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FORAGE QUALITY IN THE WALLOON REGION

2nd synthesis of the REQUASUD forage database

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Avec le soutien de la Wallonie

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INTRODUCTION

The forage production sector, catering to the livestock chain as well as the broader agricultural sector, is currently facing numerous economic, environmental, and societal challenges. Indeed, in order to compete and manage the volatility of raw material prices, it is crucial to increase productivity to meet the growing global food demand while improving farm profitability. This must of course be achieved by developing sustainable production systems that minimise the environmental and social impact of agricultural activities.

However, this evolution is not straightforward for the forage production sector, due to the limited availability of land and natural resources. There is growing competition for land and resources with industrial or energy crops and urban expansion. In addition, climate change and the increased risk of droughts and floods are crucial factors in adapting current and future practices. Livestock producers must also consider growing consumer concerns about ethics and animal welfare, which lead to changes in regulations and standards, ultimately resulting in higher production costs for farmers.

The REQUASUD laboratory network, established in 1989 by Wallonia, serves as a powerful tool to support producers facing these challenges.

An initial summary of the forage analysis results (grass, grass silage, maize silage and hay) from the REQUASUD network's database was compiled in 2006. It covered the 1994 - 2005 period and included data on nutritional values and mineral content. More than 15 years later, it was time to update this summary, focusing on the current and future needs of the sector in Wallonia, which the forage analyses conducted within the REQUASUD network can address.

Analysing the chemical composition of forages is a key step that must be carried out regularly. Although the literature provides are a large number of reference values that farmers could use to calculate their winter diets, the nutritional value of forage products, and more specifically grass products, is not constant. It varies depending on soil type, plant composition and pasture management, but also changes throughout the season. For commercial feed, there is the option to refer to the composition on the label, which is guaranteed by the manufacturer. However, with forages, there are so many variation factors at different stages of production and conservation that it is impossible to predict the nutritional value without determining the essential components. Relying on average values, farmers risk either overestimating the quality of their forages and failing to meet their animals' needs or underestimating and wasting resources.

This brochure primarily focuses on three areas concerning the calculation of feed values, forage nutrition indices and the sector's evolution in response to current and future economic and environmental constraints.

With regards feed values, there are several calculation systems in Belgium and our neighbouring countries (mainly the French and Dutch systems) and it is important to recognise that it is not always straightforward to navigate

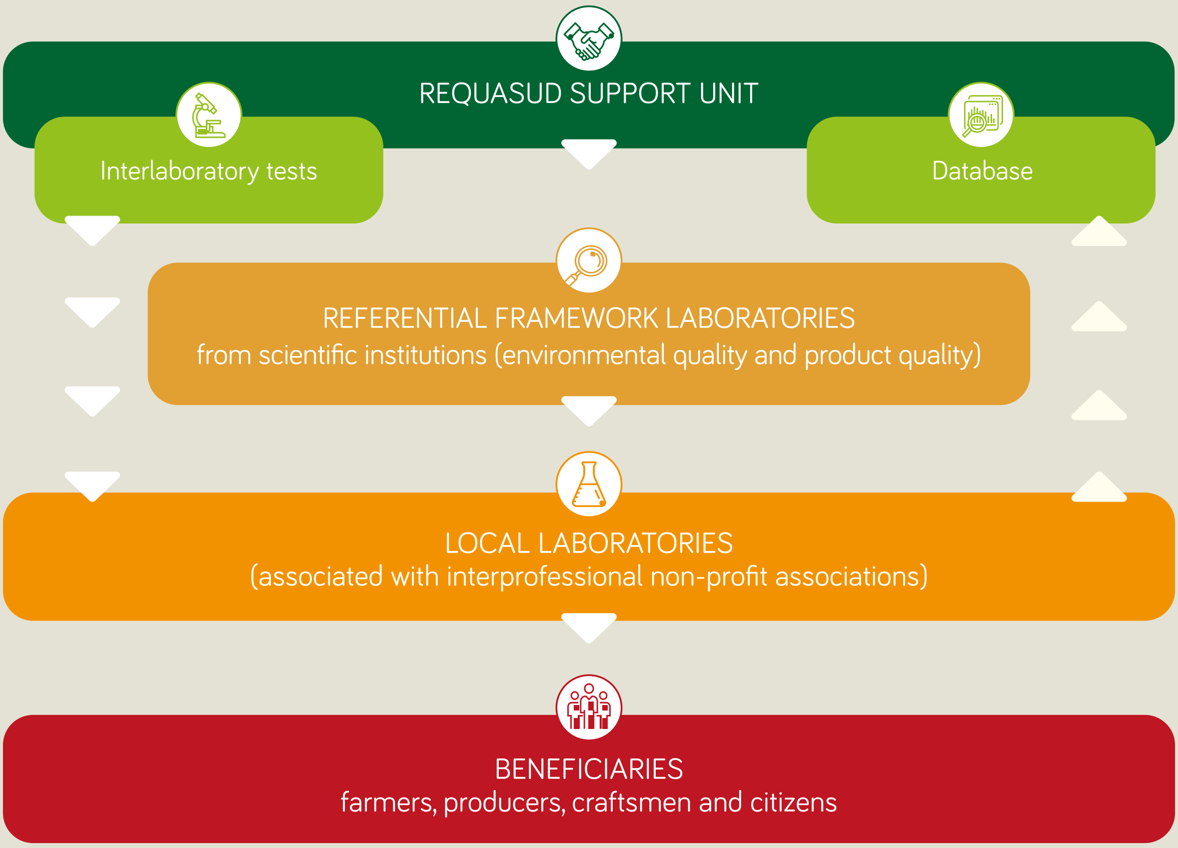
between VEM, UFL, PDI, UEB or OEB. The first objective, therefore, is to describe the different parameters that can be used to establish diet calculations based on the parameters analysed in forages and to guide their use by livestock.

Mineral nutrition of pastures is a critical component in agriculture. Beyond the issue of nitrogen, inadequate fertilisation with phosphorus (P), potassium (K), or sulphur (S) can result in yield deficits, economic losses and environmental impacts. Nutrition indices are easy-to-use tools for assessing the mineral availability in forage productions. For a defined nitrogen content, P or K levels above the target values indicate that the availability of these elements was sufficient so as not to limit yields. Conversely, levels below target values indicate insufficient nutrition. These nutrition indices, combined with soil analyses, should help optimise rational fertilisation for the coming years.

Finally, the changes to which the sector is subject (decreasing meat consumption, demographic pressure, land pressure, etc.) or to which it must adapt (global warming, changes in production costs, carbon storage in soils, etc.) require us to rethink the cropping system, in particular by modifying the types of forage productions in Wallonia.

PRESENTATION OF THE **REQUASUD** NETWORK

Wallonia has established a support structure designed to help farmers and processing producers meet society's demands in terms of sustainable development, environmental conservation and product quality. This structure provides them with an analysis and advisory service that is tailored, reliable, fast and efficient at the forefront of scientific progress. This structure, called the "Réseau Qualité Sud (REQUASUD)", brings together local analysis laboratories, associated with inter-professional associations and research laboratories that provide their own reference framework guidance. Its operation is supported by a coordination and promotion unit (the REQUASUD Support Unit based at the Walloon Agricultural Research Center (CRA-W)).

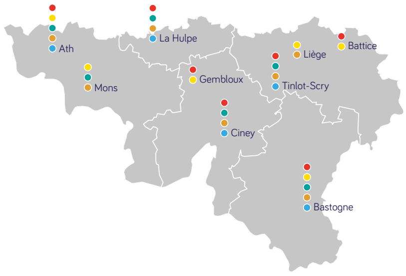


These local analysis laboratories offer a comprehensive service directly to users, including farmers, agricultural suppliers, processing producers of agricultural products, water managers and private individuals.

ANALYTICAL CHAINS

PRODUCT QUALITY

- Rapid analysis of cereals, forages, soils, feeds, compounds, etc. by near-infrared (NIR) spectrometry
  Intrinsic quality
  Feed value and technology
- Microbiological analysis of feed products
- Mineral and organic analysis of forages, farmyard manure and feed products



ENVIRONMENTAL QUALITY

- Soil analysis (agronomic and environmental parameters)
- Analysis of mineral nitrogen in the soil profile

ANALYSIS AND ADVICE FOR PRODUCERS

The network configuration ensures the necessary scientific guidance to keep their analytical tools at the forefront of technological developments and to improve the advice and interpretations that follow the analyses. The Referential Framework Laboratories (Laboratoires d'Encadrement Référentiel, LER), belonging to scientific research institutions (CRA-W, UCLouvain and ULiège Gbx ABT), ensure the reliability and performance of the entire network. This network organisation makes it possible to offer users a wide range of analyses, as well as handling a high volume of analysis requests and proposing methods suited to their needs. This structure also facilitates the establishment of common procedures to be implemented, such as for staff training, monitoring of standards and legislation, validation of analysis methods and quality control of analysis results through the organisation of interlaboratory tests to ISO 17043 standards.

CENTRALISED DATABASE

The laboratories in the REQUASUD network conduct an increasing number of analyses on a wide range of matrices (soil, forage, etc.). In general, analyses are performed at the request of farmers looking for decision-making aids for managing their soils and production.

In 1994, a centralised database was created by the non-profit organisation REQUASUD. This database pools all the information related to analyses carried out by the network's laboratories. Common rules for transferring this information to the centralised database have been established and cover two types of information: identification data for characterising the sample and its source and analytical data.

The collection of these data by the various laboratories in the network is based firstly on the harmonisation and standardisation of the procedures used to collect samples from farmers, their description and the determination of the analytical and identification data. The quality of the analysis results, and consequently the advice and recommendations provided, is guaranteed by the organisation of interlaboratory tests. The REQUASUD Support Unit is responsible for data validation. Three data validation stages are implemented to guarantee the reliability of the data transferred by the laboratories in the network.

This database is used internally by working groups (fertiliser advice, forages) to improve the tools developed as part of the standardisation of advice for local laboratories (REQUAFERTI) and for writing brochures, articles, summaries, etc. External requests are regularly completed as part of partnerships, research projects (CRA-W, universities), student work but also by private firms. In 2015, an online data validation tool called REQUAVALID was developed, so that data could be entered directly by the laboratories. It was developed to allow **online consultation** of the centralised database. This tool provides basic information (average, standard deviation) in tabular and graphical form, at regional or local level, over one or more years, for various matrices:

- chemical and mineral composition, feeding value, forage quality
- manure quality
- characterisation of cereal grains
- a region's soil quality
- ...

The tool is accessible in **public** mode for anyone wanting quick information on a particular type of product.

The database is continuously improved in partnership with the technical managers of various analysis chains. They do so by revising data encoding templates, implementing a validation programme and calculating detection limits for data outliers and traceability, consolidating data by calculating new validation limits, etc. Work is underway to standardise the various tables and codes across all the analysis chains with those used in the advisory services. This work must continue.

Wallonia currently has a relatively extensive database: for forages, approximately 191,000

samples are referenced for feed values and approximately 80,000 samples for mineral analyses.

Alongside the centralised database, the REQUASUD network has developed expertise in near-infrared spectrometry analysis. The "SPIR Forages" databases developed at CRA-W and used within the REQUASUD network, regardless of their type, contain thousands of spectra from samples analysed by chemical methods. These spectra have been acquired over the last 30 years and therefore represent a broad variability. Most of the parameters used to estimate a forage's nutritional value for farmers can be accurately measured using near-infrared spectrometry.

THE FEEDING VALUE OF **FORAGE**

DEFINITION

DEFINITION AND UNITS IN THE SYSTEMS USED IN WALLONIA

The feed value of a forage is based on two parameters: nutrient content **(energy, protein, minerals)** and **intake**.

The **energy value** is equivalent to the amount of **net energy** contained in 1 kg of dry forage. Net energy refers to the amount of energy an animal requires to cover its maintenance and production needs. In the laboratory, this value is derived from the gross energy (GE) from which various losses are subtracted (Figure 1).

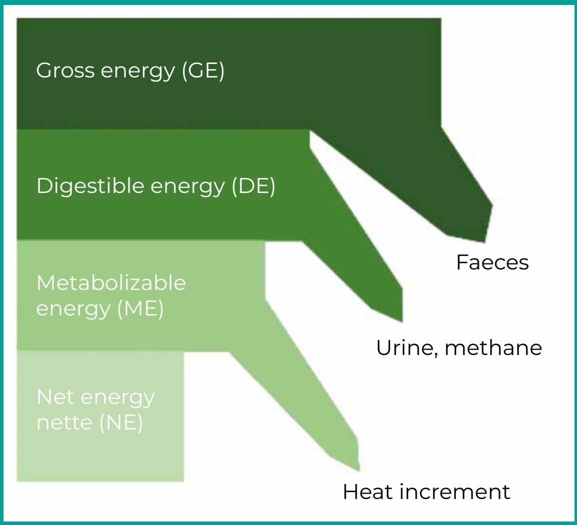


Figure 1: energy value of a forage

The **Protein value** is expressed as **proteins digestible in the intestine**. This value accounts for the significant transformation of proteins by the microorganisms present in the rumen. Another parameter is the **nitrogen balance** in the rumen, which reflects the balance between proteins and energy available to rumen microorganisms.

