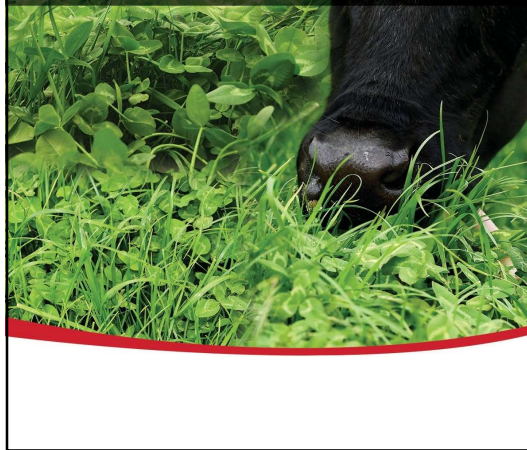


Management and establishment of grass-white clover swards



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Introduction

Recognition of the high forage quality and the nitrogen (N) fixation benefits of grass-white clover pastures has led to a resurgence of interest in its use as a means of reducing the economic and environmental costs in livestock agriculture. The EU Farm to Fork strategy has increased the urgency to focus research on the use of white clover to reduce chemical N fertiliser use. Research is being undertaken at Teagasc Moorepark, Curtins, Clonakilty and Athenry research farms on the role of white clover in our production systems. The research program to date has delivered very promising results (high N use efficiency (NUE) - close to 60%, lower N surplus and higher animal performance). There is, however, a clear challenge to ensure that grass-white clover swards are established and persist on commercial grassland farms. This booklet will discuss and set out the principles for the management and establishment of grass-white clover swards so that the benefits can be achieved at farm level.



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Benefits of white clover

The benefits of white clover tend to occur from May onwards as sward white clover content increases. The main benefits of white clover inclusion in grass swards are:

- **Increased** herbage quality compared to grass-only swards in the summer months.
- **Increased** dry matter (DM) intake in summer and autumn.
- **Higher** milk production and liveweight gain.
- **Nitrogen fixation** – white clover fixes N from the atmosphere making it available for plant growth.
- **Lower** requirement for N fertiliser application in summer.

Latest dairy research

There have been eight years (2013-2020) of research at Moorepark comparing the standard grass-only grazing system receiving 250 kg fertiliser N/ha per year with a grass-white clover system receiving 150 kg N/ha per year. Both grazing systems were stocked at 2.74 cows/ha. At Clonakilty Agricultural College a grass-only system receiving 250 kg N/ha per year was compared with a grass-white clover system also receiving 250 kg N/ha per year, stocked at 2.75 cows/ha over four years (2014-2017). The main results from the research are shown in Table 1.

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Table 1. Average herbage production, sward white clover content and milk production of a grass-only sward receiving 250 kg N/ha and a grass-white clover sward receiving 150 kg N/ha at Moorepark from 2013-2020, and of grass-only and grass-white clover swards receiving 250 kg N/ha at Clonakilty from 2014-2017

	Moorepark		Clonakilty	
	Grass-only 250 kg N	Grass-white clover 150 kg N	Grass-only 250 kg N	Grass-white clover 250 kg N
Stocking rate (cows/ha)	2.74	2.74	2.75	2.75
Annual herbage production (t DM/ha)	13.5	13.4	15.6	16.8
Silage fed during lactation (kg DM/cow)	259	333	350	430
Average sward clover content (%)	-	22.0	-	23.1
Milk solids yield per cow (kg)	490	510	437	485
Concentrate fed (kg/cow)	438	438	391	391
Net profit (€/ha)	1,974	2,082	2,369	2,674

Latest sheep research

Current grazing systems research at Athenry is focusing on the impact of incorporating white clover into pasture-based lamb production systems with special focus on the animal, environmental and economic impacts. Ewes are stocked at 11 ewes/ha, with three pasture treatments:

- Grass-only receiving 145 kg N/ha per year.
- Grass-white clover receiving 145 kg N/ha per year.
- Grass-white clover receiving 90 kg N/ha per year.



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The main results from this research to date (2018-2020) are shown in Table 2.

