Knowledge grows

The Nutrition of Oilseed Rape

Incorporating Yara's Complete Range of Fertilizers

Contents

Background

Introduction

Rapeseed has been grown in Europe for many years, however the oilseed rape crop was barely known until the 1970's. It became popular and the area grown increased significantly as a result of increasing commodity prices and targeted support from the CAP.

World Production

There are three main oilseeds produced in the world – soyabean, rapeseed and sunflowerseed. Palm oil, although not produced from a seed, is also an important part of the vegetable oil market. Rapeseed contains approximately 40% rape oil, which makes up 18% of the world vegetable oil demand. The remainder consists of rape meal, used for animal feed and a small amount of waste.

Global production has increased since the last decade and remains between around 60 - 70M tonnes.

UK Production

The area of oilseeds in the UK has been steadily rising since it was first introduced. In the last decade the area has grown to 715,000 ha in 2013 (Source FAO STAT, April 2015). Whilst the area of oilseeds in the UK has risen, the same cannot be said for average yields, which have remained static for the last 20 years. According to Defra's statistics, the average yield in the late 1980's was 3.2 t/ha, whilst in 2014 the average yield was 3.7t/ha; therefore there has been little difference in the general trend for yield. During this same period the average UK wheat yield has risen from 6.4 t/ha to around 8 t/ha.

Table 1. World Rapeseed Production (Source: USDA, March 2012)

Location	Production (M tonnes)			
	2009/2010	2010/2011	2011/2012	2011/2012
EU-27	21.6	20.7	19.1	25.6
China	13.7	13.1	12.5	14.5
Canada	12.9	12.8	14.2	17.9
India	6.4	7.0	7.0	7.8
Other	6.5	6.8	7.5	6.9
Total Production	**61.0**	**60.4**	**60.3**	**72.7**

Oilseed Yield Potential

The crop's theoretical potential is at present thought to be 8.75 t/ha with the highest yield achieved in HGCA trials being 7.5 t/ha. This yield was produced from the following:

- 50 plants/m^2
- 168 pods/plant
- 18 seeds/pod
- 4.96g - TSW

Table 2. Components of Yield

TSW (g)	Seeds (m^2)						
	90,000	100,000	110,000	120,000	130,000	140,000	150,000
3	2.7	3.0	3.3	3.6	3.9	4.2	4.5
4	3.6	4.0	4.4	4.0	5.2	5.6	6.0
5	4.5	5.0	5.5	6.0	6.5	7.0	7.5
6	5.4	6.0	6.6	7.2	7.8	8.4	9.0
7	6.3	7.0	7.7	8.4	9.1	9.8	10.5
8	7.2	8.0	8.8	9.6	10.4	11.2	12.0

Varieties

Since the 1970s plant breeders have looked to reduce the anti-nutritive factors of OSR varieties, with double low varieties now the norm in the UK. There are also HOLL (High Oleic, Low Linolenic) and HEAR (High Erucic Acid Rape) varieties grown on a much smaller scale under specific contracts (Figure 1).

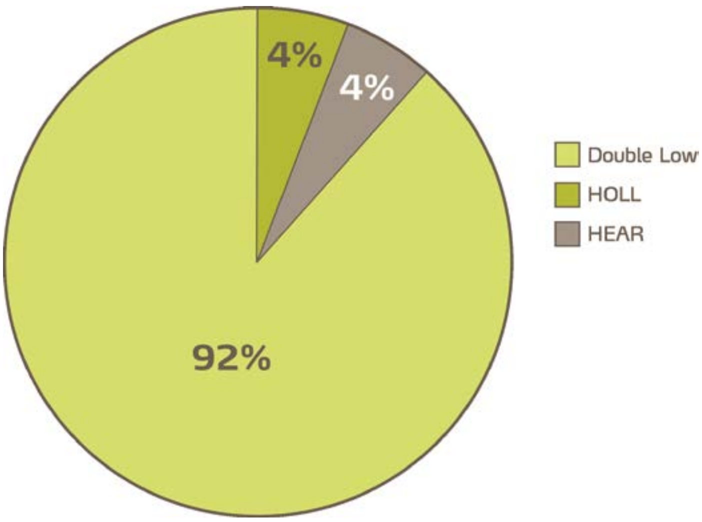
Double Low (00) eg Castille. These varieties have low concentrations of erucic acid in the oil and glucosinolates in the meal. The oil from these varieties is used for food, fuel and industrial purposes.

HOLL varieties eg Splender. These varieties have a High Oleic, Low Linolenic fatty acid oil profile that removes the need for hydrogenation, traditionally carried out to improve the oils shelf life. The hydrogenation process produces Trans Fatty Acids, which have been associated with the build up of cholesterol and other negative health effects.

HEAR varieties eg Helico. High Erucic Acid Rape varieties are low in glucosinolates and high in erucic acid. The oil from these varieties is used to produce erucimide for polythene manufacture.

Markets

Figure 1. The UK Market



Market Types

The majority of the oil produced from UK crops is used for human consumption through food manufacture, catering and retail sales. Three quarters of this market uses refined oil direct from the crush; the remainder undergoes hydrogenation and is destined for margarine and other "solid" uses.

The meal is used predominantly in compound animal feeds. 1 ha typically produces 1,400 kg of oil and 1,900 kg of animal feed.

There are also non-food uses, such as the industrial oils market, dominated by biodiesel, but also including lubricant and surfactant production. There has been a lot of media recently surrounding the production of biodiesel from vegetable oil, with demand in this sector now estimated to account for 50% of annual growth in oilseed demand. (HGCA Knowledge centre).

HOLL varieties are generally used in the catering industry, as the oil does not degenerate under high temperatures or frying, whilst HEAR oil is used in the production of biodegradable plastics, food additives and biodegradable lubricants.

Nutrients

Nitrogen

Nitrogen is critical to plant growth, and with the production of large leafy plants, the oilseed crop has a high requirement. Optimising canopy size and hence light interception by the crop is an essential role of nitrogen, which helps to maximise crop yield.

Nitrogen has an important but varied role in disease resistance. One of the most commonly assumed relationships of nitrogen to disease is that high N rates leads to an increase in disease, but optimum nitrogen nutrition normally suppresses disease. This is either as a result of resistance mechanisms, through the formation of various proteins and enzymes needed for both plant growth and disease resistance or through increased tolerance as vigorously growing plants outgrow the most damaging effects of some diseases.

Nitrogen is a key component of amino acids, therefore an excessive supply leads to higher amounts of amino acids in plant tissues. This mineral imbalance lowers the resistance to fungal diseases by creating a more favourable environment for pathogens.

As nitrogen content increases beyond sufficient levels, the amount of naturally occurring antifungal compounds in the plant decreases, increasing the risk of infection, but it also stimulates excessive weak vegetative growth favourable to disease and insect damage.

If the crop is deficient in nitrogen, the plants will appear stunted, with older leaves becoming paler or yellowing first, as nitrogen is very mobile within plants. Stems are thinner and branching is reduced with the canopy in the field remaining thin and open.

Flowering is reduced, with flowering and ripening periods shortened, decreasing pod numbers and seed size, therefore dramatically impacting on yield.