The **intake** of a forage equates to the **quantity of forage** that can be ingested when it is offered ad libitum, as a sole diet.

UNITS USED TO QUALIFY THE FEED VALUE OF FORAGES.

In Wallonia, there are two co-existing systems of units used to express the feed value of forages: the French system (INRA) and the Dutch system (CVB). Table 1 lists the different units found in these systems. Local laboratories can express the feed value of forages in both systems. This particularity is related to the type of livestock for which the forages are intended. Forage characterisation according to Dutch standards is used to establish rations for Belgian Blue cattle, for which the needs are expressed in this system. For French breeds such as Limousine, Blonde d'Aquitaine, Charolais and Salers, the French system is typically used. Dairy cows are a hybrid case. The needs of these animals are defined in both systems, so either one can be used to establish rations.

TABLE 1: UNITS USED TO QUALIFY THE FEED VALUE OF FORAGES.

		French system	Dutch system
Energy value	Forage unit	UFL, UFV	VEM, VEVI
Protein value	Proteins digestible in the intestine	PDI	DVE
	Nitrogen balance in the rumen	BPR*	OEB
Intake	Fill unit	UEL, UEB, UEM	/
	Structure value	/	VS

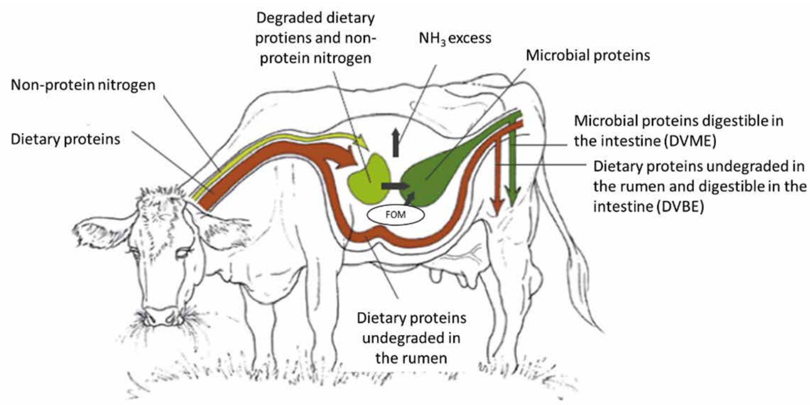
**since 2018*

In both systems, energy is expressed in **forage units**, differentiated as UFL or VEM for milk production and **UFV** or **VEVI** for meat production. In both cases, the forage unit is based on the energy value (kcal/kg DM) of 1 kg of reference barley. All feeds are therefore assessed against this reference.

In the French INRA 2007 system, **proteins digestible in the intestine (PDI)** for a forage is broken down into **PDIA** (dietary-origin PDI, undegraded in the rumen), **PDIN** (PDI produced based on the nitrogen available for the growth of rumen microorganisms) and **PDIE** (PDI produced based on the energy available for the growth of rumen microorganisms or microbial growth). The lower value between *PDIN* and *PDIE* determined the *PDI* value of the forage. The French system was revised in 2018, and now includes a single **PDI** value which is the sum of **PDIA** and **PDIM** (*PDI* of microbial origin) and a **BPR** value (rumen protein balance) that reflects the difference between the nitrogen from the degradation of dietary proteins in the rumen and the energy available in the rumen (energy from fermentable organic matter (*FOM*) in the rumen) for microbial protein synthesis.

In the Dutch CVB 1991 system, **proteins digestible in the intestine (DVE)** equal the sum of dietary-origin proteins undegradable in the rumen **(DVBE)** and proteins digestible in the intestine resulting from microbial growth in the rumen **(DVME)**, minus faecal losses **(DVMFE)**. The **rumen nitrogen balance (OEB)** value is calculated similarly to the **BPR** of the French INRA 2018 system, i.e. the difference between the microbial proteins allowed by the available nitrogen in the rumen (MREN) and those allowed by the available energy in the rumen (MREE). The Dutch system was also revised in 2007, and while the formulas used to estimate **DVE** and **OEB** values remain largely unchanged, the main changes are in the estimation of **DVME**. In the CVB 1991 system, *DVME* was proportional to the *FOM,* i.e. 150 g of microbial protein could be produced from 1 kg of FOM. The updated system postulates that microbial growth depends on the type of forage fed to animals, which means understanding the parameters linked to the degradation of forage nutrients in the rumen (degradation rate and speed).

FIGURE 2: PROTEIN DIGESTION IN RUMINANTS (ADAPTED FROM MELKVEEVOEDING, ILVO, 2011).



This change in the system for evaluating the protein value led to changes in the DVE and OEB values of certain forage types (table 2).

TABLE 2. IMPACT OF THE REVISED SYSTEM ON THE PROTEINS DIGESTIBLE IN THE INTESTINE (DVE) AND RUMEN NITROGEN BALANCE (OEB) VALUES OF THE MAIN FORAGES (CVB 2019 TABLE).

	DVE 1991	DVE 2007	DVE difference (2007 - 1991)	OEB 1991	OEB 2007	OEB difference (2007 - 1991)
Maize silage						
30 - 34% DM	50	51	**+1**	-37	-38	**-1**
34 - 38% DM	51	53	**+2**	-40	-43	**-2**
38 - 42% DM	52	55	**+3**	-42	-46	**-3**
> 42% DM	53	57	**+4**	-44	-49	**-5**
Fresh grass (16.5% DM)						
Cut before 21 June	110	98	**-12**	43	61	**+18**
Cut between 21 June and 21 August	104	92	**-12**	34	50	**+16**
Cut after 21 August	97	83	**-14**	2	19	**+17**
Grass silage (45% DM)						
Crude protein 18.5% DM	89	66	**-23**	27	54	**+27**
Crude protein 15.3% DM	81	59	**-22**	3	31	**+28**
Hay						
Crude protein 10%	53	37	**-16**	-20	4	**+24**
Crude protein 13%	70	56	**-14**	-14	8	**+22**
Crude protein 17%	84	73	**-11**	8	31	**+23**

For maize silage, the overall differences are minimal. The forages most affected by the revised CVB system are grass-based forages, which see their DVE value reduced and their OEB value considerably increased, reflecting better nitrogen availability for microbial synthesis in the rumen.

In the French INRA system, the **ingestibility** of a forage is translated by a **fill value** expressed in **fill units (UE).** There is an inverse relationship between ingestibility and the fill value of a forage: the more filling the forage, the lower the quantity ingested by the animal. As the size of ruminants varies depending on their species, the French system calculates UEs by animal category. Thus we have “UEM” for sheep, “UEB” for cattle and “UEL” for dairy cows. For each forage, the “UE” value can be calculated either from measurements taken on the animals (*in vivo* measurement) or from the chemical characteristics of the forages (INRA 2018).

In the Dutch CVB system, the **fill value** is expressed through a **structure value (VS)**. Diet structure is essential for the optimal functioning of the rumen. A fibrous feed stimulates rumen contractions, mastication and saliva production, which, with its buffering capacity, maintains an optimal pH level in the rumen (optimal pH is around 6.4), good fibre digestibility and optimal microbial synthesis. A lack of ration structure can lead to reduced ration digestibility, health problems such as acidosis or lameness and decreased intake and production (milk, growth, weight gain). The structure value of forages can be calculated from its fibre content and particle size (e.g. maize silage). It is expressed per kg of dry matter. For information on the structure value of forages, refer to the 1st REQUASUD brochure on forage quality section.

Requirement standards: it is accepted that the minimum structure need is equal to 1 for a standard cow (i.e. producing 25 kg of milk, in 1st, 2nd or 3rd lactation and receiving concentrates in two batches). The structure values of straight feeds and raw materials used in concentrates are "safe" values; they are listed in the feed tables. Those for forages can be calculated from the crude fibre content or NDF levels (table 3).

TABLE 3: STRUCTURE VALUE (SV, PER KG DM) OF THE MAIN FEEDS USED IN DAIRY COW RATIONS (MELKVEEVOEDING, ILVO, 2011).

Grass silage	VS = -0.20 + 0.0125 x CEL[1]	VS = +1.05 + 0.0060 x NDF[1]
Hay	VS = (-0.20 + 0.0125 x CEL) + 6%	VS = +1.05 + 0.0060 x NDF
Maize silage, 6 mm chop	VS = -0.10 + 0.0090 x CEL Correction for chop length: +(-) 2% per +(-) 1 mm of particle length	VS = -0.57 + 0.0060 x NDF
Straw	VS = 4.3	
Grass, 20% cellulose	VS = 2.0	
Grass, 24% cellulose	VS = 2.4	

[1] *CEL and NDF in g/kg DM*

Application:
The system uses the following equation to calculate the minimum proportion of roughage (R) required in the diet to ensure good rumen function:
[(%R/100) x VSR] + [(%Conc/100) x VSConc] + [(%S/100) x VSS] =1
where:
%R = % roughage
VSR = Structure value of roughage
%Conc = % of concentrates
VSConc = Structure value of concentrates
%S = % of supplements
VSS = Structure value of supplements

WHY REVISE FEED VALUE ESTIMATION SYSTEMS?

With the development of precision feeding, maximising production is no longer the primary objective. The efficient use of feed, in terms of animal health, respect for the environment and profitability, are just as important. Knowledge of ruminant nutrition has evolved considerably in recent decades. Research carried out on experimental farms has generated new insights regarding the digestive use of diets and their environmental impact. Key advances concern the integration of digestive processes and nutrient flows into models for estimating feed value and diets. The diet given to an animal is no longer merely the sum of its various ingredients. The use of new parameters such as the BPR in the French system or the OEB measured 2 hours after intake in the Dutch system, allows rations to be used more efficiently. As a result, this meets the animals' needs more precisely and reduces discharges (nitrogen, methane, etc.) into the environment. The current, updated systems incorporate these developments.

METHODS FOR EVALUATING THE FEEDING VALUE OF FORAGES

Several standardised reference methods are used to determine the feeding value of a forage. These provide:

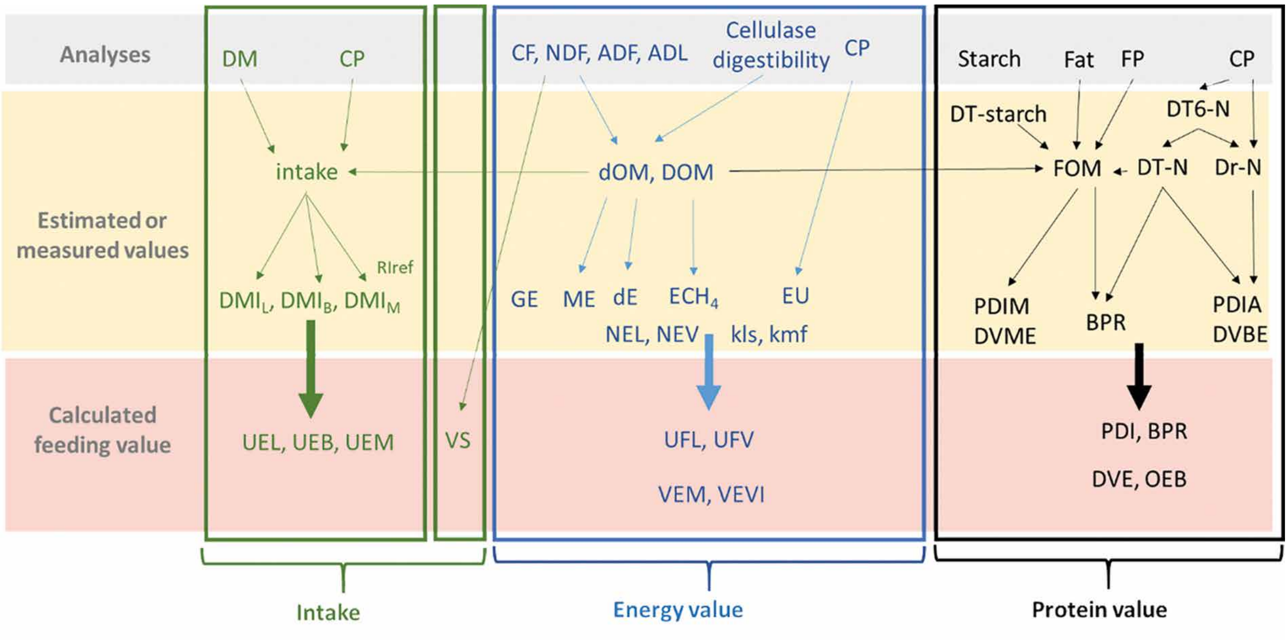
1) the *in vivo* measurement of the digestibility of organic matter and intake. This measurement is carried out in a standardised way on sheep (male, castrated), housed in individual stalls. It allows for the measurement of ingested quantities and a complete collection of faecal output. These sheep, fed solely on forage, are either fed ad libitum (in the French system) or according to their maintenance needs (in the Dutch system).

