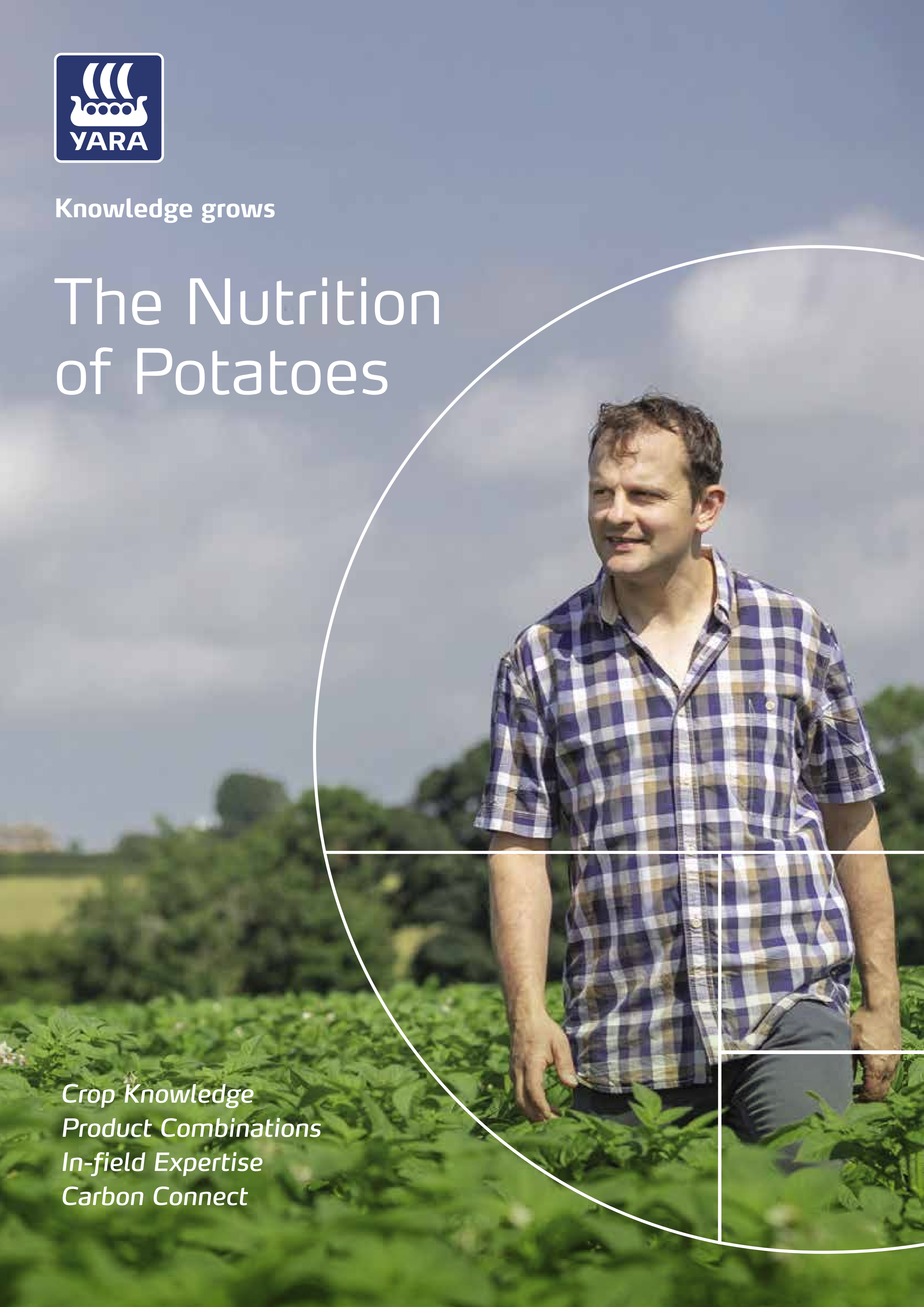
Knowledge grows

# The Nutrition of Potatoes



*Crop Knowledge*
*Product Combinations*
*In-field Expertise*
*Carbon Connect*

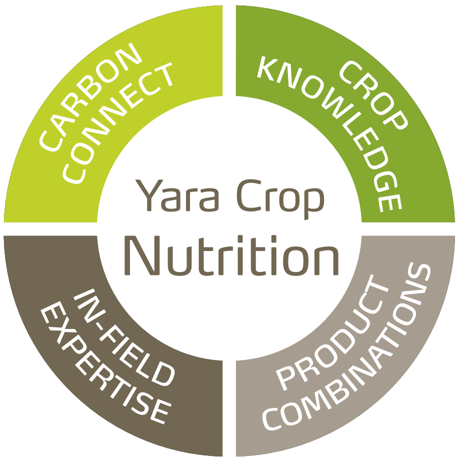
# The Nutrition of Potato Crops

## Crop Knowledge
The interpretation and application of long term research trials data into robust and reliable crop nutrition programmes.

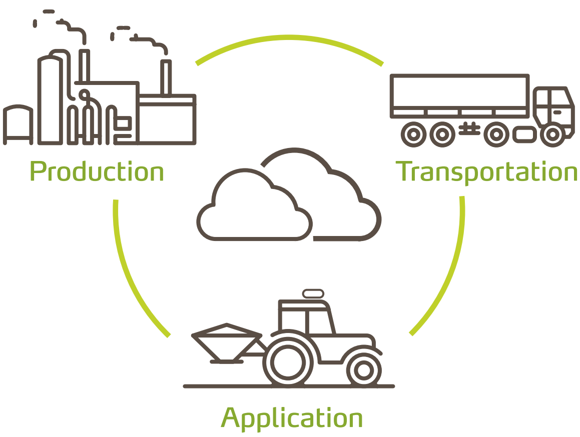
## Product Combinations
Utilising Yara's range of products to provide a complete programme to meet the plant nutrient demand

## In-field Expertise
Yara has developed a range of decision making tools and analytical services that enable nutrient recommendations to be fine tuned to field specific conditions.

## Carbon Connect
Yara's fertiliser is fully traceable, from factory to farm. Through advanced technologies production of Yara fertiliser has reduced $N_2O$ reductions, by up to 90%. With continued R&D and the use of renewable energy sources, Yara are leading the way when it comes to the production of fossil free fertiliser.