Table 2. Average herbage production, sward white clover content and lamb age at slaughter of a grass-only sward receiving 145 kg N/ha and a grass-white clover sward receiving either 145 or 90 kg N/ha in Athenry from 2018-2020

	Grass-only 145 kg N	Grass-white clover 145 kg N	Grass-white clover 90 kg N
Stocking rate (ewes/ha)	11	11	11
Annual herbage production (t DM/ha)	12.6	12.8	12.9
Average sward clover content (%)	-	12.3	14.3
Lamb age at slaughter (days)	200	194	186
Gross margin (€/ha)*	857	854	940

*Excluding direct payments

Nitrogen fixation

Nitrogen fixation is the process whereby white clover can fix N from the atmosphere and make it available for plant growth through a process called biological N fixation (BNF). This N is then available for uptake by white clover and other plants, mainly perennial ryegrass, in the sward.

The quantity of N fixed by a grass white-clover sward depends on a number of factors including:

- Sward white clover content - N fixation increases as clover content increases.
- N fertiliser application rate - N fixation declines with increasing N application.
- Soil temperature - N fixation increases as soil temperature increases.
- Solar radiation (sun light) - more sunlight, more fixation.



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Typically as N fertiliser application rate increases, N fixation decreases, as there is adequate N available for grass and white clover growth (Table 3).

Table 3. Quantity of N fixed at different N application rates	
N fertiliser application rate (kg N/ha)	Quantity of N fixed in grass white clover swards (kg N/ha)
100	100-150
150	90-130
200	70-100
250	0-40



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How does white clover grow?

There are three stages of white clover growth from germination to full establishment. These are:



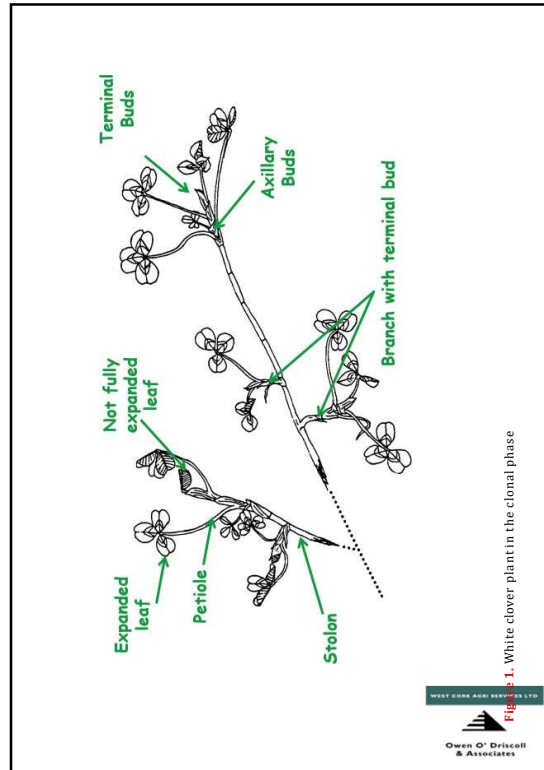
During the rosette and expansion phases white clover relies heavily on a central taproot for growth and development. In the clonal phase the plant is fully reliant on the stolons for growth and persistence.

Rosette phase	Expansion phase	Clonal phase
<ul style="list-style-type: none"> • Reliant on central taproot • Few branches • Small spread • Rosette plant form <ul style="list-style-type: none"> » <i>Small vertical primary stem surrounded by ring of short secondary branches</i> • Plant size – 10-20 cm • Phase lasts approx. three months • Clover does not fix N in this phase • Important to graze during this phase to promote growth (without damaging plant) 	<ul style="list-style-type: none"> • Reliant on central taproot • Rapid expansion – up to 15 branches, 25-30 cm in size • Initially rooting is poor on the stolons and careful grazing is required to avoid damage • Six months post-sowing roots strengthen but plant still reliant on central taproot for nutrient uptake • 12 months post-sowing taproot begins to die – can take up to 2.5 years for all taproots in the sward to die • 12-18 months post-sowing N fixation begins • Good grazing management is crucial for stolon development 	<ul style="list-style-type: none"> • No taproot. Reliant on adventitious roots which form at the nodes of the stolons • Normal status of clover in established swards (Figure 1) • Clover actively fixing N • Stolons last for 12-18 months. New stolons produced at the terminal bud • New stolons become independent plants and this cycle continues each year • Good grazing management helps maintain stolon production and white clover persistence in grazing swards

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Grazing management for white clover swards

Best practice grazing management is similar for grass-white clover swards and grass-only swards. Flexibility and willingness to adapt to the conditions are important when managing grass-white clover swards. Good grazing management is also important for increased persistence and production of white clover in grazed swards.

