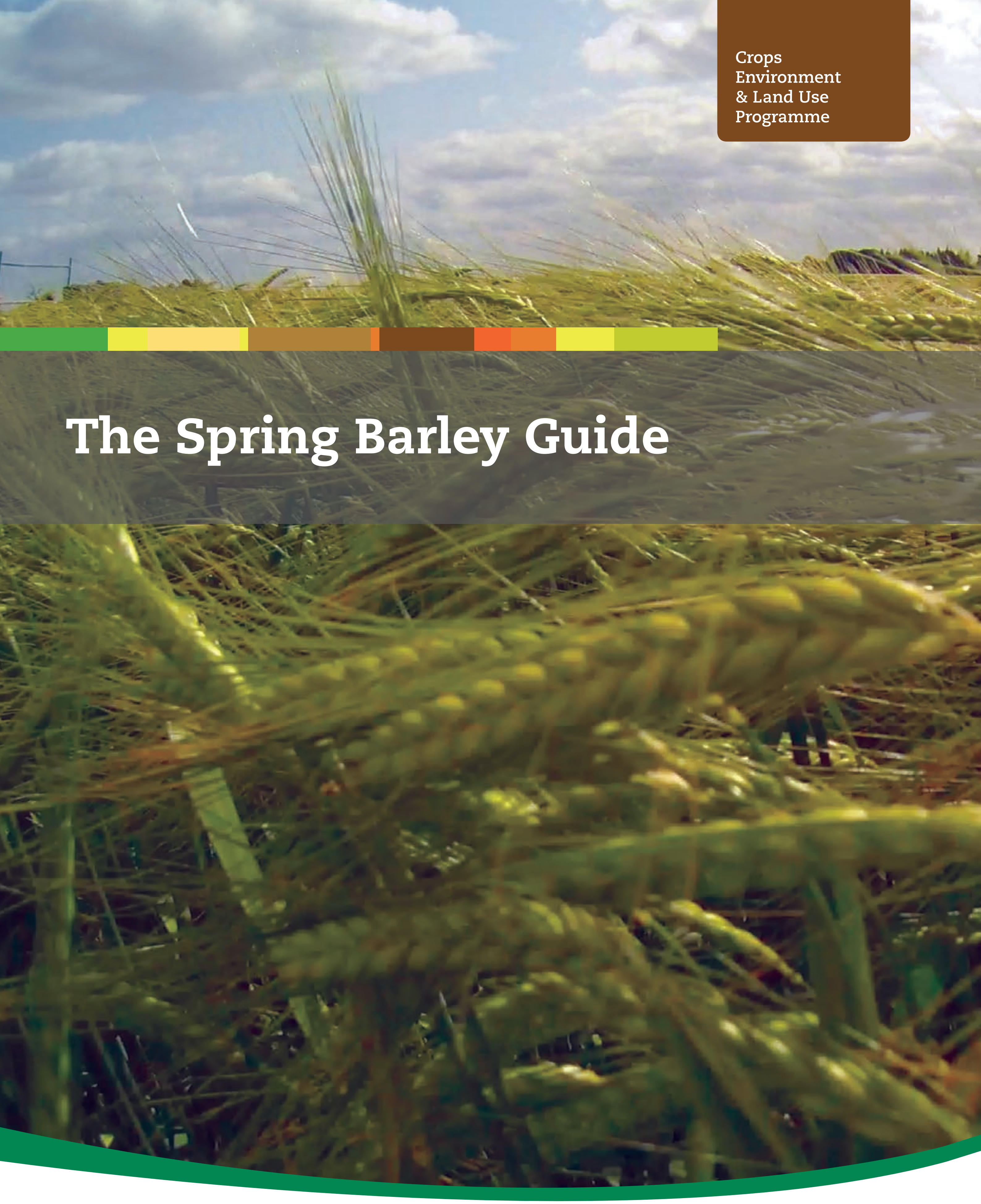


Crops
Environment
& Land Use
Programme

The Spring Barley Guide

Teagasc

Agriculture and Food Development Authority

FOREWORD

Spring barley is Ireland's most widely grown tillage crop which provides valuable feedstock for the animal feed and malting industries.

The crop is well suited to many of our soils and can perform consistently well in continuous production on farms that have limited break-crop opportunities.

Ireland's climate and soils provide good yield potential, but wet conditions can present disease and machinery timeliness challenges.

With a background of volatile grain prices, these favourable growing conditions must be fully exploited to ensure the crop is produced competitively and profitably. Yield must be optimised to increase output and to reduce the production cost per tonne produced.

A significant research effort goes into providing the most up-to-date and accurate information for growers and advisors to maximise crop returns.

This guide is based on information from a detailed crop monitoring programme undertaken to better understand how barley yield is formed. It brings together a large body of Teagasc crop production research carried out over recent years.

The guide has been produced as part of the Department of Agriculture, Food and the Marine Research Stimulus funded project 'CIVYL' (Cereal Improvement through Variety choice and understanding Yield Limitations) and includes research from that project along with contributions from other Teagasc projects.

I would also like to acknowledge input from Boortmalt particularly in the grain quality sections.
I trust this will be of use to the industry in maximising farm profitability in the coming years.

Prof. Gerry Boyle

Teagasc Director

CONTENTS

MANAGING THE CROP TO MAXIMISE RETURN

Key Facts

- Temperature drives crop development.
- Intercepted sunlight drives crop growth.
- Crop growth and yield is highest in cool bright conditions.

Introduction

Crop development or its progress through its 'growth stages', is driven by temperature. The warmer the weather, the faster a crop will develop.

Crop growth is dependent on the interception of sunlight and its conversion into crop biomass. The ideal conditions to maximise crop growth are therefore cool, bright, weather.

The greater the crop's green area (canopy size), the higher the proportion of sunlight that will be intercepted by the crop, and the faster it will grow.

However, light interception by a crop canopy follows the law of diminishing returns. For every additional unit of green area produced, a smaller amount of light is intercepted.

There is a cost associated with the production of green area: nutrients for canopy growth; herbicides to control weed competition; fungicides to avoid leaf loss to disease.

There is therefore a desirable canopy size and structure which optimises economic return to the grower, and that optimum is not necessarily the maximum possible.

Thus, knowing how well a crop is growing and developing is useful for growers. This knowledge will assist in the selection of the level of inputs required for an individual crop.

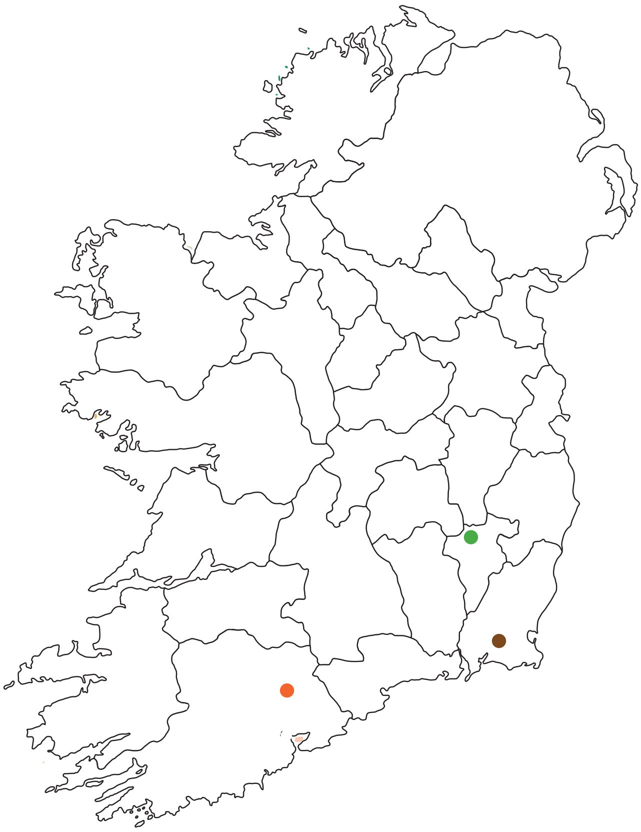
This guide is divided into two parts: The first describes the growth and development of nine reference crops grown between 2011 and 2013 and provides figures against which the progress of any crop can be judged. The second part provides the most up-to-date crop husbandry information to adjust management and maximise the return from a crop.

Understanding Crop Growth and Development

The information presented on pages 3-13 of this guide is based on data collected from 'Quench' spring barley crops grown and frequently monitored at sites in Cork, Carlow and Wexford over three growing seasons from 2011 to 2013.

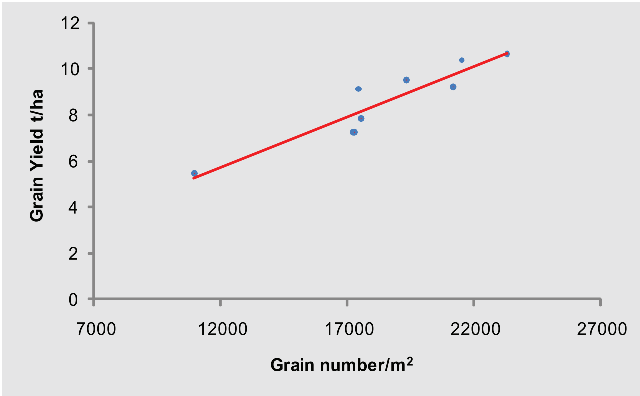
The crops were sown between the 10th of March and the 4th of April, and managed to maximise yield. The figures and data presented give the average, and range of values, for indices of crop growth and development of these crops.

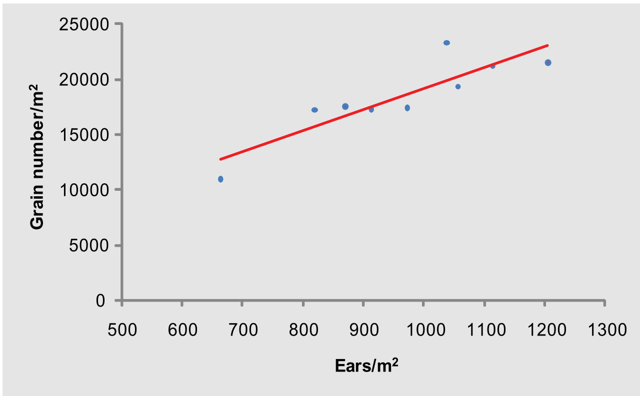
These values are not targets for crop growth, but they can be used as a guide against which the progress of a crop can be compared to assess whether it is ahead or behind normal progress.



- Carlow Town
- Duncormick, Co.Wexford
- Fermoy, Co.Cork

The yield of the reference crops was very closely related to the grain number per unit area. The main factor affecting grain number was ear number per unit area. To maximise the yield of a crop the number of ears per unit area must be high.





Crop Management

Pages 15-36 of this guide provides the most up-to-date agronomic information available. This information can be used to adjust management, either to maximise ear number in a crop, and therefore yield, or to reduce the costs of production where yield potential is low.

LEAF EMERGENCE AND TILLERING

Key Facts

- When a seed starts to grow it produces leaf initials (buds) until mid-late tillering when it switches to reproductive development. From this point it produces spikelet primordia, which will eventually form the ear.
- The first leaf emerges soon after crop emergence and the crop then produces successive leaves at a set 'thermal rate'.
- Tiller production and survival are the most important factors determining yield in spring barley.

Leaf Emergence

Leaf emergence is controlled by thermal time, each leaf will emerge at a set number of day degrees after the previous one. This thermal duration is known as the 'phyllochron' and is measured in °C days above a base temperature of 0°C.

The phyllochron is the same for all the leaves in a crop but will vary slightly between crops; in different years, between varieties and is also influenced by sowing date.

Generally the earlier a crop is sown the longer its phyllochron will be. For late-sown crops, plant development 'catches up' with earlier sown crops by producing fewer leaves and having a shorter phyllochron.

Average phyllochron = 82 °C days, range 73 - 92 °C days

Average days per new leaf in April = 10

Average days per new leaf in May = 7

Site	Average daily temperature (°C)*		Average days per new leaf	
	April	May	April	May
Dunsany, Co. Meath	8.0	10.5	10.3	7.8
Carlow, Co. Carlow	8.9	11.5	9.2	7.1
Johnstown Castle, Co. Wexford	8.5	11.1	9.6	7.4
Fermoy, Co. Cork	8.4	11.3	9.8	7.4

* 30-year mean of 1981-2010, data courtesy of Met Eireann.