Nitrogen availability is reduced on light or sandy soils especially those low in organic matter as it is readily leached. High rainfall will also lead to increased leaching, which can have a more pronounced effect in the autumn, particularly on soils with low nitrogen reserves when the root system is still small. Restricted root growth as a result of poor soil conditions, drought or damage from pests and diseases will reduce the plants ability to take up nitrogen.

Phosphate

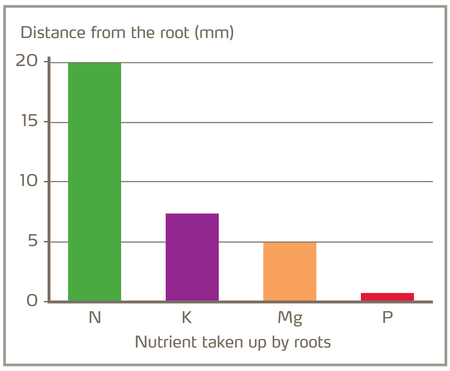
Phosphate plays an important role in energy transfer within the plant and is therefore vital during the periods of rapid growth. In early growth stages it promotes root development, which is also important for efficient uptake of other nutrients. The majority of soils will have sufficient phosphate to satisfy the early demand.

Later in the season phosphate is required for early flowering and plays an important role within the energy storage and transfer process, therefore it is important for the oilseed crop to be supplied with sufficient phosphate to increase the oil and the protein content of the seeds.

Plants deficient in phosphate appear stunted with poor root growth and thin stems. As phosphate is mobile within the plant, it is the older parts of the plants that show signs of deficiency first, with leaves and stems appearing a deep reddish to purple colour.

Acidic, alkaline and heavy clay soils all have fixing properties that render the phosphate unavailable. Phosphate is very immobile within soils with crops only able to take it up from the soil solution very close to the roots, within 1 - 2 mm (Figure 2).

Figure 2. Distance of nutrient uptake by roots



Potash

Potash helps provide strength to plant cell walls and helps to increase leaf area and leaf chlorophyll content delaying leaf senescence, therefore helping to increase canopy photosynthesis and crop growth. As potash provides strength to plant cell walls, deficiency may be one reason for early lodging. Early lodging and restricted translocation of nutrients to upper parts of the plant and seeds can have a dramatic impact on yield in the oilseed crop (see page 12).

Potassium has an essential role in plant disease resistance, probably the most effective of all the nutrients. It is a regulator of enzyme activity, and therefore involved in nearly all cellular functions that influence disease severity. From over 200 literature reports on the role of potassium on plant diseases 70% improved plant health.

Potassium is required for the synthesis of proteins, starch and cellulose; cellulose being a component of cell walls. An adequate supply of potassium is therefore required for increasing the thickness of cell walls reducing the likelihood of lodging. The function of cellulose on cell wall thickness not only acts on the plants standing power, but also as a mechanical barrier to invasion and infection by pathogens by reducing the movement of sugars out of cells.

Potassium deficiency reduces cellulose production, leading to thinner cell walls and higher sugar levels in the apoplast (space between cells) that stimulates fungal attack and germination of spores.

As a rule, susceptibility to disease decreases in response to potassium in the same way that the growth of a plant responds to increasing potassium supply. Beyond optimal supply for growth, there are no further benefits from additional potassium supply in terms of plant health.

Deficiency symptoms become noticeable on older leaves first as marginal and interveinal chlorosis, becoming necrotic in severe cases. Plants also tend to show signs of wilting on hot, sunny days, even when no other symptoms can be seen.

Soils that are low in clay content, such as light or sandy soils are prone to potash leaching, especially following heavy rainfall. Experiments on soils with high sand contents, and high rainfall have shown that 45 – 50 % of potash can be lost following application.

Availability to plants can also be reduced where the soil pH is low, or where the soil magnesium status is high, due to the interactions between these two nutrients.

Sulphur

Sulphur plays an essential role in the oilseed plant as a component of proteins, therefore if deficient, protein synthesis is inhibited. As proteins are located in chloroplasts, plants that are deficient in sulphur have paler leaves.

Because of the central role of nitrogen and sulphur in the production of proteins there is a close relationship between the supplies of the two nutrients within the plant. High rates of nitrogen can cause deficiencies of sulphur if the supply is not sufficient and conversely, the efficiency of uptake of nitrogen is improved with an adequate supply of sulphur.

Sulphur deficiency systems can be seen in younger leaves first as the nutrient is not very mobile within the plant and is expressed as a paling of the leaves. Later on in the season, it can be seen on the petals at flowering as a paling or whitening.

Levels of sulphur in the atmosphere have been falling, with the average deposition rate now just 10 kg/ha/yr. Sulphur is very mobile within the soil, even more so than nitrogen, making it easily leached, especially on light sandy soils and in high rainfall areas.

Magnesium

Magnesium is well known as being a central part of the chlorophyll molecule of green plants, and as such, plays an important role in photosynthesis, however only a small proportion of the total magnesium in the plant is found here. It also plays an important role within the synthesis of proteins and in phosphate and nitrate metabolism.

Older leaves are the first to show signs of deficiency with interveinal yellowing followed by purple colouration spreading from the leaf margins. It is also exhibited as poor growth with squat, low-yielding plants.

The majority of the plants total magnesium requirement is taken up over a short period of time leading up to flowering, therefore it is important to ensure sufficient magnesium is available to the crop during this period. Availability is reduced on light soils, due to the low portion of clay particles and the soils lack of ability to hold onto the nutrient allowing it to be readily leached. The situation is exacerbated on low pH, acidic soils. High levels of potassium in the soil, cold wet growth conditions, periods of drought and generally poor soil conditions can all further reduce the uptake by the plant.

An adequate soil magnesium status is important for satisfactory uptake by the oilseed plants, particularly at times of high demand. However due to the interactions with other nutrients such as potassium, this may not be sufficient to ensure adequate levels are taken up by the plant. As the plant has a high demand for the nutrient over a short time period it may be necessary to apply additional magnesium, either in the form of solid fertilizers or as foliar sprays.

Applications of YaraVita Magflo 300 at 2 to 4 l/ha at the onset of stem extension or up to 4 l/ha YaraVita Brassitrel Pro from then until the start of flowering will help to supply the crop with magnesium.

Boron

Boron is an important nutrient for oilseed rape, with brassica crops having a relatively high boron requirement. It plays a key role in cell wall biosynthesis, carbohydrate and protein metabolism, cell division and cell elongation, being involved in the development of root and shoot growing points. It is therefore critical for the plant at times of rapid growth during the autumn and stem extension in the spring. It is also required for pollen germination and pollen tube growth ensuring adequate seed set in the pods.

Boron is the only nutrient which, when in short supply accelerates physiological processes instead of reducing them which can result in abnormal cell growth. Leaves may be paler green with interveinal yellow mottling and a reddish tinge around the margin. A reduction in the internodes of the stems gives the plants a stunted appearance. Serious deficiencies can result in vertical cracking of the stems, which can often be hollow at the stem base.

Later in the season, flowering appears restricted and distorted with infertile flowers, leading to a reduced number of pods and fewer seeds per pod, resulting in significant reductions in yield.

Boron also plays an important role in the plants natural defence mechanism against invasion and attack from fungal pathogens.
Boron is required by plants for the formation of naturally occurring antifungal compounds and also to transport these compounds to the site of infection.

