Sustainable fertiliser use in field-grown ornamental crops

Optimising for plants and the environment

PCS

Bodemkundige Dienst van België vzw

UNIVERSITEIT GENT

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colophon

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Sustainable fertiliser use and quality crops: it's possible!

In order to deliver high-quality products, it's very important that ornamental plants have sufficient available nutrients. Losses into the environment need to be limited as much as possible, and this can be achieved through appropriate fertiliser use.

To work with nitrogen and phosphorus fertilisers in a more reasoned way, it's important to be familiar with and understand the cycles of both elements. In addition, the nutritional requirement differs greatly between ornamental crops. Soil samples can give you a good picture of the reserves of nutritional elements available, so you can adjust your fertiliser applications appropriately as long as you interpret the information correctly. You can then make a choice from a wide range of fertilisers, as described on the poster provided. You need to take into account where you are in the growing season, and the composition and release pattern of the fertiliser.

Use this guide to help you get started. Improve your plant quality with sustainable fertiliser use.

contents

This guide provides an overview of what happens to fertilisers in the soil and explains how to choose the correct fertiliser and method of application.

1. The importance of nitrogen and phosphorus for plants and the environment

As an ornamentals grower how can you use nitrogen, phosphorus and other nutrients to control plant growth? How does this affect the environment? Get to know the nitrogen and phosphorus cycles and discover how to use nutrients more efficiently.

1.1. ACIDITY LEVEL (pH) DETERMINES CROP GROWTH

The pH is a very important property of the soil, because it determines the availability of nutrients. An optimal pH is therefore a requirement for good crop growth. How high or low this needs to be depends on the crop, texture class and organic matter content. A soil analysis gives you the soil pH. Go to chapter 4 for more information about liming.

The figure below shows the availability of different nutrients according to the soil pH.

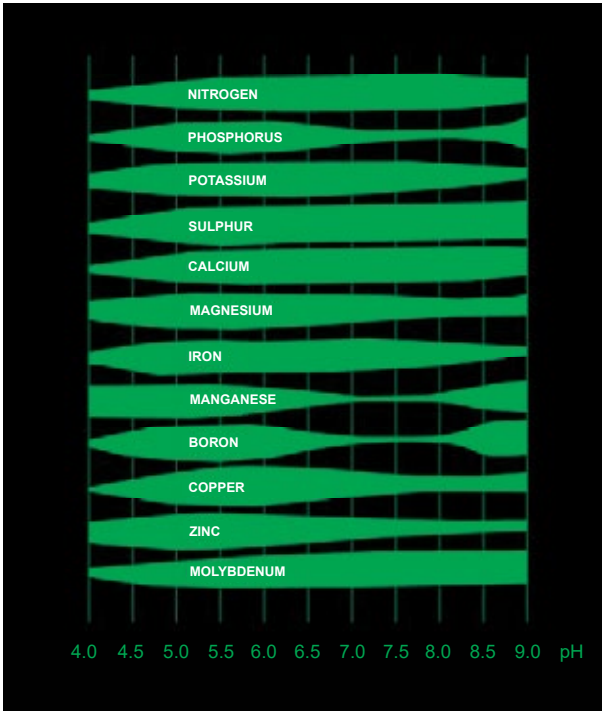


Figure 1: Availability of nutrients according to soil acidity level (pH KCl). The broader the spectrum, the better the availability of the nutrient. Many micronutrients are more readily available at a low pH. Source: Biological Activated Cocktail (BAC)

1.2. TYPES OF NUTRIENTS

As a grower, you improve the growth and quality of your plants by applying nutrients in the form of fertilisers to them. It's best to use the nutrients already present in the soil, but these aren't usually available in sufficient quantities. Below is an overview of the most important nutrients divided according to mobility in the plant. For mobile nutrients, deficiency symptoms can be seen on the older foliage. For immobile nutrients, you see deficiency symptoms on the young foliage.

1.2.1. MOBILE NUTRIENTS

DEFICIENCY SYMPTOMS ON OLDER FOLIAGE

	IMPORTANCE	DEFICIENCY	EXCESS
NITROGEN (N)	Stem growth and shoot formation	Limited growth and yellow discolouration	Too much vegetative growth and weak root growth and e.g. rot of tubers with begonia
PHOSPHORUS (P)	Root formation and flowering	Purple discolouration of foliage and stem, leaf drop and limited root growth (less nutrient uptake)	Reduced uptake of other nutrients
POTASSIUM (K)	Strength, winter hardness, drought resistance and strong growth	Yellow-brown leaf margins	Restriction of Mg and Ca uptake
MAGNESIUM (Mg)	Greenness and growth	Yellow discolouration between the leaf veins	Restriction of K and Ca uptake
MOLYBDENUM (Mo)	Linked with N processes	Yellow discolouration of leaf margins and deformed foliage	Restriction of Cu uptake
CHLORINE (Cl)	Osmotic processes	Not seen	Root scorch, reduced water uptake

1.2.2. IMMOBILE NUTRIENTS

DEFICIENCY SYMPTOMS ON YOUNG FOLIAGE

	IMPORTANCE	DEFICIENCY	EXCESS
CALCIUM (Ca)	Stem strength and root growing points	Deformed growing points	Restriction of K and Mg uptake
SULPHUR (S)	Structure of proteins, stimulation of nitrogen uptake	Yellow discolouration	Root scorch
IRON (Fe)	Foliage production	Yellow leaf discolouration between the veins	Limits Mn uptake
MANGANESE (Mn)	Nitrogen use and energy cycle	Blotchy chlorosis	Brown-purple blotches on old foliage
BORON (B)	Cell division, water balance and flowering	Young plant death, deformed foliage	Leaf tip death
COPPER (Cu)	Energy cycle	Yellow discolouration and leaf margin death	Limits Fe and Mn uptake
ZINC (Zn)	Energy cycle	Stunted growth	Limits Cu and Fe uptake

This guide focuses primarily on nitrogen and phosphorus because of their strict regulation and the negative effects of excess on the environment.

1.3. AMOUNT OF NUTRIENT UPTAKE

Ornamental crops have very variable nutrient uptake rates. This doesn't just depend on the specific crop and cultivar, but also on the climate, soil conditions and plant density. The greater the growth in biomass, the more nutrients are taken up. For perennial crops, there is usually limited uptake in the first year which increases over time. The table below shows the variation in uptake of the most important nutrients for ornamental plants.

NUTRIENT UPTAKE ORNAMENTAL CROPS (kg/ha/year)	
N	25–300
P_2O_5	15–80
K_2O	40–200
MgO	15–90
CaO	30–200

Source: Arboriculture practical research (Research Centre for Ornamental Plants, NL)

GET TO KNOW YOUR CROP AND SOIL WITH CROP AND SOIL SAMPLES

Taking crop and soil samples helps you as a grower to get to know the nutrient uptake of your crops better. This enables you to adjust fertiliser use, which benefits the environment, plant quality and also your wallet.

1.4. NITROGEN (N)

Nitrogen is the most well-known and important nutrient for increasing crop production and quality. Its cycle influences other nutrient cycles (e.g. phosphorus, potassium and sulphur).

Losses of nitrogen from the soil (caused by too much nitrate residue in the autumn, among other things) have negative effects on the environment, such as reducing biodiversity and more expensive production of drinking water.

Nitrogen in the soil is taken up by plants as **nitrate (NO_3^-)** and **ammonium (NH_4^+).** In plants it is part of chlorophyll, the green pigment that is responsible for photosynthesis. It is also part of proteins and enzymes. The main nitrogen pool is the organic nitrogen pool.

A **deficiency** of nitrogen causes the older foliage to turn yellow, which is very detrimental for the quality of ornamental plants. An **excess** on the other hand can result in too much vegetative growth.

As an ornamental grower you can optimise fertiliser use by drawing up a soil nitrogen balance sheet in which the various supply and removal processes are compared.

Figure 2: Nitrogen deficiency in *Prunus*, seen from the yellow discolouration of the old foliage.

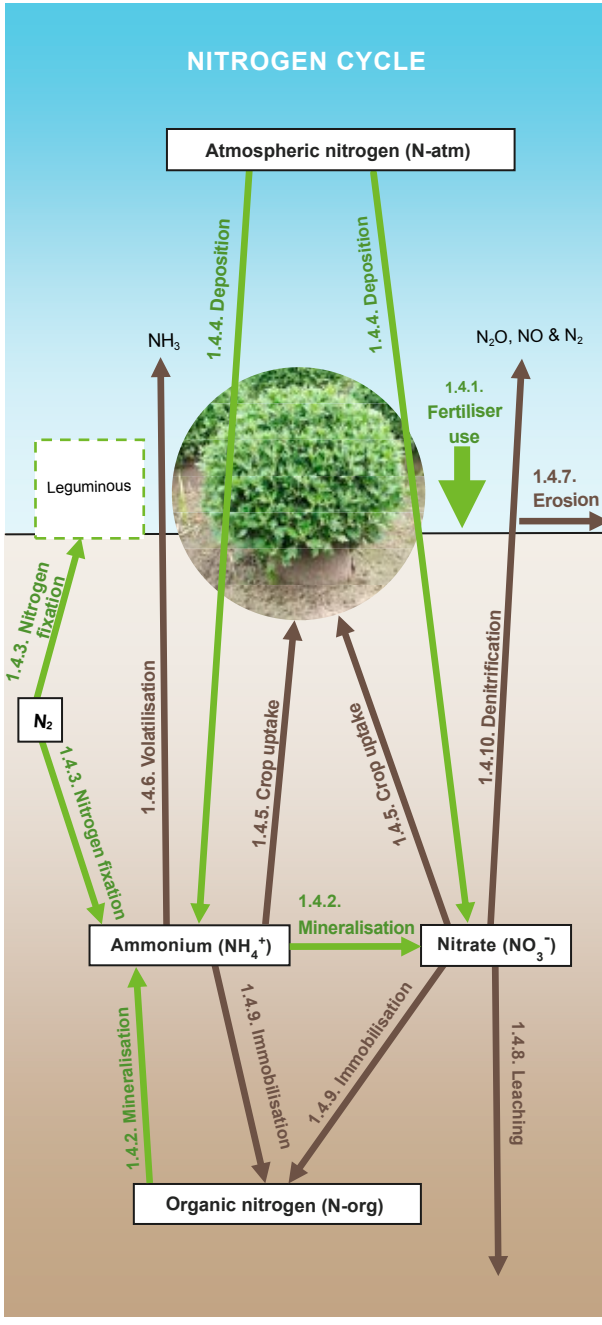


Figure 3: Nitrogen cycle in horticulture.
Key: ■ Nitrogen supply ■ Nitrogen removal

1.4.1. Nitrogen supply by FERTILISER USE

N

Nitrogen (N) can be applied to the soil both organically and inorganically via fertilisers.

INFLUENCING FACTORS

- Weather conditions

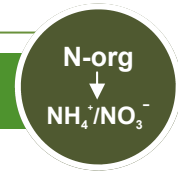
MANAGEMENT

- Choosing the right type of fertiliser (see chapter 5 and 6).
- Time of application is important for the end result.
- Choose the right method of application (see chapter 7).