Leaf Number

Spring sown crops produce fewer leaves than autumn sown crops, the earlier a crop is sown the more leaves it will produce.

Average leaf number = 8, range 7-9

Tillering

Grain number is the key determinant of yield in spring barley. This is mainly influenced by ear number, which in turn is dependent on plant number and shoot number per plant. Shoot number per plant is determined by tiller production and tiller survival. Shoot survival is more important than shoot production in spring barley.

Tiller emergence starts after the third leaf has emerged.

Maximum tiller number is generally thought to occur around the start of stem extension, but tillering can continue beyond this or stop and re-start later in certain situations, such as if a period of drought or nutrient deficiency occurs.

Shoot production is generally complete before ear emergence, but later-formed shoots can be produced e.g. when it rains following a period of drought, and will cause problems by remaining green when the rest of the crop is ready for harvest.

Average maximum shoot number = 1103/m^2, range 830-1376/m^2

Ear Number

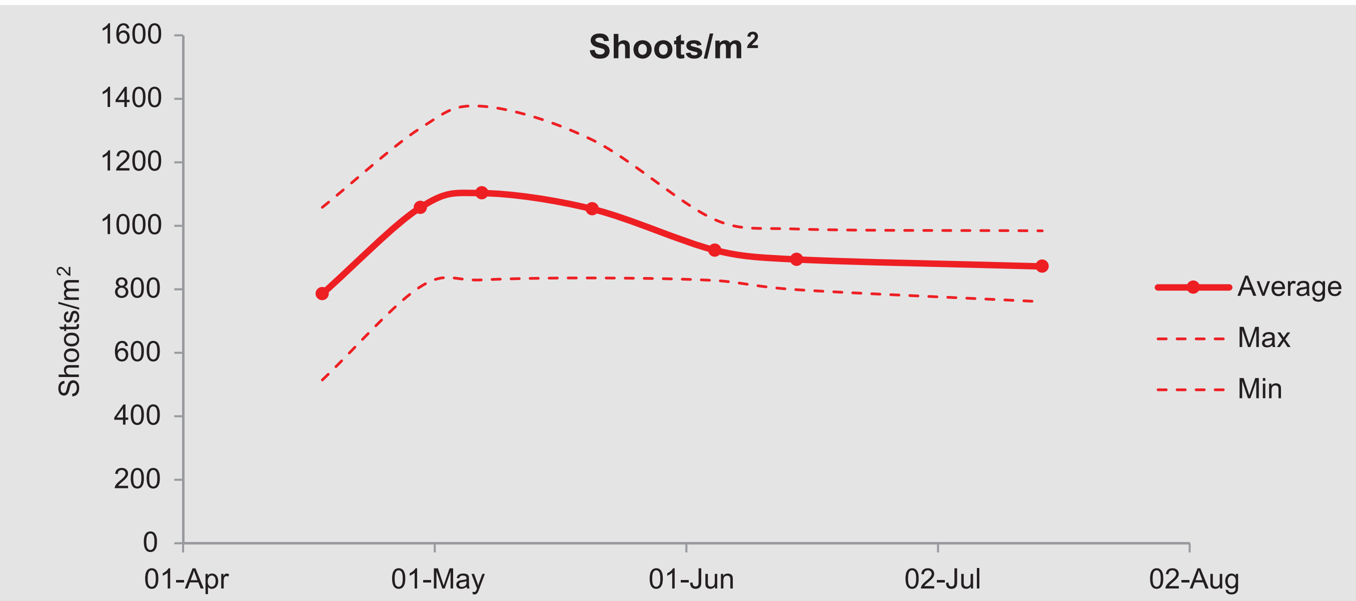
A proportion of the shoots produced will never survive to form ears. Generally the later formed shoots die first due to a lack of light, nutrients, or water.

Final shoot (ear) number is set by the time the crop flowers. Crops with a low ear number will generally have a low yield potential even if there is a favourable grain filling period.

Average final ear number = 872/m^2, range 761-984/m^2

Key husbandry factors:

- Avoid nutrient deficiencies to maximise tiller production and reduce tiller death.
- Weeds compete with the crop for light and will reduce tiller production or survival.
- Accurate leaf emergence estimates are vital to ensure efficient fungicide use.
- Target at least 950 ears/m^2.



CANOPY FORMATION AND LIGHT INTERCEPTION

Key Facts

- The formation of the crop's green canopy is the most important factor in crop growth as it is critical for light interception and dry matter production.
- Canopy size is determined by plant population, tillering, leaf emergence and leaf size.
- Crop canopy refers to all of the green components of the crop which are photosynthetic; including leaves, stems and ears.
- Canopy size is measured as green area index (GAI). GAI is the area of green material (laid out flat) per unit of ground area.
- GAI can be measured over any area of ground; i.e. m^2 of green material per m^2 of ground or acres of green material per acre of ground.

Canopy Formation

Initially canopy size increases slowly as successive leaves emerge and growth is limited by low light interception and low biomass growth.

Loss of green area early in the season due to disease reduces light interception and growth and delays canopy expansion.

Average GAI at start of tillering (GS21) = 0.4, range: 0.1-0.8

As canopy size increases the rate of canopy expansion increases. Expansion is quite rapid from the start of stem extension.

Average GAI at stem extension (GS30) = 1.1, range 0.5-1.7

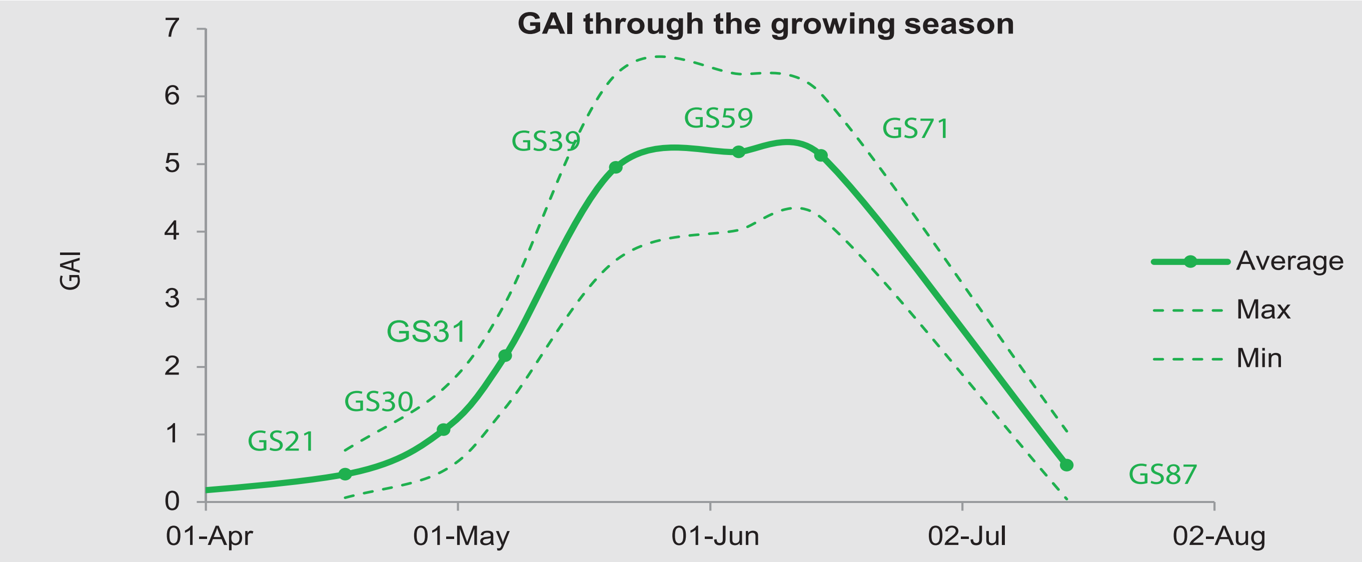
Canopy size plateau's soon after flag leaf emergence. While stem and ears continue to grow, these increases in GAI are offset by the death of leaves and reductions in GAI lower down the canopy.

Average maximum GAI = 5.2, range 4.0 to 6.3

Once the ear and stem are fully emerged there is no further canopy expansion and total canopy size starts to decline.

Grain filling is usually complete by mid-July.

Average GAI at GS87 = 0.5, range: 0.1-1.0



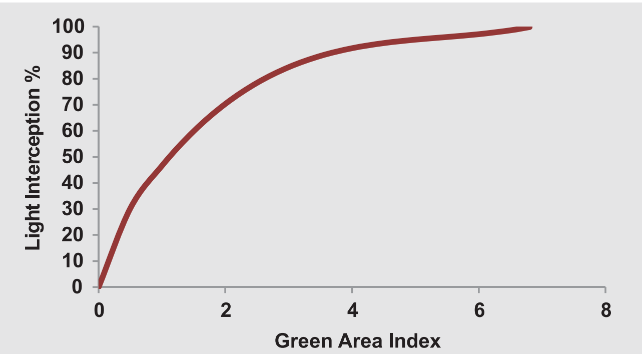
Canopy Size and Light Interception

The amount of incident light per day increases during the spring and reaches a maximum in late June/early July.

Site	Total cumulative PAR (MJ/m^2)*				
	April	May	June	July	**Total**
Dunsany, Co. Meath	205	244	258	254	**961**
Carlow, Co. Carlow	200	240	259	253	**952**
Johnstown Castle, Co. Wexford	204	260	279	279	**1022**
Fermoy, Co. Cork	195	234	251	245	**925**

* 4-year mean of 2011-2014, data courtesy of Met Eireann.
PAR= photosynthetically active radiation

The proportion of incident light (total solar radiation) intercepted by the crop increases rapidly as the canopy area starts to expand.



By the time the crop has reached GAI 2.2 at GS31 it is intercepting 68% of incident photosynthetically active radiation.

The crop will intercept 594 MJ/m^2 of photosynthetically active light from emergence to the end of grain filling. Of this 68% is intercepted before GS71 and the remaining 32% before the crop is harvested.

GAI 2.1

GAI 5.1

GAI 0.5

Key husbandry factors:

- Thin plant stands due to low plant populations will delay canopy expansion and growth.
- Ensure plants have adequate nutrient supply early in their lifecycle so that canopy expansion is not restricted.
- Control disease early to maximise canopy size.

BIOMASS PRODUCTION AND PARTITIONING

Key Facts

- Biomass production is driven by the amount of light intercepted by the crop.
- Development, or the crops progress through its lifecycle, is driven by temperature.
- Total crop growth is greatest in cool bright conditions.

Biomass Accumulation

Crop growth is initially very slow. On average the crop will have accumulated 1.8 t DM/ha of biomass by GS31, 38 days after emergence, an average growth of only 0.05 t/ha/day.

After GS31 biomass accumulates more rapidly as the crop is intercepting more of the light and days are longer. Between GS31 and ear emergence the crop accumulates a further 5.8 t/ha of biomass averaging 0.2 t/ha/day.

After ear emergence growth starts to slow, as the canopy begins to senesce. Between ear emergence and GS87 the crop accumulates a further 6 t/ha of biomass, an average of 0.15 t/ha/day.