Crops grown on soils with adequate boron levels may still be at risk of boron deficiency where availability to the plant is restricted. This could be as a result of high soil pH (where the crop follows recent lime applications), dry conditions during the growth periods or inadequate zinc supply.

Annual recommendations of boron for oilseed rape crops are between 1 and 1.5 kg B/ha for the season, which should be split at three times during the year to match the important timings for the crop. Autumn for root growth and frost tolerance, at the onset of stem extension due to rapid plant growth, and at the start of flowering to ensure pod set and seed numbers are maximised.

Yara recommendations include up to 3 l/ha YaraVita Bortrac 150 in the autumn and up to 4 l/ha YaraVita Brassitrel Pro up to the start of flowering.

Manganese

Manganese is involved in activating different enzyme processes, particularly photosynthesis and protein synthesis. It is also involved in carbohydrate metabolism and lipid synthesis; therefore plants that are manganese deficient are likely to have lower oil contents, as well as yielding less.

Manganese is also required for lignin formation, which along with cellulose is a component of cell walls, therefore manganese is required to help provide a physical barrier to infection by disease organisms. Also, like boron, manganese has a role in the formation of the plants naturally occurring antifungal compounds, helping to fight disease infection.

Deficiency symptoms appear as a change in leaf colour with the foliage showing a faint yellow mottling, seen first on recently matured leaves. Necrotic spots may follow with retarded crop development and pod fill.

Manganese deficiency often occurs in patches with plants growing better on the more consolidated areas e.g. close to tramlines. Plants require good soil to root contact for efficient uptake of manganese; therefore availability may be reduced on light, 'puffy' soils. Uptake is further reduced on soils with a high pH and those with high levels of organic matter.

Foliar applications are the most effective to prevent or correct manganese deficiency.

Applications of either YaraVita Mantrac Pro at 1 l/ha or 3 l/ha YaraVita Brassitrel Pro from the onset of stem extension up to the start of flowering will help to supply sufficient manganese for the crop.

Molybdenum

Molybdenum is required by plants for nitrate reducing enzyme systems which are involved in nitrate metabolism. It is involved in the formation of protein, with low levels reducing nitrogen utilisation and efficiency.

Deficiency symptoms show on the plant as a reduced leaf blade area with an extended midrib, similar to 'whiptail' in cauliflower. Leaves become pale and limp, resulting in a lower pod yield compared with healthy plants.

Unlike the majority of other nutrients, molybdenum availability increases with rising pH; therefore deficiency is mainly restricted to acid soils.

Although the oilseed crop requires relatively low levels of molybdenum, it should not be overlooked as insufficient levels can be damaging to yield. YaraVita Brassitrel Pro applied at up to 4 l/ha from the onset of stem extension to the start of flowering will help to ensure sufficient molybdenum is supplied.

Autumn Management

In 1840 Justus von Leibig stated in the famous “ Law of the Minimum” that crop growth is limited by the essential nutrient that is found in least supply (Figure 18). This can be modified, replacing ‘essential nutrient’ with ‘essential input’ as it is important that all inputs, soil, seed variety, population, disease control are correct to maximise the potential of the crop.

Establishment

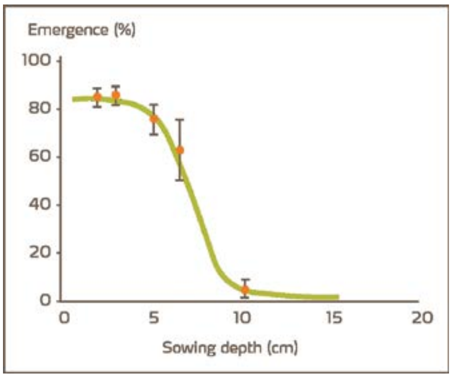
Poor or failed establishment is expensive; it occurs too frequently and can cost the industry millions each year. The risk of failure during establishment is high as the seed is small with limited energy reserves and production of a suitable seedbed is difficult, especially following difficult harvest conditions.

For optimum establishment, oilseed rape needs a good seedbed, water, oxygen and sufficiently high soil temperature. Seeds will not germinate at a temperature below 3°C and only slowly between 3 and 10°C.

The supply of oxygen to the seed and germinating seedling may become restricted where drilling occurs in wet conditions resulting in soil smearing. Where this occurs it may result in anaerobic conditions that can restrict germination and the penetration of the emerging root.

Seed size can also have an impact on germination. The HGCA conducted a trial looking into the effects of seed size and protein content of seeds on their germination. The results showed a higher germination percentage from larger seeds and higher protein contents (Figure 3). The advantage of larger seeds is their increased ability to cope with different stress factors, such as deep sowing and dry or waterlogged conditions.

Figure 3. Effect of sowing depth on OSR emergence



Drilling Date

Ideally OSR crops should be drilled prior to the end of the second week in September in England and by mid to late August in Scotland. In recent years, drilling dates have become earlier as growers look to ease the heavy autumn workload, however this can increase the risk of some diseases.

Later drilled crops may be at risk of reduced establishment as a result of poor soil conditions, therefore if being grown, hybrid varieties should occupy the later end of the drilling window due to their extra vigour.

Autumn Nitrogen

The proportion of oilseed rape crops receiving autumn applications of nitrogen has been declining over the years. In 2014 only 32% of the oilseed area in Great Britain received nitrogen. This has fallen from nearly 90% in the late 1980's (British Survey of Fertiliser Practice).

Oilseed rape has a higher requirement for nitrogen during the autumn than most other combinable crops such as cereals, and if being grown on soils with low residual nitrogen, additional applications are required.

Plant development in the autumn is critical to the crops overall performance. In the autumn, the number of leaf axils determines the potential for flowering branches in the spring.

Flower initiation usually takes place from early November (when sown in August) to mid-December (when sown in September).

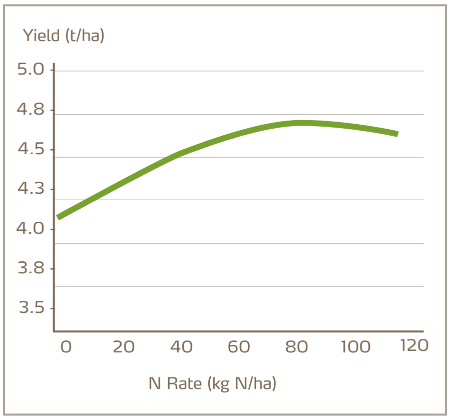
The onset of flower initiation can have a strong influence on flower, pod and seed number; therefore it is important that any limitations to its development are prevented.

Poorly established crops going into the winter will also be more likely to suffer from pigeon damage. Areas of thin or backward crops will be at greatest risk and it may be beneficial to apply nitrogen to them in order to increase crop growth before the onset of cold weather.

Applications of autumn nitrogen should be made to the seedbed, or soon after emergence. Waiting for deficiency symptoms to occur will prevent the crop reaching its full potential.

Yara trials during the 1970's and 80's have shown the benefits of applying nitrogen to oilseed rape in the autumn. The biggest responses have been seen from crops grown on light soils. These trials were recently repeated, showing a much greater response, with a larger optimum rate closer to 60kgN/ha (Figure 4).

