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**INVITED**

**Improved efficiency in temperate grass based dairy systems**

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**Abstract**

Over the coming decades, population growth, urbanisation and income growth, especially in developing countries, will result in a significant increase in demand for food. Increasing production should be obtained with an increased efficiency and respect for the environment. These formidable challenges and uncertainties point to the need to develop a new model for agriculture and food production. Grasslands cover a significant part of the earth and provide an important source of global food supply particularly for ruminants. In this context, animal production from pasture based systems will be well placed to provide foods for human consumption while also providing a wide variety of ecological services. In that regard, there has been considerable progress in the management of pastures which can deliver both high productivity and quality food production using sustainable practices. The challenge for primary producers is always to make more efficient use of pastures through improved management and decision making. In this regard the development of decision supports for efficient pasture management is a key objective for pasture based research and development agencies worldwide.

**Introduction**

Grasslands cover a large area of the world. A little bit more than 40% of the earth land surface (excluding Greenland and Antarctica) is composed of grasslands with a large diversity of vegetation (White et al, 2000). A large part of the total grassland area is composed of native or natural grassland such as the savanna in Africa, the pampa in South America, shrub land and steppes in Oceania and Asia and tundra in Europe. These areas are frequently located in vulnerable zones such as arid, humid or mountain areas, are extensively used by itinerant or herded livestock and are not influenced by human activities. In temperate areas, grasslands are often permanent pastures, meadows, or sown pastures, are more productive and are used more intensively by herbivores.

At a global or local level, and regardless of region and pasture utilization, grasslands play a major role in the ecosystem equilibrium (O'Mara, 2012 ; Huguenin-Elie et al, 2017). A lot of agro-ecosystemic services associated with grassland area have been identified including biodiversity preservation, carbon storage, erosion control, water and nutrient cycling regulation, and not forgetting food and forage production. Various papers (Soussana and Lemaire, 2014 ; Rodriguez-Ortega et al, 2014) highlight the fact that there is an optimum level of grassland utilization to maximize goods and services offered by this area. Herbivores, and principally ruminants with their ability to graze, have an important impact on maintaining grasslands and providing ecosystem services.

On the other hand, the projected rise in population globally coupled with increasing food demand associated with increasing economic prosperity in developing countries requires more food to be produced with more sustainable production systems to limit the negative impacts of production intensification on the environment. Ruminants are able to efficiently utilize grassland resources and transform grazed forages within low cost and sustainable systems into highly nutritious foods for humans. In this situation, in Europe as well as worldwide, better grassland utilization is a major challenge to increase animal production (milk, meat, etc.) and to limit the competition with arable land which is more efficiently used for grain production aimed directly for human food.

### **How to improve intake at grazing?**

In temperate areas, notably in Europe, well managed grazed grass is a “low cost high quality naturally occurring TMR” (Table 1). Grass grazed is the unique forage which is correctly balanced to meet the nutritional requirements of both large and small ruminants, including high producing dairy cows. The chemical composition (CP and ADF content) and the nutritive value, whether for energy or digestible protein contents, are entirely consistent with the nutritional requirements for dairy cows (INRA, 2010). The UFL content is nearly 0.90 UFL / kg of DM (1 UFL = 1,700 kcal of NEL) and the PDI (digestible protein in the intestine) value expressed per UFL is nearly 100 g, corresponding to the recommendations (Vérité et Delaby, 2000). With grass only diets, dairy cows are able to produce approximately 25 kg of milk with high milk fat and protein composition. In contrast, other forages such as grass silage, maize silage or hay which are commonly used to feed cows during the indoor period require nutritional supplements. For example, Peyraud et al. (2014) have calculated that every 1 kg of maize silage DM consumed by a dairy cow requires an additional 185 g of soya bean supplement to correct the large protein deficit which is characteristic of this forage. The same nutritional deficit is also present for mineral requirements.

### ***Increase grass allowance to increase intake?***

As a consequence of the high nutritive value potential of grass, the main challenge at grazing is to successfully improve and maximize intake per cow per day, both in the short term in the actual grazed paddock, but also in the long term over the grazing season. In comparison with maize silage well supplemented with protein concentrate, grass grazed is characterized by a reduced intake rate due to the form and nature of the forage offered. Consequently, the cow compensates by increasing grazing time beyond that observed in the barn (Table 2). To maximize intake at grazing, one idea is to increase grass allowance. A lot of experiments, synthetized by Delagarde et al (2001) and more recently by Pérez Prieto and Delagarde (2013), have demonstrated the positive effect of increased grass allocation on grass intake. The response curve is curvilinear with an asymptote close to 20 kg DM intake observed at very high levels of grass allowance (Figure 1). On average, as allowance, evaluated to 4-5cm above ground level, increases between 16 and 24 kg DM/cow/day, grass intake increases by 0,20 to 0,25 kg per kg of extra grass allocated. To obtain 1 kg of additional DM intake, it is necessary to allocate an additional 4 kg of DM. Consequently, 75% of the additional grass offered is not consumed and induces refusals, resulting in unconsumed patches of grass and a higher post grazing height. In addition, and unlike indoor feeding systems, these refusals will have an important negative effect on future grass quality during subsequent grazing rotations. During regrowth, the tiller sheath and stem from refusals rise up and decay in the regrown sward and it will be difficult to efficiently remove the refused material in the future without deleteriously impacting milk production performance by constraining cows to graze more severely during the following rotation. For a similar level of daily intake per cow, increased pre grazing sward height results in increased stem and sheath height, increased refusal and increased post grazing residual sward height.