2) The *in situ* measurement of ruminal degradability of forage constituents such as proteins, starch and plant walls, and their digestibility in the intestine. For ruminal degradability. This measurement is carried out using the in sacco technique, where small nylon bags containing the forage to be studied are incubated in the presence of rumen juice. The bags are removed at defined time intervals (2, 4, 8, 16, 24, 48 or even 72 h for slow-fermenting foods) and weighed to determine the disappearance of material over time. The theoretical degradability and stability of the constituents in the rumen can then be calculated from degradation kinetics. For proteins, the parameters obtained include DT-N in the French system and BRE in the Dutch system. The intestinal digestibility of forage constituents not degraded in the rumen is determined using the mobile nylon bag technique. These techniques require the presence of animals fitted with cannulas to access their rumen or intestines. However, these methods are increasingly called into question by society and alternative (enzymatic) methods are being developed to replace them.

These standardised methods are used to establish reference values, but are impossible for laboratories to use routinely. It is essential to transfer the results obtained by these reference methods to laboratory methods. Models linking the parameters of in vivo organic matter digestibility and nitrogen degradability of forages to chemical parameters and enzymatic methods of forage characterisation have therefore been developed. These models can be used to estimate the *in vivo* parameters needed to calculate the feeding value of a forage (INRA 2007 and INRA 2018, CVB 1991 and CVB 2007).

PROCEDURE FOR CALCULATING THE FEED VALUE OF A FORAGE

The diagram below shows the procedure to be followed to evaluate the feed value of a forage based on laboratory analysis.



The first step is to conduct laboratory analysis to determine:

a) **Dry matter (DM)**, which is used to establish rations in relation to the **intake capacity** of animals. Reporting analysis results in relation to DM makes it possible to compare different feeds. Target DM values vary depending on forage type (hay > 80% - maize silage > 30% - pre-wilted grass silage > 40%).

b) **Crude protein (CP)** is used to estimate **proteins digestible in the intestine** (**PDI** in the French system or **DVE** in the Dutch system) and **degradable protein balance in the rumen** (**BPR** in the French system or **OEB** in the Dutch system). Degradable protein balance in the rumen is positive if the concentration of degradable proteins in the rumen exceeds the available energy and negative if the concentration of degradable proteins in the rumen is insufficient relative to the available energy.

c) **Cellulase digestibility** is an indicator of forage digestibility and therefore its energy value. Indeed, digestible energy and digestibility of organic matter (dOM) are closely correlated for a given substrate. There are a large number of methods for estimating dOM, the most easily standardised and routinely applicable of which are enzymatic methods using pepsin and cellulase. Generally, the higher the digestibility of a forage's organic matter, the higher its energy value. Additionally, ingestibility and digestibility are positively correlated.

d) **Fibre** contributes to the energy and structure value of a forage. In analysis reports, fibre content is generally expressed in terms of **crude fibre (CF)**. A more detailed characterisation of the **cell walls** allows for the quantification of 3 distinct fractions: fibres insoluble after treatment at neutral pH, including hemicellulose, cellulose and lignin (**NDF** for Neutral Detergent Fibre); fibres insoluble after acid treatment, including cellulose and lignin (**ADF** for Acid Detergent Fibre); fibres insoluble after sulphuric acid treatment, corresponding to lignin (**ADL** for Acid Detergent Lignin). Hemicelluloses are moderately digestible fibres, obtained by the difference between NDF and ADF. The digestibility of cellulose (ADF-ADL) is slower, whereas lignin is indigestible. The higher a forage's fibre content, the less digestible it is, and the lower its energy value. The more fibrous the forage, the higher its structure value and the less digestible it is. Conversely, too little structure can lead to poor rumen function and poor animal performance.

e) **Reserve carbohydrates** are referred to as **soluble sugars** and **starch**. Sugars are the most readily available energy source for animals. Starch, the most common reserve polysaccharide, can be considered fully digestible. However, its degradability rate varies depending on its source. A distinction is therefore made between rapidly degradable starches, such as those from grains like barley and wheat, and slowly degradable starches, such as those found in maize, sorghum, etc.

f) **Total ash (ashes)** content is also used to estimate the energy value of forages. An excessively high content (ashes > 5% for maize silage; ashes > 12% for grass silage) indicates the presence of soil and leads to a reduction in the energy value.

g) In the case of ensiled forages, silage fermentation products can be determined. These are indicators of silage conservation quality. The most common include **acidity or pH** and **ammonia**. pH is the simplest way of assessing the conservation quality of non-pre-wilted silage since it primarily reflects the activity of lactic acid bacteria. The optimal pH of a silage depends on its dry matter content: the lower the dry matter content, the lower the pH needs to be to ensure quality silage. pH cannot be used to judge the conservation quality of pre-wilted silage. **Ammonia**, expressed as the ratio of ammoniacal nitrogen to total nitrogen, indicates the state of protein degradation in the silage. Ammonia is always present in forage silages, at a rate of at least 3.5% of total nitrogen. A proportion greater than 10% indicates the development of butyric flora, and therefore a higher risk of protein degradation. Finally, **organic acid** content (lactic, acetic, butyric acids, etc.) is another indicator of successful silage. They give an indication of the proper progression of fermentation. Generally, good silage contains between 1.2% and 1.5% of lactic acid on fresh matter basis; about 0.5 to 1% of acetic acid on fresh matter basis and no butyric acid, the presence of which is an indicator of poor conservation.

The second step involves incorporating these laboratory parameters into relationships that allow the calculation of:

a. Ingestibility, including **voluntarily intake of dry matter (DMI)** calculated from dOM, DM and CP of forage.

b. The **structure value (SV)** is closely linked to the characterisation of the fibres in the forage: CF, NDF.

c. The **digestibility of digestible organic matter (dOM)** and **digestible organic matter (DOM)** is based on cellulase digestibility, itself the basis for estimating a feed's energy value. **Cellulase digestibility** is the main parameter for estimating **dOM** and **DOM**, themselves the basis for estimating the **energy value (UFL, UFV, VEM, VEVI) of a forage**.

d. **Fermentable organic matter (FOM)** is the basis for estimating microbial protein synthesis and is used to determine **PDIM** and **PBR** values for the French system and **DVE** and **OEB** values for the Dutch system. **FOM** is obtained by subtracting the various fractions digested in the intestine and the **fermentation products (FP)** for the silage from the **DOM**.

e. Crude protein (CP) is the main parameter for estimating **nitrogen degradability** (**DT-N** in the French system) and **the stability of proteins in the rumen** (**BRE** in the Dutch system) used to calculate **dietary-origin proteins digestible in the intestine** (**PDIA** in the French system and **DVBE** in the Dutch system).

These estimated values derive from relationships specifically established for each type of forage (conservation method: green, ensiled, dried) and botanical families, plant development stage at harvest time, etc. Care must therefore be taken to provide the laboratory with all the information it needs to select the most appropriate estimation models.

STEPS FOR CALCULATING FEED VALUE, EXAMPLE IN THE FRENCH INRA 2007 AND INRA 2018 SYSTEMS AND IN THE DUTCH SYSTEM.

A wilted grass silage with the following near infrared (NIR) spectrometric analysis:
DM: 45.3%
CP: 164 g/kg DM
Ashes : 115 g/kg DM
CF: 282 g/kg DM
Cellulase digestibility (DCS): 69.3% (for the French system)
Cellulase digestibility (DMORT): 73.9 (for the Dutch system)
pH = 4

The first step is to calculate the in vivo digestibility of organic matter. These parameters form the basis for estimating the energy value of forages. Whatever the system, in vivo digestibility of organic matter is calculated based on cellulase digestibility.

The second step calculates the reference intake level. This step is optional for the INRA 2007 and CVB 1991 systems.

The third step will determine the energy value of the forage, i.e. UFL and UFV in the INRA 2007 and 2018 systems; VEM and VEVI in the CVB 1991 system. The parameters calculated in this step are gross energy, metabolisable energy and net energy.

The fourth step is to determine the protein value for ruminants, i.e. proteins digestible in the intestine (PDI/DVE) and nitrogen balance in the rumen (BPR/OEB). The essential parameters for this determination are fermentable organic matter (FOM) and ruminal nitrogen degradability (DT-N).

TABLE 4: MAIN STEPS IN DETERMINING THE NUTRITIONAL VALUE OF FORAGES.

	INRA 2007	INRA 2018	CVB 1991
Step 1: calculation of in vivo digestibility of organic matter (dOM, DOM)			
dMO	0.72	0.72	/
MOD (g/kg MS)	/	640	654
Step 2: calculation of reference intake level (RI)			
RI (% PV)	/	1.98	/
Step 3: calculation of the energy value (GE, DE, ME, NE, UFL and UFV, VEM and VEVI)			
GE (kcal/kg DM)	4064	4064	4333
dE	0.69	0.69	/
DE (kcal/kg DM)	/	2802	/
ME (kcal/kg DM)	2242	2327	2387
ENL (kcal/kg DM)	1335	1479	/
ENV (kcal/kg DM)	1319	1398	/
***UFL/VEM (/kg MS)**	0.79	0.84	840
***UFV/VEVI (/kg DM)**	0.72	0.79	850
Step 4: calculation of protein value (PDI, BPR, DVE, OEB)			
FOM (g/kg DM)	/	566	543
DT-N	0.76	0.77	/
dr-N	0.77	0.74	/
PDIA (g/kg DM)	33	28	/
PDIE (g/kg DM)	80	/	/
PDIN (g/kg DM)	103	/	/
PDIM (g/kg DM)	/	53	/
BPR (g/kg DMS)	/	29	/
DVE (g/kg DM)	/	/	65
OEB (g/kg DM)	/	/	29

UFL_{2007} = ENL/1700; UFL_{2018} = ENL/1760; VEM_{1991} = ENL/1648
UFV_{2007} = ENV/1820; UFV_{2018} = ENV/1760; $VEVI_{1991}$ = ENV/1648

References

INRA 2018, CVB 2007, CVB 2019

THE VALUE OF PLANT NUTRITION INDICES FOR **FORAGE CROPS**

The value of plant nutrition indices for forage crops The agronomic reasoning on which fertilisation is based is constantly evolving in line with new insights. Now more than ever, a holistic, multi-criteria vision is required in order to establish fertilisation advice that is suited to agricultural productivity, but also addresses the priority societal and environmental challenges for the coming decades.

Rational fertilisation consists in adapting supplies as closely as possible to the needs of plants. Various tools are available to achieve this, soil analysis being the primary method. Plant analysis is a useful complement, allowing, for example, the determination of nutrition indices that can be used to manage annual fertilisation in forage systems.