**Carbon life cycle of nitrogen fertilizer**




## Crop Characteristics

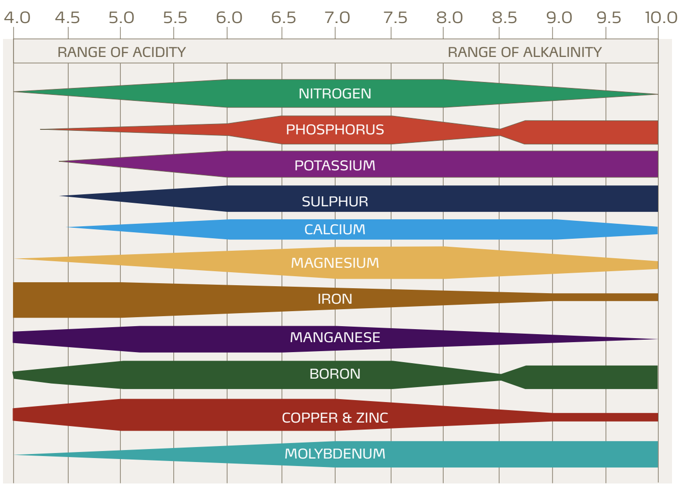
Potatoes produce a fibrous root system that is at best no more than 60cm long. As a result, potatoes are often unable to exploit nutrients and soil moisture at depth within a soil profile.

Potatoes are grown on a range of soils varying from sands to clay loams, all with different water holding capacities. An ideal potato soil is well structured, with good drainage to allow proper root aeration and tuber development with minimal root disease infestation. Potatoes prefer soils with a pH of 5.5 to 7.0 and low salinity. However, in practice potatoes are grown in soil pH's from 4.5 to 8.5 and this has a distinct impact on the availability of certain nutrients (Figure 1).