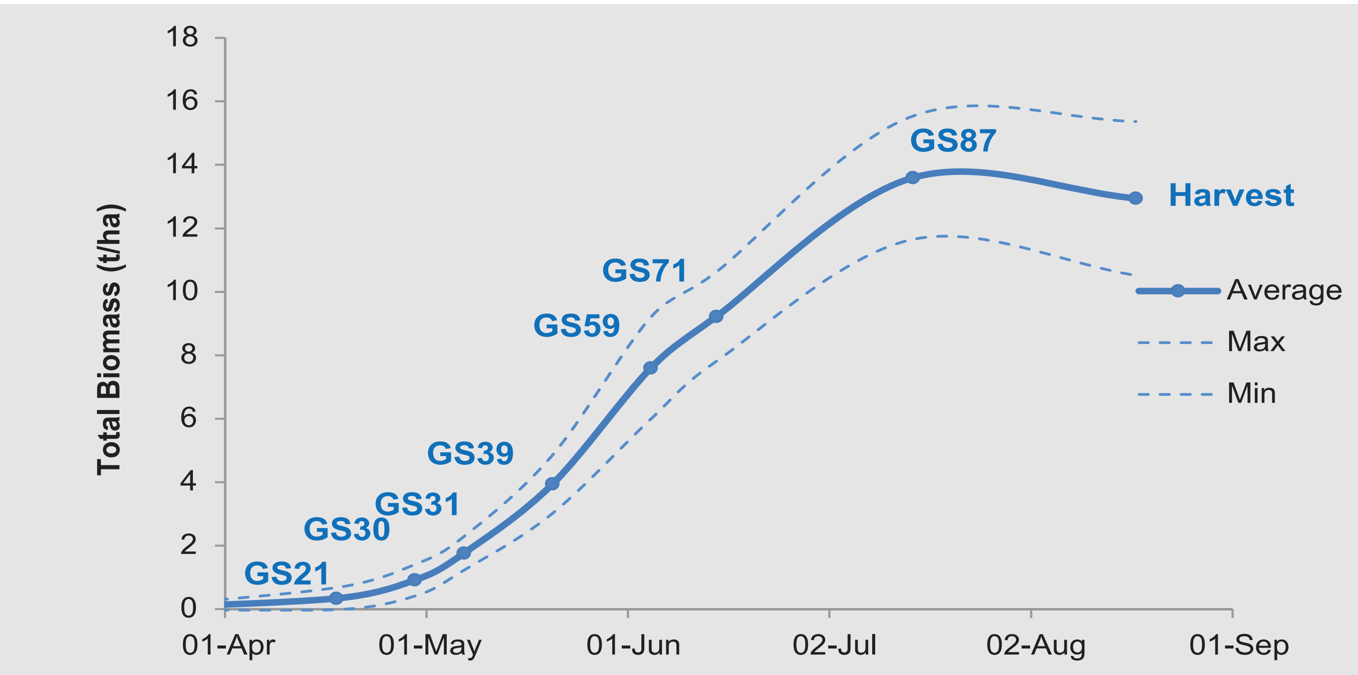
Maximum crop biomass is reached at GS87. After this point there is a small reduction in total biomass due to the shedding of leaves and plant respiration.

Average maximum biomass = 13.6 t DM/ha, range: 11.7-15.5 t DM/ha

Average final biomass = 12.9 t DM/ha, range: 10.5-15.4 t DM/ha

Average grain yield (100 % DM) = 7.0 t/ha, range: 6.0 – 7.9 t/ha

Average Green Yield = 8.4 t/ha, range: 7.2 - 9.1 t/ha



Biomass Partitioning

Until GS30, most of the biomass produced goes into leaf formation.

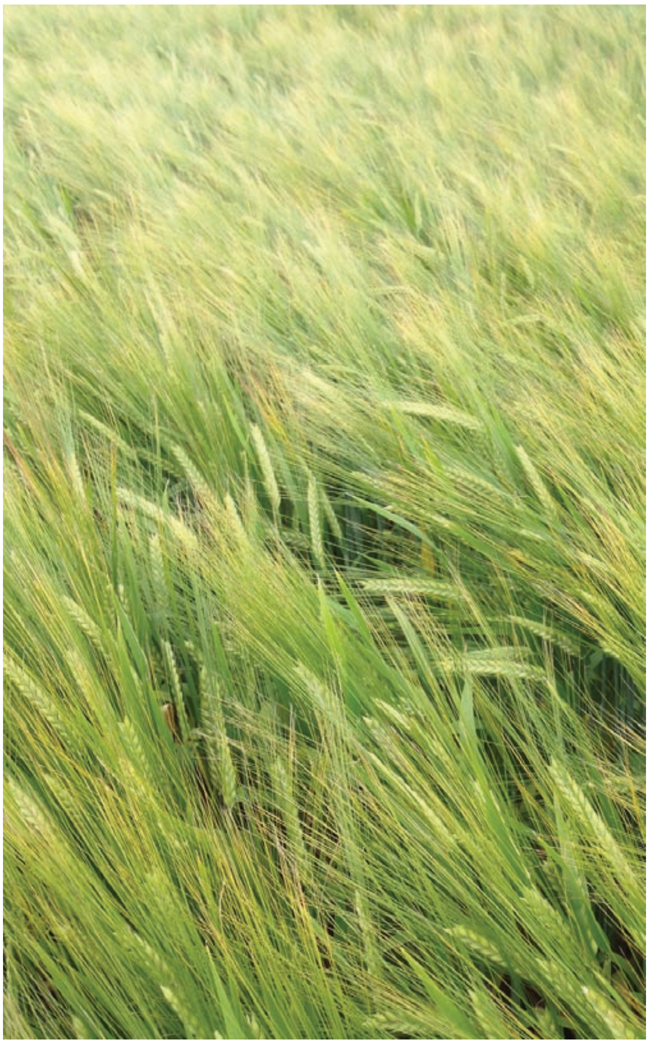
After GS31 most of the biomass produced goes into stem formation with a much smaller amount going into the formation of the ear within the stem.

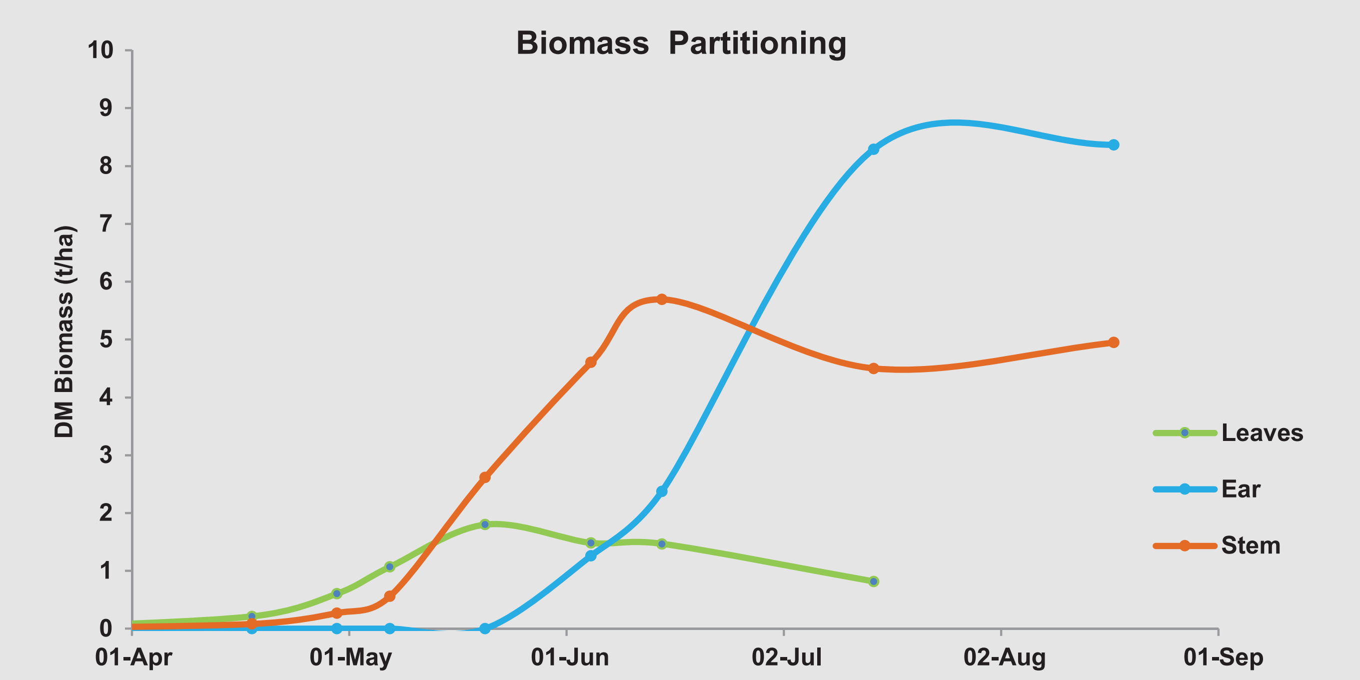
After GS39, leaf growth ceases and leaf biomass declines as lower leaves begin to die. Stems continue to grow very rapidly and ear growth accelerates.

By GS71 stem growth has ceased and all of the biomass is going into grain growth. Stem weight declines as soluble carbohydrates stored in the stem prior to grain filling are relocated into the developing grains.

By harvest, 54% of total biomass (harvest index) is located in the grain. There is a total of 4.9 t DM/ha of biomass as stems, although only about 60-70% of this will be harvestable as straw due to a proportion remaining as stubble and bailer inefficiency.

Average harvest index = 0.54, range 0.50-0.58





CROP HEIGHT

Key Facts

- The crop will have reached only 57% of its final height by flag leaf emergence.
- Crop height is an important factor in lodging risk. With tall crops, the force of wind hitting the ear will exert a stronger leverage on the base of the plant.

Stem Extension

The growing point of the crop remains at ground level until the stem starts to extend at GS30.

Once the stem starts to extend the crop becomes much more susceptible to frost damage to the growing point.

Of the eight leaves the crop will produce, only the final four will be on the extended stem, with the rest emerging at ground level.

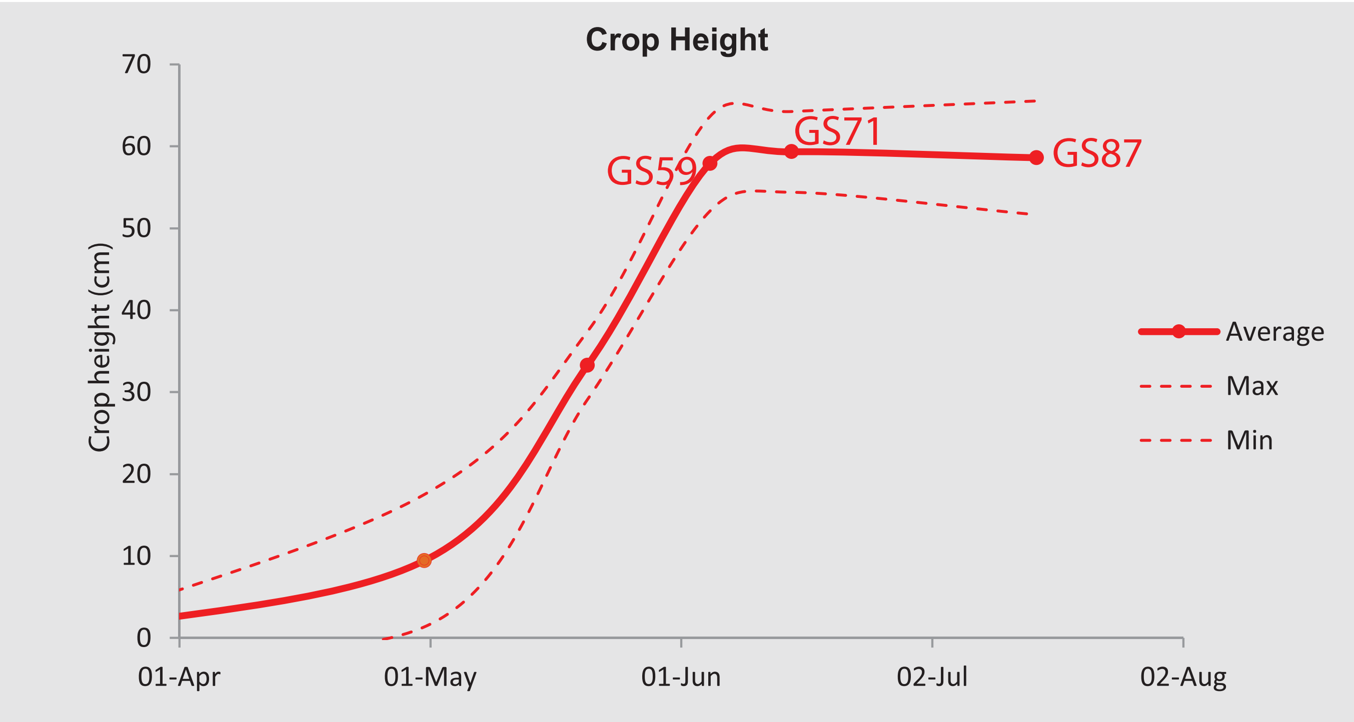
By flag leaf emergence the crop has only reached 57% of its maximum height.