AMOUNT

- Dependent on the soil reserves present, the crop and stage of growth (see crop uptake p. 20), and other nitrogen supply and removal processes present.
- The maximum amount is limited by legislation (see www.vlm.be).

1.4.2. Nitrogen supply by MINERALISATION



Bacteria and fungi convert **organic nitrogen (N-org)** into **ammonium (NH_4^+)** and then into **nitrate (NO_3^-)**.

INFLUENCING FACTORS

Increasing effect
- High carbon content
- Fresh organic material
- High soil temperature
- Optimal soil moisture
- High oxygen content due to soil tillage for example
- Increasing soil pH

Reducing effect
- High C/N ratio

MANAGEMENT
- Apply organic matter with low C/N such as slurry.
- Avoid soil compaction.
- Work in organic materials in the spring to avoid leaching in autumn.

AMOUNT
- Figures 4 and 5 on the next pages show how much nitrogen is released per soil type and carbon content (organic matter) on average per month as a result of organic matter mineralisation.
- The more organic matter there is, the more nitrogen is released.
- The soil texture has an important effect it also influences the soil temperature and moisture.
- Mineralisation stops during prolonged droughts.
- Take the amount of nitrogen that is released via mineralisation into account when choosing your fertiliser.

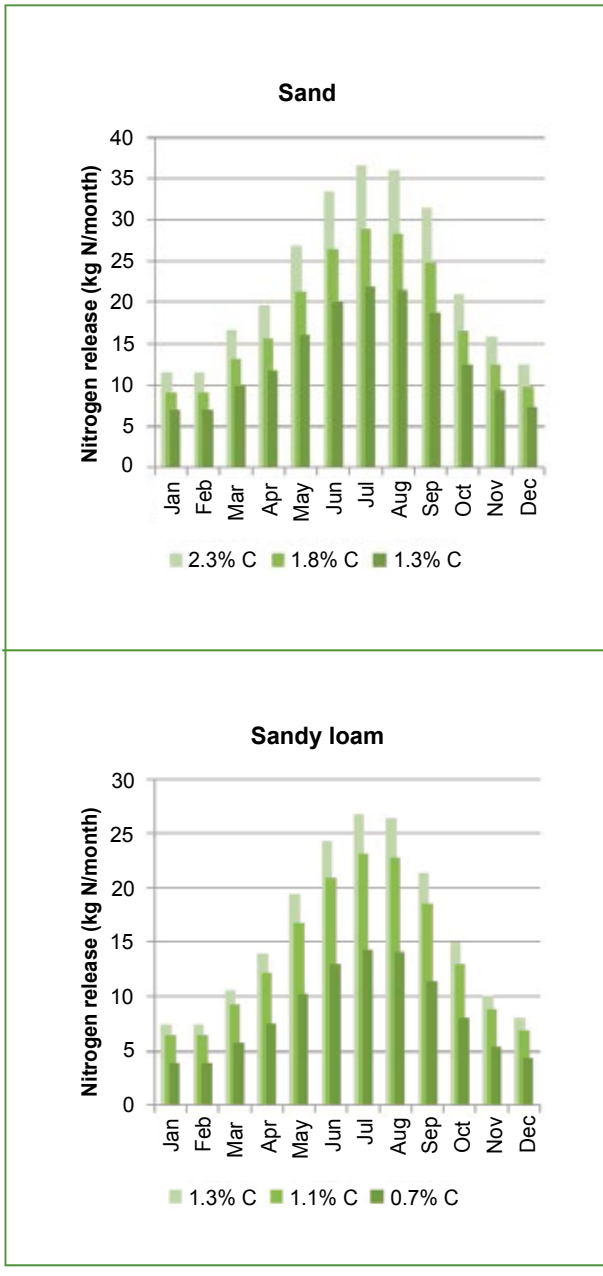


Figure 4: Estimation of the amount of nitrogen (N) that is released per month in sandy soil (**above**) and sandy loam soil (**below**) through mineralisation shown according to carbon content (C). Note: the climate has a significant influence on this. Source: N-(eco)², Soil Service of Belgium

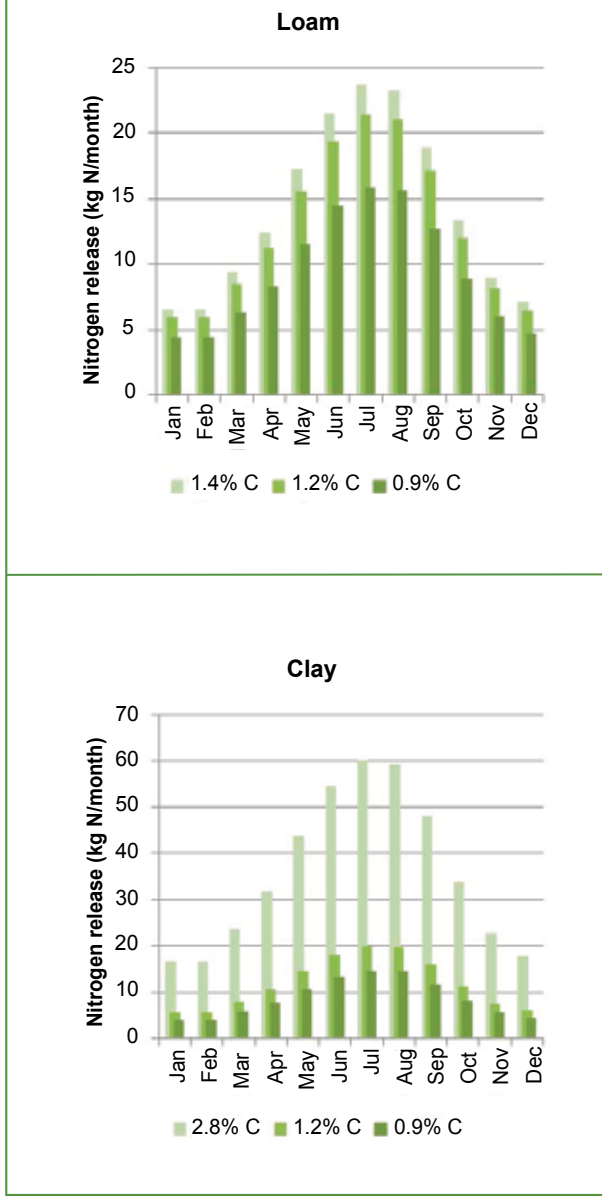
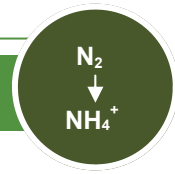


Figure 5: Estimation of the amount of nitrogen (N) that is released per month in loamy soil (**above**) and clay soil (**below**) through mineralisation shown according to carbon content (C). Note: the climate has a significant influence on this. Source: N-(eco)², Soil Service of Belgium

1.4.3. Nitrogen supply by NITROGEN FIXATION



Nitrogen gas (N_2) that is present in the soil pores can also be absorbed by certain plants and organisms after conversion to **ammonium (NH_4^+).** This happens via symbiosis of leguminous plants with certain bacteria or also by free-living microorganisms such as *Azotobacter.*

INFLUENCING FACTORS

Increasing effect
- Soil pH (>5.5)
- Higher calcium and phosphorus availability

Reducing effect
- Mineral nitrogen present

MANAGEMENT
- Cultivate nitrogen-fixing catch crops, such as clover and lupin, and incorporate these as an extra nitrogen supply.
- Ensure there is sufficient carbon in the soil. This improves the soil structure.

AMOUNT
- Up to 100 kg N/ha/year by nitrogen-fixing bacteria in symbiosis and up to 20 kg N/ha/year fixed by free-living microorganisms.

1.4.4. Nitrogen supply by ATMOSPHERIC DEPOSITION

N-atm → NH_4^+/NO_3^-

Atmospheric nitrogen (N-atm) can precipitate on the soil via dry and wet deposition/removal, including as **ammonium (NH_4^+) and nitrate (NO_3^-)**.

INFLUENCING FACTORS

Increasing effect

- Agriculture and transport sector in the surrounding area

MANAGEMENT

- Reducing N emissions at national and international level. This happens as a result of legislation regarding the spreading of animal manure, filtering exhaust emissions and similar.

AMOUNT

- The amounts of atmospheric nitrogen deposition have been decreasing since the 1990s thanks to reduced nitrogen emissions from agriculture and the transport sector.
- The map below provides an overview of nitrogen depositions in Flanders in 2017.

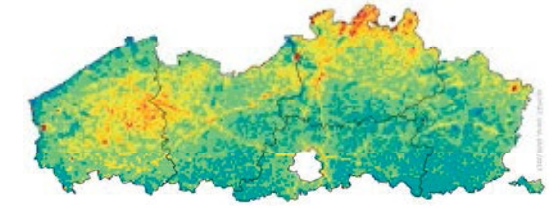
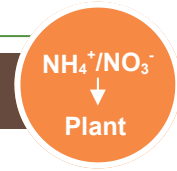


Figure 6: Nitrogen deposition in Flanders in kg N/ha/year (2017). Source: VMM

1.4.5. Nitrogen removal by CROP UPTAKE



The plant takes up nitrogen as **nitrate (NO_3^-)** and **ammonium (NH_4^+)**.

INFLUENCING FACTORS

Increasing effect

- Optimal growing conditions

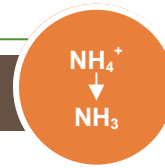
MANAGEMENT

- Ensure there is sufficient nitrogen in the soil at all times during the growing season.

AMOUNT

- The age and therefore growth in biomass is a major deciding factor. The older and therefore larger the growth of biomass, the more nitrogen is taken up. For perennial crops, there is therefore only limited uptake of nitrogen in the first year.
- There is variation during the growing season. Only a limited amount of nitrogen is taken up at the start of the growing season, and this levels off towards the end.

1.4.6. Nitrogen removal by VOLATILISATION



Under certain conditions, **ammonium (NH_4^+)** converts into **ammonia (NH_3)** which is released into the atmosphere. These losses must be minimised to combat ammonia volatilisation into the environment and prevent land losses. Fertilisers with ammoniacal nitrogen are sensitive to this (e.g. animal manure and urea).

INFLUENCING FACTORS

Increasing effect

- High temperature
- Soil pH (>7.5)
- Initially moist soil that dries out
- Fertiliser with high ammonium content

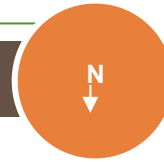
MANAGEMENT

- Use fertilisers with low emission levels e.g. by injecting manure. This reduces the volatilisation of nitrogen. Current legislation can be found at www.vlm.be.
- Do not apply fertilisers at the same time as liming.

AMOUNT

- Incorporating the manure directly limits the losses to 10% of the ammoniacal nitrogen present.

1.4.7. Nitrogen removal by EROSION



If the top layer of soil is washed away, you lose all the **nitrogen (N)** and other nutrients that were present in it. Mineral nitrogen is extra sensitive.

INFLUENCING FACTORS

Increasing effect
- Heavy rain
- High groundwater table
- Mineral nitrogen present

Reducing effect
- High crop density
- Good soil structure

MANAGEMENT
- Use green manure crops on uncultivated areas.
- Ensure sufficiently high plant density.
- Apply sufficient organic matter to the soil.