Practicing a high allowance grazing strategy to maximize daily intake per cow also has a big effect on grass utilization at the paddock level (Figure 1). Higher is the intake per cow per day, lower is the grass utilization and intake per hectare as refusals increase. At high allowance, the number of grazing days realized per hectare

is reduced as is the milk yield produced per hectare. These results are well illustrated by the literature review on stocking rate experiments synthesized in a meta-analysis by McCarthy et al (2011). In average, the increase of one cow per ha induces a reduction of 7% of daily milk yield per cow due to the reduction of daily intake but induces an increase of 21% in milk yield per hectare due to the increased number of grazing days per hectare and improved grass utilization. As stocking rate increases, post grazing residual sward height is reduced generally resulting in leafier, better quality regrowth and a positive cumulative effect along the grazing season (Tunon, 2013). Good grazing management is characterized by achieving a good compromise between maximizing intake per cow and per hectare. In this regard, the challenge for the grazing farmer is to be able to offer grass which is easy to graze to the cow.

### ***Produce grass easy to graze and at the right moment***

The characteristics of grass which is easy to graze are now well known. Leafy swards enriched by legumes, notably white clover, is probably the best sward to provide for maximizing nutrients intake by dairy cows. Consequently, the farmer will have to adjust grazing management to experiment with various combinations of species and cultivars, age of regrowth and pre grazing height or biomass to produce the ideal grass. Late heading grass cultivars offer a greater flexibility and facilitate the avoidance of heading by grazing the vegetative apex between the vegetation start and heading dates. In a 2-year grazing experiment published by Gowen et al (2003) and comparing 2 intermediate and 2 late heading cultivars, grass DM intake and milk yield were significantly higher in spring (before and during the heading period) on the late heading grass cultivars regardless ploidy.

The motivational reasons to include white clover in grazed pastures are multiple (Lüscher et al, 2014 ; Delaby et al, 2016). Research has clearly established that including white clover (WC) has many benefits with respect to cow performance due to its highly stable nutritive character compared to perennial rye-grass (PRG) only swards. One of the main benefits of white clover inclusion is to increase DM intake compared with a perennial rye-grass monoculture. This is a consequence of the superior nutritional composition of the fraction of plant harvested by the animal, composed mainly of leaves and petioles. This interest has been well demonstrated by Ribeiro-Filho et al (2003) and confirmed within a recent experiment implemented in Ireland (McCarthy et al, 2016). As presented in Table 3, introducing WC (at 40 to 45% of the total biomass) in a PRG monoculture significantly increases daily DM intake and consequently results in a higher milk yield per cow per day (Table 3). A further interesting result is the interaction between WC introduction and the age of regrowth. As regrowth matures, the difference observed in DM intake and milk yield in favor of the PRG-WC mixture increases. This result indicates that WC matures slowly, maintains high nutritive value and this is advantageous in grazing management.

Due to the changes in morphological composition (grass height, % of lamina) and the consequences on chemical composition and nutritive value of grass and large legumes (alfalfa, red clover), the role of age of regrowth is well established. Many recommendations, based on age of regrowth in average regional weather conditions, have been developed and disseminated to farmers to improve grazing management. Well known in South America, André Voisin (1957) was one of the first to formalize the grazing rotational system management according to the age of regrowth.

But, as grass growth is highly variable, reactive to practices, and difficult to predict in the short term particularly in spring, systematical rules based on regrowth age are too risky today. For this reason, according to the influence of pre-grazing height (reflecting biomass on the paddock before grazing) and of the ratio between pre and post-grazing height on grass intake (Delagarde et al, 2001 ; Pérez-Prieto and Delagarde, 2012), the actual recommendations in Europe are more organized around grass height, frequently measured with a platometer. On average, as the main ambition is to achieve a balance between intake per cow and per hectare for dairy cows, recommended practice is to obtain a post grazing height equal to 45 to 50% of the pre-grazing height

(Delaby et al, 2011). As the other main challenge is to obtain a low post grazing height to ensure leafy material in the lower layers (Parga et al, 2000) and regrowth quality (Stakelum et Dillon, 2007 a and b), the current “ideal” pre grazing height recommendation is between 9 and 12 cm (i.e 1200 to 1600 kg DM/ha of biomass above 4cm). While a low post grazing height of 4 to 5 cm is desirable, the “ideal” will change and increase during the grazing season to achieve high animal intake and be tolerant to the elongating stem, changing structure and chemical composition in the sward.

How to be successful along the grazing season?

At the scale of the grazing season, the main objective of the “grazing” farmer is to balance animal demand and the grass availability as much as possible. The herd grass demand (GD) depends on the number of cows in lactation and the individual average intake capacity (IC) corrected for the quantity of supplements (S) included in the daily ration. The grass available depends on grass growth (GG) and the grazeable area (GA). Finally, the grazing equation to solve is

$$GG \text{ (kg DM/ha/day)} \times GA \text{ (ha)} = GD \text{ (kg/day)}$$

or expressed per cow and per day

$$GG \text{ (kg DM/ha/day)} \times GA \text{ (ha/cow)} = IC - S \text{ (kg DM/cow/day)}$$

To solve this equation, it is possible to adjust every component but at different time scales and with more or less difficulty. Daily grass growth is seasonal, highly weather and soil fertility dependent and difficult to control. Equally, the calving pattern is determined 9 months before the actual grazing season and will depend of the ability of the cow to be pregnant at the right moment. Consequently, to regulate grass available in the short term, changing the grazing area and supplement allocation is most practical. To use grass more efficiently, the grazing manager must rapidly anticipate changes in grass availability and react quickly by adjusting these influential factors (area allocated and supplementation).