Maximum crop height is reached soon after ear emergence and declines during grain filling as the ear 'necks over'.

Average maximum height = 59cm, range 54-64cm

Key husbandry factors:

- Excessive nitrogen will increase crop height and lodging risk.
- Early season chlormequat-containing growth regulators have a limited effect on final crop height due to 'bounce back'.
- Late season growth regulators have a significant effect on final crop height, but can be damaging if the crop is under stress.
- Check 'resistance to lodging' when choosing varieties, tall varieties are not necessarily more lodging prone.
- Delayed sowing can lead to taller crops.



NITROGEN UPTAKE

Key Facts

- Nitrogen is a key nutrient for crop yield. It is required to
  - feed tiller production and survival
  - drive green area production
- Lack of N will reduce yields while excess N can cause lodging as well as environmental issues.
- In malting barley, nitrogen increases protein content.

When is the N taken up?

For a typical March-sown spring barley crop nitrogen uptake during the different phases of growth will be:

Sowing to GS30
(start of stem extension- typically mid/late April)
Rate of N uptake = 0.9 kg N/ha/day

Amounts required during this phase are modest as the rapid phase of growth has not yet started.

GS32 to GS39
(flag leaf emergence – typically mid-May)
Rate of N uptake = 3.6 kg N/ha/day

This is the key phase in terms of the crop's growth cycle. Large amounts of N are required to drive rapid green area production and maintain tiller numbers. Deficiencies during this period will can cause significant yield loss.

GS39 to GS59
(flag leaf emergence – typically early June)
Rate of N uptake = 1.2 kg N/ha/day

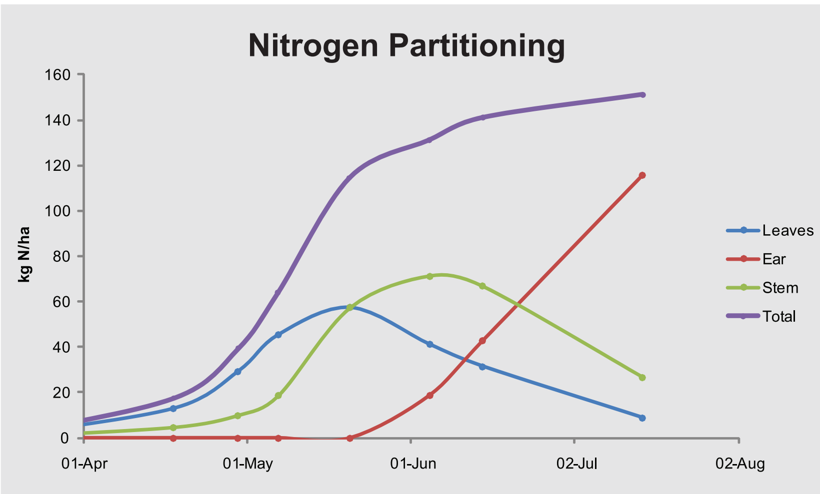
The rapid phase of leaf production has finished so the crop's requirement begins to decline.

GS59 to GS87
Rate of N uptake = 0.5 kg N/ha/day

Uptake during this period is low as the crop will have used much of the nitrogen in the soil and its requirement is low. Nitrogen taken up during this period is not required for green area production and can lead to increased grain protein content.

For a typical March sown crop the total amount of N taken up will be

- **39 kg N/ha by GS 30** (late April)
- **115 kg N/ha by GS 39** (mid-May)
- **131 kg N/ha by GS 59** (early June)
- **151 kg N/ha by GS87** (mid-July)



EAR FORMATION AND GRAIN FILLING

Key Facts

- Grain number per m^2 is the primary determinant of spring barley grain yield in Ireland. This is because climatic conditions typically allow for the production of a surplus of assimilate required for grain filling.
- Grain number is a product of the number of ears per m^2 and the number of grains per ear.

Ear Formation

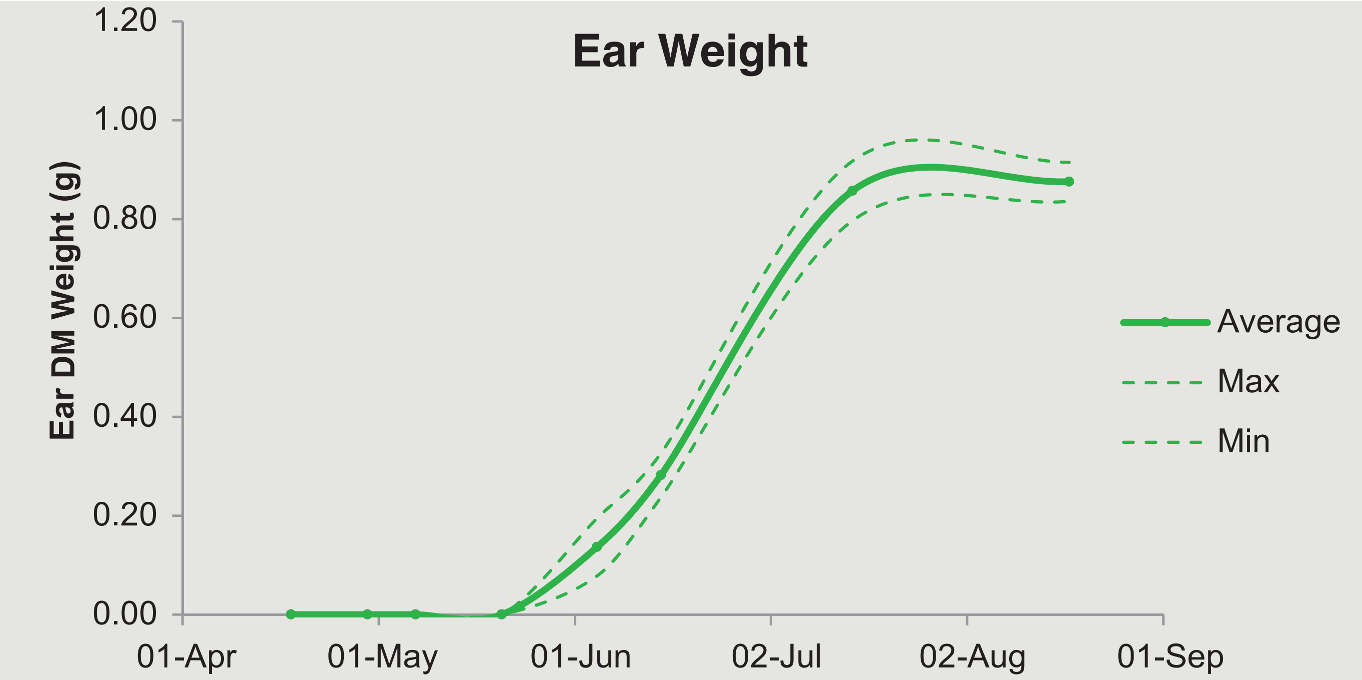
Achieving a high number of ears/m^2 is reliant on maximising the survival of fertile shoots produced early in the vegetative stage of development. This is achieved by preventing deficiencies in nutrients and avoiding periods of drought and flooding.

Grain number per ear is determined by the amount of fertile florets that develop on the ear's rachis, with one floret produced per spikelet in spring barley.

Ear development begins when the crop switches from vegetative development to reproductive development around the beginning of stem extension.

Average ear formation period = 35 days, range 32-41 days

Average ear weight at GS59 = 0.14 g DM, range 0.08-0.20 g DM



Grain Filling

During the grain filling period, the products of leaf, stem and ear photosynthesis, along with the assimilate previously stored in the stem, are distributed to the grains for storage.

The majority (65%) of the final ear weight is amassed between GS71 and GS87.

Average grain filling period = 40 days, range = 34-41 days

Average ear weight at GS87 = 0.86 g DM, range = 0.80-0.92 g DM

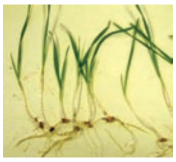
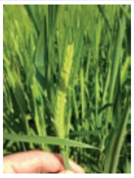
Soon after GS87, grain filling slows and the crop ripens as the moisture content of the grain decreases and the crop senesces fully.

Average GAI at GS87 = 0.5, range = 0.1-1.0

Key husbandry factors:

- Avoid nutrient deficiencies early in the growing season to prevent tiller death and resulting lower ear numbers per m^2.
- Maximise the duration of green canopy through adequate leaf and ear protection from disease to avoid limiting assimilate production and storage.
- Ensure the crop is suitably ripe before harvesting.

GROWTH BENCHMARKS

	Sown	**15th March**	
	Emerged	**2nd April**	
	**GS21**	**18th April**	**Growth stage Identification**
	Total dry weight (t/ha)	0.3	• A single tiller that has emerged from a leaf sheath is present in addition to the main shoot.
	Shoots/m^2	786	
	GAI	0.4	
	Plants/m^2	276	
	**GS30**	**30th April**	**Growth stage Identification**
	Total dry weight (t/ha)	0.9	• After dissecting the main shoot, the shoot apex, is located 1cm or more from the lowest point that a leaf attaches to the stem.
	Shoots/m^2	786	
	GAI	1.1	
	**GS31**	**7th May**	**Growth stage Identification**
	Total dry weight (t/ha)	1.8	• After dissecting the main shoot, an internode (between nodes) greater than 1cm is present, but the internode above it is less than 2cm.
	Shoots/m^2	1103	
	GAI	2.2	
	Light Interception (%)	95	
	Phyllocron (°C days)	82	
	**GS39**	**21st May**	**Growth stage Identification**
	Total dry weight (t/ha)	3.9	• The ligule of the flag leaf on the main shoot is visible.
	Shoots/m^2	1053	
	GAI	5.0	
	Crop Height (cm)	33	
	Total leaf number	8	
	**GS59**	**5th June**	**Growth stage Identification**
	Total dry weight (t/ha)	7.6	• The ear is fully emerged on greater than 50% of all shoots in the crop.
	Shoots/m^2	923	
	GAI	5.2	
	Crop Height (cm)	58	
	**GS71**	**15th June**	**Growth stage Identification**
	Total dry weight (t/ha)	9.2	• The grain is approx. 3mm long and contains clear liquid.
	Shoots/m^2	894	
	GAI	5.1	
	Crop Height (cm)	59	
	Stem dry weight(t/ha)	5.7	
	Ear dry weight(t/ha)	2.4	
	**GS87**	**15th July**	**Growth stage Identification**
	Total dry weight (t/ha)	13.6	• Grains are at hard dough, with dry contents and a finger-nail impression remains. Very little green colour remains in the crop.
	Shoots/m^2	873	
	GAI	0.5	
	Crop Height (cm)	59	
	Grainfilling period(days)	41	
	**Harvest**	**19th August**	**Growth stage Identification**
	Total dry weight (t/ha)	12.9	• Grain cannot be dented with thumbnail.
	Stem weight (t/ha)	4.9	
	Grain Weight(mg;15% moisture)	55	
	Grain Hectolitre Weight(kg/ha)	63	
	Grain Yield(t/ha;15% moisture)	8.3	
	Grain Number/m^2	18597	

Crop Management

Agriculture and Food Development Authority

SOIL CULTIVATION

Key Facts

- The type and intensity of soil cultivation used impacts on: crop establishment; nutrient uptake; yield; weed growth; soil structure; greenhouse gas emissions and production costs.
- Ploughing remains the most reliable establishment system for spring crops on most soils.
- Min-till is fast and can reduce costs but is not suited to all soils and requires careful management to avoid grass weed, compaction, and yield loss challenges.
- Whatever the system, good seed/soil contact, and the appropriate aggregate size and soil structure, in and below the seedbed, will optimise crop performance.

Cultivator/drill working on ploughed ground.