Spring

- Target early spring grazing - this benefits white clover growth
- Avoid poaching/damaging swards - poaching reduces white clover content in the sward
- Be flexible - use on/off grazing, graze wetter paddocks in drier weather, etc.
- Target post-grazing sward height of 3.5 cm

Mid-season (April to July)

- Maintain pre-grazing herbage mass between 1,300 and 1,600 kg DM/ha (8 to 10 cm)
- Target post-grazing sward height of 4.0 cm
- Chemical N fertiliser may be reduced on swards with good white clover content ($\geq 25\%$) (see Figure 2 for guideline sward clover content and section on N fertiliser strategies)

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- Autumn**
- Build grass on the farm from early to mid-August by extending rotation length
 - Close the farm in rotation from early October
 - Target post-grazing sward height of 3.5 to 4.0 cm on the final rotation
 - Avoid poaching/damaging swards
 - Be flexible – use on/off grazing, graze wetter paddocks in drier weather, etc.
 - Chemical N fertiliser may be reduced in August on swards with good white clover content ($\geq 25\%$) (section on N fertiliser strategies below)
 - Close paddocks with a high sward white clover content (i.e. $> 30\%$) towards the end of the final rotation (end of October to start of November)

An average annual sward white clover content of approx. 20 – 25% is desirable for animal and sward production benefits. Sward white clover content increases through the spring, into summer and generally peaks in August/September (Figure 2). Good grazing management is key to maintaining sward white clover content.

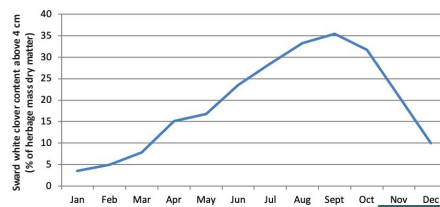


Figure 2. Average annual sward white clover content across the year



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Nutrient management

Nitrogen fertilisation strategies

White clover does not have the ability to fix N for the first 12 to 18 months post-sowing. Nitrogen fertiliser is important during this period to encourage growth and development. White clover needs a higher soil temperature for growth than grass. Grass starts growing at soil temperatures of 5-6°C while white clover needs soil temperature of 8°C. As a result, the contribution of white clover to the sward in early spring is low. As our systems have a requirement for pasture to feed animals in early spring, N fertiliser must be applied at similar rates to those used in grass-only swards. In the summer, when sward white clover content is increasing ($\geq 25\%$), N fertiliser application can be reduced. Some N fertiliser is required in autumn so N should be applied in late-August/early September (before 15th September) to ensure pasture availability in the autumn. Suggested N application strategies for grass-white clover swards with average annual white clover content of 20% or greater are shown in Table 4 and 5.

Table 4. Nitrogen fertiliser application rates by rotation for white clover in dairy swards

Date (rotation)	N fertiliser application (kg N/ha)
Mid-late January	28
Mid-March	28
April (2 nd rotation)	33
Early-May (3 rd rotation)	9
Late-May (4 th rotation)	9
June (5 th rotation)	9
Early-July (6 th rotation)	9
Late-July (7 th rotation)	9
August (8 th rotation)	9
Mid-September	12
Total	150



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Date (rotation)	N fertiliser application (kg N/ha)
Early-mid Feb	20
April (2 nd rotation)	20
May (3 rd rotation)	12
June (4 th rotation)	12
Late July/early August	12
Early-Sept (7 th rotation)	14
Total	90

Macro- and micro-nutrients

White clover has a poor competitive ability to absorb most soil nutrients compared to grass due to the different characteristics of the root systems of the two species. Perennial ryegrass has a denser longer, thinner and more finely branched root system compared to white clover. As a result, white clover is generally at a disadvantage when it comes to nutrient uptake from the soil.

Soil pH is critical for white clover development. White clover is more sensitive to lower soil pH than grass.

- Soil pH should be greater than 6.3.
- Low soil pH reduces soil nutrient availability for plant growth.
- Low pH soils can be deficient in plant available calcium (Ca) and magnesium (Mg) which are necessary for rhizobia (N fixing bacteria) survival.
- In low pH soils manganese (Mn) and aluminium (Al) toxicity can have a major effect on white clover development.
- Formation of nodules for N fixation is reduced below soil pH 5.8.