1.4.8. Nitrogen removal by LEACHING

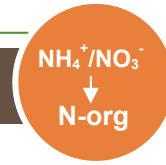
Nitrate (NO_3^-) washes down to deeper layers of soil and groundwater. This means it is no longer available for the plant, especially not for crops with shallow roots such as tuberous begonia or newly planted nursery stock crops.

INFLUENCING FACTORS

Increasing effect
- Lots of rain
- High groundwater table
- Mineral nitrogen present

MANAGEMENT
- Limit the amount of mineral nitrogen in the soil, e.g. by splitting fertiliser applications or using slow-release fertilisers.
- Keep the field covered with a catch crop such as winter rye or fodder radish during the winter months.
- Plant crops that are not sensitive to frost in the autumn. This ensures they can take root into the soil in time and are more resistant to drought in the spring.

1.4.9. Nitrogen removal by IMMOBILISATION



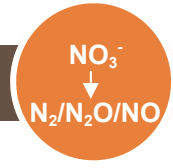
Immobilisation temporarily fixes **nitrate (NO_3^-)** and **ammonium (NH_4^+)** in organic nitrogen. This is achieved through the addition of organic matter with a low nitrogen content (high C/N) such as farmyard manure that is rich in straw or undigested green compost.

INFLUENCING FACTORS

Increasing effect
- High C/N ratio

MANAGEMENT
- Take immobilisation into account when deciding when to apply organic fertilisers or green manure.

1.4.10. Nitrogen removal by DENITRIFICATION



Nitrate (NO_3^-) is converted into **nitrogen gas (N_2), nitrous oxide (N_2O)** and **nitrogen monoxide (NO)** under anaerobic conditions (no oxygen).

INFLUENCING FACTORS

Increasing effect
- High level of soil moisture

Reducing effect
- Good soil structure

MANAGEMENT
- Ensure good soil drainage.
- Only cultivate when the soil condition permits, i.e. not too wet.
- Apply sufficient organic matter to the soil.

AMOUNT
- Up to 0.1–0.2 kg N/ha/day in loam– and clay–rich ground.
- No problem with well-drained sandy soil.

1.5. PHOSPHORUS (P)

The importance of the phosphorus cycle has become increasingly apparent over the last decade. Applying animal manure over many years has led to a saturation of phosphorus in the soil. Even though this element is immobile in the soil, it washes out when saturated. Groundwater and the environment suffer as a result of this. Well-reasoned phosphorus fertiliser use is therefore essential.

Phosphorus is taken up by plants as **orthophosphate** and is part of plant proteins. It is important for root growth and flowering. It also increases resistance to cold.

The concentration of orthophosphate in the soil solution is very low. This can lead to deficiency symptoms in the crop, even though the total phosphorus in the soil is sufficient. A **lack** of phosphorus can lead to purple discolouration and reduced growth. But (extra) fertiliser isn't always the best solution. It's essential to determine where the problem originates. For example, low temperatures at the start of the growing season, and poor rooting as a result of soil compaction, can limit phosphorus uptake. An **excess** of phosphorus results in reduced uptake of other nutrients. Drawing up a balance sheet of soil phosphorus in which the different supply and removal processes are compared is useful for optimising your fertiliser use.

Figure 7: Phosphorus deficiency in *Tilia*. Noticeable by the purple discolouration of the foliage.

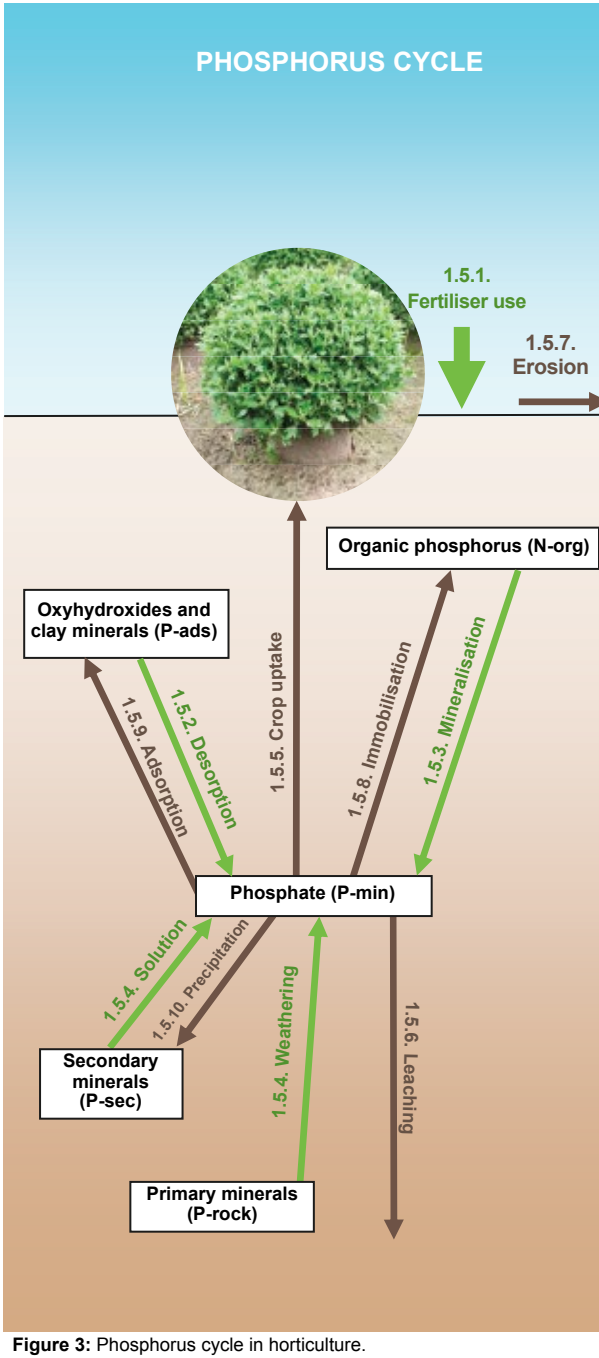


Figure 3: Phosphorus cycle in horticulture.
Key: ■ Phosphorus supply ■ Phosphorus removal

1.5.1. Phosphorus supply by FERTILISER USE

During fertiliser application, **phosphorus (P)** is mainly added in an organic form to the soil, and to a lesser extent inorganically.

INFLUENCING FACTORS

- Weather conditions

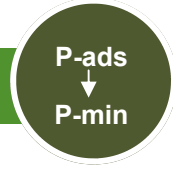
MANAGEMENT

- Choose the right type of fertiliser (see chapter 5 and 6).
- Time of application is important for the end result.
- Choose the right method of application (see chapter 7).

AMOUNT

- Dependent on the soil reserves present, the crop and its stage of growth (see crop uptake p. 28), and other phosphorus supply and removal processes present.
- The maximum amount is limited by legislation (see www.vlm.be).

1.5.2. Phosphorus supply by DESORPTION



Phosphorus that is adsorbed to soil particles (P-ads) can be released as **phosphate (P-min)** which makes it available to the plant. Only some of this desorbs easily.

INFLUENCING FACTORS

Increasing effect

- Presence of humic acids, fulvic acids and microorganisms
- High soil pH

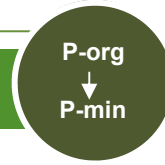
Reducing effect

- Al- and Fe-oxyhydroxides present

MANAGEMENT

- Apply organic matter, humic acids or fulvic acids.
- Lime the soil if too acidic.

1.5.3. Phosphorus supply by MINERALISATION



Bacteria and fungi convert **organic phosphorus (P-org)** into **phosphate (P-min).**

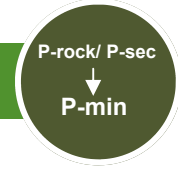
INFLUENCING FACTORS

Increasing effect
- High carbon content
- Fresh organic material
- High soil temperature
- Optimal soil moisture
- High oxygen content due to soil tillage for example
- Increasing the soil pH

Reducing effect
- Low C/N/P ratio (lots of phosphorus in relation to the carbon content)

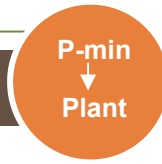
MANAGEMENT
- Apply sufficient organic matter.
- Avoid soil compaction.

1.5.4. Phosphorus supply by WEATHERING AND SOLUTION



Phosphate (P-min) is also released by the weathering of rocks containing phosphorus **(P-rock)**. Secondary minerals can also dissolve and release phosphorus. This is the reverse process to what is explained under precipitation on page 30.

1.5.5. Phosphorus removal by CROP UPTAKE



Plants takes up **phosphate (P-min)** in the first half of the growing season. After this, phosphorus in the plant moves to the parts most in need. Plant strategies for increased uptake are expanding the root system, excretion of plant exudates and symbiosis with mycorrhiza.

INFLUENCING FACTORS

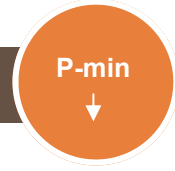
Increasing effect
- Optimal growing conditions
- Good soil structure

Reducing effect
- Low temperature
- pH too high

MANAGEMENT
- Ensure there is sufficient phosphorus available in the soil, especially at the start of the growing season.
- Avoid soil compaction.
- Apply sufficient organic matter.

AMOUNT
- 15–80 kg/ha. This depends on the crop, stage of growth and growing conditions.

1.5.6. Phosphorus removal by LEACHING



Phosphate (P-min) washes down to deeper layers of soil and groundwater.

INFLUENCING FACTORS

Increasing effect
- Phosphate saturation: amount of phosphorus bonded in the soil compared with the number of binding sites

MANAGEMENT
- Use deep-rooting green manure crops. These can take up some of the phosphorus from the deeper layers of soil and release it again in the top layer.

1.5.7. Phosphorus removal by EROSION

P ↓

Just like with nitrogen, **phosphorus** losses **(P)** also take place with soil erosion as discussed on page 22.

1.5.8. Phosphorus removal by IMMOBILISATION

P-min ↓ P-org

Immobilisation causes **phosphate (P-min)** to become temporarily fixed in organic phosphorus **(P-org)**. This happens by applying organic materials with a low phosphorus content.

INFLUENCING FACTORS

Increasing effect

- High C/N/P ration (not much phosphorus in relation to the carbon content)

MANAGEMENT

- Take immobilisation into account when deciding when to apply organic fertilisers or green manure.

1.5.9. Phosphorus removal by ADSORPTION

P-min ↓ P-ads

Phosphate (P-min) quickly adsorbs to Al and Fe oxyhydroxides and clay particles in the soil, which means it is no longer available for the plant. This is the reverse process of desorption described on page 26.

1.5.10. Phosphorus removal by PRECIPITATION

P-min ↓ P-sec

Phosphorus precipitates with calcium in alkaline soils, and in acidic soils phosphorus precipitates as iron and aluminium phosphates.

INFLUENCING FACTORS

Increasing effect
- Calcium content

Reducing effect
- Soil pH (see figure 9)

MANAGEMENT
- Adjust soil pH by applying lime or using acidifying fertilisers.