At lower pH values potatoes can suffer from aluminium and other heavy metal ion toxicity, as well as restricted P or Mo availability.

At pH values above 7.5, nutrient availability, in particular of phosphorus and the micronutrients, can be reduced, even though high total amounts of these elements may be present in the soil. Liming can ameliorate undesirable, low pH values although care must be taken to ensure that the lime is applied at least 6 months before the potatoes are to be planted. Potatoes are more prone to common scab when grown in high pH soils.

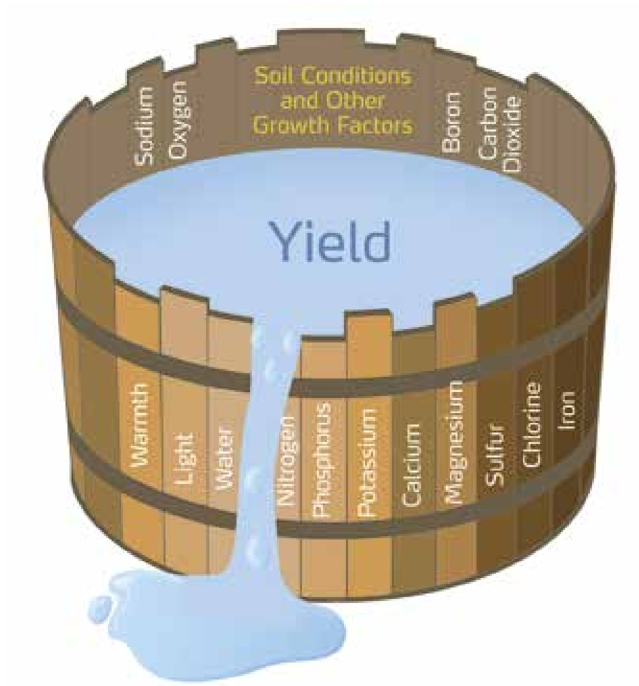
Figure 1. Soil pH has a direct influence on nutrient availability




## Analysis

As well as being important within their own right, most nutrients have the role of ensuring that the most is made of any nitrogen applied.

*This is illustrated by Leigbig's barrel – The Law of the Minimum.*




Typically nitrogen is the most limiting factor, but shortages of any other nutrient will limit yield and limit the benefit of nitrogen applied.

The starting point for identifying any nutritional limitations is soil analysis. This can help to show the levels of each nutrient that are held in the soil. This isn't however the full picture as there are many other factors that can affect the amount of any nutrient that the crop is able to get hold of. Dry soil conditions in particular can dramatically reduce the availability of a nutrient to the crop, but also soil structure, rooting and the interactions between nutrients can all have a bearing.

# Petiole Analysis

## Interpretation of potato petiole analysis

Independent research has demonstrated the particular importance of phosphorus for tuber bulking. The longer the phosphorus level in the crop is maintained at a high level, the greater the yield potential. Yield potential is increased by around 0.5 t/ha for each extra day that the phosphorus level in the petiole is kept above 0.22%. However the level of phosphorus in the petiole peaks at tuber initiation and then declines as the season progresses. In northern European conditions the phosphorus level normally arrives at 0.22% around 100 to 110 days after planting. Any “premature deficiency” incurs a yield penalty of 0.5 tonne per hectare per day.

## Predicting the $P_2O_5$ requirement

If prediction of the $P_2O_5$ requirement can be made early in the season then the 0.5 tonnes per hectare per day through the bulking phase can be saved - or gained. Yara has the answer in its petiole analysis databank and range of effective foliar phosphates.

## Megalab potato petiole programme

Since 1993 Lancrop Laboratories have been analysing petiole samples from UK potato crops and our database currently stands at many thousands of samples and continues to rise. Biometric analysis of results allows us to establish phosphorus values early in the season which are equivalent to the critical figure of 0.22% at 100 days after planting (shown by the red line in Figure 2).