### ***Early turnout or how well start the grazing season?***

Turnout in spring is the first step of the grazing season. And early turnout, in line with the commencement of grass growth is critical to the overall success of the grazing season. O'Donovan et al (2004) have highlighted the numerous benefits to practice early turnout (Table 4). Early grazed swards had improved grass quality with a higher proportion of leaf, and consequently a higher nutritive value in terms of both energy (UFL) and protein content. At medium stocking rate during the subsequent rotation, the pre grazing height was lower in early grazed paddocks resulting in a reduced grass allowance and grass DM intake (- 0.8 kg DM) for the early grazed treatment, but with no effect on daily milk yield and milk solids production. At high stocking rate, early grazing achieved a similar grass DM intake during the subsequent rotation, while the grass quality improvement resulted in increased daily milk yield (+1.1 kg). As the grass regrowth structure is more favorable after early grazing, the post grazing height is lower and the grass is better utilized during subsequent rotations. As observed by Kennedy et al. (2006), lax grazing on late spring grazed swards had a cumulative negative effect on grass dry matter intake after four rotations.

### ***The right cow managed within a compact calving system***

In the temperate area, as the grass growth is seasonal and increases rapidly in spring, early turnout needs to synchronize the animal demand and grass available. Consequently, grass-based systems of milk production require rapid calving in spring to match feed supply and herd demand (Figure 3 – Horan, 2017). Calving date and rate are important determinants of milk production and feed utilization in grass-based systems, through its impact on the alignment of feed demand with supply. Compact calving in spring is based on achieving high rates of pregnancy within a short period of time following the start of breeding. Altering the mean calving date

of the herd may have a role in reducing the reliance of grass-based farm systems on purchased feeds particularly at higher stocking rates. Both Dillon et al. (1995) and McCarthy et al. (2013) observed that delaying calving until March achieved a better alignment of dairy herd requirements and grass growth within Irish grass-based milk production studies, increased milk production from grazed grass, reduced the requirement for purchased supplements and achieved a greater efficiency of energy utilization particularly at higher stocking rates.

Other advantages of compact calving in spring include the alignment of the non-lactation period in winter with the low availability of pasture. In compact calving grazing systems, the low nutritive requirements non-lactation period is aligned with the conserved forage feeding period. As conserved forages are always difficult to harvest with high quality and require expensive supplementation for lactation, this is avoided by having all animals with low feed requirements during this period.

In light of this, and to address the risk of dried summers and the lack of grass in France, Pottier et al (2007) have proposed to split the dairy herd into two calving seasons with 50% calving in 2 months in Mar-Apr, and the other 50% 6 months later, in Sep-Oct. In this system approach, all cows are dried off on the same day, in Jan-Feb and Jul-Aug, for all the cows of the respective seasonal group. This has multiple advantages. As 50% of the cows are dried in summer and winter, feed demand during both winter and summer, when grass growth declines, reduced overall herd feed demand and gives the 50% of the herd in milk a better opportunity to graze on a large area due to the overall reduction in stocking rate. In terms of heifer rearing, it is possible to plan a first calving at 30 months with calves born in spring subsequently calving for the first time in autumn and conversely. This allow more rearing time and reduces the high feeding level requirements for a 2-years calving and reduces the requirement for concentrate supplementation to achieve target weights thereby reducing the total cost of the dairy feeding system. In term of milk delivery, the two-calving seasons are characterized by a more flat monthly profile of milk production which is advantageous to the dairy industry demand in some countries.

In systems based on compact calving, grass-grazed based feeding and low levels of supplementary feeding, dairy cows with high fertility in a short breeding period are required to utilize forages efficiently. Typically, continental Holstein dairy cows are not suitable due to their high milk yield potential which is detrimental to the maintenance of adequate body condition to facilitate conception at the right moment and to avoid ill health within a restricted feed environment (Baumont et al, 2014 ; Delaby and Fiorelli, 2014). A more equilibrated cow is beneficial. Dual purpose or cross breed cows seem more flexible and better adapted to grazing and have improved health, milk value, reproductive performance, feed efficiency and beef value (Delaby et al, 2014). If milk composition has a big effect on the received milk price, then milk volume per cow is not beneficial to guarantee high income. Consequently, researchers have defined the “ideal” cow (Berry, 2015) and redefined the selection scheme to increase the emphasis on fertility (35% of the global index) and to reduce the milk index (to 11%; Berry, pers. comm.). A similar approach has been developed in France to better equilibrate the global index (Figure 4) and to offer to the farmer a larger panel of AI's bulls which are appropriate for the diversity of dairy systems practiced (Brochard, pers. comm.).

