse
3. Fat Hen
4. Groundsel
5. Annual meadow grass
6. Knotgrass
7. Redshank
8. Mayweed
9. Speedwell
10. Purple deadnettle
11. Fumitory
12. Prickly sowthistle
13. Orache
14. Swine cress
15. Charlock
16. Sun spurge
17. Spear thistle
18. Cleavers
19. Black bindweed
20. Annual nettle

Examples of fertilisers available with percentage nutrient analysis

Fertiliser	N	P	K	Ca	Mg	S
0-7-30		7	30			
0-10-20		10	20			
7-6-17 (contains S of potash)	7	6	17			
6-10-18 +B 0.33%	6	10	18			
8-3-18 +B 0.33%	8	3	18			
8-5-18 +B 0.33%	8	5	18			
10-10-20	10	10	20			
18-6-12	18	6	12			
27-2.5-5	27	2.5	5			
Classic NP	25	4				
Classic NK	18.9		15			
Basic slag + trace elements		4.5	16.5			
Calcium ammonium nitrate (CAN)	27					
Calcium nitrate	15.5			19		
Epsom salts					10	13
Granuphos + Ca, Mg, Zn		11.5				
Ground rock phosphate		12				
Keserite (magnesium sulphate)					17.5	
Mono potassium phosphate		23	28			
Muriate of potash			50			
Potassium nitrate	13		38			
Replenish + trace elements	18	2.5	14			2
Sulphate of ammonia	21					24
Sulphate of potash			42			16
Superphosphate		16				
Urea	46					

Conversion Table Metric – Imperial

Linear				
Centimetres (cm)	→ x	0.3937	÷ ←	Inches (ins)
Metres (m)	→ x	3.2808	÷ ←	Feet (ft)
Metres (m)	→ x	1.094	÷ ←	Yards (yd)
Kilometres (km)	→ x	0.621	÷ ←	Miles
Area				
Square metres	→ x	10.764	÷ ←	Square feet
Square metres	→ x	1.196	÷ ←	Square yards
Hectares	→ x	2.471	÷ ←	acres
Weight				
Grammes (g)	→ x	0.0352	÷ ←	Ounces (oz)
Kilogrammes (kg)	→ x	2.2046	÷ ←	Pounds (lbs)
Kilogrammes	→ x	0.01968	÷ ←	Cwts
Kilogrammes	→ x	0.000984	÷ ←	Tons
Volume/liquids				
Millilitres (ml)	→ x	0.0352	÷ ←	Fluid ozs
Millilitres (ml)	→ x	0.0018	÷ ←	Pints
Litres (L)	→ x	0.22	÷ ←	Gallons
Cubic metres (m3)	→ x	1.308	÷ ←	Cubic yards
Pressure				
Bar	→ x	14.705	÷ ←	psi

NOTES

NOTES

A Guide to Vegetable Growing

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