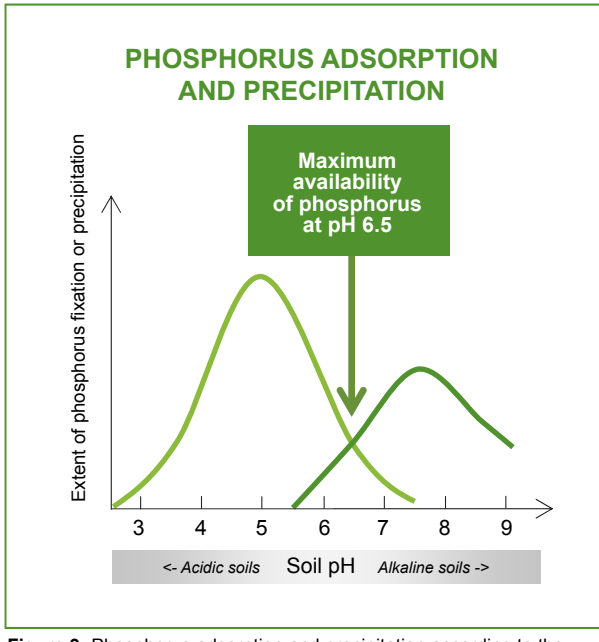


Figure 9: Phosphorus adsorption and precipitation according to the soil acidity level (pH-KCl).
Key: ■ Insoluble Fe and Al phosphates ■ Insoluble Ca phosphates

As shown in figure 9, phosphorus is most available in soil with a pH of 6.5. This pH is however not ideal for e.g. sandy soil and also not for all crops. For a different soil pH, you therefore need to take into account the fact that phosphorus is less available. Fertilisers can significantly lower (<5) or raise the pH locally, which therefore also influences the availability of phosphorus. Soil texture and clay types also affect this.

CONCLUSION

Fertiliser plans nowadays are a lot more than simply applying fertiliser to the field. Knowing the underlying processes and having your soil analysed can help you make a well-considered decision about which fertilisers to use and when to apply them. This means you no longer waste fertilisers unnecessarily, which only benefits the crop and the environment.

2. Why take a soil sample?

What is the use of soil samples? What types are available and when is the best time to take them? Are some samples compulsory?

2.1. THE IMPORTANCE OF SOIL SAMPLES

The soil is a source of reserves of nutritional elements for the plant. But a soil sample needs to be taken to know exactly what is in the soil. Fertiliser advice can be drawn up on the basis of the soil analysis, and crop and field data, for both the base fertiliser needs and any additional fertiliser. This enables you to do more targeted fertiliser applications and achieve good plant quality, possibly with less fertiliser.

2.2. TYPES OF SOIL SAMPLES

There are different types of soil samples, each with their own specific use depending on the time of sampling and the crop.

2.2.1. STANDARD SOIL ANALYSIS

WHAT
- Soil texture, pH, organic carbon content, P, K, Mg, Ca and Na.
- 0 – 23 cm depth.

WHEN
- In the autumn or winter, or at the start of the growing season, ideally before fertiliser application or liming.

WHY
- Optimise your base fertiliser use and liming.

2.2.2. STANDARD SOIL ANALYSIS SUPPLEMENTED WITH SALT CONCENTRATION AND MINERAL NITROGEN (e.g. CEMA Control and Evolution of the Minerals and their Accumulation)

WHAT
- Soil texture, pH, organic carbon content, P, K, Mg, Ca, Na, salt concentration and mineral nitrogen.
- 0 – 30 cm depth.

WHEN
- In the spring, ideally before fertiliser use and liming.
- During the growing season to determine any additional fertiliser need.

WHY
- Optimise your base fertiliser, nitrogen fertiliser, liming and additional fertiliser use.

2.2.3. N INDEX

WHAT
- Mineral nitrogen and the estimate of nitrogen available during the growing season, organic carbon content, pH and texture.
- 0–30/30–60/60–90 cm depth (depending on the root depth of the crop).

WHEN
- Shortly before applying the base fertiliser.
- During the growing season to determine any additional nitrogen fertiliser requirement.

WHY
- Optimise your nitrogen fertiliser plan, possibly via split applications.

2.2.4. NITRATE RESIDUE

WHAT
- Mineral nitrogen present in 0–90 cm (+ poss. pH).
- 0–30/30–60/60–90 cm depth.

WHEN
- Between 1 October and 15 November.

WHY
- Check whether mineral N was used optimally during the previous growing season. The mineral nitrogen that is still present in the soil washes out during late autumn and winter, so you lose it.

2.3. LEGISLATION

Nitrogen and phosphorus leaching into groundwater leads to algal bloom and so reduced water quality. This results in higher costs for purifying water and has drastic consequences for biodiversity. Taking certain soil samples is essential to encourage growers to apply fertilisers in a reasoned way. They help you implement the best possible nitrogen fertiliser use, which ensures good plant quality with a limited impact on the environment. Go to www.vlm.be to check current legislation.

CONCLUSION

Taking a soil sample lets you know what your soil needs. You combine this information with your crop and field data to achieve a well-considered fertiliser plan.

3. How do I put fertiliser advice into practice?

When a soil sample is analysed, you will receive fertiliser advice. This chapter explains how you can convert this into the optimal use of fertilisers.

3.1. SOIL ANALYSIS

You have a soil sample taken and analysed at the start of the growing season. You then receive appropriate fertiliser advice. But what should you do with it? This chapter uses an example analysis to explain how you can convert this advice into practical liming, organic matter and fertiliser application.

EXAMPLE

A CEMA (Control and Evolution of the Minerals and their Accumulation) sample was taken mid-February to draw up your base fertiliser needs for a new planting of deciduous trees. These are the analysis results:

Basic details:

- Humus content (C in %): 1.2 Low
- Calculated volume density (ssg): 1.387 kg/litre
- Soil type: 15 = Fine sand
- Sampling depth: 30 cm

RESULTS ANALYSIS AND ASSESSMENT

PARAMETER	TARGET FIGURE	31/01/18	ASSESSMENT
pH-KCl	5.7	5.2	Quite low
Soluble salts	450	250	Quite low
Nitrate-N	70	3	Very low
Ammonium-N		10	
Phosphorus	430	984	High
Potassium	230	268	Normal
Magnesium	170	161	Normal
Calcium	1900	1301	Normal
Sodium	75	16	Very low

The following is notable:

- Low organic matter content.
- Quite low pH.
- Low reserve of mineral nitrogen.
- High reserve of phosphorus and normal levels of potassium, magnesium and calcium.

The following fertiliser advice is provided with these results.

EXAMPLE FERTILISER ADVICE	
Liming	10.5 abc/are (100 m^2)
N	1.37 kg/are
P_2O_5	0.30 kg/are
K_2O	1.2 kg/are
MgO	0.8 kg/are

We convert this advice into the use of lime, organic matter and fertilisers.

3.2. USING LIMING ADVICE TO CHOOSE THE RIGHT LIME

The liming advice is expressed in acid-binding capacity (abc), also called neutralising value (NV), per are (100m^2). You can use the formula below to convert this into the amount of a certain type of lime required (kg/are). You can find the acid-binding capacity of the lime type on the packaging or check with the manufacturer.

$$\text{lime (kg/are)} = \frac{\text{liming advice (abc/are)} \times 100\ \text{kg}}{\text{abc of lime type used}}$$

EXAMPLE

The previous example advised liming 10.5 abc/are. If you want to use a lime with 54 abc, in this case you need to administer 19.44 kg per are to bring your soil pH back to the target level.

Amount of lime = 10.5 abc/are x 100 kg/54 abc
= 19.44 kg/are

It's best not to apply lime together with the nitrogen fertiliser. This avoids or limits nitrogen volatilisation and therefore losses. If the crop allows, it's best to apply lime in the autumn. This allows the lime to start working in the winter months.

3.3. APPLYING ORGANIC MATTER

Applying organic matter is essential to maintain the organic matter levels in the soil. If the soil does not have enough organic matter content, it's best to use stable organic matter such as compost. When carrying out a standard soil analysis up to a depth of 23 cm, you can use the CSLIM© module at www.bdb.be to simulate the organic matter structure and degradation in the soil according to the soil improvers and fertilisers that you want to apply.

EXAMPLE

The organic matter content in the soil is low. It is therefore best to consider using stable organic matter such as compost. This makes a better contribution to your organic matter structure than farmyard manure.

3.4. USING FERTILISER ADVICE TO CHOOSE THE RIGHT FERTILISER

The fertiliser advice is expressed in units of nitrogen (N), phosphate (P_2O_5), potassium oxide (K_2O) and magnesium oxide (MgO) per are. The fertiliser advice can be implemented using organic soil improvers (e.g. compost) or organic fertilisers, possibly in combination with inorganic fertilisers.

In order to use the fertiliser advice to decide the correct dose of commercial products, compost or farmyard manure to be applied, the following formula can be used for each nutrient:

$$\text{fertiliser (kg/are)} = \frac{\text{fertiliser advice (kg/are)}}{\text{fertiliser contents}}$$

You also need to take the legal standards into account here. You can find these at www.vlm.be.

EXAMPLE

In the context of MAP 5, the maximum rate of active N on sandy soil is limited to 160 kg N/ha (active) and 45 kg total P_2O_5/ha for phosphate, if it concerns an area with P-class IV. The legal rate may be administered for 3 years for perennial arboricultural crops. In this case, this is not recommended. With sandy soils there is a lot of nutrient leaching with potassium and nitrogen for example during the winter months, so that you cannot make optimal use of the extra nutrients. There is also a risk of salt stress during the first year after application during periods of low rainfall.

It is recommended to partly supplement the fertiliser application with green compost in order to contribute to the organic matter content. The table below shows the average composition of green compost (VLACO).

AVERAGE COMPOSITION OF VLACO GREEN COMPOST

	TOTAL	ACTIVE*
N	0.7%	0.105%
P_2O_5	0.28%	0.14%
K_2O	0.6%	0.48%
MgO	0.3%	0.045%

*according to MAP 5

In order to know how much green compost to apply, it's best to use the potassium advice as your starting point. Otherwise there is a risk of salt stress. Check the amounts of active nutrients.

Amount of green compost
= 1.2 kg/are / 0.48%
= 250 kg/are

250 kg green compost can therefore be applied per are. This contains the following amounts of active nutrients:

- 250 kg /are x 0.105% N = 0.26 kg N/are
- 250 kg/are x 0.14% P_2O_5 = 0.35 kg P_2O_5/are
- 250 kg/are x 0.48% K_2O = 1.2 kg K_2O/are
- 250 kg/are x 0.045% MgO = 0.11 kg MgO/are

This slightly exceeds the phosphorus advice of 0.30 kg P_2O_5/are, but it's still within the legal standards of 45 kg in total P_2O_5/ha.

The following amounts of nitrogen and magnesium still need to be applied:

- Nitrogen: 1.37 kg/are − 0.26 kg/are = 1.11 kg N/are
- Magnesium: 0.80 kg/are − 0.11 kg/are = 0.69 kg MgO/are

You can apply these nutrients by making use of straight fertilisers. These are fertilisers that only contain one nutrient. If you choose ammonium nitrate (27% N) for the nitrogen fertiliser, you need 4.11 kg/are (1.11/27%). This is a quick-release fertiliser. You therefore need to apply it in a split way. Otherwise the nitrogen will leach and will not be used by the plant. It's best to apply half of it before planting and the rest over two applications (e.g. end of May and mid-July). You can also choose to apply a slow-release fertiliser to reduce the risk of leaching.