PHOSPHORUS AND POTASSIUM

Under satisfactory growth conditions (absence of limiting factors), the composition of plant tissues is balanced between the elements nitrogen (N), potassium (K) and phosphorus (P). The absorption of K and P, among other factors, must in fact be adjusted to the rate of new plant tissue development and therefore to the dynamics of nitrogen and carbon absorption and metabolism. In other words, the K and P levels in grass depend on its nitrogen content, regardless of the level of intensification and type of pasture (unless the proportion of white clover exceeds 25%). For production levels of between 2 and 5 tonnes DM/ha, the following equations can be used to determine non-limiting concentrations for growth permitted by nitrogen in plants (Salette and Huché, 1991; Mathot *et al.*, 2009):

$$\%K = 1.6 + 0.525 \times \%N$$

$$\%P = 0.15 + 0.065 \times \%N$$

These concentrations are independent of the nitrogen availability level and can be used as thresholds reflecting normal behaviour. Any deviation from this normal behaviour, as expressed by the nutrition indices, reflects insufficient or excessive absorption of the concerned element. The following equations can be used to determine these indices based on forage analysis (Salette and Huché, 1991):

$$KI = 100 \times \%K/(1.6 + 0.525 \times \%N)$$

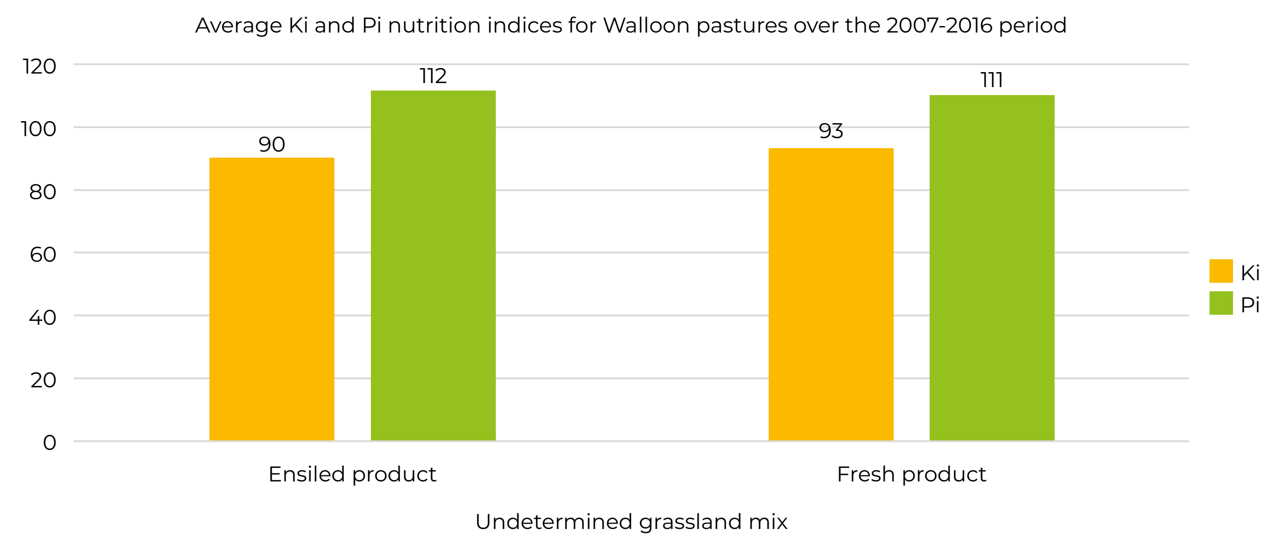
$$PI = 100 \times \%P/(0.15 + 0.065 \times \%N)$$

The index is considered good when it is between 80 and 120. This indicates that the concerned mineral is sufficiently available for the plant. A lower index suggests a lack of availability and a higher index excessive availability.

The analysis of nutritional indices for P and K in the pastures of Wallonia shows that these indices are generally satisfactory for the 2007-2016 period. The average PI was 112 (sd=22) and 111 (sd=20), and the average KI was 90 (sd=20) and 93 (sd=23) for ensiled and fresh grasses respectively.

PI	Ensiled (%)	Fresh (%)
< 80	2	7
80-100	20	21
100-120	50	40
> 120	28	32

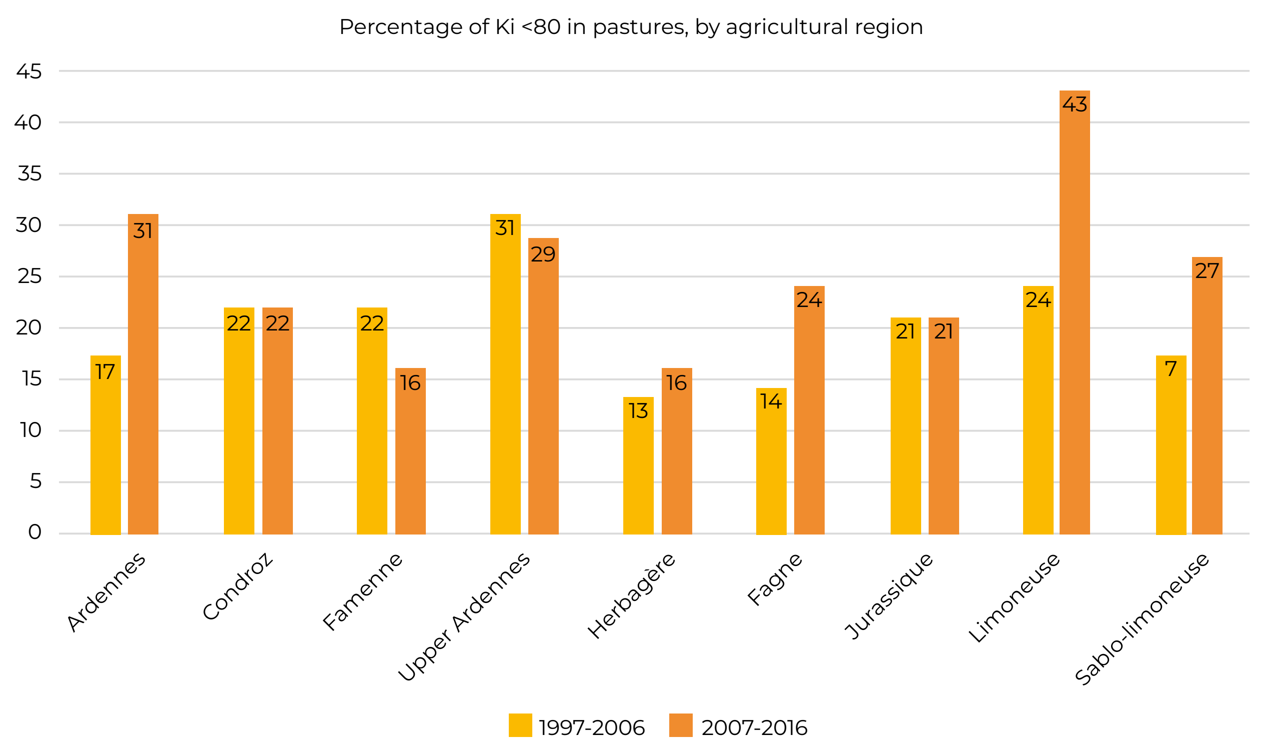
BREAKDOWN OF POTASSIUM (K) AND PHOSPHORUS (P) NUTRITIONAL INDICES FOR WALLOON PASTURES FOR ENSILED AND FRESH PRODUCTS FOR THE 2007-2016 PERIOD



However, while the proportion of insufficient PI (< 80) is very low (<5%), that of KI is around 30%. This means that 30% of pasture plots in Wallonia have insufficient potassium nutrition.

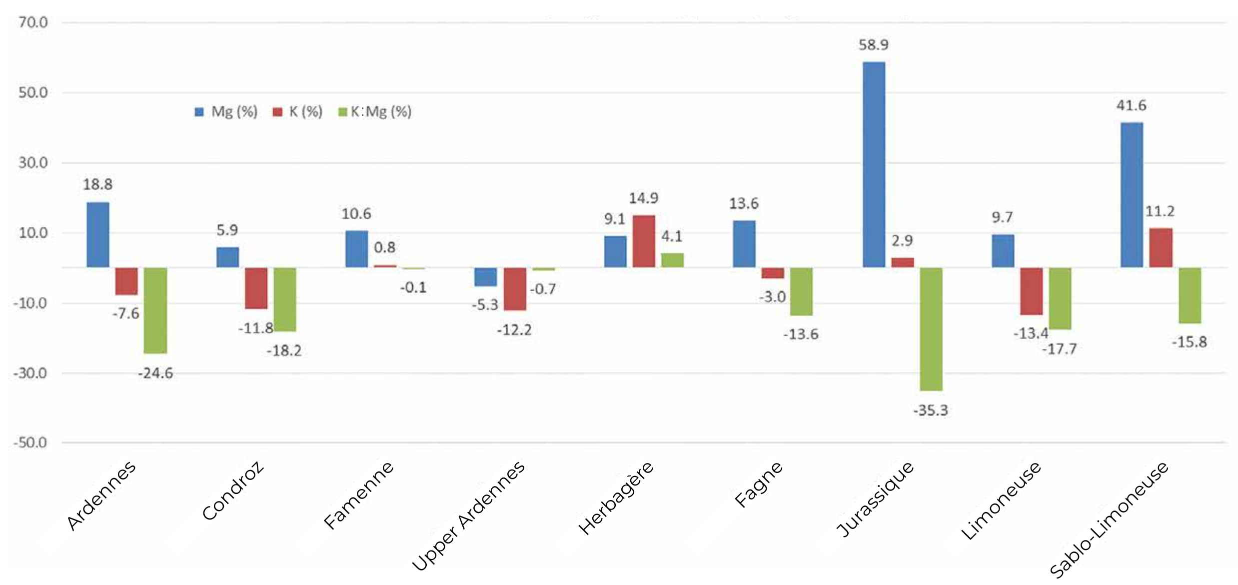
PI	Ensiled (%)	Fresh (%)
< 80	31	27
80-100	40	31
100-120	23	32
> 120	7	10

These data were compared with those for the previous decade (1997-2006). We can see that the proportion of unsatisfactory indices has fallen slightly in Famenne (-6%) and High-Ardenne (-2%), is steady in Condroz and Jurassic Region and is rising everywhere else, with significant increases in Ardenne (+14%), Fagne (+10%), Loamy Region (+19%) and Sandy-Loamy Region (+20%).



Correlations with soil condition monitoring using the same REQUASUD database were carried out to try and explain this finding. While no overall trend in the evolution of K levels in the soil was observed, the same could not be said for magnesium (Mg). Indeed, the increase in Mg levels in soils, already observed by Genot *et al.* 2012, between 1994 and 2008, was confirmed over the 1997-2016 period except in High-Ardenne (-5.3%). This accumulation of Mg in the soils, mainly caused by magnesium amendments (dolomite), Mg-rich fertilisers and the addition of Mg to livestock feed and concentrates, a significant proportion of which is excreted, induces a profound imbalance in the soil's K:Mg ratio (Cremer *et al.* 2016). This imbalance is exacerbated in certain regions where K inputs are reduced and where the average soil K contents decreased, such as in the Ardenne (-7.8%) and the Loamy Region (-13.4%). This could partly explain the significant increase in deficient indices in these two regions during the 1997-2016 period. The average Mg levels in Ardenne soils rose by 18.8%, while average K levels fell. This resulted in a downward trend in the K:Mg ratio of 24.6% in this region over this period. However, in the Jurassic Region, Mg content rose significantly (+58.9%), K content remained stable (+2.9%) and the K:Mg ratio decreased substantially (-35.3%), with no noticeable difference in the number of deficient indices. Finally, in the Grassland Region, the average potassium content increased (+14.9%), as did the Mg content (+9.1%) and the K:Mg ratio (+4.1%), but despite this the percentage of unsatisfactory situations from the perspective of the indices also increased by 3%.

Trends in K and Mg content and K:Mg ratio over the 1997-2016 period



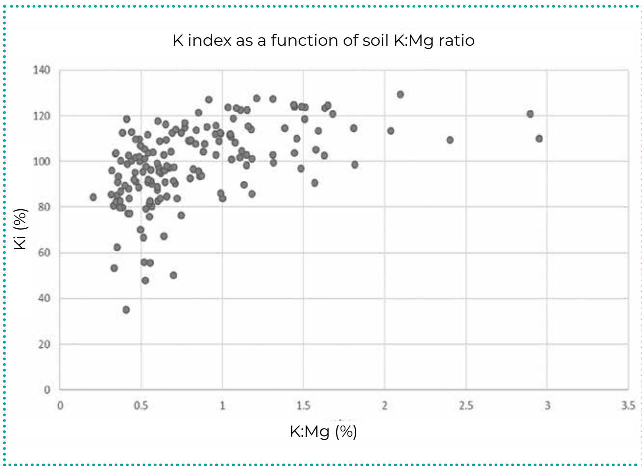
It is therefore important to put these results into perspective and determine whether these observations are really due to the K:Mg ratio limiting K availability or causing it to leach out, or solely to K levels becoming too low due to lack of inputs.