The Yara petiole Megalab system is therefore much more PROACTIVE because when a petiole sample is analysed we are asking the question “Will this crop make it to 100 days after planting before the phosphorus level drops below 0.22%?”. Another benefit is that normally only one sample per season is needed, however, if extremes of weather occur, a further petiole sample 3-4 weeks later will highlight any adverse trends.

## Other nutrients

Similar trends exist for the other important nutrients for the potato crop. So using Megalab means that yield potential is not limited by reduced levels of major, secondary or micro nutrients.

## Sampling instructions for potato petiole analysis

Choose the youngest fully expanded leaf (usually 4th) at a stage no earlier than 10% flowering. For each complete leaf, separate the leaflets from the petiole and discard the leaflets as soon as possible after sampling. Keep samples in a cool dark place and send to the lab as soon as possible.

## Sampling pattern

Draw from at least 20 different locations in the field. At each location take one leaf branch from each of 3-4 plants (minimum of 60-80 branches in total remembering to strip the leaves from the petiole). Do not sample fields within 3-5 days after being sprayed with pesticides or foliar nutrients.

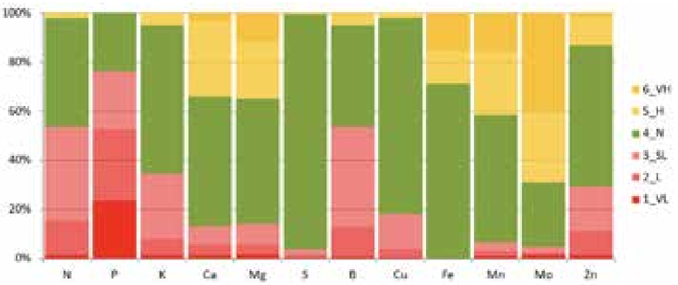
Nutrition is also important for plant health, improving resistance or tolerance to disease. Shortages in any nutrient (particularly potassium, calcium, boron, manganese, copper or zinc) could lead to an increase in disease levels, which if not controlled effectively through fungicides can also decrease the yield response from nitrogen.

## Tissue Sampling

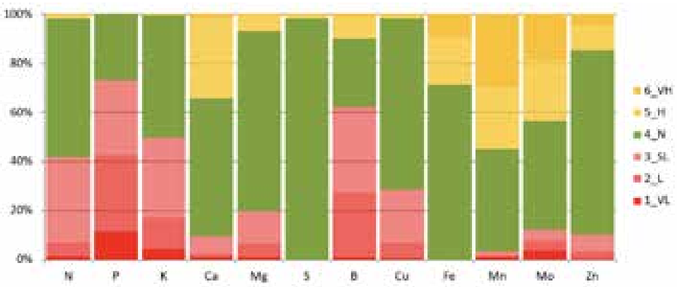
Broad spectrum tissue sampling is also a good indicator of phosphate levels, as as well as other nutrients - particularly the key micronutrients mentioned above. When taking a tissue sample the same sampling pattern can be used as for the petiole test but the youngest fully expanded leaves should be taken as the sample, not the whole leaf branch. You will get results showing the levels required for each nutrient and whether your sample was sufficient or deficient using a colour-coded system, then enabling you to correct any deficiencies with applications.