For example, magnesium can be applied in the form of magnesium sulphate (16% Mg). You need 4.3 kg per are for this (0.69/16%). It is best to apply the magnesium fertiliser before planting.

3.5. FERTILISER PLAN

Once you have chosen which lime, organic soil improvers and fertilisers to apply, it's best to create an overview to check that your proposal satisfies the advice and legal standards. If you have a standard soil analysis carried out to a depth of 23 cm, it's best to also create a simulation of the organic matter content in the soil on CSLIM© (www.bdb.be). It's best to not let the level drop.

EXAMPLE

Below is an overview of how the fertiliser advice can be implemented. You can of course also opt for other fertilisers.

FERTILISER PLAN OVERVIEW

kg/are	DOSE	LIME (abc)	N	P_2O_5	K_2O	MgO
Lime with 54 abc	19.44	10.5				
Green compost	250		0.26	0.35	1.2	0.11
Ammonium nitrate	4.11		1.11			
Magnesium sulphate	4.3					0.69
FERTILISER USE		10.5	1.37	0.35	1.2	0.8
ADVICE		10.5	1.37	0.3	1.2	0.8

CONCLUSION

A soil analysis provides you with lots of useful information about the soil's nutritional value. Use this information to determine the amounts of lime, soil improvers and fertilisers required. The following chapters can help you select the right products. This can be different for every situation. In the event of any doubt about the calculations, you can contact the Soil Service of Belgium or PCS.

4. Adjusting the soil pH to the required level

Good soil pH is essential for optimal growth. It determines nutrient availability. Have your soil analysed a couple of times per year and apply lime if necessary.

4.1. WHY APPLY LIME?

You need to apply lime to the soil every couple of years to keep your soil at the right pH level. An optimal soil pH ensures good availability of nutrients. Liming is also good for the soil structure.

4.2. HOW MUCH LIME TO APPLY?

The pH can be determined by taking a soil sample. This also gives you liming advice, which explains how much lime you need to apply. The amount of lime that you need depends on the acidity level (pH) of your soil, the organic matter content, the texture class and the crop rotation.

The higher your soil's organic matter content, the less quickly it will acidify. But if you wait too long to apply lime and have acidic soil, you need to use more lime to bring it back to the right level.

4.3. WHEN TO APPLY LIME?

You can apply lime in both the spring and the autumn. Applying lime in the autumn gives it time to start working over the winter so you have better soil in the spring. If you can only apply lime in the spring because of your crop, it's better not to do so at the same time as applying fertiliser. This volatilises the nitrogen as a result of the local increases in pH levels. Wait a few weeks between fertiliser application and liming. You should also be aware that lime will boost the mineralisation. Take into account the extra nitrogen that will be released.

4.4. HOW TO CHOOSE THE RIGHT LIME?

The effect of a lime is determined by its acid-binding capacity (abc). The higher this value, the greater the effect on the pH will be. The speed

Figure 10: Liming the soil.

of the action is also important. The finer the lime, the faster it works. Types of lime with a higher level of moisture have been used over recent years because they form less dust when applied. A dry lime though gives a better distribution on the field.

You also need to choose between lime with more or less magnesium. You can make this choice based on the soil analysis results. Does your soil still need extra magnesium? Then it's best to use a type of lime that contains magnesium. If your soil already contains lots of magnesium, you should avoid lime containing magnesium. Too much magnesium leads to poorer uptake of calcium and potassium. Types of lime that contain magnesium also work a bit slower.

CONCLUSION

If you want to apply fertiliser in a sustainable way and cultivate a high-quality crop, you mustn't forget to apply lime in good time. An optimal soil pH ensures good availability of nutrients and is also good for the soil structure.

5. Adjusting the organic matter content of the soil to the correct level

You have an opportunity to work on the organic matter content of the soil at the start of the growing season and planting, which you should take advantage of. Organic matter has numerous benefits, providing improved moisture retention and nutrient buffering. Find out in this chapter how to go about it.

5.1. THE IMPORTANCE OF ORGANIC MATTER

Organic matter is very important in field-grown ornamental horticulture and ensures:

- Improvement of the soil structure.
- Better water management.
- Less soil erosion and compaction.
- Better aeration.
- Nutrient availability.
- Increased nutrient retention capacity.
- More balanced soil life.

In order to increase or maintain the organic matter content of the soil, you need to apply stable organic matter, expressed as effective organic matter. It's better to apply a low level of stable organic matter every year than a larger amount every few years. Alternating different types of organic matter supply ensures a more balanced soil life and a better build up of organic matter. A soil analysis provides you with information about the organic matter content in your soil.

Challenges

- The major challenge in the build-up of organic matter is not to obtain too high a nitrate residue in the autumn. This is because organic fertilisers also contain nitrogen which is partially released via mineralisation until the autumn (see also chapter 1.4.2.).
- As a grower, you also need to check the phosphorus content in the organic matter source. This is limited by legislation.

5.2. TYPES OF SOIL IMPROVERS

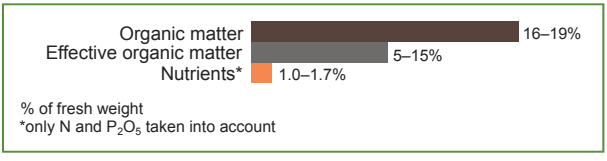
This section briefly discusses some soil improvers in terms of their composition and release of nitrogen.

5.2.1. FARMYARD MANURE

Farmyard manure is a commonly used source of organic matter which provides significant amounts of nitrogen and phosphorus. The table on the next page gives an indication of the fertiliser value of different types of farmyard manure. You can find more information in 'De Mestwegwijzer' (Fertiliser Guide) from the Soil Service of Belgium.

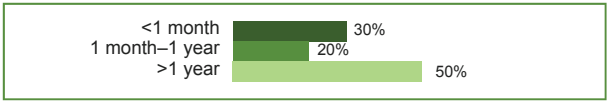
COMPOSITION

- Dependent on animal, age, diet, situation…
- Pig manure contains more phosphorus than cattle manure.
- Poultry manure is the richest in nutrients.
- It's best to have a sample taken to find out the exact composition and fertiliser value of the manure.



NITROGEN FUNCTION AND RELEASE

- A significant amount of the nitrogen is released straight away, but much of this is lost through volatilisation and possible leaching and denitrification.
- It's important not to underestimate the after-effects of farmyard manure in the second and third year after application.



APPLICATION

- It's preferable to apply farmyard manure in the spring to limit losses through leaching and denitrification.
- Do not apply at the same time as liming. This increases the volatilisation and so also the nitrogen losses.

FERTILISER VALUE FOR FARMYARD MANURE WHEN APPLIED IN THE SPRING* (KG FERTILISER UNIT PER 10 TONS OF MANURE)

	DRY MATTER	N	P_2O_5	K_2O	MgO	Na_2O	EFFECT ON PH (0, + OR ++)	EFFECTIVE ORGANIC MATTER
CATTLE	2320	15	17	50	12	6	0	460
PIGS	3200	30	59	65	33	12	0	570
LAYING HENS	5970	134	148	161	72	25	++	1480
BROILER CHICKENS	6190	151	90	174	62	24	+	1450
HORSE MANURE	3100	12	16	46	9	40	+	520
SPENT MUSHROOM COMPOST	3300	18	21	49	15	6	++	1210

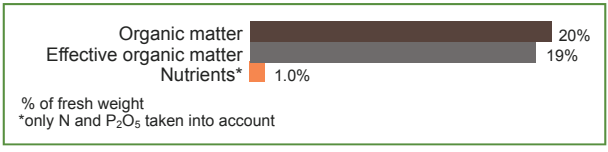
* The mineral fertiliser can be reduced by the fertiliser units shown in the first year after application.
Source: Explanatory note for the soil analysis, Soil Service of Belgium

5.2.2. GREEN COMPOST

Green compost is made from green waste such as pruned matter and grass cuttings. Over recent years, this has increasingly been used as an alternative to farmyard manure because the nitrogen and phosphorus are released more gradually, and it contributes more to the soil's organic matter content.

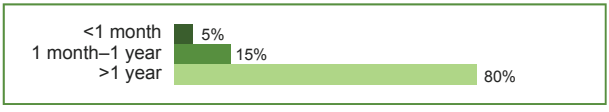
COMPOSITION

- Dependent on the materials used.
- If lots of grass is used, the compost contains more quick-release nitrogen.
- It's best to have a sample taken to find out the exact composition and fertiliser value of the green compost.



NITROGEN FUNCTION AND RELEASE

- Nitrogen can be immobilised first upon application. This is released again later.
- Much of the nitrogen is only released after a year or more.



APPLICATION

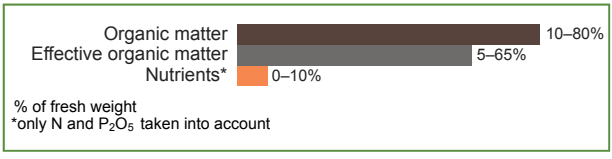
- It's best to apply compost in the spring.

5.2.3. ORGANIC SOIL IMPROVER

These soil improvers increase the amount of organic matter in the soil, provide a stimulus for the soil life and result in less leaching. They do not pose a risk of root scorch.

COMPOSITION

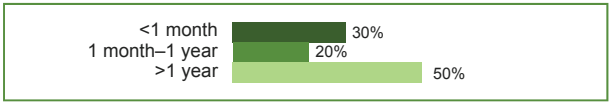
- The composition varies greatly from product to product. Consult the packaging to find out about the composition.
- The legal standards for the composition can be found at www.fytoweb.be.



% of fresh weight
*only N and P_2O_5 taken into account

NITROGEN FUNCTION AND RELEASE

- The release of nitrogen depends on the raw materials used to make the soil improver.



APPLICATION

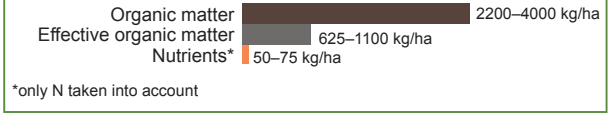
- Apply these soil improvers in the planting hole until just before planting.

5.2.4. GREEN MANURES

Among other things, green manures are used for organic matter distribution and sometimes for nematode control. They also ensure soil coverage and so combat weed growth, erosion and soil compaction.

COMPOSITION

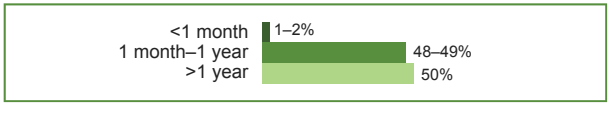
- Dependent on the crop. You will find some examples of available green manures on the next page.
- Leguminous plants absorb extra nitrogen from the air, whereas grasses ensure a higher supply of organic matter.
- Deep-rooting crops in turn take up more nutrients from deeper layers of soil which are no longer available for the main crop.



*only N taken into account

NITROGEN FUNCTION AND RELEASE

- The green manure absorbs nitrogen and other nutrients from the soil. Incorporating the green manure ensures a gradual release for the next crop.
- Grass green manures releases their nitrogen more gradually than leafy green manures.