Figure 4. Response to Autumn Nitrogen in Oilseeds



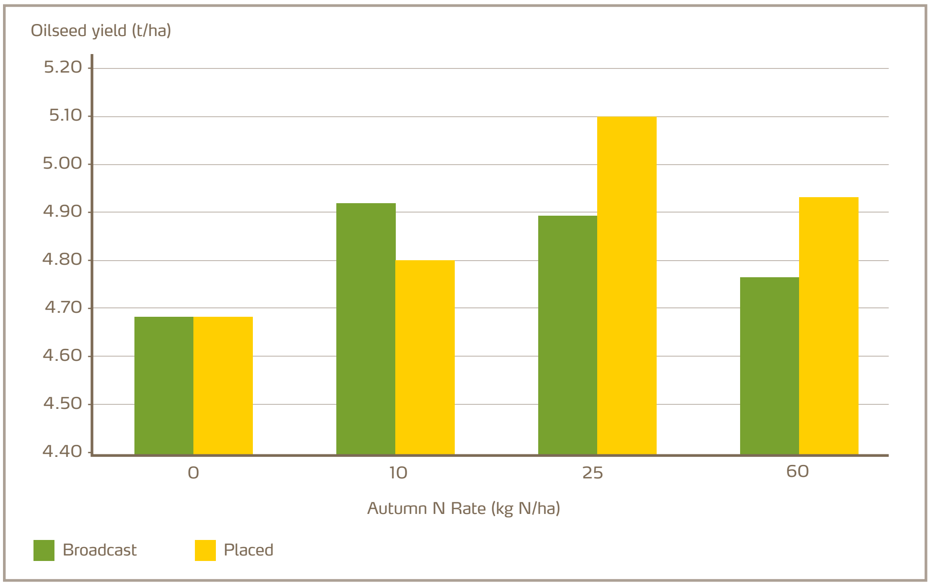
Autumn Nitrogen Application Methods

With optimum nitrogen rates in Yara's trials higher than the permissible 30kgN/ha maximum allowed under NVZ regulations and more oilseed rape being established on wider row spacings, there is an option to concentrate nitrogen applications at drilling to just the areas of the field where the plants are growing.

Theoretically, this method of 'placing' fertilizer will allow lower rates of nitrogen to be applied over the whole field area, whilst applying close to the optimum rate on the area of the field which is cropped – meeting the plants needs whilst working within the restrictions of the current NVZ legislation.

In 2010 Yara began a series of trials looking at the optimum rates of autumn nitrogen when 'placing' fertilizer compared to broadcast applications. The results so far show a benefit of placing small amounts of nitrogen, around 25 kgN/ha (Figure 5). There also appears to be an additional benefit from including phosphate at drilling, an extra 0.29t/ha was recorded in trials in 2011, whilst the trials in 2012 showed a 0.57t/ha benefit from placing a small amount of nitrogen with phosphate.

Figure 5. Comparison of Placed vs Broadcast Autumn Nitrogen Applications (Yara, 2010-11)



Phosphate

It is important for the oilseed rape crop to be supplied with sufficient phosphate during the early growth stages for the promotion of root development, essential for the extraction of other nutrients from the soil. On soils with an index 0, applications of phosphate should be made in the autumn to provide sufficient phosphate for establishing plants.

Boron

Figures from Lancrop Laboratories consistently show over 90% of soil samples received in autumn to be below the guideline level for boron. Boron is an essential nutrient for oilseed rape, with a 4 t/ha crop requiring as much as 350 g/ha during the season, especially during the critical growth phases during the autumn.

Plants grown on low Boron soils are more severely affected by low temperatures (<10°C) than those with an adequate boron supply. Boron deficiency is accentuated as the plants shoot:root ratio is increased and boron uptake and partitioning to the young expanding leaves is impaired.

During the months of September, October and November there will be rapid growth at root and shoot tips as roots, leaves and eventually floral parts of the plant develop.

These 'meristems' (growing points) all require a continued supply of boron. Indeed, cessation of root elongation is one of the first and most rapid responses to boron deficiency due to its effect on the accumulation of natural plant growth regulatory compounds.

Applications of boron will stimulate root elongation giving a well-structured plant that will explore soil available nutrient more efficiently.

In studies during the 1970's boron treated plants have shown an increase in phosphate uptake. There has been limited trials work looking at autumn boron in isolation, however some Canadian work in 2005 on a deficient site showed a yield increase of 21% where boron had been applied at planting.

Oilseed crops should receive up to 3 l/ha YaraVita Bortrac 150 or up to 4l/ha Brassitrel Pro in the autumn to provide boron to the growing plants and to increase their frost tolerance.

Summary

To withstand a cold winter individual plants need to reach the 6–8 true-leaf stage, with a well-developed root (diameter of >5 mm) and a shoot length of <20 mm.

In the autumn, the number of leaf axils also determines the potential for flowering branches. Flower initiation usually takes place from early November (when sown in August) to mid-December (when sown in September). The onset of flower initiation can have a strong influence on flower, pod and seed number. It is thus important to monitor the oilseeds through this period and prevent limitations to its development.

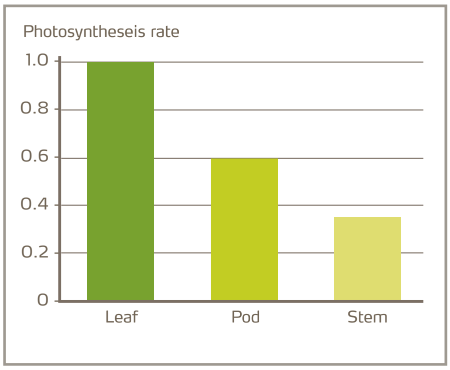
A leaf analysis is a good route to checking the soil nutrient supply especially for Boron and Phosphate.

Spring Management

Canopy Structure

From trials it has been shown that light interception is optimised at a green area index (GAI) of between 3 and 4, however the canopy structure of this crop is important for optimising photosynthetic rates. Different components of the plant have differing photosynthetic abilities, with the leaves being the most efficient dry matter producers and stems the least (Figure 6). It is therefore not just important to ensure that the GAI is between 3 and 4, but also that there is the correct leaf to stem ratio in order to make the most efficient use of the light that is intercepted.

Figure 6. Photosynthetic rate of OSR

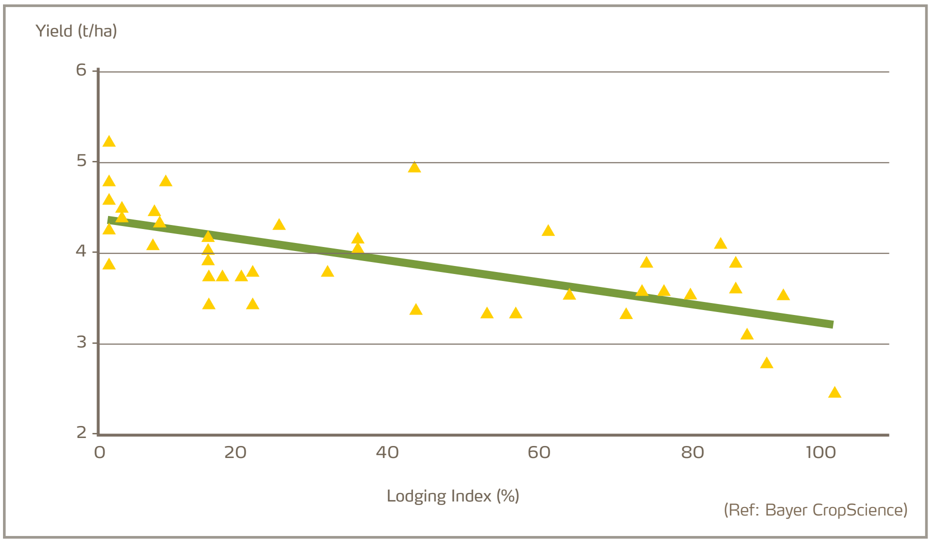


Dense Canopies

Where canopies are too dense, the number of leaves per plant is reduced and light penetration to the leaves and lower pods is poor. Around 80% of the sunlight at the critical point of photosynthesis can be reflected causing seeds in pods to abort. The first formed pods on the terminal raceme are those with the highest yield potential, however these are likely to abort where shading occurs, having a major impact on yield potential.