Figure 2. Difference in deficiency levels from potato leaf analysis

2017




2022



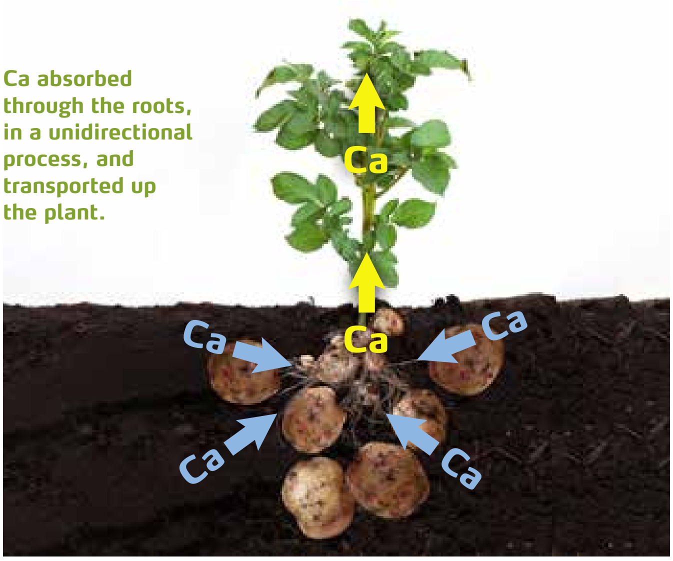
# Are your potatoes getting enough Calcium?

Nutrition is also important for plant health, improving resistance or tolerance to disease. Shortages in any nutrient (particularly potassium, calcium, boron, manganese, copper or zinc) could lead to an increase in disease levels, which if not controlled effectively through fungicides can also decrease the yield response from nitrogen.

Calcium is a vital nutrient for high quality potatoes:

- Calcium is required for maintenance of cell walls and healthy leaf and tuber development
- Calcium reaches developing tubers directly from stolon roots and absorption through the tuber skin
- Calcium is not redistributed from the leaves to the tubers
- Tuber uptake relies upon having a readily available source of calcium in the soil surrounding the developing tubers

## Figure 3. Calcium uptake and movement




## Figure 4. Internal Rust Spot

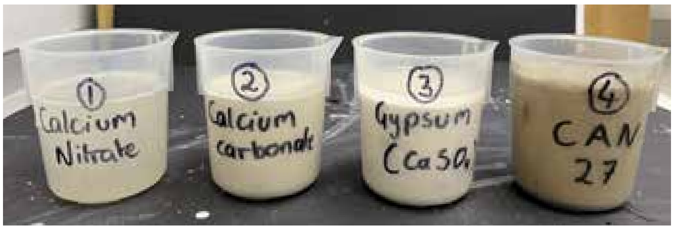
a recognised calcium deficiency disorder.

## Figure 5. Improve skin finish

addition of calcium promotes strong cell walls.

## Figure 6. Resist bacterial soft rot invasion

improve tuber cell wall calcium pectate content.

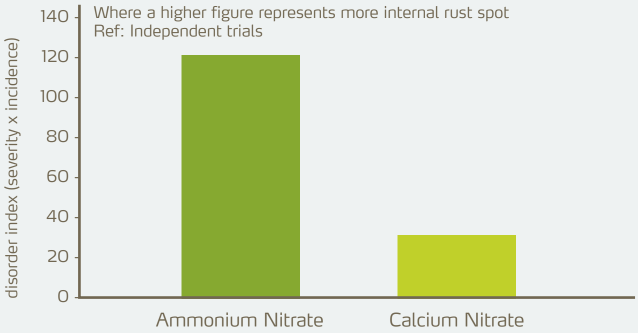



## Solubility of Calcium Nitrate vs Calcium Carbonate

When applying calcium, a soluble plant available form is necessary to ensure plants can uptake the calcium provided. In the picture, 1kg Tropicote dissolves in 1 litre of water, were as it takes 66,000 litres to dissolve 1kg of calcium carbonate.