APPLICATION

- Work in the green manure as part of the pre-planting cultivations.
- If the green manure is not sensitive to frost or if it's been a mild winter, treat the green manure so that it cannot start growing as a weed within the crop.
- Green manure can also be sown between the rows for perennial crops.
- Sow the green manure in good time so that there can still be sufficient growth before winter.

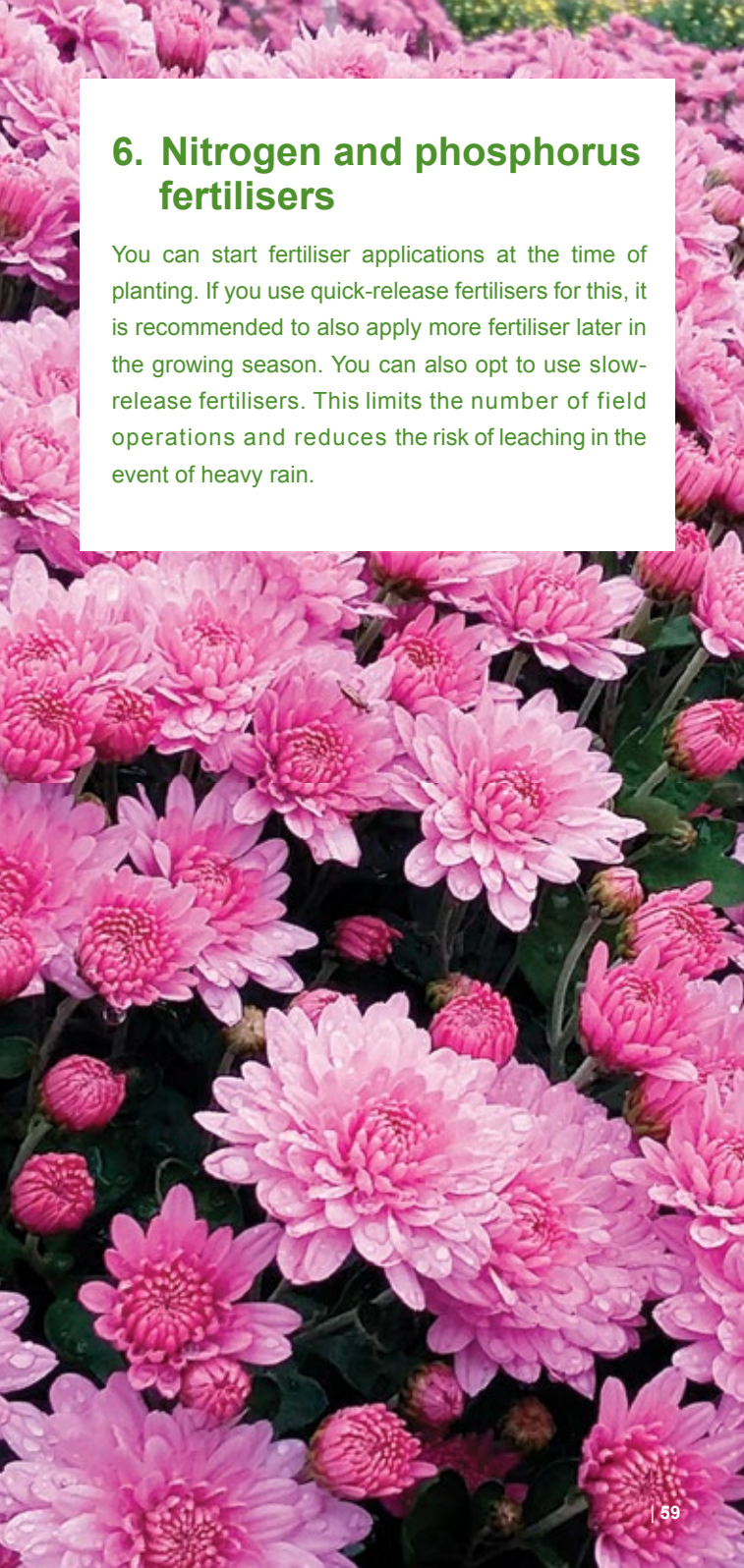
GREEN MANURES IN HORTICULTURE

	SENSITIVE TO FROST	ROOTING	ORGANIC MATTER	SOW	COMMENTS
FRENCH MARIGOLDS *(TAGETES PATULA)*	Yes	Intense	Low	May–July, minimum 3 months growth	Control of root lesion nematodes, weed management required
ITALIAN RYE GRASS (GRASS)	No	Intense, shallow	High	April–October	With a late sowing, only limited soil coverage in the winter
WINTER RYE (GRASS)	No	Intense, shallow	High	August–October	With a late sowing, only limited soil coverage in the winter
FODDER RADISH (LEAFY)	Yes	Deep	Low	May–September	Fast development
YELLOW MUSTARD (LEAFY)	Yes	Deep	Low	August–September	Fast development
LEGUMINOUS	Moderate	Deep	Dependent	April–August	Early nitrogen release

CONCLUSION

Don't forget to maintain the organic matter content of your soil. This will help to prevent or reduce problems such as erosion, soil compaction and drought. It also provides nutrients such as nitrogen and phosphorus. Take this into account.

Be careful with nitrate residue excesses in the autumn when applying large amounts of farmyard manure or compost, especially in combination with the incorporation of green manure in the spring!



6. Nitrogen and phosphorus fertilisers

You can start fertiliser applications at the time of planting. If you use quick-release fertilisers for this, it is recommended to also apply more fertiliser later in the growing season. You can also opt to use slow-release fertilisers. This limits the number of field operations and reduces the risk of leaching in the event of heavy rain.

Fertilisers are classified in different ways. In this guide, the fertilisers are classified according to their release pattern, as they also usually are on manufacturer and supplier websites. You can look up the legal standards at www.fytoweb.be.

6.1. SLOW-RELEASE FERTILISERS

Do you want to perform fewer field operations to apply fertiliser? Slow-release fertilisers can help you with this. You apply the fertiliser at the start of the growing season and the fertiliser is released gradually during the growing period. This reduces the chance of leaching after heavy rainfall. You can take another soil sample later in the growing season to optimise crop nutrition. The raw materials used, and their ratios and processing, determines the composition and speed of action of the end product. Choose a release period that matches the period of growth of the crop.

Note: the term slow-release is used here for fertilisers that work more slowly than conventional mineral fertilisers. These fertilisers do not always correspond with the definition of slow-release fertilisers used by the VLM.

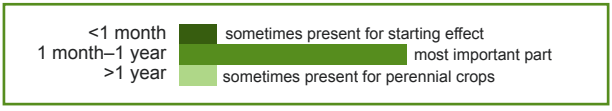
6.1.1. MINERAL FERTILISERS

Various mechanisms have been developed with slow-release mineral fertilisers which ensure the nitrogen releases more slowly. The mechanisms are explained below.

COMPOSITION

NITROGEN FUNCTION AND RELEASE

- Each type of mineral fertiliser has its own release pattern. This affects the release of nitrogen.
- The poster provides more information about the specific release patterns of products.



Type I: coated fertilisers

- Slower release of nutrients through coating.
- Partially coated fertilisers provide a greater starting effect.
- The temperature and moisture level determines the speed of release. Controlled release fertilisers (CRF) are mainly influenced by the temperature. The warmer it is, the faster the nutrients are released.

Type II: fertilisers with low solubility

- Complex nitrogen chains result in low solubility. These chains must be broken before the nitrogen can be taken up by the plant.
- Mainly moisture, and to a lesser extent heat and microorganisms, determine in the decomposition of the complex nitrogen chains.
- Isobutylidenediurea is an example of this.

Type III: stabilised fertilisers

- Nitrification inhibitors slow down the conversion of ammonium into nitrate. This means less nitrogen is lost through the leaching of nitrates.
- E.g. calcium cyanamide. Cyanamide breaks down into into ammonium and dicyandiamide. The latter has an inhibiting effect on the conversion of ammonium into nitrate. The cyanamide that is present on the soil to start with has a herbicidal effect. The lime ensures the pH is maintained.

Type IV: fertilisers with microbial degradation

- Microorganisms gradually convert the synthetic type of unavailable nitrogen into ammonium and nitrate.
- Crotonylidene diurea is an example of this.

APPLICATION

- You can apply these fertilisers both at the start of and during the growing season if necessary to maintain crop nutrition.
- These fertilisers are sold in solid form.

6.1.2. ORGANIC MINERAL FERTILISERS

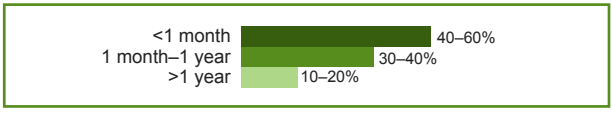
These fertilisers enrich the organic matter and have a long release period, but also supply quick-release fertilisers for an immediate effect.

COMPOSITION

- The composition varies greatly from product to product. Consult the packaging for the composition.
- The legal standards for the composition can be found at www.fytoweb.be.

NITROGEN FUNCTION AND RELEASE

- The mineral nitrogen is released quickly, whereas the organic bound nitrogen is released over a longer period.



APPLICATION

- You can apply these fertilisers both at the start of and during the growing season if necessary to maintain crop nutrition.
- These fertilisers are sold in solid form.

6.1.3. ORGANIC FERTILISERS

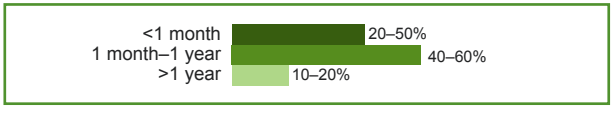
These fertilisers are of organic origin only. They have less of an initial effect compared to quick-release mineral fertilisers. Raw materials from both plant and animal origin can be used, such as slurry.

COMPOSITION

- The composition varies greatly from product to product. Consult the packaging for the composition.
- The legal standards for the composition can be found at www.fytoweb.be.

NITROGEN FUNCTION AND RELEASE

- Fertilisers based on plant products work more slowly than fertilisers made from animal products.



APPLICATION

- You can apply these fertilisers both at the start of and during the growing season if necessary to maintain crop nutrition.
- These fertilisers are sold in both solid and liquid form.

6.2. QUICK-RELEASE FERTILISERS

Do you want to provide crop nutrition as accurately as possible? Or do you need to make up for a shortage in the short term? The use of quick-release fertilisers can help you with this. After taking a soil sample during the growing season, apply whatever there is a shortage of to the soil.

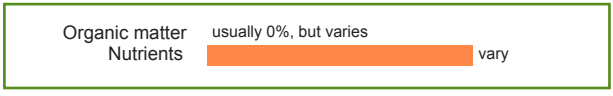
Plants only take up a limited amount of nitrogen at the start of the growing season. It's therefore best to only apply a limited amount of quick-release nitrogen fertiliser at the start of the growing season. Phosphorus fertilisers are more appropriate here because they stimulate root growth.

6.2.1. NITROGEN (N)

Nitrogen is present in various forms in quick-release fertilisers. Each from is briefly explained below.

COMPOSITION

- The composition varies greatly from product to product. Consult the packaging for the composition.
- The legal standards for the composition can be found at www.fytoweb.be.



NITROGEN FUNCTION AND RELEASE

Type I: nitrate fertilisers

- Nitrate is the most easily available form of nitrogen.
- They have a positive effect on the soil pH.
- The disadvantage is that it's very sensitive to leaching and so needs to be applied in split doses.