White clover requires a minimum of soil Index 3 for P (5.1 – 8 mg/l) and K (101 – 150 mg/l).



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- Soil P and K availability are important for BNF which is reduced when there is a P and/or K deficiency. Grasses tend to dominate K deficient soils resulting in low sward white clover content.

In sulphur (S) deficient soils white clover growth and BNF will be reduced. Other soil nutrients such as calcium (Ca), sodium (Na) and molybdenum (Mo) are important for white clover growth. Cobalt (Co), boron (B), Ca Mo, iron (Fe), Co, Ca and copper (Cu) are important for nodule development and function. A summary of the relevant importance of macro- and micro-nutrients in grass-white clover swards is presented in Table 6.

Phosphorous	+++
Potassium	+++
Sulphur	++
Calcium	++
Sodium	+
Molybdenum	+
Cobalt	+
Boron	+
Iron	+
Copper	+
Manganese	+ (toxicity in low soil pH soils)
Aluminium	+ (toxicity in low soil pH soils)



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Establishing a grass-white clover sward on your farm

Establishing white clover on farm will take a number of years using a combination of reseeding and over-sowing. Incorporating white clover in a full reseed is the most reliable method of establishing white clover and provides the best opportunity for weed control.

Over-sowing is a simple and low cost method of introducing white clover into swards. Success is very much dependent on soil fertility, weather conditions at sowing, soil moisture, post-sowing grazing management and competition from the existing sward. Suitable paddocks for over-sowing are those with good soil fertility, high perennial ryegrass content and low weed content.

Reseeding

- Aim to reseed as early in the year as possible (April, May, June) when soil temperatures are high and increasing, and there is adequate opportunity for weed control.
- Soil sample for P, K and pH.
- Spray off the old pasture with a minimum of 5 L/ha of glyphosate; allow a minimum of 7 to 10 days after spraying before cultivating.
- Prepare a fine, firm seedbed.
- Use grass and white clover varieties from the Irish Recommended List.
- Cattle sowing rate - 28 to 30 kg/ha of grass plus 3.5 to 5.0 kg of medium leaved clover.
- Sheep sowing rate - 25 to 28 kg/ha of grass plus 5.0 to 6.0 kg of small leaved clover.
- Avoid sowing white clover seed too deep - sowing depth approx. 10 mm.
- Roll well to ensure good contact between the seed and the soil.



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Over-sowing

- Do not over-sow old 'butty' swards with a low content of perennial ryegrass - white clover will not establish well in these.
- Control weeds before over-sowing white clover as weed control options afterwards are more limited. Some herbicides have a residue of up to 4 months - always check the residual time on the label of the product or seek advice on a suitable weed control product.
- Take a representative soil sample for P, K and pH analysis and correct soil fertility prior to over-sowing. Optimum soil fertility when over-sowing will help increase the chances of success.
- White clover seed can be broadcast onto the sward or stitched in using a suitable machine.
- If broadcasting with a fertiliser spreader:
 - *Mix clover seed with 0:7:30 fertiliser and only add white clover to the spreader when you are in the field to avoid white clover settling at the base of the spreader.*
 - *Do a maximum of 1 ha at a time (to avoid seed settling) and spread in 2 directions across the field.*
- Stitching in white clover seed with a drill/harrow ensures better seed to soil contact. Stitching *must be* used for over-sowing sheep grazed swards due to the denser nature of swards.
- Over-sow directly after grazing (≤ 4 cm post-grazing sward height) or after cutting the paddock for surplus bales - ideally only over-sow three to four paddocks at a time.
- Sow at a rate of 4.0 to 6.0 kg of white clover seed/ha.
- Soil contact post over-sowing is one of the most crucial factors affecting germination.
 - *Roll paddocks post-sowing to ensure soil contact.*
 - *Apply watery slurry (if available) - ideally around 2000 gallons/ac.*
- Reduce N fertiliser post over-sowing for one to two rotations to reduce grass growth.