Cultivation Systems

Cultivation systems are described by their primary tillage operation e.g. ploughing; min-till, strip-till or direct drill. Depth and intensity of tillage can vary within and between systems, e.g. min-till depth can be 75-200mm.

Min-till uses non-inversion stubble cultivation, stale seedbed creation and cultivator drill sowing. Strip tillage cultivates strips rather than full-area disturbance. Direct drilling places seed directly into the untilled soil.

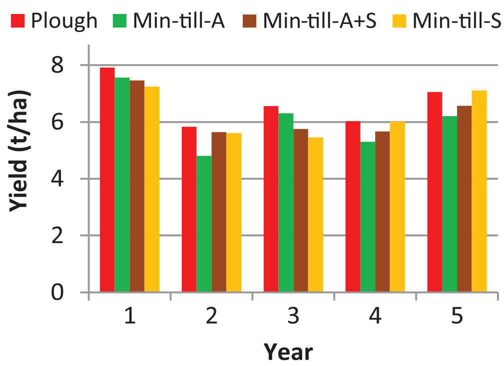
Cultivation for spring barley

Ploughing, which gives relatively intensive cultivation to 175-250mm depth with soil inversion, has proved a reliable system for rapidly establishing spring crops.

Min-till systems with their less intensive cultivation, lower power requirement, and fast work-rate are worth considering as a lower-cost, sustainable establishment system. A short growing season and grass weed control presents challenges on many soils.

Oak Park cultivation systems research

On medium clay-loam soils, plough–based establishment proved the most consistent when compared with a number of min-till systems over a five-year period.



Establishment was 16% lower with min-till. A dense crop was needed from GS 25 to ensure rapid uptake of nutrients to optimise yield.

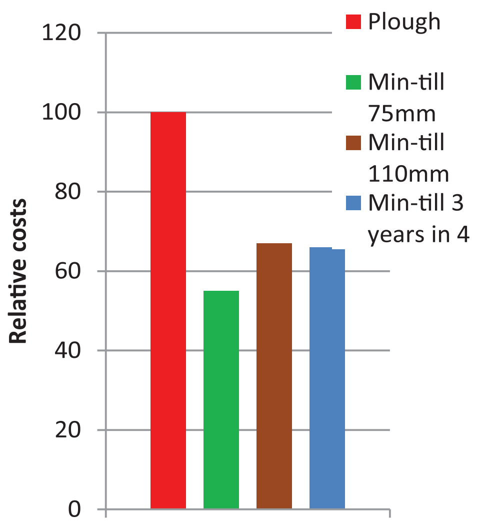
Herbicide control of grass weeds was necessary where min-till was used.

On heavier soils, min-till could delay sowing date. On lighter soils min-till establishment of spring barley was successful with yield capacity similar to that of plough-established crops.

The effect of min-till adoption on GHG emissions was limited, with min-till conserving soil carbon but elevating NOx emissions.

Min-till cultivation for spring barley

The lower energy requirement and lower machinery costs of min-till systems, coupled with very high work rates, makes it attractive to growers with large crop areas.



Machinery costs to establish cereals with different cultivation/sowing systems.

Min-till cultivation for spring barley.

Soil Management

Soil is a key resource that must be managed. Examining the soil to spade depth (300mm) coupled with surface indicators such as surface water and poor crop growth can identify structure problems. Soils of medium or light texture without structure problems may suit spring min-till establishment. Plough-based systems can work well on all soils.

Where compaction is evident, deep loosening (subsoiling) should only be considered if re-compacting the soil can be avoided. Subsoiling should be carried out in dry conditions and only as deep as is necessary. To reduce compaction avoid working wet soils; use larger tyres for lower ground pressure; reduce the number of machinery passes and consider controlled traffic systems. Know your machine weight and fit tyres large enough to work at low pressures: <1.0 bar for ploughing; < 0.8 bar for secondary cultivation.

To get barley established quickly, a fine firm seedbed will give good seed/soil contact, ensuring ready access to water and nutrients. Beneath the seed, good structure is essential for drainage and root development. Cultivation should be used to achieve these conditions in a timely fashion with minimum input to protect the soil and control costs.

Strip tillage seeding.

Key husbandry factors:

- Plough early to allow weathering assist tilth formation. Only cultivate as deep as needed. Ploughing at 175mm rather than 250mm can reduce costs by 30%.
- Consider pressing soils that benefit from consolidation or to avoid difficult clod formation when drying later.
- While timeliness is important, cultivate seedbeds only when the soil is dry enough to produce a good tilth and to support traffic.
- Use the minimum number of passes to reduce both costs and soil structure damage.
- Select cultivation elements (tines, discs, packers/rollers etc) to suit your soils.
- With min-till and strip-till systems, choose cultivation depth, timing and weed control strategies carefully.
- Consolidation during, and subsequent to, sowing operations is essential for even and rapid establishment on many soils.
- Know your costs: Cultivation/sowing accounts for about 20% of production costs but varies widely. Select machines carefully and avoid over-capacity. Hire, share, or use a contractor if ownership is not economic.

SEED RATE AND ESTABLISHMENT

Key Facts

- Establishing the correct number of barley plants is essential for the crop to achieve high yields.
- Adjusting seed rate for individual seed lots and field conditions is essential to achieve the desired plant stand.

Barley will compensate somewhat for higher or lower plant numbers by producing higher or lower tiller numbers but there is a limit to how much a crop can adjust. The ability to compensate for suboptimal plant numbers is influenced by time of planting, overall plant stand, pest/weed/disease interaction, nutrition, etc.

In order to plant the correct number of seeds take into account:

- Seed quality
- Seed bed conditions
- Pest/weed burden
- Time of planting

Seed Quality

Buying Irish Certified Seed will ensure guaranteed germination %, weed free seed and a low risk of seed borne diseases.

Seed quality is the most important element of good establishment. The main seed quality factors are: germination capacity, thousand grain weight (TGW) and disease levels on the seed.

Germination capacity can be reduced by a wet harvest, excessive heat during drying or where a large disease burden is present. As a minimum, all home saved seed should have the germination capacity and disease level checked.

Germination capacity should be as high as possible, ideally over 85%, and certified seed must have a germination capacity of at least 85%.

Thousand grain weight (TGW) refers to the weight of 1000 grains. Generally plumper grain will weigh more than shrivelled grain therefore seed with plumper grains will require higher seed rates.

Some seed suppliers display TGW on each lot number making seed rate calculations easier. Where the TGW is not displayed, ask your merchant to supply the information.

Seed-borne diseases of barley include: net blotch, Rhynchosporium, seedling blights caused by Microdochium nivale, bunt, ergot and loose smut. Ergot carries a maximum threshold in certified seed whereas all other diseases have advisory thresholds.

A moderate-to-high disease load can affect seed germination capacity. Generally, fungicide seed dressing will reduce the risk of infection to acceptable levels. A final germination test should be completed on fungicide treated seed.

Seed Rate

Seed rate will directly affect yield components in barley as plants/m^2 influence shoots/m^2 which in turn influences the total grain numbers/m^2.

To calculate the seeding rate start with the number of plants you want to establish. This should be adjusted to take into account all the factors affecting how many seeds will eventually produce plants.

Calculating the Seed Rate

The seed rate is calculated by completing the following:

$$Seed\ rate\ \left(^{kg}/_{ha}\right) = \frac{Target\ population \times TGW}{Expected\ establishment\ (\%)}$$

Where the desired plant population is 300 plants/m^2 and the barley has a TGW of 48g with an expected establishment of 90%, the calculation is as follows:

$$\frac{300 \times 48}{90\%} = 160$$

Seedbed conditions, pest burden and fertility of the soil should also be considered before reaching a final seeding rate.

Earlier sown spring crops will produce more leaves. The plant has the capacity to produce a tiller from the base of each leaf. Later sown crops develop faster and enter stem extension more quickly, limiting the number of leaves and potential tillers. Consequently, later sown crops should be sown to achieve a higher plant stand compared to earlier sown crops.

Suggested target plant/m^2 and ready reckoner of seed rates.

Sowing date	Up to mid-March	Mid-March to mid-April	Mid- to late April
Target plant number/m^2	280	300	325
Expected establishment (%)	85	85	90
TGW	kg/ha		
40	132	141	144
45	148	159	162
50	165	177	181
55	181	194	199

Seed drills need to be calibrated for each batch of seed as TGW can vary considerably from batch to batch.

Measuring Establishment Rates

It is important to measure establishment rates to determine if agronomic actions are needed where the plant stand is too low or high.

To assess plant populations walk the entire field in a W pattern, taking random samples. Average all samples to give an overall plant stand for the field. Also take note of areas where populations are lower or higher than average. These areas may require action and recording these areas is useful to spot trends in the field for further years.

To measure plant stands use a 0.2/m^2 hoop. To get the numbers per m^2, count the plants inside the hoop and multiply the number by five.

A 0.2m^2 hoop can easily be constructed by connecting/looping 158 cm of stiff wire or 12 mm Wavin pipe.

Plant number per hoop	40	50	60	70	80
Plant number per m^2	200	250	300	350	400
	v. low	low	✓	✓	high

Key husbandry factors:

- Target plant populations taking account of seed quality, seedbed condition and time of sowing.
- Test home saved seed for germination and disease levels.
- Increase seeding rates when sowing after mid-April.
- Measure and record established plant populations for future husbandry decisions.

NITROGEN MANAGEMENT

Key Facts

- N is critical for canopy formation, tiller production and retention.
- 30% of total N should be applied at drilling or crop emergence.
- N requirement is based on previous cropping and yield potential.

Nitrogen Timing

The objective of a fertiliser strategy should be to match the timing of fertiliser N inputs to crop demand. Normally two applications will be made to spring barley:

- Approx. 30% of total nitrogen will be applied at sowing or, alternatively, as soon as the crop emerges, to supply the crop during the early stages.
- The remainder of the nitrogen (main split) will normally be applied at the mid-tillering stage of crop growth (typically mid-April for a March sown crop). This timing ensures that the nitrogen will be in place when the rapid phase of N uptake occurs between late April and mid-May.

How Much?

A typical spring barley crop will have accumulated 151 kg N/ha by the end of grain filling. A crop will use both naturally occurring nitrogen in the soil and nitrogen supplied by fertilisers and manures. Typically, 40-60 kg N/ha of this total will be supplied from the soil, where the soil N index is 1, with the remainder coming from fertilisers/ manures. Typically only 50% of applied fertiliser N is recovered by the crop. Fertiliser N recommendations are therefore, always higher than the amount of N that the crop requires.

Tillage crop N indices.

N index	Previous cropping.
1	Cereals, Maize.
2	Break crops, leys, 3rd or 4th crop after permanent pasture.
3	1st or 2nd crop after permanent pasture.
4	1st or 2nd crop after permanent pasture (only grazed).

Recommended nitrogen inputs to crops in Ireland are determined using a soil N index system. The system gives an indication of the likely supply of nitrogen from the soil which in turn determines the amount of fertiliser nitrogen to be applied. The N index of a field is based principally on the previous cropping history. Fertiliser N recommendations will be higher where soil N supply is likely to be lower (e.g. after continuous cereals) compared to where soil N supply is high (e.g. following ploughing of permanent pasture).

Recommended rates for each Soil N index are given below. Nitrogen inputs to all crops are subject to maxima set out in SI31 of 2014.

N recommendations for spring barley.

N index	N rate*		
	6.5 t/ha	7.5 t/ha	8.5 t/ha
1	135	155	175
2	100	120	140
3	75	95	115
4	40	60	80

**An extra 20kg/ha may be applied to contracted malting barley to address proven low protein problems.*

Sources of N

Calcium ammonium nitrate is the main form of straight N applied to spring barley and will often contain sulphur. Compound fertilisers containing phosphorus and potassium, as well as nitrogen, are commonly used in the seedbed. Urea is normally a less expensive source of N but is susceptible to loss of N by volatilisation when applied to the soil surface, although the use of a urease inhibitor can alleviate this. Urea should not be combine drilled as it can reduce establishment. Crops fertilised with urea can exhibit slower early growth but differences are normally not apparent at harvest.