Type II: ammonium and urea fertilisers

- Ammonium is converted into nitrate in the soil. Some of the nitrogen will therefore be taken up in the form of ammonium, and some in the form of nitrate.
- These fertilisers have the advantage that they leach more slowly.
- These fertilisers acidify the soil.
- Ammonium fertilisers are sensitive to nitrogen losses via volatilisation, especially when they contain urea. You can counteract this by using ammonium fertilisers with urease inhibitors.

Type III: ammonium nitrate fertilisers

- This is a mixture of ammonium and nitrate.
- It is slightly acidifying to the soil.
- This combination gives you the highest nitrogen uptake, except under wet conditions, where you lose lots of nitrogen through denitrification and leaching.
- It's best to use fertilisers with a higher ammonium content in early spring.

Type IV: organic nitrogen fertilisers

- The organic nitrogen ensures a slightly longer effect.

APPLICATION

- These fertilisers are particularly useful for use during the growing season. You can also apply some at the start, but not too much. Any excess that you apply will be wasted.
- These fertilisers are available in solid and liquid form.

6.2.2. PHOSPHORUS (P)

Phosphorus is not very mobile in the soil. Applied mobile phosphorus quickly becomes immobile in the soil if it isn't taken up by the plant straight away.

COMPOSITION

- The composition varies greatly from product to product. Consult the packaging to find out the composition.
- The legal standards for the composition can be found at www.fytoweb.be.

Organic matter	usually 0%, but varies
Nutrients	vary

PHOSPHORUS FUNCTION AND RELEASE

- Phosphorus is mainly available shortly after application.
- Soil properties such as the binding capacity of the soil particles and the current level of phosphorus determine the further release of phosphorus.

Type I: orthophosphate fertilisers

- Orthophosphates are available for the plant as long as they are in solution. After application, they quickly bind to soil particles, which means they are no longer available for the plant.
- Examples of this are mono- and triple-superphosphate.

Type II: polyphosphate fertilisers

- Polyphosphates are chains of orthophosphates. They do not bind to soil particles and so remain in solution. They gradually decompose into orthophosphates that are taken up by the plant.
- Polyphosphates have only proven their worth in soils with a shortage of available phosphate.

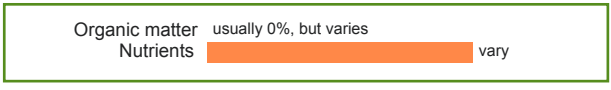
APPLICATION

- These fertilisers are particularly useful at the start of the growing season.
- Apply as close as possible to the plant roots.
- These fertilisers are available in solid and liquid form.

6.2.3. COMPOUND FERTILISERS

You usually need various nutrients at the same time. You can therefore use compound fertilisers for this. Choose a mix that matches the needs of your plants and soil as closely as possible.

COMPOSITION
- The composition varies greatly from product to product. Consult the packaging for the composition.
- The legal standards for the composition can be found at www.fytoweb.be.
- You can use different mixes to arrive at a good ratio.



NUTRIENT FUNCTION AND RELEASE
- This is highly product-dependent.

APPLICATION
- These fertilisers are particularly useful for use during the growing season. You can also apply some at the start, but not too much. You will waste any excess of nitrogen and potassium that you apply.
- These fertilisers are available in solid and liquid form.

6.3. BIOSTIMULANTS

Biostimulants can provide a better availability of nutrients that are already present in the soil or ensure better take up by the plant, as well as affecting the resilience of the plant.

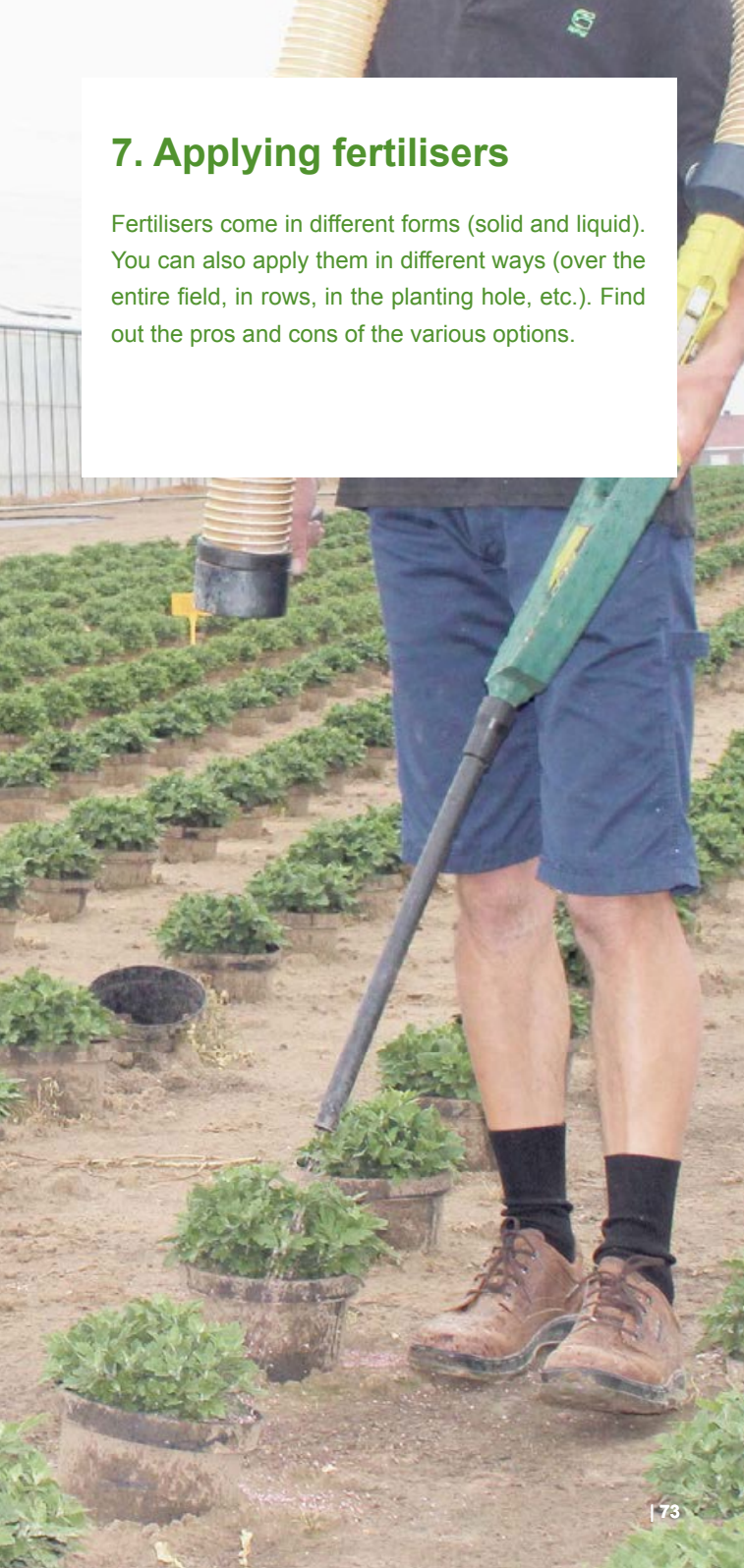
There is lots of research currently being done in new biostimulants and their applicability. There has been a recent explosion in the development of biostimulants, and many new products are appearing on the market. An example of this are fulvic and humic acids for improving the rooting and availability of nutrients, as well as *Bacillus* bacteria for a better release of phosphorus. Biostimulants are sold as a separate product but are also often added to fertilisers. For more information about biostimulants, contact PCS.

CONCLUSION

There are many types of fertilisers. To decide which fertiliser to use, you need to consider how many field operations you want to or can carry out and the desired release period of the fertiliser. The more often you apply fertiliser, the more precise you can be. But this requires lots of work. You can therefore also opt to use slow-release fertilisers. It is recommended to choose a slow-release fertiliser for the start of the growing season and to adjust this with a quick-release fertiliser during the growing season if necessary. The weather also plays a role. Never apply a large dose of quick-release nitrate fertiliser if heavy rain is expected. In this case it's better to wait before applying any fertiliser or choose a different source of nitrogen.

7. Applying fertilisers

Fertilisers come in different forms (solid and liquid). You can also apply them in different ways (over the entire field, in rows, in the planting hole, etc.). Find out the pros and cons of the various options.



7.1. REGULATION

As well as choosing the type of fertiliser, you also need to consider how you apply it (full field, strip, row, point or planting hole), when and in what form (granule, liquid/soluble, foliar fertiliser) you are going to apply it.

It is important that the nutrients are released from the fertilisers when the plants need them. The fertiliser application regulation also determines the times at which you are allowed to apply fertiliser. This reduces the leaching of nutrients into the groundwater. It's also important to use fertilisers with low emission levels. This means that you are curbing nitrogen volatilisation. So, there is less nitrogen in the air and more in the field. The amounts of nitrogen and phosphorus that can be applied are also regulated.

You can find the current legislation regarding this at www.vlm.be.

7.2. FORMULATION

Fertilisers can be applied in different forms. The machinery and installations available, as well as the type of fertiliser, determine this choice. Slow-release fertilisers are mainly available in solid form.

7.2.1. Applying to soil
SOLID

You apply these fertilisers over the field or on certain parts of the field (e.g. along a row or at specific points). This is normally done using machinery. You need to ensure that the granules are distributed uniformly between the plants to achieve uniform growth and optimal use of nutrients.

ADVANTAGES
- This is a useful form for applying slow-release fertilisers.
- Useful for applying large amounts of fertiliser.

DISADVANTAGES
- You need to ensure good, uniform distribution. Round granules roll away faster than granules that are irregular in shape.

7.2.2. Applying to soil
SOLUBLE/LIQUID

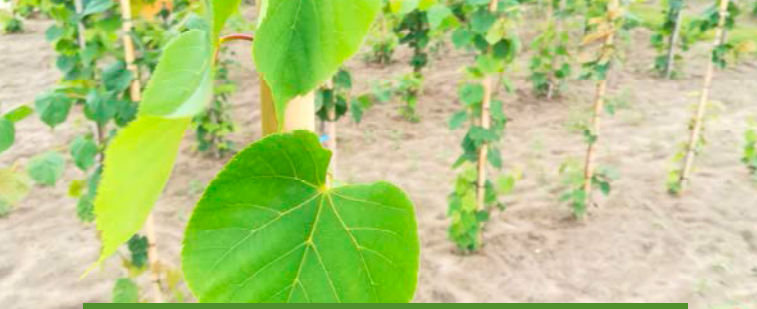
These fertilisers can be used in fertigation systems. This can be done using automated systems whereby different fertilisers can be combined to achieve a unique solution.

ADVANTAGES

- You can carry out precise fertiliser applications with various nutrients by using mixing systems.
- Applying fertiliser using an automated fertigation system requires less work.

DISADVANTAGES

- You need knowledge of the system if you want to apply fertiliser automatically.
- Applying it manually requires lots of work. You can only apply a small amount of fertiliser each time.



7.2.3. Applying to foliage
SOLUBLE/LIQUID

You can use foliar feed to supplement soil applied fertilisers and apply specific nutrients during the growing season. Soil fertiliser application remains important for developing a good root system, and so also for plant strength and the uptake of water and nutrients.