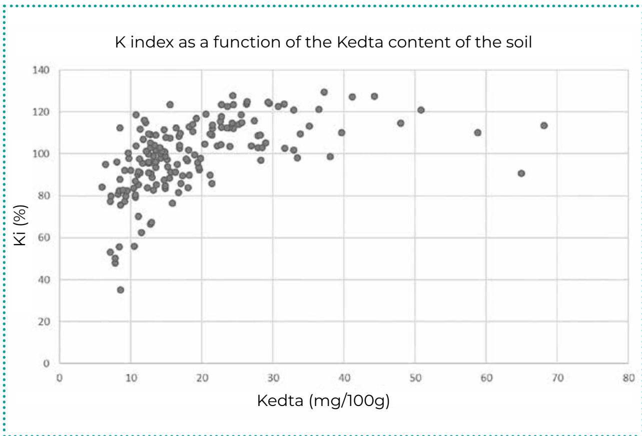
Scientists agree that soil elements must be present in balanced ratios: the elements K, Ca and Mg must optimally occupy the CEC while respecting certain balances. Otherwise, antagonisms can arise between the elements, adversely affecting plant nutrition. However, there is not yet a consensus on the values of these ratios. The values observed in the literature range from 0.3 to 4 for the K:Mg ratio (element mass/soil mass ratio). These can depend on the type of soil, but also on the crop in question. The latest research summarised by COMIFER (COMIFER, 2017) generally indicates a K:Mg ratio of 1.62 (element mass/soil mass ratio), with the negative CEC charges occupied by magnesium being twice as numerous as those occupied by potassium. Furthermore, scientists agree that excess potassium can lead to (induced) magnesium deficiency. The reverse is much less certain. However, a soil with an excessively high magnesium content can run the risk of soil structure breakdown due to the reduced attraction forces of the Mg^{2+} ion compared to the Ca^{2+} ion.

A more local study carried out between 2018 and 2019, mainly in the Ardenne, provides forage nutrition indices and soil analyses of the corresponding plots carried out on the same date (n = 166).

The situations (n=17) where the KI are insufficient (<80) correspond to situations where the K:Mg ratio is considered poor (<0.75) and K levels low (K_{EDTA} <13 mg/100g). These situations only represent 10% of all monitored plots and the inverse of these observations is not necessarily true. In fact, many situations (n=63) also presenting deficient K:Mg ratios (<0.75) have quite satisfactory KI values ranging between 85 and 118 for K levels of 6.5 to 23 mg/100g DM. There are two possible explanations for this finding. On the one hand, the addition of organic matter, mainly in the form of slurry or digestate, or potassium fertilisers at the beginning of the season, would enable the forage to obtain the necessary K despite the low soil content. A second hypothesis is that the index is good due to limited nitrogen availability, resulting in more limited plant growth and therefore reduced K requirements. As the protein content of the whole plant at the end of the growing season is not a good indicator, nitrogen nutrition indices carried out on the top 10 cm of plants could determine if nitrogen was sufficiently available to allow optimal growth (Deprey *et al.*, 2005).

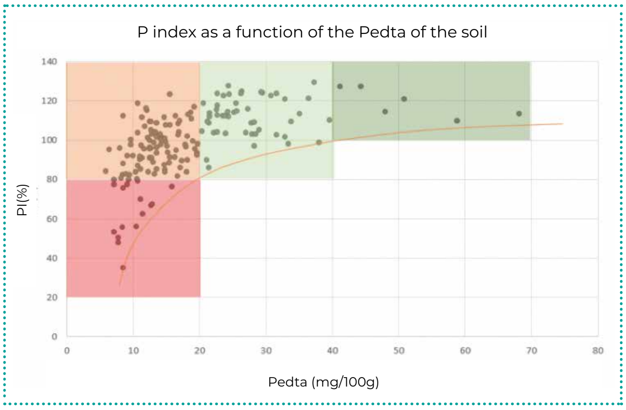
POTASSIUM NUTRITION INDICES FOR 166 FORAGE CROPS AS A FUNCTION OF THE K:MG RATIO OF THE SOIL AND THE K CONTENT OF THE SOIL IN MONITORED PLOTS.

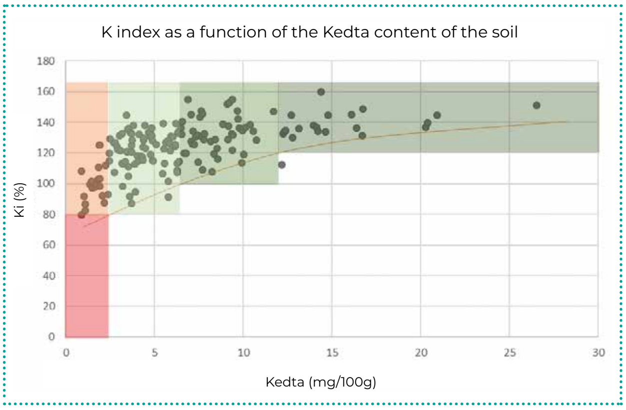




Trials in a deficient conditions (K_{EDTA} < 12mg/100g and K/Mg= 0.5) have shown that an addition of around 200 units of K can significantly increase yields (by approximately 15%) and restore satisfactory indices (from 85 to 110) for the first two cuts. However, these K inputs, although combined with a lack of Mg inputs, did not improve the balance of these soils, which continued to deteriorate from an average K:Mg ratio of 0.5 to 0.4 and an average K_{EDTA} content of < 9 mg/100g from 2014 to 2018 (Cremer *et al.* 2018). A larger input would be necessary to rebalance the soil, but unfortunately this is not always economically viable for the farmer.

In addition, the analysis of the envelope curves of the indices compared to the soil contents can be used to establish threshold levels for soils above which no deficient index is observed.





The phosphorus envelope curve indicates that an index below 80 corresponds to a P_{EDTA} content of less than 2.5 mg/100g. Only one plot with a phosphorus level below this has an index considered deficient. There are a few cases below this threshold where the indices are considered at least satisfactory. In these instances, it can be assumed that another factor is limiting production and P requirements. These situations must be monitored. Plots with P_{EDTA} values of between 2.5 and 6.5 mg/100g have PI indices of at least 80 to 100 and are therefore considered at least satisfactory in terms of P. Above a P_{EDTA} content of 6.5 mg/100g, the PI exceeds 100. The index of 120, considered excessive, is always reached when P_{EDTA} exceeds 12.5 mg/100g.

When the K content exceeds 20, the KI are always above 80. Below a K content of 20, the KI can be lower than 80, indicating that the K content might be a limiting factor. However, it is quite common for the KI to exceed 100, even when the soil K content is below 20. In these cases, as with P, it can be assumed that another factor is limiting production and therefore K requirements. This could be inadequate nitrogen fertilisation, a deficiency in another element or an environmental factor.

If these observations are compared with the thresholds in force within the REQUASUD laboratory network, it can be seen that the envelope curves of the indices accurately reflect the thresholds adopted in Ardenne. In fact, the P threshold for a heavy soil (soil codes E or U) is 2.6 and the threshold for a medium soil (soil codes P, L and A) is 3 for KCl pH below 5.5. For K, the acceptable content threshold in Ardenne is set between 16 and 20. Analysis of the indices confirms that a value of 20 is indeed desirable to avoid any deficiency issues.

NITROGEN

The nitrogen nutrition index (NNI) requires measuring or estimating the amount of above-ground biomass produced at the time of sampling and analysing the actual nitrogen content to compare it with the critical nitrogen content calculated based on the nitrogen dilution curve in relation to biomass when nitrogen is not limiting. Sampling is carried out by collecting grass samples (4-5 cm above ground level) from plots of known surface area. The critical nitrogen content (the minimum content that allows maximum growth) is determined by the following equation:

N% = 4.8*DM $^{-0.32}$ (Salette and Lemaire, 1984)
where DM = above-ground biomass in t of dry matter.

Due to the "dilution" of nitrogen as grass mass grows, the amount of nitrogen required to produce 1 t dry matter decreases as the biomass increases.

Various authors have adapted these factors depending on the species cultivated or the age of the pasture. The values of the adapted coefficients are shown in Table 5.

TABLE 5: COEFFICIENTS A AND B OF THE EQUATION N% = A * DM^{-b}, WHICH RELATES CRITICAL NITROGEN CONTENT TO ABOVE-GROUND BIOMASS.

Cultivated species	a	b	Reference
Grass pastures **• Pastures > 4 years** **• Ray grass**	4.8 3.7 4.1	0.32 0.35 0.38	Salette and Lemaire, 1984 Bélanger and Ziadi (2008) Marino *et al.*, 2004
Alfalfa	4.6 - 5.5	0.29 - 0.36	Lemaire *et al.*, 1985
Other crops **• Wheat** **• Maize** **• Sorghum** **• Peas**	5.3 3.4 3.9 5.1	0.44 0.37 0.39 0.32	Justes *et al.*, 1994 Plénet, 1995 Plénet & Cruz, 1997 Ney *et al.*, 1997

The N nutrition index (NNI) then represents the ratio between the measured nitrogen content and the critical content, which characterises the nutrition status of the plot:

NNI = 100 * N%/(4.8*DM $^{-0.32}$)
(LEMAIRE et al., 1989 for a tall grass meadow)

The result is expressed as a %: a value above 100 indicates luxury consumption (the element is in excess of growth requirements); between 100 and 80 indicates sufficient availability; a situation below 80 is considered deficient, i.e. production increases if nitrogen intake is increased.

Nitrogen use efficiency depends mainly on weather conditions and plant growth. To limit variations in soil nitrogen supply, it is recommended that the nutrition status of the surface part of the canopy is measured halfway through regrowth. Lambert (2001) demonstrated that beyond a certain date (late May-early June depending on the year) when biomass exceeds approximately 2 t of dry matter per hectare, the NNI calculated according to Lemaire decreases significantly as a function of biomass accumulation.

The work of Gastal *et al.* (2001), confirmed by Deprez *et al.* (2005) and Louarn et al, (2020), showed that the nitrogen nutrition index can also be determined on the basis of the N content of the upper part of the crop canopy (5 to 10 cm). This eliminates the time-consuming step of estimating biomass in situ.

The following relationship, defined by Deprez on Walloon pastures, can then be applied:

NNI = 100 * ((Nupp%*0.22) -0.07)

Applying this relationship to 106 Walloon pastures analysed in 2018 and 2019, gives an average NNI of 66 (+/-12), which then represents a majority of deficient situations (72% NNI < 80). However, these situations do not necessarily require additional nitrogen inputs. An NNI of 60 could represent a production optimum above which additional nitrogen would not significantly improve yield or forage quality. It would also be necessary to analyse the conditions under which plants with a low NNI were found. For example, nitrogen content could be low in poorly drained soils (root asphyxia). The deficient NNI could also reflect a deficiency caused by another limiting element. Monitoring over several years would make it possible to take account of climate fluctuations and provide a more accurate picture of cultivation practices.

In addition, close attention must be paid to how NNIs are interpreted in practice. The use of nutrition indices to diagnose the level of nitrogen available in pastures covers temporary and permanent grassland soils, but comes up against overestimates when the proportion of legumes is relatively high, e.g. >25% white clover (Cruz. *et al.,* 2006, Mathot *et al.,* 2009). Legumes have tissues with a very high nitrogen content, which is almost constant throughout the growth cycle. The established critical curve is then no longer valid. Moreover, it is best to avoid carrying out such a diagnosis during a period of drought. In addition to the direct effect of a water deficit that overestimates the value of the index (same content for a lower biomass) on growth, there is an indirect compensatory effect due to a reduction in nitrogen absorption that underestimates the soil's N supply.

SULPHUR

Like nitrogen, sulphur is an essential element for plants. It is also involved in the composition of the amino acids that make up proteins and certain vitamins. As a component of proteins, it plays a role in forage quality. So if the N:S ratio is too high, protein synthesis is limited and non-protein nitrogen accumulates.

Soil contains sulphur in organic form, but this cannot be directly assimilated by plants, as they take it up in the form of sulphate (SO_4^{2-}). However, in this form, it is easily leachable. Sulphur deficiency also reduces nitrogen fertilisation efficiency, resulting in higher nitrate leaching (Brown *et al.*, 2000). In Wallonia, trials have shown that sulphur can be a limiting factor in intensive pasture production (Mathot *et al.*, 2009). However, it is important to note, that an excess of sulphur is also detrimental to forage quality, as it can lead to deficiencies in other essential elements such as copper or selenium (antagonistic effect).

Ruminants can use non-protein nitrogen, such as urea or ammonia added to the ration, to a certain extent, due to the bacteria present in the rumen. However, sufficient sulphur must be available to ensure protein synthesis with an adequate amount of sulphur-containing amino acids, otherwise the risk of metabolic issues increases. The nitrogen/sulphur balance generally recommended for cattle is around 12:1, and the recommended S content in the ration is 0.2% of DM, without exceeding 0.4%. Maize silage generally contains little sulphur. Its content is between 0.05 and 0.1%. Grass and especially legumes (clover, alfalfa) and cruciferous plants are richer in sulphur and therefore more demanding. If the ration contains a lot of maize silage, there's a high risk of having too little sulphur in the feed.