Dense canopies are also more likely to lodge as plants have thinner, weaker stems. Lodging can have a severe impact on yield, with losses of up to 30% possible (Figure 7).

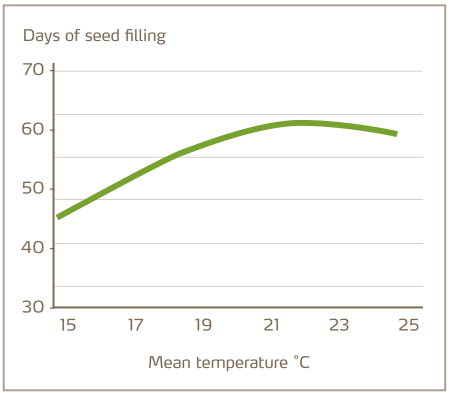
Figure 7. Impact of lodging on OSR



Seed Fill

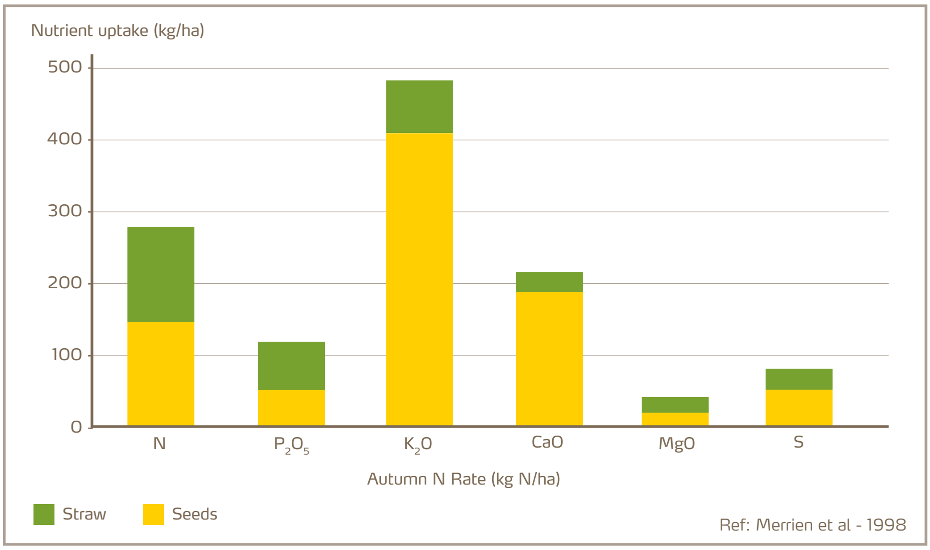
Seed fill begins to occur from mid-flowering onwards, with cool bright conditions being favourable. Higher temperatures at this time are likely to reduce the number of days of seed fill, with 750 day degrees the optimum. Leaf retention and green area duration are critical during this period as there is limited relocation of dry matter from the stems after mid-flowering.

Figure 8. Effect of temperature on duration of seed filling



Spring Nutrient Requirements

Figure 9. Total Uptake of Macronutrients of Oilseed Rape



Nitrogen Management

The spring nitrogen management should aim for the two important development phases, stem extension and the flowering period. The stem extension timing helps to build the canopy (Green Area Index), whilst the flowering timing increases the canopy duration (Green Area Duration).

The stem extension and flowering nitrogen management strategy for oilseed crops should contain three elements:

- The optimum application rate.
- The optimum nitrogen source.
- The optimum timing.

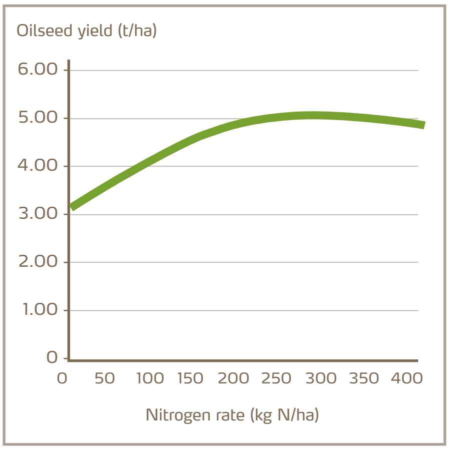
Yara's continued research programme focuses on all these areas helping to develop robust and reliable recommendations.

Spring Stem Extension Nitrogen

The Optimum Rate

It is essential to develop a canopy with a Green Area Index of 4 that will be the foundation for maximum yield. The spring application of nitrogen will be the main determinant of the size and structure of the canopy. Dose response trials since the late 1990's have shown that varieties continue to require approximately 190 – 220 kgN/ha applied during the months of February, March and April (Figure 10).

Figure 10. Nitrogen dose response trials (Yara, 2007-2014)



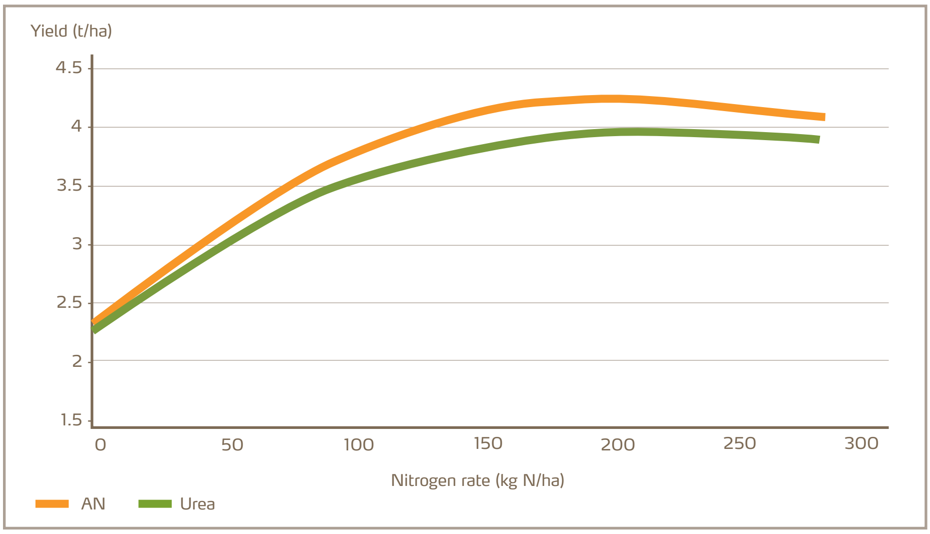
The Optimum Nitrogen Source

Having established the optimum nitrogen rate it is important to select the most efficient form of nitrogen to apply. The options are urea or nitrate based fertilizers. Trials throughout the 1990's have concluded that nitrate based fertilizer is the most efficient form giving higher yield than the urea alternative (Figure 11).