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Post-sowing management - full reseed or over-sowing

- Graze as soon as the new plants are strong enough to withstand grazing.
 - *Early grazing is important to allow light to the base of the plant to encourage stolon development.*
- The first grazing of a new reseed can be completed at a pre-grazing yield of 600 to 1000 kg DM/ha.
- Light grazing by animals such as calves, weanlings or sheep is preferred as ground conditions may still be somewhat fragile, depending on the seedbed preparation method used.
- Graze swards tight for at least the first three grazings post-sowing, keeping pre-grazing herbage mass <1,100 kg DM/ha and graze swards to ≤ 4 cm. This allows light to penetrate to the base of the sward, which is essential for white clover establishment.
- Freshly reseeded or over-sown swards should not be closed for silage in their first year of production as the shading effect of heavy covers results in poor white clover establishment and an open sward which is liable to weed ingress.
- If possible, reseeded or over-sown swards should be closed later in the autumn to avoid carrying heavy covers over the winter period.



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Weed control in reseeded and over-sown grass-white clover swards

Reseed	Over-sown
<ul style="list-style-type: none"> • Weeds in new reseeds are best controlled when grass is at the two to three leaf stage. • Docks and chickweed are two of the most critical weeds to control; it is important to control these at the seedling stage. When white clover is included in the sward use a clover safe herbicide. 	<ul style="list-style-type: none"> • Control established weeds before over-sowing as weed control options post-sowing will be limited. • Consider residue time of non-clover safe sprays from application of spray to over-sowing the white clover - it can vary from one to four months. Contact your local advisor or merchant for advice if spraying before over-sowing. • For established grass-white clover swards the herbicides Eagle and Prospect are white clover safe options. • All pesticide users should comply with the regulations as outlined in the Sustainable Use Directive (SUD).



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Grazing management to prevent bloat

Bloat can be an issue in swards with high white clover content. Bloat can occur at any time of the year but it is more likely to occur in the second half of the year when white clover content in the sward is highest. Good grassland management can minimise and prevent the risk of bloat.

Bloat prevention

- Avoid switching between grass-only and grass-white clover swards (as much as is possible).
- Keep post-grazing sward height at 4 cm, not below.
- When entering a grass-white clover paddock in risky conditions (high white clover content / hungry animals / wet morning / very lush pasture) provide a small area in the paddock for the first 2-3 hours after turn-out to prevent the initial gorging on white clover.
- Provide anti-bloating agent in the water supply – starting the day prior to entering the risky paddock.
- Check cows after initial turnout and regularly for first three hours of grazing during high risk periods.



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White clover varieties

White clover cultivars are categorised by leaf size.

Small leaf white clover

- Lower yielding
- More persistent
- Tolerant of tight grazing, e.g. sheep grazing

Medium leaf white clover

- Intermediate for yield and persistency
- Suitable for cattle grazing

Large leaf white clover

- Higher yielding
- Aggressive and can dominate a sward
- Include in silage swards

Small leaf white clovers are recommended for sheep grazing and medium leaf white clovers for dairy or beef cattle grazing.

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Recommended White Clover Varieties 2021					
Variety name	Leaf size*	Total yield ¹	Clover %	Year first tested	Breeder
Barblanca	Large (0.76)	105	50	2009	Barenburg
Violin	Large (0.75)	101	44	2020	DLF
Dublin	Large (0.73)	102	50	2018	Teagasc
Alice	Large (0.73)	99	50	1995	Teagasc
Chieftain	Medium (0.68)	98	47	2005	Teagasc
Buddy	Medium (0.58)	100	45	2015	Teagasc
Iona	Medium (0.56)	94	44	2014	Teagasc
Crusader	Medium (0.56)	95	42	2009	Barenburg
Aberherald	Medium (0.55)	97	45	2003	IBERS
Coolfin	Small (0.51)	104	47	2017	Teagasc
Galway	Small (0.36)	95	38	2017	Teagasc
Aberace	Small (0.26)	95	33	2016	IBERS

¹Control Mean - 9.4 t DM/ha; controls in 2016 Trial were Barblanca, Alice, Chieftain and Crusader

*Values in brackets indicate leaf size compared to the variety 'Aran' (i.e. Aran = 1.00) based on data from UK D.U.S. tests.


The Irish Recommended Grass and Clover List is published annually by the Department of Agriculture, Food and the Marine.