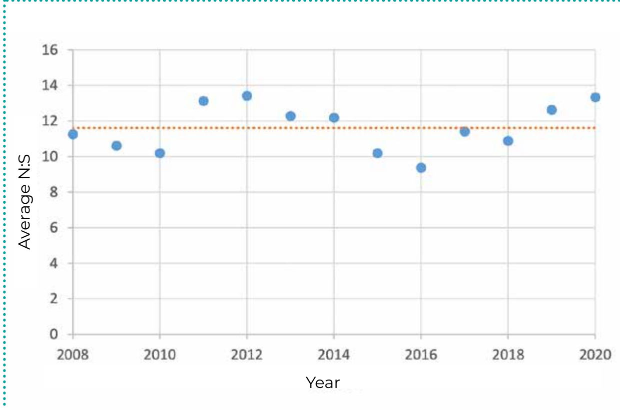
SHEEP HAVE HIGHER SULPHUR REQUIREMENTS BECAUSE THIS ELEMENT IS A CONSTITUENT OF WOOL. THE RECOMMENDED N:S RATIO FOR SHEEP IS THEREFORE 10:1.

In recent decades, there has been greater interest in sulphur fertilisation, as atmospheric depositions have been greatly reduced following measures taken to reduce air pollution and "acid rain". Indeed, there are now around 20 times fewer depositions than in the 1970s (150-170 kt of SO2 in 2014-2019 compared with 3500 t in the 1970s). This corresponds to an average deposition of 3.3 kg/ha/year today, compared with around 60 kg/ha/year previously (Citepa data). However, these depositions vary greatly depending on location and are difficult to predict exactly. Nonetheless, the sulphur balance (inputs - outputs) in agriculture, which was generally positive, is now negative in many situations. This is why, in recent years, the situation of sulphur in pastures in Wallonia has been studied more specifically. Indeed, depending on the crop, requirements can vary from 10 to 80 kg/ha. For example, cereals need 10 to 40 kg/ha, rapeseed needs 60 to 80 kg/ha and legumes need 20 to 50 kg/ha.

Grass samples (first cycle in spring) were collected by the Protect'eau action centre teams and analysed by the Centre de Michamps laboratory. In addition, since 2008, the Centre de Michamps has been analysing the sulphur content of a representative sample of forage harvested in the Province of Luxembourg to determine the frequency of deficiency situations.

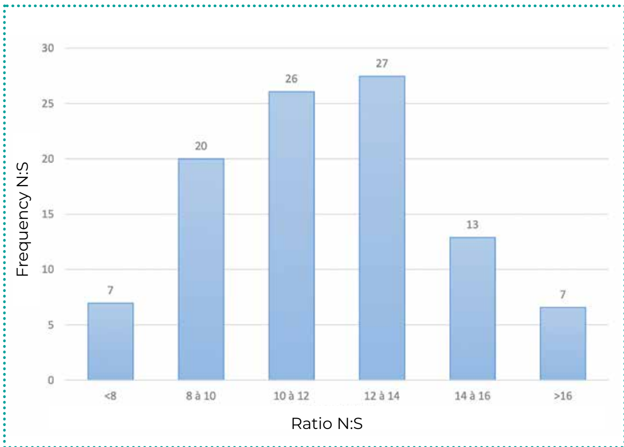
A total of 790 grass samples have been analysed since 2008. From 2008 to 2017, samples came exclusively from the Province of Luxembourg, then from 2018, from all over Wallonia. The average N:S ratio over the 13 years of monitoring is 11.6. However, results vary greatly between years, probably due to the atmospheric depositions that vary from year to year, weather conditions that are more or less favourable to mineralisation and plant requirements that depend on growth. The lowest average annual N:S ratio (9.3) was observed in 2016 and the highest (13.4) in 2012 (Figure 3).

FIGURE 3: AVERAGE N:S RATIO FROM 2008 TO 2020 (DOTTED LINE) AND ANNUAL VARIATIONS IN THIS AVERAGE N:S RATIO.



Based on the average N:S ratio of 11.6, it can be estimated that in 11% of cases, the N:S ratio was too high, meaning the S content was too low in relation to the nitrogen content to meet plant requirements. However, considering that animals need an N:S ratio of less than 12, the proportion of sulphur-deficient pasture rises to 47% (figure 4).

FIGURE 4: FREQUENCY DISTRIBUTION OF THE N:S RATIO OF FIRST-CUT FORAGES FOR THE 2008 TO 2020 PERIOD



SBased on the S content of the grass, we also arrive at a proportion of around 50% of first-cut forage that is deficient (S content < 0.2%). The proportion of samples exceeding the maximum limit of 0.4% of S is less than 1%.

Soil sulphur content and the sulphur nutrition index of forage

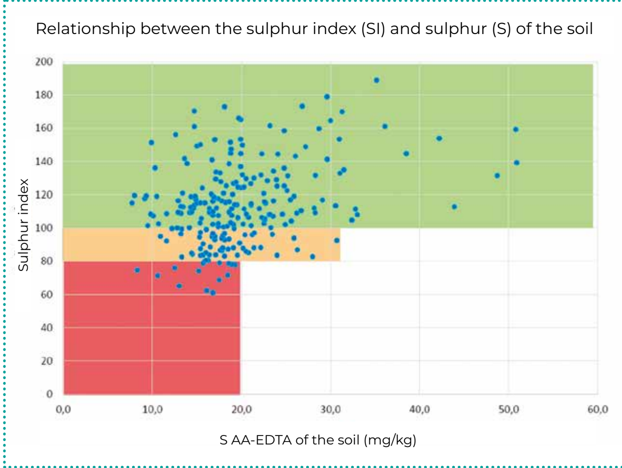
Traditional soil analysis cannot yet be used to estimate whether soil reserves and supply will be sufficient to nourish pastures properly. The laboratories in the REQUASUD network are working together to establish an indicator that can be used routinely. However, sulphur provision will remain partly dependent on depositions, but mainly on various inputs (farmyard manure, minerals, etc.) and soil mineralisation (Sorg = 60 to 95% of the S stock in soils, depending on soil type, etc.). Estimating the sulphur mineralisation of soil is currently challenging, but the development of sulphur analysis in organic fertilisers will soon make it possible to quantify part of the flow supplied.

In order to establish an initial reference system for interpreting soil S content, 233 pastures were selected in Wallonia in 2018, 2019 and 2020. Soil analyses for S (AA-EDTA method) were carried out on these 233 pastures, along with forage analyses and determinations of sulphur nutrition indices (SI). The SI are used to characterise the level of sulphur nutrition in the pasture based on the total nitrogen (N) and S content of the grass:

SI = 100*S%/(0.662*N%-0.0198)

with S% and N% the total S and N content of the forage expressed as % of dry matter (Mathot *et al,* 2009).

The soil S contents observed ranged from 8 to 50 mg S/kg SC (avg. = 19.9 ± 6.9) and SI from 61 to 190 (avg. = 113 ± 24.6). 28% of forage had deficient SI (<100), including 21% with significantly deficient SI (<80). These deficiencies only appear when the soil content is below 31 mg S/kg SC for SI<100 (90% of pastures analysed) and below 20 mg S/kg SC for SI<80 (64% of soils analysed). However, S deficiency is highly dependent on climatic and mineralisation conditions and SI is also correlated with N content and hence availability. As previously explained, based on the S content of the grass, we arrive at a proportion of around 50% of first-cut forage that is deficient (S content < 0.2%).



It can be concluded that in almost 50% of the pastures analysed, an application of sulphur fertiliser in spring could have a positive effect on forage quality and in 10% of cases, also impact quantity. Deficiency risk is difficult to predict and is influenced by countless climatic, pedological and phytotechnical factors. A rainy winter (heavy leaching) and a cold spring (reduced mineralisation) are major risk factors. Filtering, sandy, stony and shallow soil, significant mineral nitrogen fertilisation and little organic input are also factors that favour the appearance of deficiencies. Pastures with many legumes also have higher sulphur requirements than grasses alone.

Limited data is currently available, but an estimate of around 2 to 4 kg/t for manures and approximately 1 kg/t for slurries seems reasonable based on preliminary analysis results.

Consequently, given the high frequency of deficiency situations, it is recommended that 30 to 50 units of SO_3 are applied with the first nitrogen fraction in spring (e.g.: 30 m^3 of slurry already satisfies about 30 units of these requirements, 20 t of manure alone can meet the entire requirement, depending on the actual content of the manure). Sulphur analysis of farmyard manure allows better characterisation and optimisation of sulphur fertilisation. These inputs can potentially be adapted depending on the frequency of organic inputs.

CATION-ANION BALANCE (CAB)

Controlling the balance between cations and anions in the ration is crucial in livestock farming, and especially in dairy farming. It plays a key role in preventing post-partum hypocalcemia (milk fever), which can also lead to other secondary problems such as ketosis, acetonemia, displaced abomasum, difficult calving, retained placenta, mastitis or failure of uterine involution.

There are many equations for assessing the ionic balance of feed, the most commonly used being the Dietary Cation-Anion Balance (DCAB):
DCAB = $(Na^{+} + K^{+}) - (Cl^{-} + S^{2-})$,

DCAB is expressed in mEq/kg of DM of the total ration and measures the acidity or alkalinity of feed. Sodium $[Na^{+}]$ and potassium $[K^{+}]$ have an alkalinizing effect, while chloride ions $[Cl^{-}]$ and sulphur-containing ions [S, in various chemical forms] have an acidifying effect. Depending on the contributions of all feed, the DCAB of the ration is either positive or negative. DCAB recommendations differ depending on the breed and the physiological stage of the dairy cow. There are many reference books detailing all these needs.

However, it can be specified here that for a dairy cow, these needs are for the lowest possible DCAB at the beginning of the drying-off and even a negative DCAB in preparation for calving. In practice, recommendations on the DCAB value of the rations for dry cows focus on the 3 weeks prior to term, with a target value of -100 meq/kg DM. An anionic diet (negative DCAB) mobilises calcium more easily. The ideal DCAB ration for lactating cows is then between 200 and 400 mEq/kg DM.

Analyses of chlorine and sulphur in forage have recently been developed and standardised within the laboratories of the REQUASUD network.

The initial analyses do not yet allow for regional references on the content of these minerals in the main Walloon forage crops and their DCAB value. gères wallonnes et de leur valeur BACA).

TABLE 6: AVERAGE MINERAL CONTENT AND DCAB VALUE OF THE MAIN FORAGE CROPS ANALYSED AT THE CENTRE DE MICHAMPS BETWEEN 2017 AND 2021.

Forage category	Number of data	Average	Standard deviation
Immature Cereal	18	275	151
Miscellaneous	6	39	72
Timothy	20	222	37
Alfalfa	7	345	87
Silage maize	37	161	120
Undetermined grassland mix	409	351	212
Silage			
Ensiled product	235	377	237
Ensiled product: bale	53	301	146
Ensiled product: corridor silo	45	479	145
Fresh/dry			
Fresh product	36	246	86
Dry product	40	221	141
Clover	4	715	33
Orchard grass	2	691	26
Legumes	4	425	33
General total	**507**	**330**	**210**

WHAT DO **ANIMALS NEED** AND CAN WALLOON FORAGES MEET THESE NEEDS?

ANIMAL NEEDS, WHAT ARE THE PARAMETERS?

Dairy and suckler cattle have their own specific needs. Similarly, within a herd, different categories of animals (lactating cows, calves, young replacement cattle, fattening cattle) live side by side, each with their own nutritional requirements.

Dietary recommendations cover the protein, energy and mineral requirements for defined production levels. In addition to these values, indications on the proportion of forage in rations and on the intake capacity of the animals are also useful. For example, for suckler cows and replacement heifers, the proportion of forage in the diet can reach 80% of DM. For dairy cows, a minimum of 60% of DM in the form of forage is generally recommended. For meat production, the energy and protein requirements of fattening males are the highest, and for this livestock category, the proportion of forage in the ration does not usually exceed 50% of the ration's DM. Tables 7 and 8 show the requirements and intake capacity of the different animal categories in dairy and suckler herds.