The Optimum Timing

The timing of the stem extension applications needs to start with an application in February of typically 60-80 kg N/ha. The rate of the following application(s) will depend on the canopy development with more being applied to crops with a low GAI (e.g. <1.5).

Figure 11. Effect of nitrogen source on OSR yield (1994-2014)



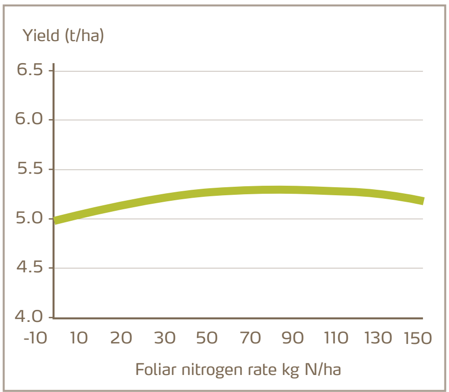
Flowering Application of Nitrogen

The application of nitrogen to increase Green Area Duration is a recent strategy developed in Yara trials to improve the output of the oilseed crop. Again the key components of rate, source and timing need to be considered. This application has also been shown to be independent of the spring stem extension application of nitrogen.

The Optimum Rate

Research since 2004 has shown that the optimum rate for this timing needs to be approximately 40-60 kgN/ha. Whilst lower rates have given a yield response, the higher rates have had the greatest impact on output.

Figure 12. Dose response to flowering nitrogen (Yara, 2007-10)



The Optimum Nitrogen Source

Limited data is available on the different sources of nitrogen, but the experience in Yara's R & D has been that this is a function of weather at the time of application. If dry conditions prevail then foliar applications of Nufol have given the most consistent results, with solid Extran fertilizer applications being effective when rainfall is expected. Due to the size of the canopy an application with a sprayer is normally more practical than using a spreader.

The Optimum Timing

Trials to date have so far been non-conclusive as to which timing is most effective. If the choice is to use solid fertilizer then practicality and the moisture requirement will dictate that this application is made at the beginning of flowering. If the choice is to use a liquid Nufol application, then the timing should be made to avoid covering petals with nitrogen that will drop to the ground rendering the fertilizer unavailable. This will therefore be at the end of flowering when the first pods are set.

A trial in 2006 that included a trace element mix with the application gave the largest yield response above the control plot where no flowering nitrogen was applied (Figure 17).

In 2008 Yara established a trial to look into the interactions between stem extension and flowering nitrogen by applying three flowering Nitrogen dressings (0, 50 & 100 kgN / ha) to three spring dressings (0, 100 & 300 kgN / ha). The aim of these three spring dressings was to provide a very underfertilized crop coming into flower, an underfertilized crop and an overfertilized crop.

Another Yara trial focusing on nitrogen dose response in OSR in the same field using the same variety showed the biological optimum nitrogen rate for that site to be around 250 kgN / ha, (therefore proving the 300 kgN /ha plot to be overfertilized).

The results of this trial showed that a response to flowering nitrogen was possible at all spring nitrogen rates, but the optimum rate to use was dependant on the spring dose (Figure 13). The underfertilized crops benefited from the higher flowering rates, showing better responses to the 100 kgN / ha application, however closer to the optimum N rate there was a benefit from the 50 kgN /ha, with a response of 0.78 t/ha in the over fertilized plot.

In 2010 a similar trial looked at an additional 50kg N/ha applied as Nufol at flowering on top of a range of spring nitrogen rates (figure 14). The results showed a similar response with a yield increase seen at all nitrogen rates, except the very high rates of 400kg N/ha.

HGCA trials in 2009-10 also showed similar responses at all spring nitrogen rates from an additional 40kg N/ha applied as Nufol at flowering, with an average of 0.25t/ha.

Figure 13. Response to flowering N in OSR (Yara, 2008)

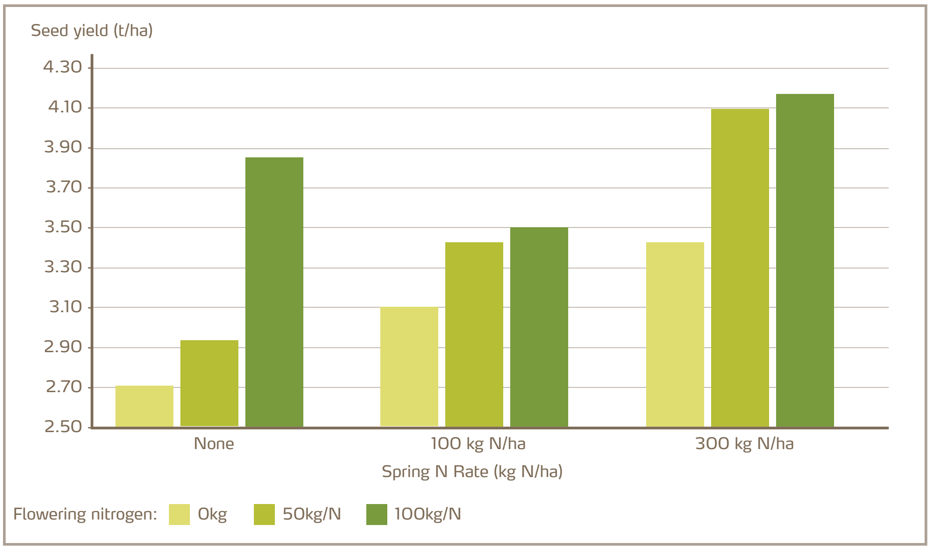


Figure 14. Yield responses to foliar N during flowering in OSR (Yara & ADAS, 2004-14)

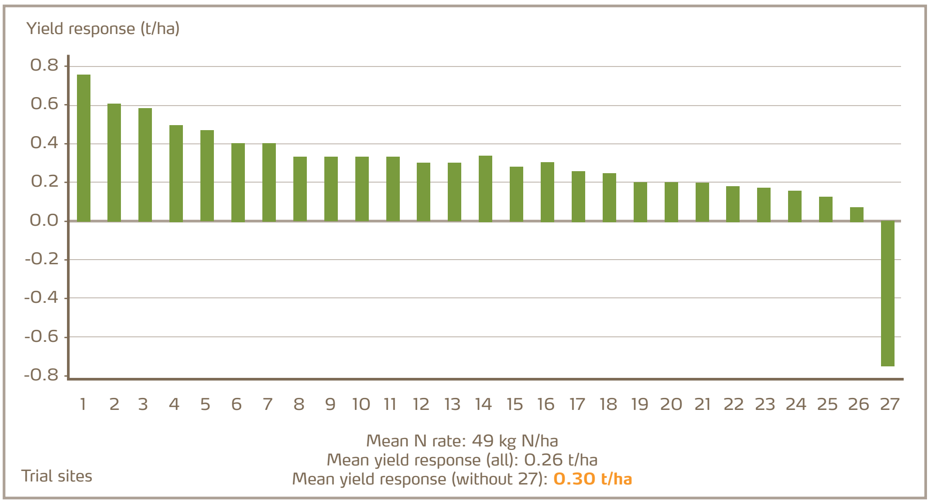


Table 3. Comparison of elemental sulphur applied in the autumn with ammonium sulphate applied in spring