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Red clover

Red clover is a relatively drought tolerant, deep tap rooting, N fixing legume that is primarily used for silage production but can also be grazed by cattle or sheep in the autumn. It offers high yields of high quality forage and can fix 150-200 kg N/ha per year. Red clover has a different growth habit to white clover and requires different management to optimise its performance. The crown of the red clover plant acts as the growing point and is located above ground level. The stem grows upwards from the crown. The crown of the plant must be protected from overgrazing or cutting too low in order to maintain red clover in the sward.



Latest research

Research at Teagasc Grange has shown promising results from grass-red clover silage mixtures in plot experiments over a six-year period. Some of the main results from this work are:

- Under a silage cutting regime a grass-red clover sward receiving no N fertiliser produced similar total annual DM yield to a grass-only sward receiving 412 kg N/ha per year (15,785 vs. 15,697 kg DM/ha).
- Mean DM yields of the grass-red clover sward were consistent over a 6-year period.
- Early harvest (26th May) compared to late harvest (11th June) increased sward red clover content (62% vs. 46%) and increased total annual DM yield (15,039 vs. 14,773 kg DM/ha).
- Red clover content and herbage production were greater on swards when 0 kg N/ha were applied (61% and 15,039 kg DM/ha, respectively) compared to when 50 kg N/ha were applied (48% and 14,773 kg DM/ha, respectively).

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Red clover sward management

- Red clover seeding rate - 20 to 22 kg/ha of grass seed plus 7 to 10 kg/ha of red clover seed. White clover can also be added to the mix at a rate of 1 kg/ha if required.
- In the establishment year, red clover should be allowed to flower before harvesting the first cut of silage to help root development and the growth of the bacteria that fix N.
- In subsequent years, silage harvesting should occur at intervals of six to eight weeks, any time between bud development and early flowering.
- Three to four silage cuts can be taken each year. Approximately 80-90% of total annual yield will be obtained from silage cuts completed by late July-early August. The final cut should be taken no later than mid-October.
- In the autumn, herbage should be cut or grazed (ideally in October) without poaching, soil compaction and physical damage to the plant crowns.
- Cut silage crops to a residual height of 7-8 cm above ground level.
- Optimum post-grazing sward height is 6 cm.
- Optimum over-wintering sward height is 4-6 cm above ground level.
- Red clover can contain up to 1% oestrogenic compounds. Oestrogen levels can lower ewe fertility. Therefore, do not allow breeding ewes to graze red clover swards or eat red clover silage for a period of 6 weeks before and after mating to avoid any adverse effect of red clover oestrogens on lambing percentage. Store lambs can be offered red clover swards and silage at any time.
- Similar to white clover, there is a risk of bloat when grazing red clover. Bloat management practices as outlined previously are effective for red clover.
- Red clover typically has a relatively short lifespan at farm level - two to four years. The correct management, as outlined above, is critical to ensure the crown of the red clover plant is protected and that red clover is maintained in the sward.

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Red clover varieties

There are no official red clover evaluation trials in Ireland so red clover varieties are not included in the Recommended List of Grass and Clover Varieties published by the Department of Agriculture, Food and the Marine each year. Therefore, the United Kingdom (UK) Recommended List of Red Clover Varieties should be used when selecting a red clover variety. Fearga is the first ever Irish bred red clover variety and was the highest yielding variety in the UK in the most recent Recommended List evaluation. The total annual DM yield of varieties available on the UK Red Clover Recommended List 2020-2021 are presented in Figure 3.

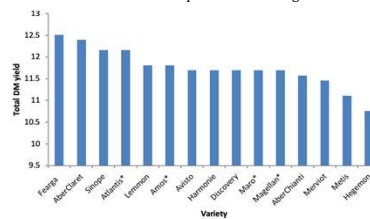


Figure 3. Total annual yield (Average = 100 at 11.69 t DM/ha) of varieties on the UK Red Clover Recommended List 2020-2021. (* = Tetraploid)




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Useful links

Irish Recommended Grass and Clover lists
<https://www.gov.ie/en/publication/43ec9-grass-and-white-clover-varieties-irish-recommended-list-2020/>

UK Recommended Grass and Clover lists
<https://ahdb.org.uk/knowledge-library/recommended-grass-and-clover-lists-2020-21>






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5%	Score = 1	10%
		
15%	Score = 2	20%
		
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35%	Score = 4	40%
		
45%	Score = 5	50%
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>60%		

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