Organic sources of N can also be used on barley. Where organic manures with a high percentage of available N are used (slurries, poultry manures) these should be incorporated in to the soil as soon as possible (within 2-3 hours) to avoid loss of N. For organic manures with low amounts of available N (composts, farmyard manure) rapid incorporation is less urgent.

Nitrogen and Protein Content

Nitrogen rate is more important than nitrogen timing for protein content. Where all of the N is applied before GS32, altering the timings will have little effect on protein content. Applying N after the flag leaf has emerged can increase protein somewhat as N taken up after this point will generally end up in the grain.

Key husbandry factors:

- Some fertiliser N needs to be applied at sowing or soon after emergence to stimulate tillering.
- The main application of N should be in advance of stem extension to drive canopy growth and tiller retention.
- N rate is more important than N timing for protein content.
- Avoid late N applications where low protein is required.

CROP NUTRITION - Lime, P, K and Micronutrients

Key Facts

- Soil fertility management is a key component in producing high yields of quality spring barley on an annual basis.
- P and K management is essential for early crop development.
- A soil pH of 6.5 will ensure optimum availability of both major and minor nutrients.

Soil Testing

Soil testing is the basis for formulating lime and fertiliser programmes. Soils should be tested once every three to five years to establish; soil pH, P, K, Mg, Cu, Mn and Zn with an S4 soil test.

A soil standard sample costs €1.25/ha/year.

Soil pH and Lime

The ideal pH for spring barley is pH 6.5; this will ensure optimum availability of both major and minor nutrients. To achieve this, apply lime as recommended on the soil test report. Ground limestone should be worked into the seedbed before sowing in spring time. Don't exceed 7.5t/ha in a single application and where quantities in excess of this are recommended apply half in the first year and the remainder two years later.

Where soils are low in magnesium, apply Mg lime (Dolomitic limestone). Granular lime is fast acting but must be applied annually.

P and K management essential for early crop development.

Phosphorus (P) and Potassium (K)

- Phosphorus is critical in the first six weeks of establishment (for both root and tiller development).
- Potassium plays a vital role in building more robust plants and maintaining water balance. Plant K uptake is highest during the reproductive phase.

P and K Advice

The rates of P and K required will depend on the soil test P and K reading. The table below shows the recommended fertiliser rates of P and K for spring barley crop yielding 6.5 t/ha. These fertiliser application rates need to be increased where yields are higher. An additional 3.8 kg P/ha and 9.8 kg K/ha extra needs to be applied per tonne of grain yield above 6.5 t/ha. For example a 7.5 t/ha crop at soil P and K Index 3 will require 29 kg P and 85 kg K/ha.

Soil P and K Index, soil test reading and fertiliser advice for spring barley.

Soil Index	Soil Test (mg/l)		Advice[1], [2] (kg/ha)	
	P	K	P	K
1	0-3.0	0-50	45	105
2	3.1-6.0	51-100	35	90
3	6.1-10	101-150	25	75
4	>10	>151	0[3]	0

[1]Advice based on reference grain yield of 6.5 t/ha @20% MC. [2]Annual maximum soil P application rates under S.I. 31 of 2014. [3]Note, on Index 4 soils with soil pH >7.0, an application of 20 kg/ha P is allowed.

Managing P and K Applications

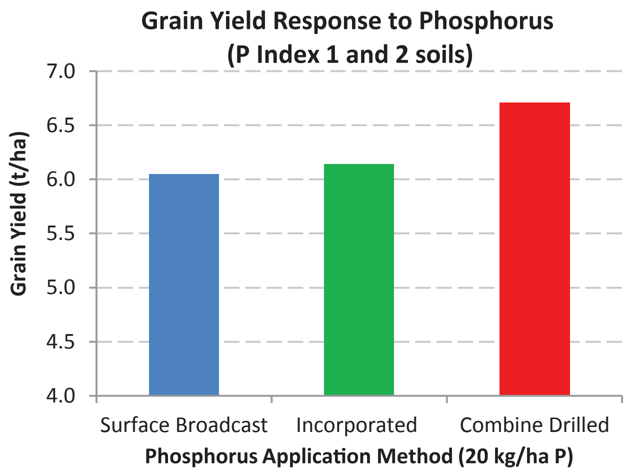
- Soils at P and K Index 1 and 2 have a high nutrient demand. This is required to build soil fertility to index 3 plus meet annual crop P and K requirements for yield.
- Soils at Index 3 for P and K have optimum levels to maximise grain yield annually. Advice at index 3 is to replace P and K removed at harvest time (grain and straw) to maintain soil fertility.
- Soils at index 4 have a high nutrient supply and offer the opportunity to save on fertilisers. Omit P for 2 to 3 years after which a soil test should be taken to assess soil P levels. For K, omit applications for 1 year and revert back to index 3 advice until the next soil test. Ensure soil pH is in optimum range for soil P and K availability.

Application and Timing of P and K Fertiliser

Recommended rates of P and K fertiliser should be applied at sowing and incorporated into the seedbed for the developing barley seedling. Adequate P is particularly important at this time for rapid root and tiller development.

Effect of P (-/+) on rooting and tillering in spring barley seedlings on P Index 1 soils.

On soils with very low levels of P (Index 1 and 2 soils) research shows that placing P next to the seed is the most efficient way to achieve target yields. Therefore, consider combine drilling the appropriate compound fertiliser with the seed where possible.



Combine drilling fertilisers can give a high response particularly in dry conditions.

Other Nutrients

Sulphur (S)

Cereal crops grown on light to medium type soils are most responsive to sulphur. Apply 15 kg/ha S with 1st N split.

CROP NUTRITION - Lime, P, K and Micronutrients

Magnesium (Mg)

Check Mg levels on the soil test report and apply if less than 40 mg/l. Correct soil magnesium when liming by applying Mg lime. Where there is no lime requirement apply Mg-fertiliser once every three to four years.

Trace Elements

Trace elements such as copper, manganese and zinc are important for cereal production. Soil levels will depend on the soil type and factors such as high soil pH or recent liming. Apply trace elements where soil levels are low based on the S4 tillage soil test.

Soil index and test levels (mg/l) for Cu, Mn and Zn.

Soil Index	Cu	Mn	Zn
1	<1.0	<90	<1.0
2	1.01 – 1.5	90.1 - 120	1.01 – 1.5
3	1.51 – 3.0	>120 1	.51 – 3.0
4	>3.0 -	-	>3.0

Copper (Cu)

Copper deficiency is found most often on light textured, acidic or alkaline soils where deficiency can occur at index 3. On heavy soils only apply if index 1. Copper sulphate applied to soil can be an effective option to improve Cu levels. Alternatively apply foliar Cu formulations where a deficiency is present. Copper can be added to fertilisers and applied at sowing time.

Manganese (Mn) deficiency symptoms in spring barley.

Manganese (Mn)

Manganese deficiency is one of the most widespread trace element deficiencies in cereals. There are a number of risk factors including: deficient soils and low availability due to poor soil conditions, low soil temperature/moisture and loose seedbeds. The soil test is a poor indicator of Mn deficiency. Treat crops based on previous field experience, ensure seedbeds are well consolidated and check crops regularly early in the season for symptoms of Mn deficiency. Options to control deficiency include Mn treated seed, Mn added to fertilisers or foliar Mn applications.

Zinc (Zn)

Zinc deficiency is most common on light textured soils. High soil pH (>7.0) in conjunction with high soil P levels reduce Zn availability. A soil test result of less than 1 mg/l is a very reliable indicator of possible deficiency. Zinc deficient soils can be treated with zinc sulphate. Alternatively apply foliar Zn in the early stages of crop development.

Organic Manures

Organic manures (slurry/FYM) are a valuable source of organic matter and can provide major plant nutrients.

To maximise the fertiliser value of manures ensure the following:-

1. Agitate/mix manures before application.
2. Check nutrient (N, P and K) content.
3. Apply evenly and accurately at a consistent rate.
4. Incorporate within two to three hours especially for high N manures (pig/poultry manures) to maximise N recovery.
5. Adjust bag fertiliser application rates based on manure type and rates of application.
6. Check your Farm Fertiliser Plan to determine quantity of manure import.

Typical available N, P and K values for a range of manures.

Manure type	N (kg/m³)	P (kg/m³)	K (kg/m³)
Cattle Slurry	0.7	0.5	3.3
Pig Slurry	2.1	0.8	1.9
Solid Manures kg/tonne			
Poultry			
Broiler litter	5.5	6.0	12.0
Layers (30% DM)	6.8	2.9	6.0
Layers (55% DM)	11.5	5.5	12.0
FYM	1.4	1.2	6.0
Mushroom Compost	1.6	1.5	8.0
To convert kg/m³ to units/1000 gallons multiply by 9			

Organic manures are a good source of N, P and K.

Key husbandry factors:

- Apply lime as recommended to maintain soil at pH 6.5.
- Apply recommended rates of P and K at sowing time based on soil analysis.
- Select a suitable fertiliser to deliver the correct balance of N, P and K.
- On P index 1 and 2 soils placing P fertiliser next to the seed is the most effective technique.
- Apply trace elements where low soil levels are indicated on the soil test report.
- Adjust crop fertiliser requirements where organic manures are applied.

WEED CONTROL

Key Facts

- Where a weed challenge is significant, yield responses of over 1.2 t/ha can be expected from herbicides.
- Target herbicide applications early (GS14-23) for maximum effect.

Crop growth and ultimately, yield, is driven by green leaf area. Weeds compete with the crop for light, water and nutrients, all of which can reduce the crop's ability to amass green leaf area. Ear number is a key determinant of yield and weed competition can reduce the shoot number especially during early tillering.

Barley can tolerate low levels of weeds as it will compete well where barley plant numbers are high.

Weeds differ in their ability to compete with barley. Wild oats and charlock are the most competitive with corn marigold, poppy, fat hen, fumitory, chickweed, redshank, and knotgrass less competitive, dead nettles and field pansy are least competitive.

The yield benefits from controlling weeds can be small if the weed challenge is low but leaving weeds uncontrolled increases the overall seed burden and can interfere with harvesting.

Assessment of the weed species and their density is critical to achieving good control. Other factors which influence weed control include:

- Crop health and growth stage
- Type and size of weed
- Growing conditions
- Herbicide choice and rate
- Correct application

Types of Herbicides

Herbicides that can be applied to barley generally fall into three categories:

- Sulfonylurea (SU) herbicides (Metsulfuron, thifensulfuron, etc.) control a range of weeds but are best mixed with a hormone herbicide. SUs can be slower acting than hormones but still require good growing conditions for best control.
- Hormone herbicides (CMPP, MCPA, dicamba, Fluroxypyr, etc.) generally have a limited weed spectrum. Good growing conditions are necessary for best control.
- Grass weed herbicides (Isoproturon, pendimethalin, Pinoxaden, etc.) can control annual meadow grass, wild oats and other grass weeds.

Generally a mix of an SU and a hormone herbicide is desirable to control a broad range of weeds and to address weed resistance issues.

ALS herbicide (SU herbicides) resistance such as in corn marigold, chickweed and poppy are the most common in Ireland. Check field history and general herbicide control each year to avoid a build-up of resistant populations. Adjust herbicide programmes where resistance issues are known.

Herbicide Timing

Where perennial weeds are a problem apply glyphosate to the preceding stubble or on a false seed bed.

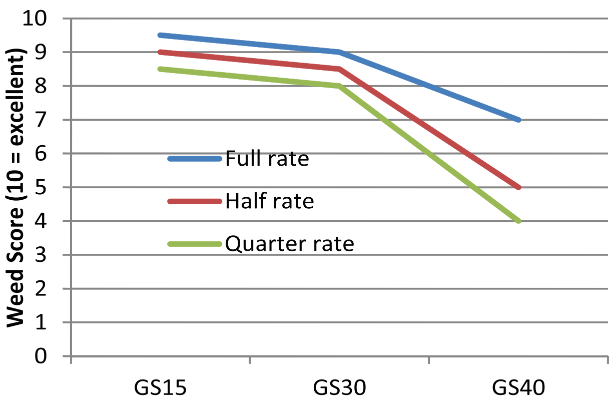
There are relatively few pre-emergence options for weed control (IPU and pendimethalin) in spring barley. Pre-emergence treatments can be useful especially where high levels of annual meadow grass are expected.