### ***Tools to support grazing management and make timely decisions***

To efficiently use grass and the capability of dairy cows to transform grass to milk, the farmer has to manage a dynamic system which is more variable than a confinement-based system. Grass based systems are unstable, and require anticipation and flexibility on the part of the manager to take the right decision at the right moment. This is not so easy and methods and tools are needed to simplify information and assist successful decision making in the longer term. Regardless of the grazing system, or the proportion of grazed grass in the dairy cow diet, the most important grazing management requirement is to measure grass supply weekly on the grazing platform, to calculate the grazing days ahead, to identify possible surpluses or deficits quickly and to plan the

grass utilization for the next period. Frequently updated knowledge of the situation is very important to take the right decision. In France, a grazing tool named *Herb'Avenir*, has been developed in 2005 (Defrance et al, 2005) to help the farmer to anticipate the variation in grazing days ahead according to some hypothesis on grass growth in the immediate future. Similarly, the Grass Wedge concept<sup>1</sup> described in the Grazing Notebook (Dillon and Kennedy, 2009 – Figure 5) allows the evaluation of the state of grazing in relation to animal demand. After learning to use the methods, it is relatively easy to interpret the graph obtained and to imagine the probable future situation. Recently in Ireland, Teagasc has developed on a web site, *PastureBase Ireland* (Hanrahan et al, 2017). This database allows the farmer to enter data weekly, to view the current grass supply according to the grass wedge concept and also quantifies the grass growth between the current and previous grass measurements, which will help to anticipate and grass budget over the week ahead. For the researchers, this is also an amazing opportunity to capture information on the grazing practices of Irish farmers (stocking rate, fertilization, pre and post grazing heights ...), to aggregate grass growth and grazing information at local, regional and national levels. The main difficulty to successfully use the grass wedge concept is that you must anticipate or to fix the rotation length and the immediate stocking rate, two components of the grazing system which depend on the future grass growth.

Taking account of this limit, a more recent decision support system named *Pastur'Plan* has been developed with an advisory company in France (Delaby et al, 2015) which is also based on the Grass Wedge concept but has been adapted to integrate the possibility of non-equal paddock areas and differences in the between-paddock potential. Other advantages of *Pastur'Plan* are to facilitate scenario implementation and to evaluate the consequences of different options according to different forecasted grass growth curves. The major interest resides in the capability to describe and illustrate the anticipated evolution of grass supply and demand at the paddock level (Figure 6). At the end of the simulation, according to the farmers preferred grazing management decision, *Pastur'Plan* suggests the next few days grazing calendar.

All these tools are based on the same approach summarized in 3 steps: to measure the state of play, to simulate different options in term of grazing management and finally, to decide the future grazing plan. In all cases, the objective is to facilitate reflection and anticipation to simplify decision making for better grass utilization.

## Conclusion

Improved efficiency in grass based dairy systems is a big challenge for the future. A lot of convergent events require grass based farmers to produce more and better with less. The world demand for food is high and will increase further with both population growth and increased economic prosperity in Asian and African. The European Community has decided to suppress the milk quota system in 2015 and to encourage farmers to produce more food in a liberal economical world with less and less trade frontier protections. Finally, the world has recently understood that Earth is unique and must be protected for future generations. Consumers, aided by media, are insistent that milk and beef production systems are sustainable without negative impacts on animals and the environment. In the face of this situation, grazed grass based dairy systems have an interesting opportunity to take. If cereals and legumes have to be kept for direct human consumption and to a lesser extent for monogastric feeds, grassland is devoted to efficient ruminant production. Without ruminants and ruminant breeders, grassland will disappear. At the same time, grassland provides many eco-systemic services and interesting possibilities for “green” products to opportunistically respond positively to consumers demand. As described in this text, in the last 20 years, a lot of progress has been made in terms of an improved understanding and management of grazing. Now is the time to transfer knowledge to help dairy farmers to be and to do better.

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<sup>1</sup> It is a snapshot in time of the amount of grass that is on a farm and its relationship to livestock demand in the form of a bar chart with each bar representing the pasture cover of an individual paddock in descending order. The demand line indicates the amount of feed required for a specific stocking rate, rotation length and livestock requirement (Hanrahan et al, 2017).

with each bar representing the pasture cover of an individual paddock in descending order. The demand line indicates the amount of feed required for a specific stocking rate, rotation length and livestock requirement (Hanrahan et al, 2017).

Table 1: Chemical composition and nutritive value of grass offered along the grazing season

a/ INRA, Le Pin-au-Haras, Normandy (Delaby et al., unpublished).

Month	March	April	May	June	July	Aug	Sept	Oct	Nov
ADF (g/kg DM)		225	250	264	264	264	253	237	218
CP (g/kg DM)		195	182	158	150	157	175	192	192
OMd (%)		79	78	75	73	72	73	75	71
UFL (/kg DM)		0.94	0.95	0.91	0.87	0.86	0.87	0.87	0.77
PDIE (g/kg DM)		100	99	92	89	90	93	96	89

b/ TEAGASC, Moorepark, Co Cork, (Horan et al., unpublished).