	Control	Autumn Elemental Sulphur	Spring Ammonium Sulphate	LSD
Plant % S (March)	0.44	0.46	0.62a	0.04
Seed % S	0.39	0.40	0.44	0.06
OSR Yield (t/ha)	4.00	4.12	4.55a	0.37
OSR S Yield (kg/ha)	14.34	15.05	17.80a	2.25

a: Denotes a result which is statistically significant at 95% confidence interval

Sulphur Rates

In the late 1990s Yara carried out a number of trials looking at optimum rates of sulphur on different soil types. The results of these trials showed that similar optimum rates where required for crops growing on light soils to those growing on medium and heavy soils, however the response to sulphur was greater on the lighter soils. The optimum rate of sulphur for oilseed rape on all soil types is 75 – 100 kg/ha SO_3.

Sulphur Timing & Source

Sulphur is a very mobile nutrient within the soil, more so than nitrogen, therefore with the oilseed crop requiring relatively high amounts it is best not to apply the whole in one as the plant is unlikely to be able to utilise it all, with the remainder lost via leaching.

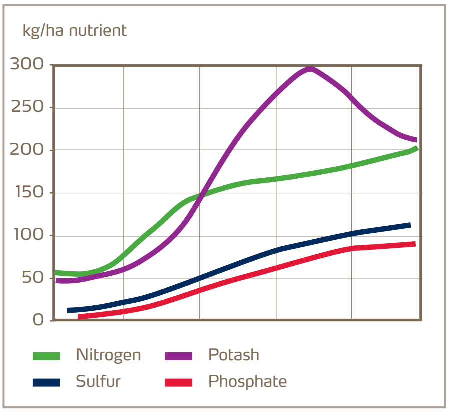
It is for this reason that Yara recommends applying ‘little and often’ at the nitrogen timings.

Yara has also compared applications of elemental sulphur in the autumn with applications of ammonium sulphate in the spring. The results of these trials showed conclusively the lack of effect the autumn applied elemental sulphur had on raising the sulphur levels of the leaves and seeds (see Table 3).

Potash

In spring, the oilseed rape goes through a period of rapid growth, during which the uptake requirements of several nutrients increases dramatically, especially potash. The demand for potash may be in excess of 12 kg/ha/day, with a total requirement of up to 300kg K_2O by the end of flowering for a 3t/ha crop. Where soil indices are low, or where root growth has been restricted (due to low phosphate availability / poor soil conditions) the plants may not be able to get hold of sufficient quantities of potash, therefore spring top dressing will help satisfy the large daily requirement (Figure 15).

Figure 15. OSR nutrient uptake graph



Phosphate

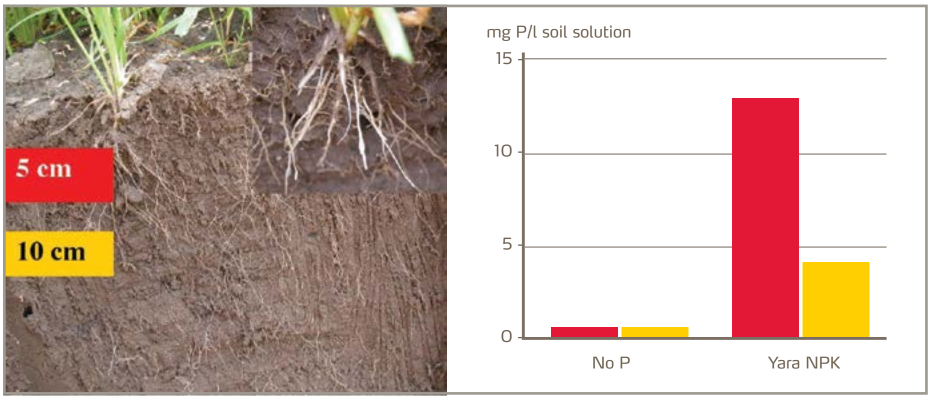
The demand for phosphate in the spring is not as great as that of potash, however it is still important that the crop is sufficiently supplied with phosphate due to its role in root development and hence the plants ability to extract nutrients from the soil.

Due to the very low mobility of phosphate in the soil, a lot of the nutrient in the soil will be unavailable to the plants whilst the rooting system is small. Fresh applications in the spring can help to supply plant available phosphate to the upper soil close to where the young roots are (Figure 16).

Traditional methods of managing phosphate and potash in arable crops have been very soil focussed, with less attention paid to the crop as to what and when its requirements are for these nutrients. Yara Crop Nutrition seeks to address this imbalance, bringing all of its unique strengths in Crop Knowledge, Product Combinations and In-field Expertise together to produce a robust and reliable programme of crop nutrition that delivers the key nutrients at a time when there is high crop demand.

The Yara Crop Nutrition Oilseeds programme combines spring NPK(S) compounds as the first top-dressing in spring, with the NS fertilizer Sulphur Plus for the later applications to provide the required sulphur rates.

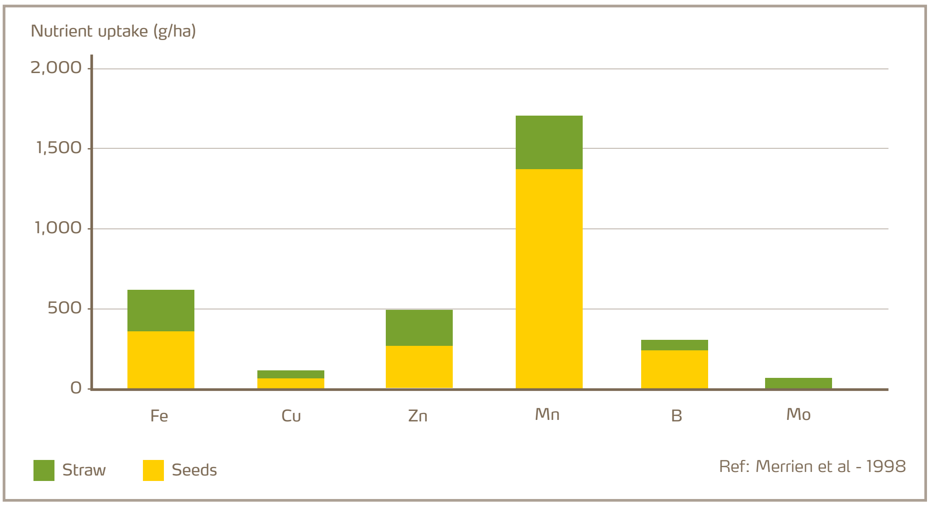
Figure 16. Phosphate in soil solution



Micronutrients

Micronutrients should not be overlooked in any crop programme as although they are not required in such large quantities as the major and secondary nutrients, they are vital to optimising the crops performance and therefore yield (Figure 17).