Most herbicides are applied post emergence and the effectiveness of the herbicide is heavily influenced by the timing of application.

Crops under stress (nutrient deficiency, etc.) will compete poorly against weeds and can be adversely affected by the herbicide applications.

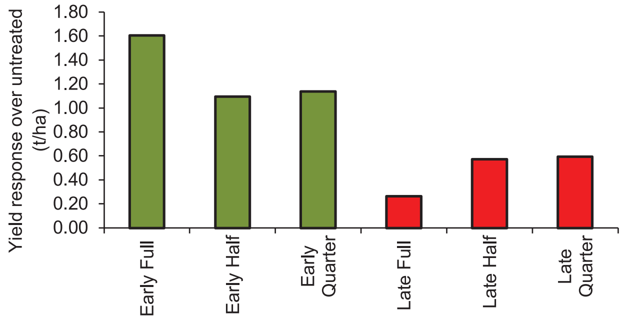
Crop damage from herbicide application in poor conditions. The dark green area is unsprayed.

To get the best from herbicides, apply during a period of good growing conditions and where the crop is not under stress from nutrient deficiency or physical damage (rolling). Applying herbicides early (GS 14-23) will reduce weed competition and allow the crop to develop to its full potential.



Effect of dose and timing on effectiveness of weed control.

Application of herbicides at (GS 14-23) will give good weed control despite the fact all weeds may not have emerged. Broadleaf weeds not emerged at the time of application will generally be smothered by the growing crop.



Early = GS21, late = GS30, Full/half/quarter label rate of SU + hormone.

Where weed competition is high the application of a reduced rate of herbicide at an early timing (GS 21) increased yield compared to late herbicide timing (GS 30). An early timing herbicide at a reduced rate can outpreform a high rate of herbicide applied at a later timing.

Key husbandry factors:

- Use glyphosate pre-drilling where perennial weeds are a problem.
- Weeds compete with the crop for light and nutrients and will reduce tiller production, therefore apply herbicides early (GS14-23) for best yield results.
- Use field history and weed assessment to correctly select a herbicide.
- Match herbicide rates to the weed size. The larger the weed the higher the rate.
- Use a mix of herbicide types to prevent resistance (SU + hormone herbicide).
- To achieve the best control apply the herbicide with three days of good growing conditions either side of the herbicide application.

Key Facts

- Aphids, leatherjackets and slugs are the main pests of spring barley.
- Late sown crops are more prone to yield loss due to BYDV.
- A fine, firm, seedbed will reduce the risk of damage from both slugs and leatherjackets.

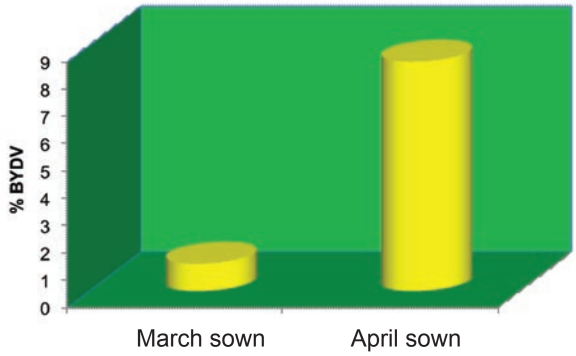
Aphid (BYDV) Management

Aphids are the most serious pests of cereal crops in Ireland. Damage occurs in two ways:

1. By transmitting virus disease (BYDV) to and within crops.

2. By direct feeding on tillers.

The Grain-Aphid, *Sitobion avenae*, is the most common aphid vector of BYDV in Ireland. BYDV can reduce the yield of April drilled barley by 2 t/ha, while feeding aphids can reduce yield by 0.8 t/ha. In general, March drilled barley is at lower risk of significant BYDV damage than April drilled barley due to aphid activity patterns (see graph).



Recent research in Ireland has confirmed the development of resistance to pyrethroid insecticides (e.g. cypermethrin) in the Grain-Aphid. Growers need to be aware of this development and consult with their advisors on a suitable integrated pest management strategy.

Aphid Control

- Apply an aphicide at the 3-5 leaf stage (GS13-15) in crops at risk of BYDV.
- All aphicides (incl. pyrethroids) should be applied according to their labels, ensuring good spray coverage.
- Monitor aphid activity after application and where control is poor; consult your advisor and consider applying a non-pyrethroid (e.g. primicarb, chloropyrifos) as a follow-up treatment.
- Do not use pyrethroids to control feeding aphids in cereal ears, use pirimicarb instead.
- Once crops are at milk dough stage (GS75), the yield effect from feeding aphids is negligible.

Leatherjackets

Leatherjackets are the grub of the Crane Fly (Daddy Long-Legs) and are sporadically a pest of spring barley. Where numbers are high (possibly as a result of high autumn rainfall), damage can be significant, especially in slowly emerging crops. Leatherjackets reduce yield by reducing plant and tiller numbers.

Leatherjacket Control

- Monitor cereals (in high risk fields) for leatherjacket damage at early crop emergence.
- Spray with chlorpyrifos if more than 10 leatherjackets are found in ten 30 cm drill length at 13 cm spacing.
- Rolling will help, as will fertiliser.

Slugs

Slugs can also be a problem in slowly emerging crops and reduce yield by reducing tiller numbers. Monitoring numbers by laying traps is the key to their management. Loose seedbeds, previous cropping and field history are important considerations.

Slug Control

- Bait newly sown crops with some muesli or layer mash (not slug pellets due to the risk to wildlife and pets) under a slate. Leave traps overnight and examine early the following morning. If you find >4 the next morning, consider treatment options.
- Concentrate on fields/areas known to suffer damage.
- If thresholds are breached and the crop is being damaged more than it is growing, consider slug pellet application.
- The common slug control products are based on Metaldehyde and Ferric Phosphate.
- The formulation process of the pellet is important where an extended period of control is required.

Key husbandry factors:

- Early (March) sown crops are less susceptible to yield loss due to BYDV.
- Fine, firm and well consolidated seed beds will reduce the risk of both slug and Leatherjacket damage.

DISEASE CONTROL

Key Facts

- Main diseases include Rhynchosporium, net blotch, Ramularia, powdery mildew.
- Diseases reduce both yield quality and quantity.
- Use cultural techniques and varietal resistance as well as chemical control to minimised yield loss due to disease.
- Disease early in the season can significantly reduce yield potential.
- There are a wide range of fungicides with good activity for disease control in barley.
- Avoid over use of individual fungicides to reduce the risk of resistance development.

For effective disease control in barley it is important to utilise all available control measures as part of an integrated pest management system. Over reliance on any one tool will be ineffective and unsustainable.

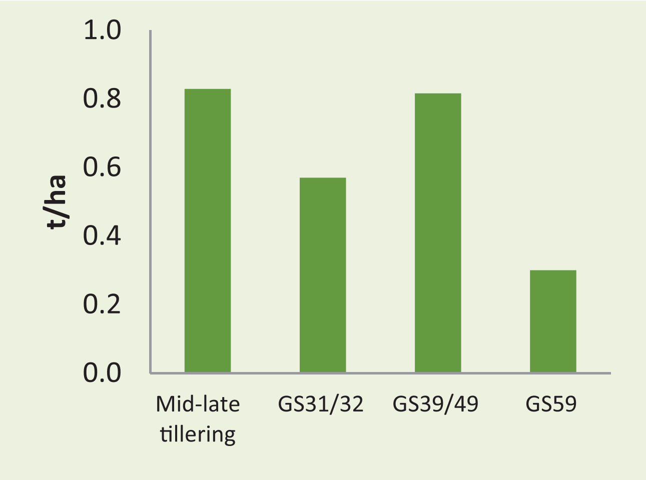
Key to good disease control is the reduction of inoculum by all available means: cultural, varietal and chemical. The avoidance of a 'green bridge' through the early destruction of volunteers from previous crops will reduce inoculum carryover. Varieties should have good disease resistance (refer to DAFM recommended list) and seed should be certified and disease free. Fungicides have a key role, the timing and choice of which is important to ensure optimum control.

Fungicide Timing

Early season disease control in spring barley is essential to protect developing tillers and reduce the potential for disease epidemics, especially in early sown crops. The greatest response to fungicides is achieved at mid-late tillering and GS39/49.

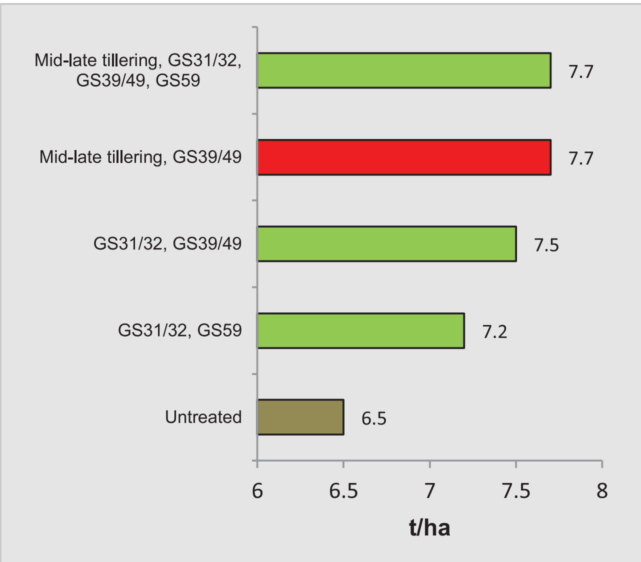
These applications protect tiller survival and

green leaf retention. Delaying the final application timing until GS59 can lead to a reduction in the yield potential of the crop.



Response of individual fungicide timings over six experiments in three years .

The fungicide programme for the crop should be made up of two applications; an early application at mid-late tillering and a second and final application at GS39/49. Additional applications provide no additional benefit.



There was no benefit from more than two correctly timed applications in six experiments over three years.

Growth Stage	Emergence GS 1-10	Mid-late Tillering GS 25-30	Booting GS 39-49
Diseases	Seed-borne	Foliar & Ear Diseases	
Control	Clean seed Seed treatments Good seed bed	Avoiding continuous cropping Removing crop debris Correctly timed fungicide applications	
Fungicide Timing	To seed pre-planting	**T1** Protecting Tillers	**T2** Maintaining Green Leaf
Target Diseases	Activity against: Smuts Seedling Blights Leaf Stripe Net blotch	Activity against: Rhynhcosporium Net Blotch Rust	Activity against: Rhynhcosporium Net Blotch Rust Ramularia Fusarium
Fungicide Choice	Fludioxonil Azoles Carboxin Thiram	Minimum of two active fungicides (azoles, SDHI, strob, multisite) Mildewcide where required	Minimum of two active fungicides (azoles, SDHI, strob, multisite) Mildewcide where required

Key husbandry factors:

- Remove volunteers in stubbles as early as possible to avoid disease carry over.
- The key fungicide timings are mid-late tillering and flag leaf to awns emerging.
- There is rarely any response to more than two sprays, particularly very late sprays.
- Always use a minimum of two actives in each spray to achieve optimal disease control and to reduce the risk of resistance development.

MAJOR DISEASES

Barley Scald

(Rhynchosporium commune)

Rhynchosporium is usually the most common foliar disease of barley crops in Ireland. Prefering cool wet weather, if present early in the season it can reduce tiller survival and potential yields. When present on the upper leaves it will reduce the plant's ability to fill the grains. Control relies on the use of resistant varieties and timely application of fungicides.

Net Blotch

(Pyrenophora teres)

Net blotch can occur throughout the growing season although it favours mild humid weather. Its impact is similar to Rhynchosporium, with early disease affecting tiller survival and its presence later in the season reducing green leaf area. Control is dependent on use of resistant varieties and timely application of fungicides.

Ramularia

(Ramularia collo-cygni)

Ramularia is a foliar disease that is often only observed later in the season after flowering and following periods of wet weather. By rapidly reducing green leaf area it can reduce both quantity and quality of the grain. Varietal resistance is limited and control is often best achieved by applying an active fungicide during booting (GS39-49).