TABLE 7. DAIRY HERD REQUIREMENTS IN THE DUTCH SYSTEM

	Dairy cow			**Dry cow**	**Heifer**		
	Milk production (L4, kg/d)				6 months	12 months	20 months
					Average daily gain		
	20	25	30	/	0.850	0.700	0.700
Intake (kg DM/d)	18	20	22	10-12	5.5	7.5	9.5
VEM/kg DM	800	873	950	550-850	640	720	830
DVE g/kg DM	60	71	81	15-50	47	41	47
Ca g/kg DM	3 to 5			2.4 to 2.8	5	3.5	2.8
P g/kg DM	2.5 to 3.5			1.9 to 2	3.5	2.3	1.8
Mg g/kg DM	2 to 2.5			1.9 to 2.1	1.7	1.8	1.9
Na g/kg DM	1 to 1.5			0.6 to 0.7	0.6	0.5	0.5

L4 = standard milk at 4% TB (L4 = 0.337 + (0.116 x % TB) + (0.06 x % TP)] x Milk.)
Source Melkveevoeding, 2011

TABLE 8. SUCKLER HERD REQUIREMENTS (TYPE BELGIAN BLUE WHITE CATTLE (BBB)) IN THE DUTCH SYSTEM

	Suckler cow	Heifer			Fattening	
		6 months	12 months	24 months	Bull calf	Cull cow
Average daily gain (kg/d)	/	0.750	0.750	0.850	1.400	1.000
Intake (kg DM/d)	9 to 15	3.5	6	10	8 to 12	9 to 15
VEM/kg DM	744	860	815	879	1050	>950
DVE g/kg DM	38	53	46	44	85	/
Ca g/kg DM	4.3 to 5.5	6.5	6.5	5.7	5.3	/
P g/kg DM	3 to 3.5	3.6	3.8	3.9	3.5	/

Ca:P ratio = 2:1
Source Voeding van runderen, van het belgische witblauwe ras, 2013.

DOES THE FORAGE PRODUCED IN WALLONIA COVER THE ANIMALS' NEEDS?

The answer varies depending on the type of forage and the type of livestock for which the forage is intended. By definition, the feeding value is the contribution of the feed to meeting the animal's needs. This feeding value therefore incorporates the nutritional value (energy, protein and mineral content) and intake. It is therefore important to characterise the different forage categories present on the farm, so as to allocate them to the appropriate animal categories.

Maize silage is energy-rich and well suited as a basic forage to cover the energy needs of dairy cows and fattening cattle, but its protein and mineral content is low. In the diets, this type of forage combines well with grass silage, legume-based forage and concentrates that provide the essential protein supplement.

TABLE 9. NUTRITIONAL VALUE OF MAIZE SILAGE, REQUASUD DATABASE 2013-2017

	N	Average	Lower quartile 1	Median	Upper quartile 3
DM %	5915	34	31	33	36
VEM/kg DM	5915	937	920	938	955
VEVI/kg DM	5915	975	951	976	998
DVE g/kg DM	5915	46	45	46	48
OEB g/kg DM	5915	-28	-31	-28	-25
Ca g/kg DM	575	1.8	1.5	1.7	2.0
P g/kg DM	575	2.0	1.8	2.0	2.2

Grass products come in a wide range of variations. Their nutritional value and mineral content vary depending on the type of plant cover, from monocultures of grasses or legumes such as alfalfa to multi-species mixtures, the development stage of the plants at harvest and the type of conservation (fresh grass, silage, hay, etc.). The richest forage, both in energy and protein, will be reserved for the most productive livestock (lactating dairy cows or fattening cattle). More fibrous forage is well suited to young cattle, as its high fibre content ensures good rumen development. With its high energy and protein content, grazed grass is the feed of choice for dairy cows.

TABLE 10. NUTRITIONAL VALUE OF GRASS SILAGE, REQUASUD DATABASE 2013-2017

	N	Average	Lower quartile 1	Median	Upper quartile 3
DM %	10235	46	35	45	56
VEM/kg DM	10235	832	794	835	877
VEVI/kg DM	10235	838	789	842	895
DVE g/kg DM	10235	62	54	61	70
OEB g/kg DM	10235	14	-7	11.0	32.2
Ca g/kg DM	5048	5.8	4.5	5.3	6.6
P g/kg DM	5048	3.4	3.0	3.4	3.8

TABLE 11. NUTRITIONAL VALUE OF HAY, REQUASUD DATABASE 2013-2017

	N	Average	Lower quartile 1	Median	Upper quartile 3
DM %	1211	83	81	84	86
VEM/kg DM	1211	813	744	812	878
VEVI/kg DM	1211	862	768	864	948
DVE g/kg DM	1211	62	47	59	75
OEB g/kg DM	1211	-36	-50	-40	-27
Ca g/kg DM	624	4.4	3.1	4.0	5.3
P g/kg DM	624	2.6	2.1	2.5	3.1

TABLE 12. NUTRITIONAL VALUE OF FRESH GRASSES, REQUASUD DATABASE 2013-2017

	N	Average	Lower quartile 1	Median	Upper quartile 3
DM %	1930	30	16	23	38
VEM/kg DM	1930	936	869	944	1006
VEVI/kg DM	1930	973	888	984	1066
DVE g/kg DM	1930	84	73	87	97
OEB g/kg DM	1930	10	-20	9	36
Ca g/kg DM	1253	5.4	4.1	5.0	6.2
P g/kg DM	1253	3.5	3.0	3.4	4.0

NEW
FORAGES

Climatic variations, marked by periods of heatwave and drought, are undermining traditional forage production, which is the basis of feed autonomy for ruminants. What new forage resources should be explored in order to secure stocks? In recent years, more drought-tolerant plants have been tested in our climates, for both their yield potential and their nutritional value for ruminants. Cup plant, kernza, tall fescue, moha, teff grass, sorghum, sudan grass, pearl millet, mediterranean clovers, cowpea, lablab, forage chicory, plantain - all potentially interesting plants for coping with drought. However, it's important to note that even though these forages are better at withstanding heat and require less water, they still require a minimum amount of water, especially at sowing time. These alternative forages can be divided into 2 categories: perennials and annuals.

PERENNIAL FORAGES:

Silphium perfoliatum (cup plant) is native to North America. This plant was grown in Europe until the 1970s, when it was replaced by corn. It grows up to 3.5 m tall and has many yellow flowers that attract pollinators. Due to its deep root system, the plant is drought-tolerant. It can also withstand winter temperatures and frost. Its drawback is that it takes a long time to establish; it should not expected to be harvested it the first year. It can therefore be planted under maize. For forage production, it can be harvested for the first time in June, with a second cut possible in September. In a normal year, yields can reach 14 t DM/ha in 2 cuts. It can be stored as wrapped bales or in silos. Once established, cup plant can remain in place for more than 15 years. Tests are currently underway in France to determine its nutritional value.

Kernza[1] (Thinopyrum intermedium) is a perennial gramineous (3 to 10 years) that can be processed into grain (brewing, milling) and forage. The plant provides a forage harvest in spring, a grain and straw harvest in summer, and a second forage harvest in autumn. According to recent trials, in our climates, the spring and autumn cuts produce 3 to 4 t DM/ha. With 14 t DM/ha, the straw harvested in summer accounts for the bulk of production. Little is known about its nutritional value, which depends on the plant's development stage at harvest. At the recovery stage, its nutritional value is comparable to that of young grass (> 950 VEM/kg DM and 100 g DVE/kg DM), but yield is relatively low (2.6 t DM/ha). At harvest, the nutritional value is similar to that of straw (495 VEM/kg DM and 15 g DVE/kg DM) (Dufrane, 2021, Réussir lait, 2021).

ANNUAL FORAGES:

Forage catch crops and intermediate nitrate-trap crops are interesting for many reasons. Integrated into crop rotations, they offer agronomic and environmental benefits. They provide soil cover, trap nitrates and are sources of biodiversity (Herremans *et al.* 2018). Their main purpose is to provide additional forage stocks, especially during periods of drought. They can be grazed or green fed or stored as silage. Two types can be distinguished, depending on when they are sown and harvested (summer sowing

1 - Réussir lait Dossier 359, July-August 2021 and pre-winter harvesting and pre-winter sowing and spring harvesting). In all cases, the forages are relatively young at the time of harvest, so the nutritional value of the green forage is good. When stored as silage, the main disadvantage is the low dry matter content at harvest. Another drawback is the difficulty in implementing harvesting operations. Table 13 shows the average nutritional value of ensiled catch crops in Wallonia.

TABLE 13. COMPOSITION AND AVERAGE NUTRITIVE VALUE OF ENSILED CATCH CROPS ON WALLOON FARMS (2015 - 2016 - 2017) (HERREMANS *ET AL*. 2018).

	Average	Standard deviation	Conservation method		Harvest year		
			Silo	Bale	2015	2016	2017
n (number of samples)	91		30	61	19	30	42
Growing time (days)	73	15	79	71	80	68	73
Pre-wilting time (days)	2.5	1.5	1.8	2.9	2,9	2.2	1,8
DM (%)	38.2	15.4	28.6	43.1	32.5	43.0	37.3
CP (g/kg DM)	157	38	154	159	164	148	161
Ashes (g/kg DM)	128	43	138	122	150	122	122
CF (g/kg DM)	281	34	280	281	274	292	277
UFL* (/ kg DM)	0.76	0,11	0.73	0.78	0.75	0.74	0.78
PDIE* (g/kg DM)	81.2	10.8	75.8	84.1	80.9	80.2	82.0
PDIN* (g/kg DM)	102.0	24.1	98.6	104.1	105.3	96.6	104.3

** Calculated according to INRA (2007)*

Another characteristic of these combinations is the great variability of the mixtures present. For example, during an on-farm sampling campaign, out of 91 silages analysed, more than 40 species combinations were present including, in most cases, a gramineous (oats or ryegrass) combined with one or more legumes and/or protein crops (Herremans *et al.* 2018).

Annual grasses from warm regions, such as teff grass[2], moha, millet and sorghum; **secondary legumes from the Mediterranean basin**, including sainfoin, Persian clover and serradella; and **African legumes**, such as lablab and cowpea, are currently being presented as promising plants that are more tolerant of heat and drought. However, it is important to remember that these plants still need water, especially at the time of planting, and that their cultivation practices, nutritional value and yield are still poorly documented under our soil and climate conditions. There are therefore no "miracle" plants, and the grass-legume association needs to be carefully considered based on the farm's needs, soil conditions and climate (Réussir Lait, 2021).

Fibrous or **lignified forages** such as miscanthus, crop residues, cereal and protein straws can be interesting supplementary forages. The nutritional value of **cereal or protein crop straws**, obtained after harvesting the dry grains, is low (Table 14), but their high fibre content ensures good rumination, especially in diets with a high intake of concentrated feed. As supplementary feeds, these forages should be reserved for young or dry cows.

2 - See Réussir lait Dossier 359, July-August 2021

TABLE 14. EXAMPLE OF THE NUTRITIONAL VALUE OF DIFFERENT STRAWS (INRA 2018)

		Fill unit (/kg DM)		Energy (/kg DM)		Protein (g/kg DM)	
	DM	UEL	UEB	UFL	UFV	PDI	PBR
Barley straw	88	1.6	1.8	0.43	0.32	48	-55
Oat straw	88	1.6	1.8	0.46	0.35	50	-55
Pea straw	88	1.55	1.7	0.51	0.41	50	-61
Faba bean straw	86	1.14	1.27	0.55	0.46	59	-41
Rapeseed straw	87	1.17	1.33	0.47	0.36	53	-49

PDI, proteins digestible in the intestine; BPR, protein balance in the rumen.

Rapeseed straw[3] is very rich in fibre and highly lignified (80 to 120g lignin/kg DM). Its energy value is lower than that of cereal straw, so it should be seen as a rumination stimulant. It is recommended that it is distributed chopped into strands of 2 to 3 cm.

Corn straw[4] which is rarely used in animal feed, is made up of the stalks with or without the husks, crushed and generally stored in silos. The dry matter content of this residue and its nutritional value are highly variable (17 to 54%) and depend on the maturity of the plant at harvest. The fibre content is lower than that of wheat straw. One point of attention is its frequent contamination by moulds (mycotoxin problem).

Pea leaves[5] can be an interesting resource, richer than cereal straw (protein content between 5 and 10% and lower fibre content). They can be stored in hay or wrapped. The main difficulty is harvesting, which is sometimes difficult to carry out depending on climate and soil conditions.

Miscanthus[6] is a tropical perennial grass. It is a very important forage resource in the tropics that can be grazed, green fed or even stored as hay or silage. The fresh product has highly variable protein and fibre contents (TPM: 2.8 to 23% DM; NDF: 29.5 to 52% DM), depending on the plant's development stage at harvest. In Wallonia, **miscanthus** is mainly harvested to produce biomass for energy purposes. In recent times, its use as bedding or in ruminant rations as a replacement for cereal straw has been growing. The nutritional value of this type of product is currently little known, as its main role is to encourage animals to ruminate.

Woody forages, hedges, trees and shrubs are currently little-used forage resources in our regions. Yet foliage is far from being devoid of nutritional value. Studies conducted in France (Emile *et al.* 2017) indicate variable protein contents that can reach values close to those of alfalfa. Digestibility can also be high for certain types of foliage (white mulberry, blackthorn, lilac, privet). Most contain condensed tannins, which can greatly reduce the availability of proteins to rumen microorganisms and the actual digestibility of proteins in the intestine (protein protection) (table 15). In Wallonia, a recent study reports the same observations, i.e. varying protein and fibre contents between species. Variability is also marked between seasons, with late summer foliage being less digestible than spring foliage (Vandermeulen *et al.* 2016). According to this study, the palatability of woody species varies depending on the season, with hawthorn, hornbeam and hazel being the most popular species in spring. Similarly, preferences vary between animals.