Month	March	April	May	June	July	Aug	Sept	Oct	Nov
ADF (g/kg DM)	245	236	243	252	265	266	269	266	257
CP (g/kg DM)	218	226	208	194	197	194	191	232	234
OMd (%)	81	80	81	81	78	76	78	76	77
UFL (/kg DM)	1.00	0.98	1.01	0.99	0.96	0.93	0.96	0.93	0.93
PDIE (g/kg DM)	102	102	102	99	98	98	97	100	101

Table 2 : Comparison of dry matter intake and intake components between a indoor TMR and grass grazed (INRA, unpublished data)

Ration	Maize silage (70%) Concentrate (30%)	Perennial ryegrass grazed
Total intake (kg DM)	22 - 24	16 – 18
Intake rate (g DM / min)	80 - 100	25 – 35
Intake time (min)	200 - 300	500 – 550
DM content (%)	40 - 50	15 – 20



Table 3 : Effect of white clover inclusion in interaction with age of regrowth on dairy cow performance at grazing (after Ribeiro Filho,2003)

Comparing Regrowth age	to pure PRG	PRG / WC 19 days	PRG / WC 35 days
Intake (kg DM/day)		+ 1.8	+ 3.0
Milk yield (kg/day)		+ 1.4	+ 2.2
Fat content (g/kg)		- 1.5	- 1.3
Protein (g/kg)		+ 0.9	+ 0.5

Table 4: Consequences of the first grazing date and the later stocking rate on grass use and dairy cow performance (O'Donovan et al, 2004).

First grazing date / Later stocking rate	Early grazed High	Early grazed Medium	Not grazed High	Not grazed Medium
Grass allowance (> 5cm – kg DM/cow/day)	12.7	15.9	18.2	21.9
Pre grazing height (cm)	12.2	12.4	14.8	14.2
Leaf proportion (at ground level - % DM)	41	41	39	35
UFL value (1 UFL = 1700 kcal NEL/kg DM)	0.99	1.00	0.94	0.94
Crude protein (g/kg DM)	202	184	171	176
Post grazing height (cm)	4.4	5.0	6.4	6.8
Grass intake (kg DM/cow/day)	13.9	16.2	16.3	17.0
Milk yield (kg/cow/day)	20.3	23.9	22.8	23.9
Milk solids (g/cow/day)	1356	1550	1508	1554

First grazing occurred in March for the early treatment. The Not grazed treatment was grazed for the first time in April. The results presented are those observed during the two later rotations in April and May.

Figure 1 : Effect of grass allowance on dry matter intake per cow and grass utilization per hectare (after Delagarde et al, 2011)

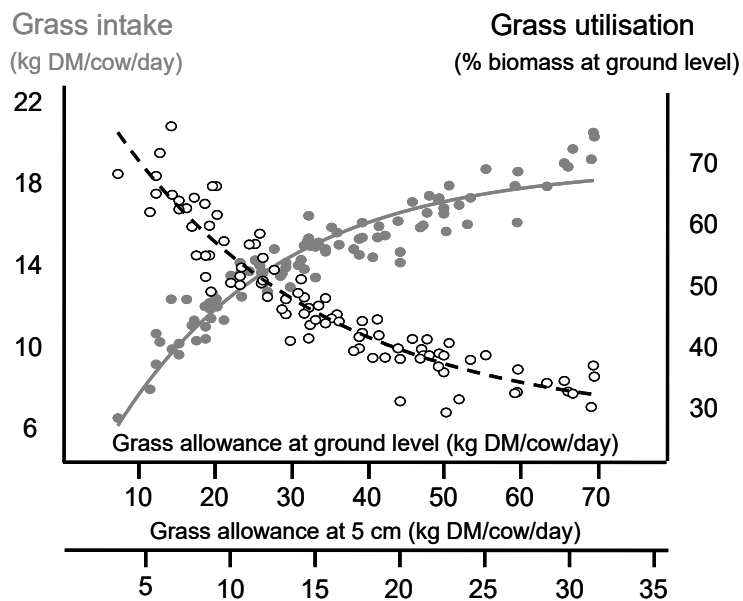


Figure 2 : Relationship between pre-grazing height, post-grazing height and dairy cow intake at grazing (Delagarde et al, 2001).

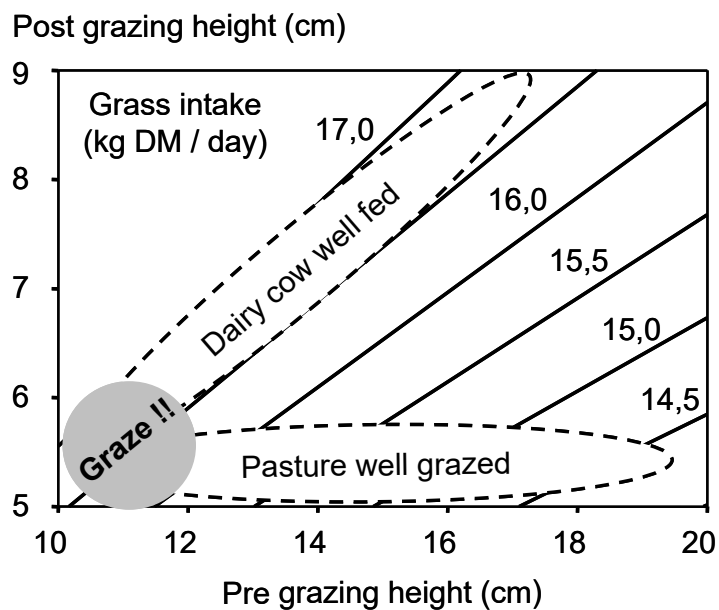


Figure 3 : The alignment of grass supply and herd demand is conditioning by the success management of the reproduction period (Horan, 2017)