Plant hormones and enzymes are sometimes added to foliar feed which stimulate plant growth. But it has not yet been clearly demonstrated how this works.

ADVANTAGES
- Fast and efficient uptake by the plant.
- There is no soil intervention.
- This means your plants can also take up nutrients if the root system struggles with e.g. cold, drought or nematodes.
- You can apply it using a sprinkler irrigation system.

DISADVANTAGES
- Limited amount of nutrients applied each time, so multiple applications are required.
- You need to carry out extra field operations if you do not have an automated irrigation system.
- In the event of heavy rainfall, it's better not to do apply foliar fertilisers.The fertilisers will simply wash off the foliage.
- Risk of scorching the foliage at high temperatures (>20°C) and in direct sunlight.

7.3. METHOD OF APPLICATION

You can apply fertilisers in different ways. In order to apply them in a more sustainable way, you should only apply fertiliser to the places where plants have roots and so can take up the nutrients. The planting distances adopted are important when selecting the method of fertiliser application. The conditions under which fertiliser application takes place also play an important role in terms of efficiency and sustainability, and so also for the plant growth and quality. When using fertilisers that are only release slowly and aren't really mobile in the soil, it is strongly recommended to apply the fertiliser in a targeted way and not to the open field if there is insufficient root development.

Ideal fertiliser application conditions

- Light to no wind (especially for compost, dried manure or foliar feed application).
- Low air humidity when applying fertiliser.
- Constant driving speed for even distribution.
- Good driving conditions on the field: not too wet.

If you have soil samples taken for additional fertiliser or nitrate residue, you must inform the person taking the sample of the fertiliser application method used.

Sampling method

- For top dressing application: only sample soil where fertilisers have been applied (strip, row, point, etc.)
- For nitrate residue: sample the entire field, the average field value counts.

Fertiliser advice always indicates the amounts of nutrients required for full field treatment. Opting for a different method of application can result in savings on fertilisers. The recommended amounts must be converted for the effective surface area to be treated, so e.g. only the row or planting hole.

7.3.1. FULL FIELD FERTILISER APPLICATION

You distribute the fertiliser equally over the field. For good total treatment, you therefore need more fertiliser in comparison with other methods of application if rooting is not extensive throughout the field. Some of the nitrogen and other nutrients will therefore remain unused in this case.

CROPS
- For crops with a high plant density, such as tuberous begonia.
- For older trees in a nursery where they have created an extensive root system. This means almost the entire field contains some root system so you have fewer losses.

TIMING
- Possible both before and after planting.
- No more can be incorporated after planting.

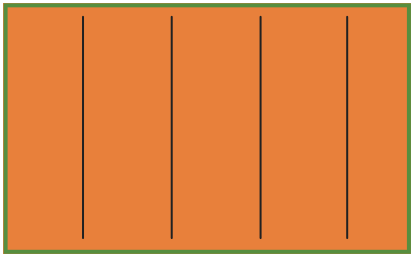


Figure 11: Plan for full field fertiliser application.
Key: | Plant Row ■ Fertiliser use

7.3.2. STRIP FERTILISER APPLICATION

With this technique, you apply the fertilisers in a strip. Then you plant or sow in the same strip. This prevents unnecessary fertiliser application in the aisles between the plants.

CROPS
- For crops in a row, such as standard trees.
- For crops with multiple rows close to each other, such as forestry.

TIMING
- Possible both before and after planting.
- No further incorporation possible after planting, unless by mechanical weed control.

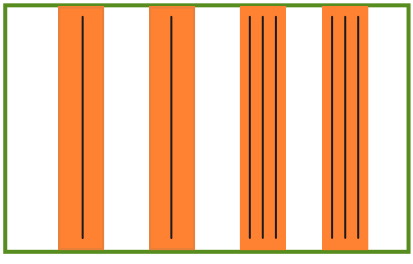


Figure 12: Plan for strip fertiliser application.
Key: | Plant Row ■ Fertiliser use

7.3.3. ROW FERTILISER APPLICATION

You apply the fertiliser in a row next to the plants. This ensures the fertiliser is close to the plant roots. You avoid unnecessary fertiliser application between the rows where there are no roots.

CROPS
- For crops in rows with a large distance between the rows, such as standard trees.

TIMING
- Possible both before and after planting.

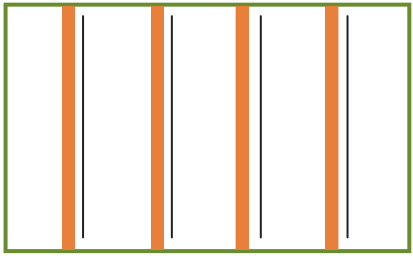


Figure 13: Plan for row fertiliser application.
Key: | Plant Row ■ Fertiliser use

7.3.4. POINT FERTILISER APPLICATION

You only apply the fertiliser next to the plant and incorporate it if necessary. This method only treats the places where there are plant roots present, which means you need less fertiliser. Avoid using too high a dose to avoid the risk of root scorch.

CROPS
- For crops that are a large distance apart, such as pot chrysanthemum.

TIMING
- Possible both before and after planting.

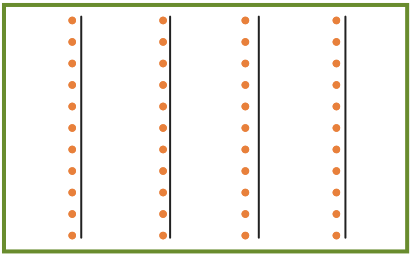


Figure 14: Plan for point fertiliser application.
Key: | Plant row • Fertiliser use

7.3.5. PLANTING HOLE FERTILISER APPLICATION

You apply the fertiliser directly in the planting hole with this method. You must make sure you don't apply too much fertiliser because otherwise the plant roots can be scorched.

CROPS
- For crops that are planted in a planting hole, e.g. when planting perennial nursery stock crops.

TIMING
- Only possible before planting.

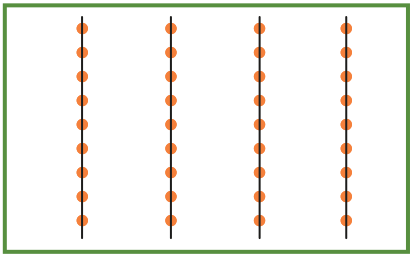
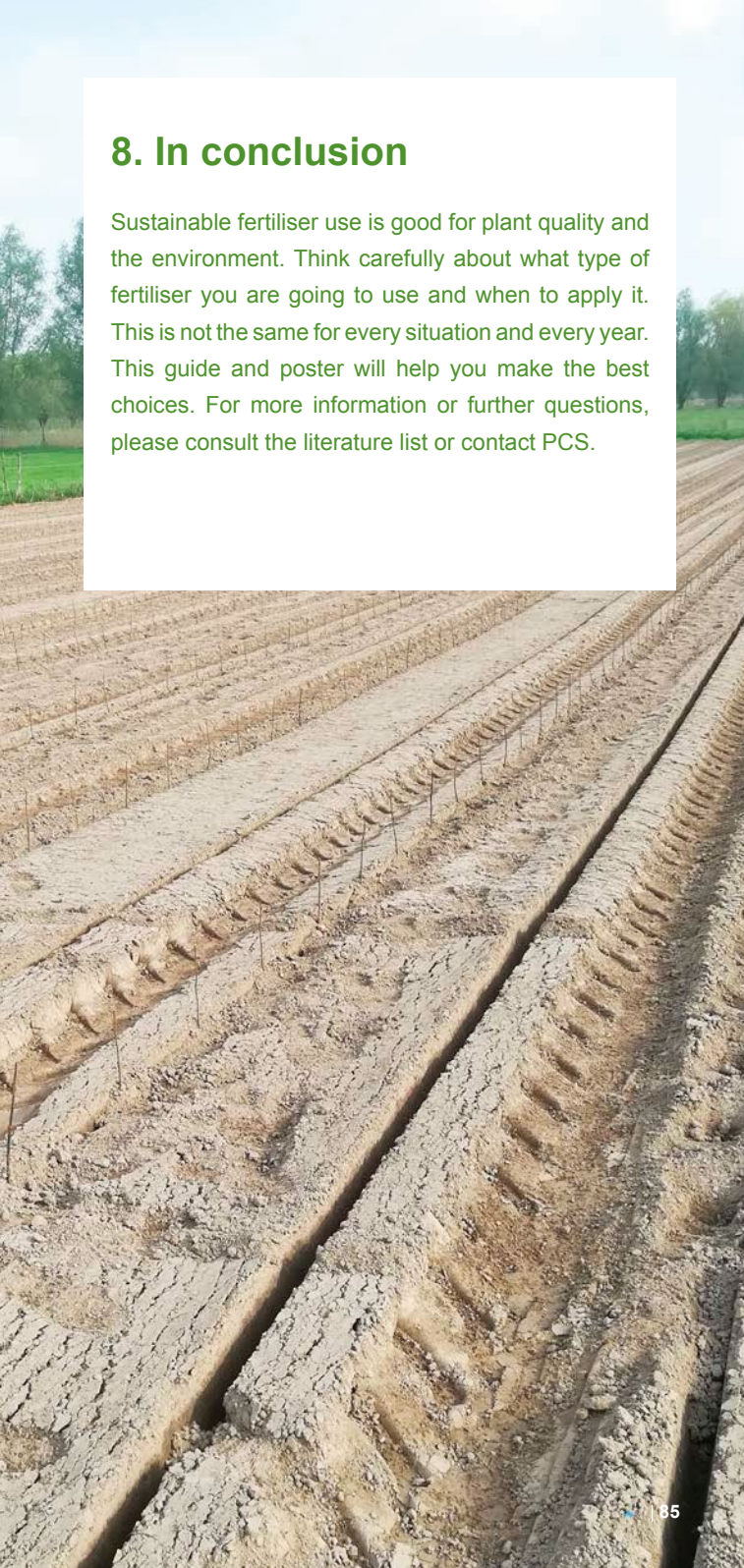


Figure 15: Plan for planting hole fertiliser application.
Key: | Plant row • Fertiliser use

8. In conclusion

Sustainable fertiliser use is good for plant quality and the environment. Think carefully about what type of fertiliser you are going to use and when to apply it. This is not the same for every situation and every year. This guide and poster will help you make the best choices. For more information or further questions, please consult the literature list or contact PCS.



Literature list

Aendekerk, G. (2000). Adviesbasis voor de bemesting van boomkwekerijgewassen: vollegrondsteelt. Boskoop, Nederland, Boomteeltpraktijkonderzoek, 74 p.

Coppens, G., Vandendriessche, H., Moens, W., Bries, J. (2009). De mestwegwijzer. Heverlee, Bodemkundige Dienst van België, 95 p.

Tits, M., Elsen, A., Deckers, S., Boon, W., Bries, J. & Vandendriessche, H. (2016). Bodemvruchtbaarheid van de Akkerbouw– en Weilandpercelen in België en Noordelijk Frankrijk (2012–2015). Heverlee, Soil Service of Belgium, 218 p.

www.fytoweb.be, October 2018

www.vlaco.be, September 2018

www.vlm.be, June 2018

www.vmm.be, September 2018

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