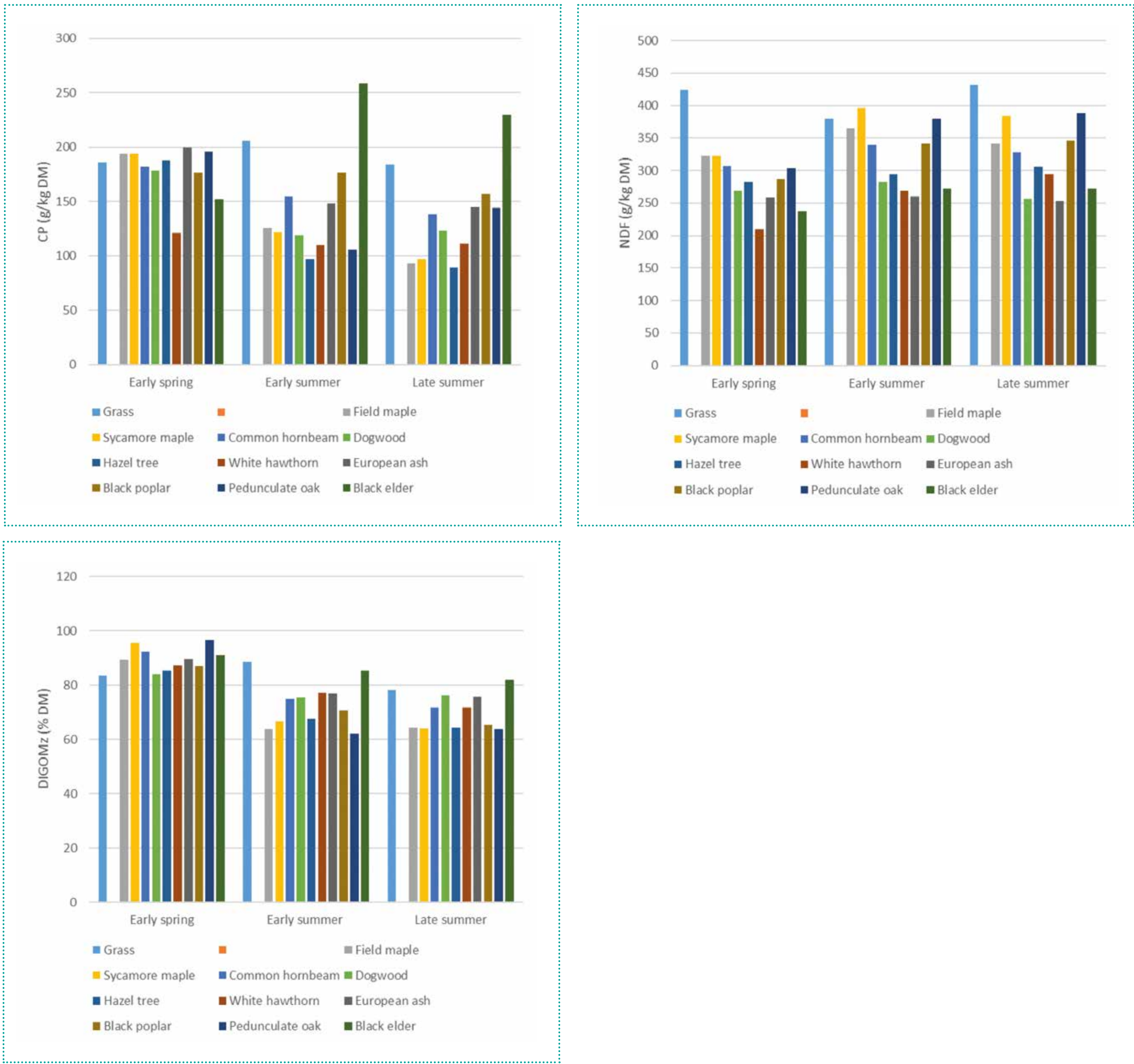
3- https://idele.fr/comite-national-des-coproduits/publications/detail?tx_atolidelecontenus_publicationdetail%5Baction%5D=showArticle&tx_atolidelecontenus_publicationdetail%5Bcontroller%5D=Detail&tx_atolidelecontenus_publicationdetail%5Bpublication%5D=3360&cHash=1a4c5ee6d2ba7535e1003f7860a474af
4 -https://www.feedipedia.org/node/16072
5 - http://animalsciencejournal.usamv.ro/pdf/2017/Art15.pdf
6 - https://www.feedipedia.org/node/395

TABLE 15. EXAMPLE OF CHEMICAL COMPOSITION AND ENZYMATIC DIGESTIBILITY OF FOLIAGE FROM TREE, SHRUB AND CLIMBING SPECIES COLLECTED IN AUGUST (EMILE *ET AL.* 2017).

Species	n*	DM	ashes	CP	NDF	ADF	ADL	TANc	DIGz*
		g/kg	g/kg DM						% DM
Trees									
Italian alder	1	412	60	173	440	312	210	13	60.8
Black alder	1	386	51	184	430	232	114	8	67.9
Chestnut tree	2	366	46	159	502	275	92	3	62.0
Cork oak	1	538	35	101	550	349	166	15	53.3
Red oak	1	469	39	135	516	275	136	13	56.8
Holm oak	2	544	35	78	580	383	143	52	46.7
Field maple	1	543	64	117	397	217	95	25	58.0
Fig tree	1	315	143	188	321	204	54	2	78.5
European ash	4	433	92	147	348	218	92	2	74.6
White mulberry	2	371	140	165	300	148	50	2	83,2
Hazel tree	2	456	61	148	469	240	129	39	52.9
Common walnut	1	335	70	141	393	243	94	11	75.6
Ulmus Lutèce	1	463	130	148	391	152	59	30	64.1
Black Locust	2	369	63	206	491	289	137	169	52.8
Shrubs and climbers									
Common hawthorn	1	485	82	126	397	174	85	-	68.8
Campsis	1	279	57	131	440	279	110	2	60.0
Dog rose	1	455	71	117	312	153	60	-	80.3
Passion fruit	1	600	138	152	225	141	44	4	87.4
Holly	1	402	54	86	514	368	140	1	51.5
Winter jasmine	1	376	69	159	289	167	85	-	84.2
Kiwi	1	313	139	134	416	245	98	52	70.5
Ground ivy	1	340	74	87	437	323	148	-	70.1
Lilac	1	365	67	97	257	156	81	-	86.5
Blackthorn	1	526	85	156	337	162	93	-	80.2
Bramble	1	503	39	125	373	172	50	2	73.1
Privet	1	436	45	112	261	177	121	-	84.1
Vine	9	306	56	175	364	273	191	66	67.9
Average data									
Trees	15	429	73	149	438	253	112	27	63.4
Shrubs and climbers	13	414	75	127	356	215	100	21	74.2
Alfalfa control	1	355	85	176	439	304	77	1	64.3

** n: number of samples for this species; Chemical composition: DM/TA/CP: dry matter/total ash/crude protein, NDF/ADF: fibres, insoluble in neutral/acid detergents, ADL: lignins insoluble in acid detergents, TANc: condensed tannins, DIGz: enzymatic digestibility (%).*

CHEMICAL COMPOSITION (G/KG DM) AND IN VITRO DIGESTIBILITY OF ORGANIC MATTER OF WOODY SPECIES AND GRASS ACCORDING TO SEASON, IN WALLONIA (VANDERMEULEN *ET AL.* 2016).



FORAGE FROM ORGANIC FARMING IN WALLONIA

Organic farming continues to grow in Wallonia (11.5% of UAA in 2019) and organic livestock farming needs to move towards forage self-sufficiency. It is therefore necessary for farmers to adjust their forage supply to the needs of their herds, both in terms of quantity and quality. *For more details, see the CRA-W files on food autonomy in organic cattle farming.*

The practices that differ from those of conventional farming suggest that forage production is different between these two systems. The traditionally-used reference systems therefore undoubtedly need to be revised. Some experimental data is available, but this does not yet cover the entire sector.

Where are we with the REQUASUD database? At the time of writing this brochure, there are only about twenty organic forage samples in the database. This information in the data is relatively recent (2018) and this number is expected to grow over the next few years, provided that farmers continue to analyse their production.

CONCLUSIONS
AND PERSPECTIVES

This new report demonstrates the usefulness of the analyses from both an economic and environmental perspective, whether in terms of managing forage production by establishing rational fertilisation schemes best suited to the characteristics of the plots, or in terms of managing stocks and establishing rations. The REQUASUD network laboratories remain an essential tool for Walloon farmers to optimise and characterise the quality of their forage production.

Rapid analysis techniques such as near-infrared spectrometry, used in all the network's laboratories, are an additional advantage. This tool now allows for the quick establishment of parameters needed to calculate feed rations with the utmost precision. The development of new databases concerning other forages likely to be produced in our region, will also be a benefit in the coming years. The existing database can now be considered a first-rate decision-making tool, enabling farmers to manage their forage resources more effectively.

Wallonia's forage production sector will need to continue adapting to meet current and future challenges. One of the main focuses will be to continue increasing the diversity of forage crops to reduce their vulnerability to climate variations, while increasing the resilience of production systems. Farmers will need to select forage crop varieties that are more resistant to climate variations, such as alfalfa or clover, which are more tolerant of drought.

Cultivation practices also need to adapt to changing climatic conditions, especially in terms of water resource management. Increasing a soil's water retention capacity is undoubtedly the best medium- and long-term option for meeting this challenge.

However, it is important to continue investing in research and development in the sector to identify and implement technologies and farming practices best suited to the challenges of climate change, conservation of natural resources and societal evolution.

GLOSSARY

ADF	Acid Detergent Fibres
ADL	Acid Detergent Lignin
CAB	Cation-Anion Balance
BBB	Belgian Blue
PBV	Protein balance in the rumen
BRE	Protein stability in the rumen
CF/CEL	Crude Fibre
CEC	Cation Exchange Capacity
COMIFER	French Committee for the Study and Development of Rational Fertilisation (Comité Français d'Étude et de Développement de la Fertilisation Raisonnée)
Conc	Concentrates
CRA-W	Walloon Centre for Agronomic research (Centre wallon de Recherches Agronomiques)
CVB	Centraal Veevoeder office
DCS	Cellulase digestibility for the French system
dOM	Digestibility of organic matter
DMORT	Cellulase digestibility for the Dutch system
DT-N	Theoretical nitrogen degradability (French system)
DVE	Protein digestible in the intestine
DVBE	Dietary-origin proteins digestible in the intestine undegraded in the rumen
DVME	Microbial proteins digestible in the intestine
DVMFE	Endogenous proteins in faeces
GE	Gross energy
R	Roughage
h	Hour
KI	Potassium Nutrition Index
ILVO	FLANDERS RESEARCH INSTITUTE FOR AGRICULTURE, FISHERIES AND FOOD
NNI	Nitrogen Nutrition Index
PI	Potassium Nutrition Index
K	Potassium
kcal	KiloCalorie
K_{EDTA}	Potassium extracted with ammonium acetate and EDTA in acid medium

Kg	Kilogramme
m	metre
CP	Crude protein
mEq	milliequivalent
Mg	Magnesium
DOM	Digestible Organic Matter
MREE	Microbial proteins enabled by the energy available in the rumen
MREN	Microbial proteins enabled by the nitrogen available in the rumen
DM	Dry matter
DMI	Voluntarily Intake of Dry Matter
N	Nitrogen
NDF	Neutral Detergent Fibres
OEB	Nitrogen balance in the rumen
P	Phosphorus
PDI	Proteins digestible in the intestine
PDIA	Dietary-origin proteins digestible in the intestine
PDIE	Proteins digestible in the intestine when energy limits microbial synthesis
PDIN	Proteins digestible in the intestine when nitrogen limits microbial synthesis
P_{EDTA}	Potassium extracted with ammonium acetate and EDTA in acid medium
FP	Fermentation product
pH	Potential of Hydrogen
S	Sulphur
UAA	Utilised agricultural area
SO_3	Sulphur trioxide
SO_4	Sulfate ion
t	tonne
UE	Fill unit
UFL	Forage unit for milk in the French system
UFV	Forage unit for meat production in the French system
Uliège GX ABT	University of Liège - Gembloux Agro Bio Tech
VEM	Forage unit for milk in the Dutch system
VEVI	Forage unit for meat production in the Dutch system
VS	Structure value
SVR	Structure value of roughage
SVS	Structure value of supplements

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