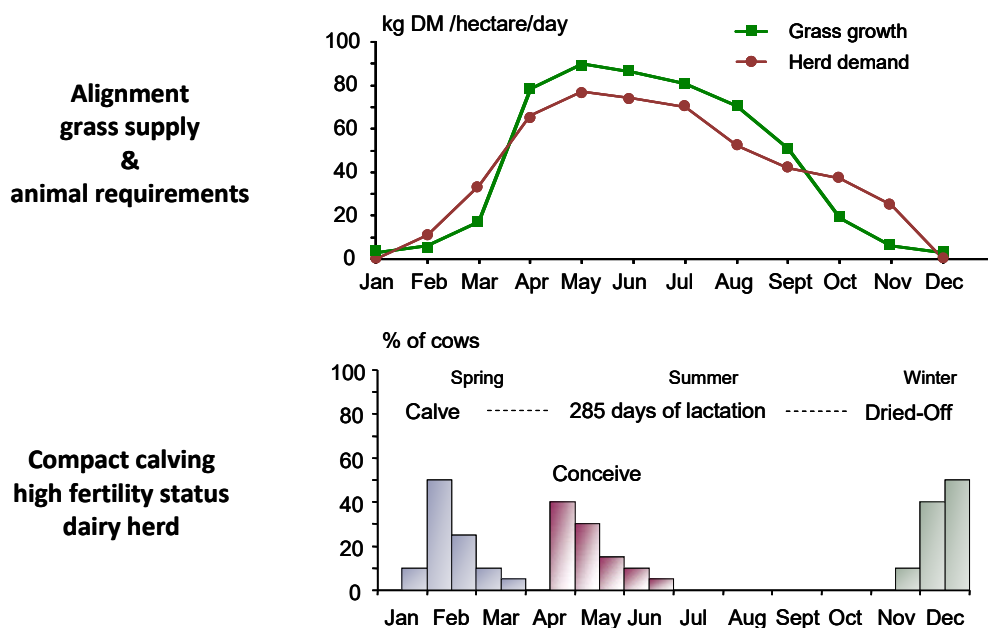


Figure 4 : Evolution of the weight of the different genetic components for the Holstein breed in the French global index (M. Brochard, pers. comm.)

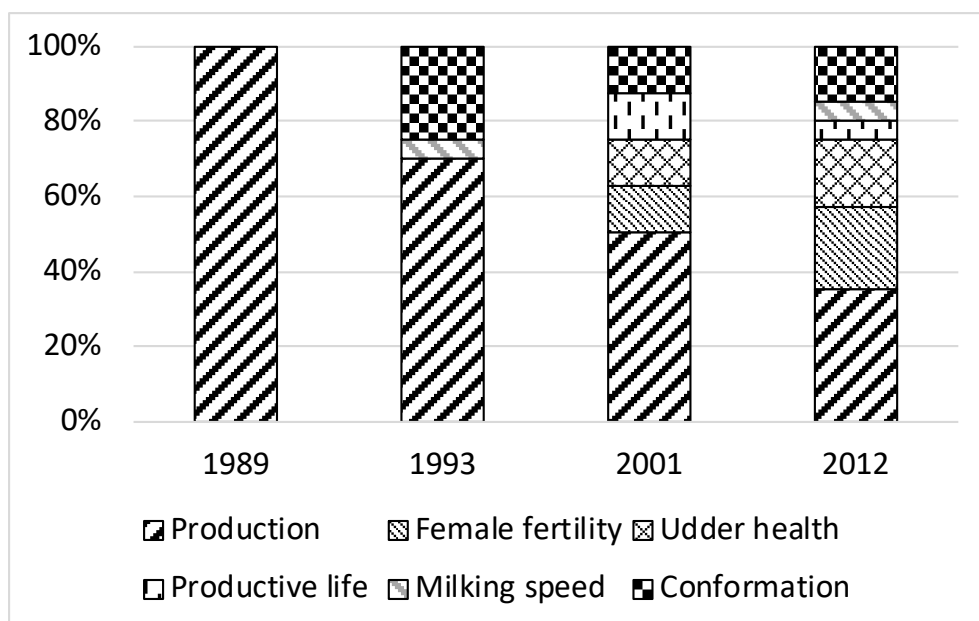
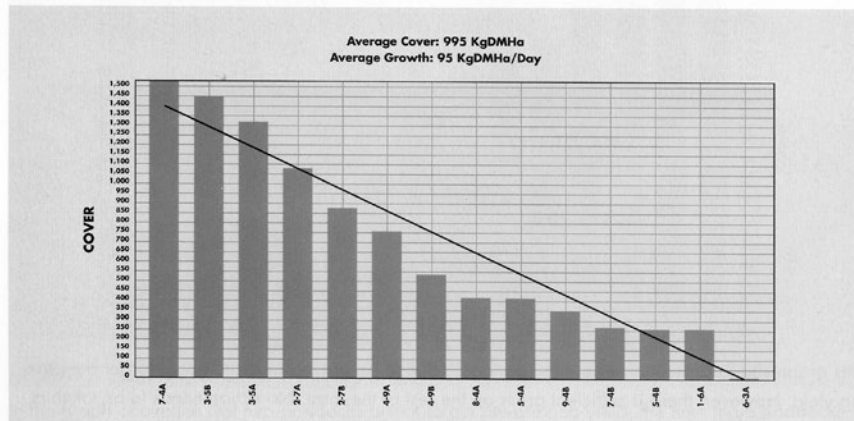