Figure 17. Total Uptake of Micronutrients of Oilseed Rape



In 1840, Justus von Liebig stated in the famous "Law of the Minimum" that crop growth is limited by the essential nutrient found in least supply. This still holds true today, with plants that are lacking in any major, secondary or minor nutrient less likely to reach their optimum yield (Figure 18).

For the oilseed crop, the trace elements of greatest importance are Boron, Manganese and Molybdenum. Even plants growing on soils containing sufficient quantities of these nutrients can suffer from deficiencies, as the plants struggle to get hold of enough. This may be due to their distribution within the soil relative to the roots, restrictions in root growth or due to their requirement at a time of the year when the plant is growing rapidly.

Transient deficiencies such as these may not appear to last very long, but can cause harm to the plant during critical growth phases. In these situations foliar applications of the appropriate nutrients may be required in order to avoid the potentially negative impacts.

YaraVita Brassitrel Pro is a unique flowable suspension concentrate combining significant quantities of Boron, Manganese, Magnesium and Molybdenum specifically designed for the oilseed crop. Recommendations are for up to 4l/ha at the 4-9 leaf stage and again at the onset of stem extension up to the start of flowering.

A field-scale trial carried out on behalf of Yara in 2006 showed the benefit of the addition of a YaraVita multinutrient product with Nufol at flowering. In this trial, all sources of foliar nitrogen increased the yield, with Nufol being the most effective. When a multinutrient product was included with the Nufol the yield increased by 0.78t/ha above the control (Figure 19).

Figure 18. A Deficiency of any Single Nutrient is Enough to Limit Yield

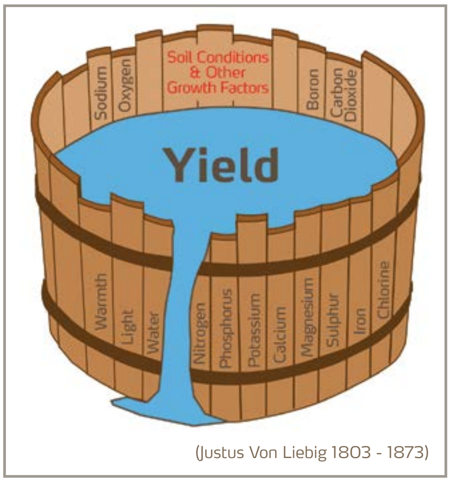
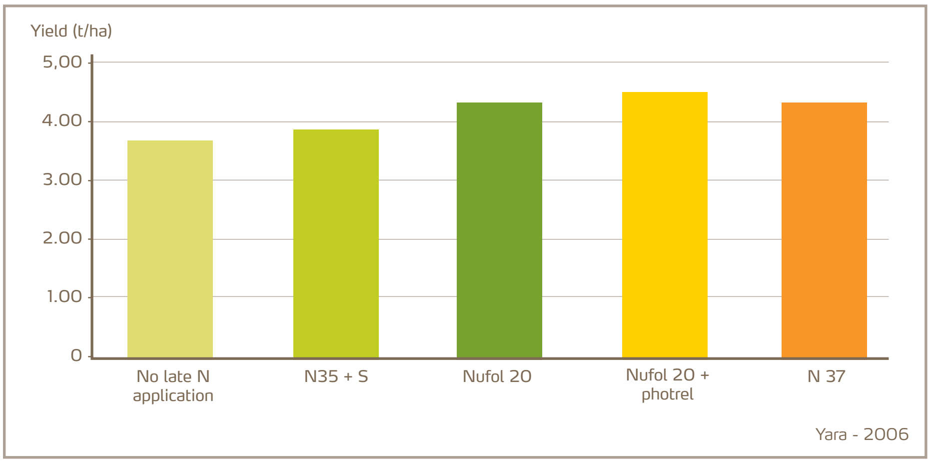


Figure 19. Effect of Flowering Nitrogen on OSR Yield



Crop Programme Solid Fertilizers

	Autumn	February	Spring	Stem extension	During flowering
YaraBela®	EXTRAN or CAN* **				
YaraVita®	Bortrac 150 up to 3 l/ha				
YaraVita®				BRASSITREL PRO up to 4 l/ha	
YaraMila®		ACTYVA S* **			
YaraBela®			SULPHUR PLUS or SULPHAN* **		
YaraBela®					EXTRAN* 120-180kg/ha

**** Alternative N+S or NPK+S grades are available as required***
***** Rate depending on SNS and N Plan recommendation***

Read label before application of any YaraVita product

Soil applied products
Foliar applied products

Crop Programme Liquid Fertilizers

	Autumn	February	Spring	Stem extension	During flowering
CHAFER™	**CHAFER 25-12.5-0 or CHAFER 18-27-0*** **				
YaraVita®	**Bortrac 150** up to 3 l/ha				
YaraVita®				**BRASSITREL PRO** up to 4 l/ha	
CHAFER™		**CHAFER 11-10-10+5%SO_3*** **			
CHAFER™			**CHAFER NURAM 32+S*** **		
CHAFER™					**CHAFER NUFOL** 200 l/ha

**** Alternative NP, N+S or NPK+S grades are available as requitred***
***** Rate depending on SNS and N Plan recommendation***

Read label before application of any YaraVita product

Soil applied products   Foliar applied products

Cost Benefits of Using Yara Fertilizers

Yara Crop Nutrition Winter Oilseeds

This data looks at the costs of the full Yara Crop Nutrition Programme compared with a traditional crop nutrition system, highlighting the cost of the two as well as the financial benefits possible through adopting the Yara Crop Nutrition system.

Current Yield	- tonnes / ha	**3.5**
Yara Target Yield	- tonnes / ha	**4.65**
Crop Value	- £ / tonne	**£260**

	Cost £/ha	N	P_2O_5	K_2O	SO_3	B	Mn	Ca	Mg	Cu	Zn	Mo
Yara Crop Nutrition Programme	358.98	258	80	80	82	360	420	534	420	0	0	24
Traditional Programme	212.00	207	48	48	0	0	0	0	0	0	0	0
Yara Crop Nutrition Cost £/ha	146.98											
Break even Yield Increase t/ha	0.57											

Benefits of Yara Crop Nutrition	t/ha	Value £/ha
Yield response to extra autumn N	0.15	£39.00
Value of spring phosphate	0.22	£57.20
Value of spring potash	0.20	£52.00
Response to Brassitrel Pro	0.17	£44.20
Response to Yara Chafer Nufol	0.26	£67.60
Response to the Yara N-Sensor	0.14	£14.40
Response to a uniform NPK vs a blend	0.15	£39.00
Total Yara value Proposition	1.14	£274.40
Yara Crop Nutrition return on investments / £ investment	**£1.87**	

The values shown as benefits of the Yara Crop Nutrition Programme are calculated using average yield increases from trials conducted by Yara.

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About Yara

Yara's knowledge, products and solutions grow farmers and industrial customers' businesses profitably and responsibly, while nurturing and protecting the earth's resources, food and environment.

Our fertilizers, crop nutrition programmes and technologies increase yields, improve produce quality, and reduce environmental impact from agricultural practices. Our industrial and environmental solutions reduce emissions and improve air quality from industry and transportation, and serve as key ingredients in the production of a wide range of goods.

Founded in 1905 to solve emerging famine in Europe, Yara today has a global presence with more than 12,000 employees and sales to more than 150 countries. **www.yara.com**

YARA

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