Fusarium Head Blight

(Fusarium/Microdochium)

FHB will reduce both the quantity and quality of grain (of particular concern for malting barley). The presence of specific species will lead to contamination of the grain with mycotoxins. The disease prefers wet conditions at flowering. Best control is achieved by including active triazole fungicides in the final spray, however high levels of control are difficult to achieve.

Powdery Mildew

(Blumeria graminis f. sp. hordei)

The development of resistant varieties has reduced the importance of this disease in recent decades. However it continues to cause significant problems in susceptible varieties, especially spring varieties. As with other foliar pathogens powdery mildew can reduce tiller survival and grain filling. Control is achieved with resistant varieties and fungicides.

Seed-borne Diseases

These include loose smut (as in picture), covered smut, seedling blight (FHB infected grain), leaf stripe but also grain infected with net blotch, Rhynchosporium and Ramularia. Control of seed-borne disease should always start with the planting of disease-free certified seed where possible and treatment of seed with a fungicide where necessary.

QUALITY

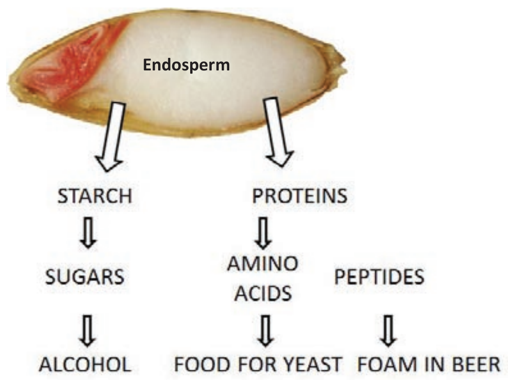
Key Facts

- Malting requires high starch and low protein
- Malting specification:
  - Moisture: <18%
  - Screenings: <6% (2.25mm screen)
  - Protein: 8.8 – 10.8%
  - Germinative capacity: >98%
  - Full compliance to all food safety regulations

Feed barley is sold to a specific specification. Barley failing to meet these specifications can be rejected or discounted in price. Merchants have a graded price for barley delivered over 15% moisture content and can discount the price for poor hectolitre weight if large volumes are anticipated. The specifications for feed barley are outlined below

Feed Barley Specifications	Standard	Range produced
Moisture %	<15%	14-25%
Hectolitre weight (KPH)	62 kph+	55-72
Admixture	Max 2%	

The main outlets for malting barley are brewing and distilling. Both require barley with high starch content (sugar/carbohydrates), which is transformed into alcohol during the fermentation phase of the brewing and/or distilling process.



Protein is also required, as food for the yeast, allowing it to ferment the sugars into alcohol:

- o **High protein** content in the grain = **Low starch** content in the grain
- o **Low protein** content in the grain = **High starch** content in the grain

Starch granules are embedded in a protein matrix and can only be broken down into fermentable sugars after the degradation of the proteins. The amount of protein (nitrogen) also affects water uptake during the malting process.

Based on the total protein level, grains can be:

- o "steely" with high protein levels (11 – 14%)
- o "mealy" with low protein levels (<11%)

Grains with "steely", tightly packed, endosperm will have a delay in water uptake, being more difficult to process.

The purpose of malting is to achieve good degradation of the protein matrix and sufficient degradation of the endosperm increasing the availability of the sugars and thus the extract potential.

Malting Traits for Brewing Barley

Brewers are looking for a balance between the amount of alcohol (translated in starch content in the grain) and flavour (the amount of protein in the grain).

If the protein content is too low, it will negatively influence the enzyme potential.

- Protein: 8.8 – 10.8%
- Extract (sugars) in malt: >81%DM
- FAN >210mg/l
- High enzyme potential to ensure; protein and sugar degradation, high extract level and to give small nitrogen compounds for yeast
- Plump kernels = more sugars
- Even size kernels = homogenous malting
- Strong husk = improve brewing process

Malting Traits for Distilling Barley

Distillers are looking for low protein barley with as high an extract as possible translated into Production Spirit Yield (PSY) (L alcohol/T malt).

Unlike beer, whiskey production aims at very high extract levels, with no interest in flavour driven by malt. As such, distillers are looking for barley with very low protein levels relative to sugar levels and zero Glycosidic nitrile (GN)

- Protein: 8.5 – 9.3%
- PSY: >410 Litres of alcohol
- Bold kernels = more sugars
- Even size kernels = homogenous malting
- Strong husk = improve brewing process

Green Barley Specification

- Moisture: <18%
- Screenings: <6% (2.25mm screen)
- Protein: 8.8 – 10.8%
- Germinative capacity: >98%
- Full compliance to all food safety regulations

Grain Quality

Grains should have no **pre-germinated kernels**, as this will negatively affect:

- Level of sugars in the grain
- The homogeneity of the process

Thin husk, to ensure easy and even water uptake.

Large kernels will give malt with higher extract (above 98% kernels should be larger than 2.2mm).

Grain moisture at harvest: desirable <18%. The higher the moisture the higher the loss of germinative energy and the risk of microorganisms and mycotoxins developing.

Each barley variety has its own genetic characteristics, making it more suitable for either brewing or distilling. These traits include:

- Size of the grains
- Protein content
- Crystalline structure of the protein matrix
- Capacity to produce high enzyme levels
- Level of beta-glucans (compounds involved in the structure of the endosperm)

Among these traits, the protein content can be influenced by the farmer via the timing and amount of nitrogen fertiliser used.

When deciding upon a certain barley variety and its outlet; **agronomic, yield and malting traits** should be considered.

Environmental conditions have just as big an impact on the malting quality of the grain as the varieties genetic make-up. Temperature during harvest strongly affects starch granules: **high temperatures might reduce both the size and the number of starch granules. This will have a negative impact on the total extract available**.

Small starch granules require higher gelatinisation temperatures which can increase on energy usage and extend cycle times in the brewhouse.

Key husbandry factors:

- Good agronomic practices during barley cultivation and harvest are essential in ensuring the production of correct quality malting barley for the end user.

ECONOMICS

It is essential for farmers to examine crop profitability and to take steps to manage the price risks inherent in world commodity markets:

1. Calculate your net cost of production per tonne using the Teagasc E-Crops and Machinery Calculator at **www.teagasc.ie/crops/crops_margins/**. It is essential to know your production costs before investing capital in a crop. This allows you to make informed decisions and assess the various grain marketing options available.

2. Benchmark your own costs against other similar farms using the Teagasc Profit Monitor at **www.teagasc.ie/advisory/farm_management/**. This will guide you as to how well your farm system is performing each year and may highlight areas that could be improved.

3. Explore the suitability of land access options for your farm such as leasing and share-farming at **www.teagasc.ie/collaborativearrangements/**.

4. Plan your annual crop budgets using Teagasc Crop Margins calculator at **www.teagasc.ie/crops/crops_margins/**. This is essential where land is rented or share-farmed. 'Hidden costs' such as fertility issues, perennial weed control etc must be included in the budget.

The margins you calculate should provide a useful guide to potential profit but land suitability, rotation, risk avoidance and convenience should also be considered. There is little difference in margins between spring and winter feed cereals. Achieving the required grain specification to receive bonuses is vital. In the case of malting barley, the availability of contracts and fulfilment of contract requirements may limit the attainment of these margins. Potential malting growers must also be aware of extra costs associated with seed purity, variety characteristics, and extra inputs needed to ensure specifications are met.

Yield has a major influence on profitability. Decisions on input strategies must be tailored for individual fields and farms. Timeliness and attention to detail in carrying out all operations are vital to maintaining profitability in crop production. Fixed costs will need close attention. In particular, investments in machinery and land rental need thorough financial appraisal before a decision is taken. The average machinery cost (incl. repayments, depreciation, fuel and repairs) on 38 tillage farms (7,000 ha) in 2013 was €314/ha.

This guide was written by

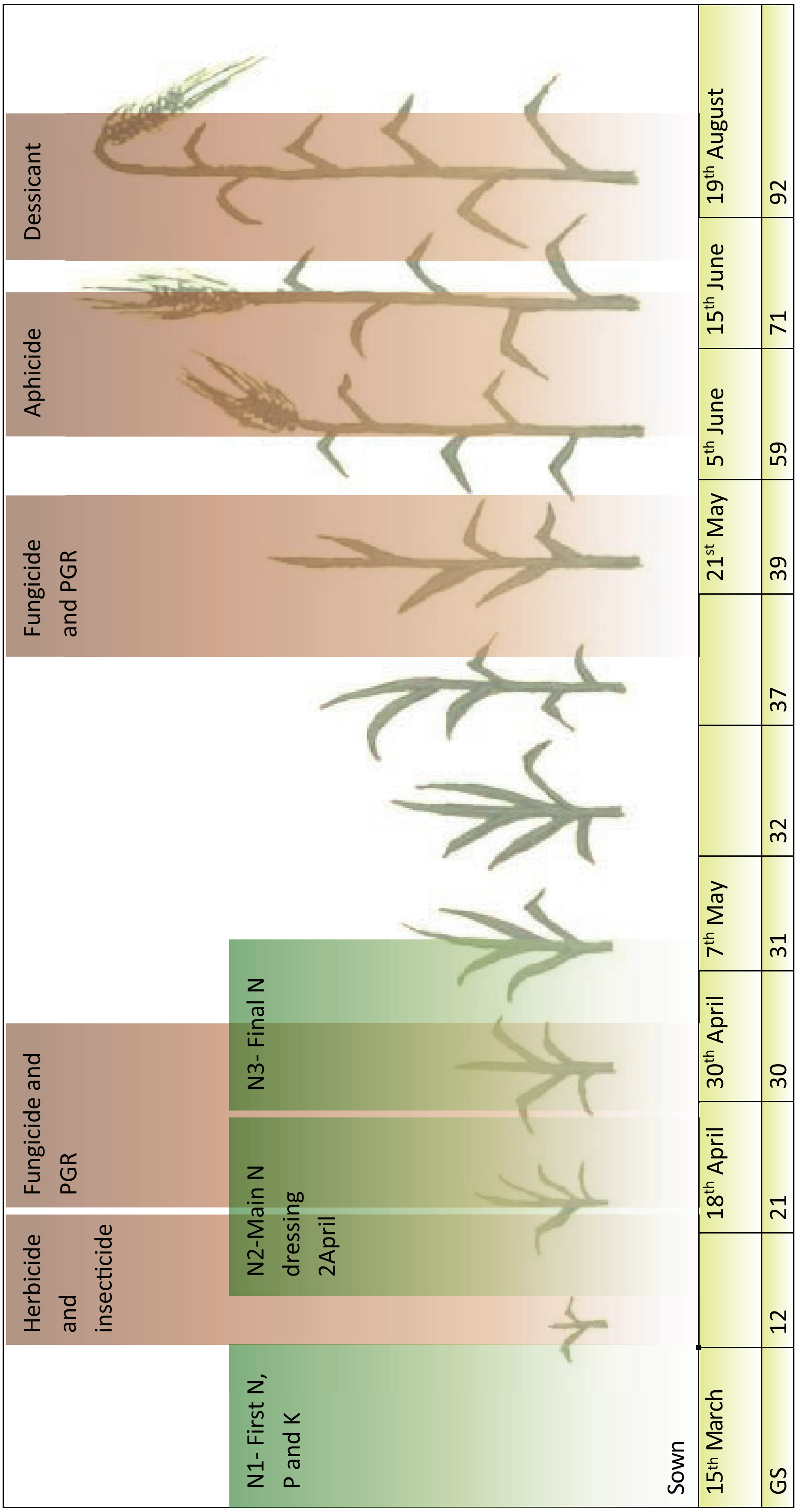
Teagasc

John Spink, Michael Hennessy, Joseph Lynch, Tim O'Donovan, Dermot Forristal, Richie Hackett, Steven Kildea, Liz Glynn, Ciaran Hickey, Shane Kennedy, Mark Plunkett, David Wall.

Boortmalt

Tom Bryan.

THE CROP MANAGEMENT SEASON



Contact Details:

Teagasc,
CELUP,
Oak Park, Carlow.
Tel: +353 59 917 0200
Fax: +353 59 914 2423

www.teagasc.ie

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