Figure 5 : Illustration of the grass wedge concept of grass availability

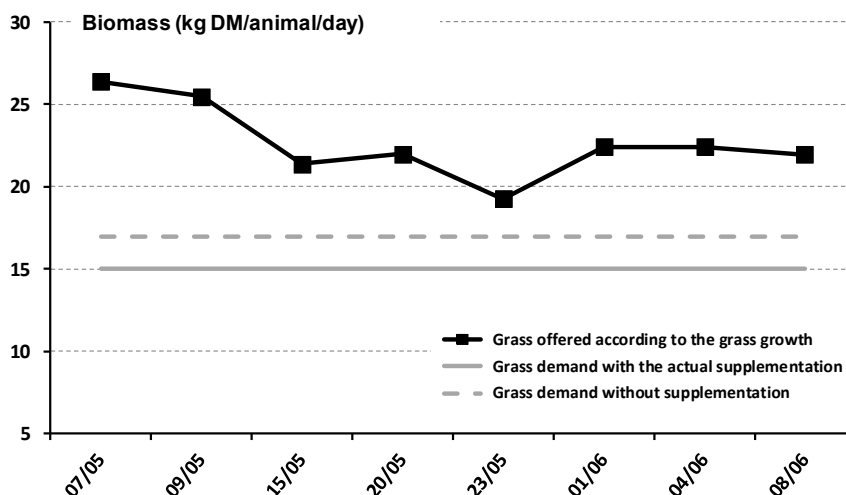
#### Adequate Grass Supply but at Different Levels

Initially it may appear that there is a surplus or deficit however when the graphs are examined it is clear there is sufficient grass on the farm.



It is clear from this graph that there is surplus grass in the first three paddocks but there is a deficit on the way. On balance there is sufficient grass on this farm and no action needs to be taken. Target residuals must be achieved on the paddocks with surplus grass. This will slow down the grazing round and give more time for the paddocks below the target line to catch up.

Figure 6 : Anticipated grass offered and grass demand evolution according a Pastur'Plan simulation



## References

- Baumont, R.; Lewis, E.; Delaby, L.; Prache, S.; Horan, B. 2014. Sustainable intensification of grass based ruminant production. *In* EGF at 50; the Future of European Grasslands. Grassland Science in Europe, Vol. 19. Proceedings of the 25th General Meeting of the European Grassland Federation, Aberystwyth, Wales, 521-534.
- Berry, D. 2015. Breeding the dairy cow of the future: what do we need ?”, *Animal Production Science*, CSIRO Publishing, 55 : 823-837.
- Defrance, P. ; Delaby, L. ; Seuret, J.M. 2005. Herb’Avenir : un outil simple d’aide à la décision pour la gestion du pâturage. *Rencontre Recherches. Ruminants*, 12 : 80.
- Delaby, L.; Leurent, S. ; Carbonnier, Y., Leloup, L. 2011. Au pâturage, des indicateurs pour faciliter les décisions de sortie de parcelles des vaches laitières. *Rencontre Recherches. Ruminants*, 18 : 43.
- Delaby, L.; Duboc, G.; Cloet, E.; Martinot Y. 2015. Pastur’Plan, a dynamic tool to support grazing management decision making in a rotational grazing system. *In* Grassland and forages in high output dairy farming system, Grassland Science in Europe Vol. 20, Proceedings of the 18th Symposium of the European Grassland Federation, Wageningen, the Netherlands, 200-202.
- Delaby, L. ; Fiorelli, J.L. 2014. Elevages laitiers à bas intrants : entre traditions et innovations. *Inra, Productions Animales*, 27(2) : 123-134
- Delaby, L. ; Hennessy, D. ; Gallard, Y. ; Buckley, F. 2014. Animal choice for grass-based systems. *In* EGF at 50: the Future of European Grasslands. Grassland Science in Europe, Vol. 19. Proceedings of the 25th General Meeting of the European Grassland Federation, Aberystwyth, Wales, 795-797
- Delaby, L. ; Comeron, E.A. ; McCarthy, B. ; Pavie, J.; Peyraud, J.L. 2016. Les légumineuses fourragères, indispensables à l’élevage de demain. *Fourrages*, 226,77-86.
- Delagarde, R.; Prache, S.; D’Hour, P.; Petit, M. 2001. Ingestion de l’herbe par les ruminants au pâturage. *Fourrages* 166 : 189-212.
- Delagarde, R.; Peyraud, J.L.; Parga, J.; Ribeiro, H. 2001. Caractéristiques de la prairie avant et après un pâturage : quels indicateurs de l’ingestion chez la vache laitière ? *Rencontre Recherches. Ruminants*, 8 : 209-212
- Dillon, P.; Crosse, S.; Stakelum, G.; Flynn, F. 1995. The effect of calving date and stocking rate on the performance of spring-calving dairy cows. *Grass and Forage Science* 50 : 286-299.
- Dillon, P.; Kennedy, J. 2009. “Grazing Notebook” Teagasc and Irish Farmers Journal, Dublin, Ireland, 56 p.
- Gowen, N.; O’Donovan, M.; Casey, I.; Rath, M.; Delaby, L.; Stakelum, G. 2003. The effect of grass cultivars differing in heading date and ploidy on the performance and dry matter intake of spring calving dairy cows at pasture. *Animal Research* 52 : 321–336.
- Hanrahan, L.; Geoghegan, A.; O’Donovan, M.; Griffith, V.; Ruelle, E.; Wallace M.; Shalloo, L. 2017. PastureBase Ireland: A grassland decision support system and national database. *Computers and Electronics in Agriculture*, 136 : 193-201
- Horan, B. 2017. Key drivers for grassrich intensive grazing systems”. *Positive Farmers Conference*, Day 1, Cork, 43-51.
- Huguenin-Elie, O.; Delaby, L.; Klumpp, K.; Lemauiel-Lavenant, S.; Ryschawy, J.; Sabatier, R. 2018. The roles of grasslands for biogeochemical cycles and biodiversity conservation. *In* Improving grassland and pasture management in temperate agriculture. Ed Burleigh Dodds, Cambridge, UK, in press.
- Kennedy, E.; O’Donovan, M.; Murphy, J. P.; O’Mara, F. P.; Delaby, L. 2006. The effect of initial spring grazing date and subsequent stocking rate on the grazing management, grass dry matter intake and milk production of dairy cows in summer. *Grass and Forage Science*, 61 : 375-384.
- Lüscher, A.; Mueller-Harvey, I.; Soussana, J.F.; Rees, R.M.; Peyraud, J.L. 2014. Potential of legume-based grassland-livestock systems in Europe: a review. *Grass and Forage Science* 69 : 206-228.
- McCarthy, B.; Dineen, M.; Guy, C.; Coughlan, F. 2016. Incorporating white clover into spring calving pasture-based production systems to increase performance – the Clonakilty experience. *In* Proceedings of the Positive Farmers Conference, Cork, Ireland, 51-64.
- McCarthy, B.; Delaby, L.; Pierce, K.M.; Journot, F.; Horan, B. 2011. Meta-analysis of the impact of stocking rate on the productivity of pasture-based milk production systems. *Animal* 5(5) : 784-794
- McCarthy, B.; Pierce, K.M.; Delaby, L.; Brennan, A.; Fleming, C.; Horan, B. 2013. The effect of stocking rate and calving date on grass production, utilization and nutritive value of the sward during the grazing season. *Grass and Forage Science* 68 : 364-377.
- O’Donovan, M.; Delaby, L.; Peyraud, J.L. 2004. Effect of time of initial grazing date and subsequent stocking rate on pasture production and dairy cow performance. *Animal Research* 53 : 489-502.
- O’Mara, F.P. 2012. The role of grasslands in food security and climate change. *Annals of Botany* 110(6) : 1263-1270
- Parga, J.; Peyraud, J.L.; Delagarde R. 2000. Effect of sward structure and herbage allowance on herbage intake and digestion by strip-grazing dairy cows. *In* Grazing Management, BGS Occasional Symposium N034, Ed A.J. Rook and P.D. Penning, Harrogate, UK, 61-66

- Pérez-Prieto, L.A.; Delagarde, R. 2012. Meta-analysis of the effect of pregrazing pasture mass on pasture intake, milk production, and grazing behavior of dairy cows strip-grazing temperate grasslands. *J. of Dairy Sci.* 95(9) : 5317-5330
- Pérez-Prieto, L.A.; Delagarde, R. 2013. Meta-analysis of the effect of pasture allowance on pasture intake, milk production, and grazing behavior of dairy cows grazing temperate grasslands. *J. of Dairy Sci.* 96(10) : 6671-6689
- Peyraud, J.L.; Delaby, L.; Delagarde, R.; Pavie, J. 2014. Les atouts sociétaux et agricoles de la prairie. *Fourrages* 218 : 115-124
- Pottier, E.; Delaby, L.; Agabriel, J. 2007. Adaptations de la conduite des troupeaux bovins et ovins aux risques de sécheresse. *Fourrages* 191 : 267-284.
- Ribeiro Filho, H.M.N.; Delagarde, R.; Peyraud, J.L. 2003. Inclusion of white clover in strip-grazed perennial ryegrass swards: herbage intake and milk yield of dairy cows at different ages of sward regrowth. *Animal Science*, 77 : 499-510
- Rodriguez-Ortega, T.; Oteros-Rozas, E.; Ripoll-Bosch, R.; Tichit, M.; Martin-Lopez, B.; Bernues, A. 2014. Applying the ecosystem services framework to pasture-based livestock farming systems in Europe. *Animal* 8 : 1361-1372.
- Soussana, J.F.; Lemaire, G. 2014. Coupling carbon and nitrogen cycles for environmentally sustainable intensification of grasslands and crop-livestock systems. *Agriculture Ecosystems & Environment* 190 : 9-17.
- Stakelum, G.; Dillon, P. 2007a . Effect of grazing pressure on rotationally grazed pastures in spring/early summer on subsequent sward characteristics. *Irish Journal of Agriculture and Food Research* 46 : 15-28
- Stakelum, G.; Dillon, P. 2007b . Effect of grazing pressure on rotationally grazed pastures in spring/early summer on the performance of dairy cows in the summer/autumn period. *Irish Journal of Agriculture and Food Research* 46 : 29-46
- Tunon, G.; Kennedy, E.; Horan, B.; Hennessy, D.; Lopez-Villalobos, N.; Kemp, P.; Brennan, A.; O'Donovan, M. 2013. Effect of grazing severity on perennial ryegrass herbage production and sward structural characteristics throughout an entire grazing season. *Grass and Forage Science* 69 : 104-118
- Vérité, R.; Delaby, L. 2000. Relation between nutrition, performances and nitrogen excretion in dairy cows. *Animal Research* 49 : 217-230
- Voisin, A. 1957. Productivité de l'herbe. Ed La France Agricole, Paris, 432 pages.
- White, R.; Murray, S.; Rohweder, M. 2000. Grassland Ecosystems. World Resources Institute, Washington, USA, 81 pages.