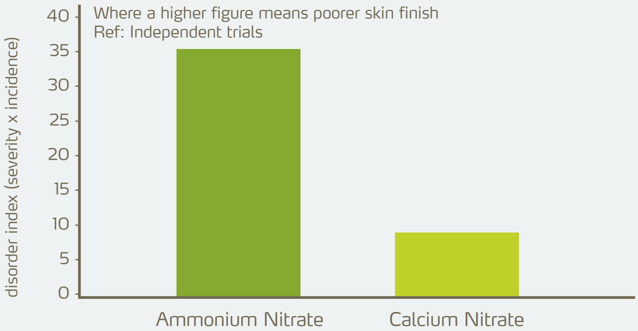
### Figure 7a. **YaraLiva™** TROPICOTE

can help reduce Internal Rust Spot



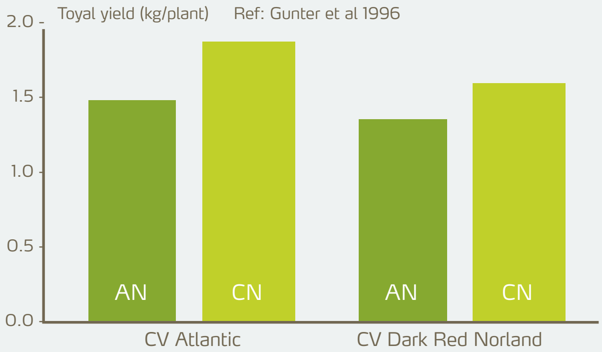

### Figure 7b. **YaraLiva™** TROPICOTE

improves skin finish




### Figure 7c. **YaraLiva™** TROPICOTE

produces seed potato tubers with greater yield and vigour potential




## Benefits of **YaraLiva™** TROPICOTE

- Suppression of internal rust spot
- Improved skin finish
- Suppression of soft rots in store
- Helps stress relief (heat)
- Reduced incidence of bruising
- All nitrate nitrogen
- Improved fry colour in crisping varieties
- Healthier seed crop

## Recommendations

Apply 60 - 70% of the recommended nitrogen requirement in the base dressing.

Top-dress the remainder as YaraLiva Tropicote™ at tuber initiation 3 - 4 bags/ac (375 - 500 kg/ha).

Applying a minimum of 400 kg product/ha provides over 100 kg/ha of readily available calcium (CaO).

# Application Accuracy

## YaraMila™ Compounds

The Yara brand sets the standard in fertilizer quality. The aim is to provide consistency from bag to bag and from year to year. The majority of Yara's NPK grade range of products are true uniform compounds where all the nutrients are contained in each granule or prill which assures accurate spreading of nutrients. For easy identification, these grades are clearly branded YaraMila™ followed by the brand name and analysis.

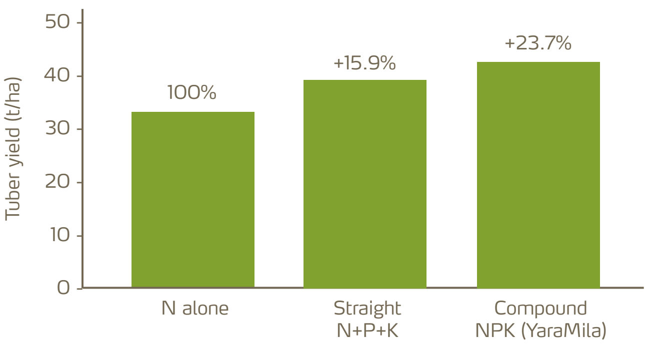
All Yara products are formulated to the declaration and the analysis is guaranteed, giving confidence that "What is on the bag is in the bag". On occasions Yara may blend some products. Yara's high quality blends are produced with size and moisture matched components to give good spreading characteristics.

All YaraMila™ grades are produced in Yara factories which have installed Yara's developed $N_2O$ catalytic abatement technology - reducing our emissions by 90% - with further reductions targeted. They have a guaranteed carbon footprint < 4 kg $CO_2$-eqv / kg N. This in conjunction with our in-field advice means using Yara's nitrate based fertilizers can reduce the fertilizer carbon footprint by ~ 50% (taking account of the life cycle approach (LCA) to their use).

Uniform application and distribution of nutrients is one of the key benefits of using a true uniform compound fertiliser, as found in the YaraMila range, providing better access for the plant roots to all nutrients. Every prill or granule contains all the stated nutrients, ensuring a balanced supply.

Since 1989, the Yara Research Centre at Hanninghof has been running a long term trial with a cereal-potato crop rotation. Results from nine potato harvests show the highest yield response with a YaraMila grade in all years. With N, P and K applied as straights, yield increased on average by 15.9%, and with YaraMila the yield increase was 23.7% (Fig. 8).

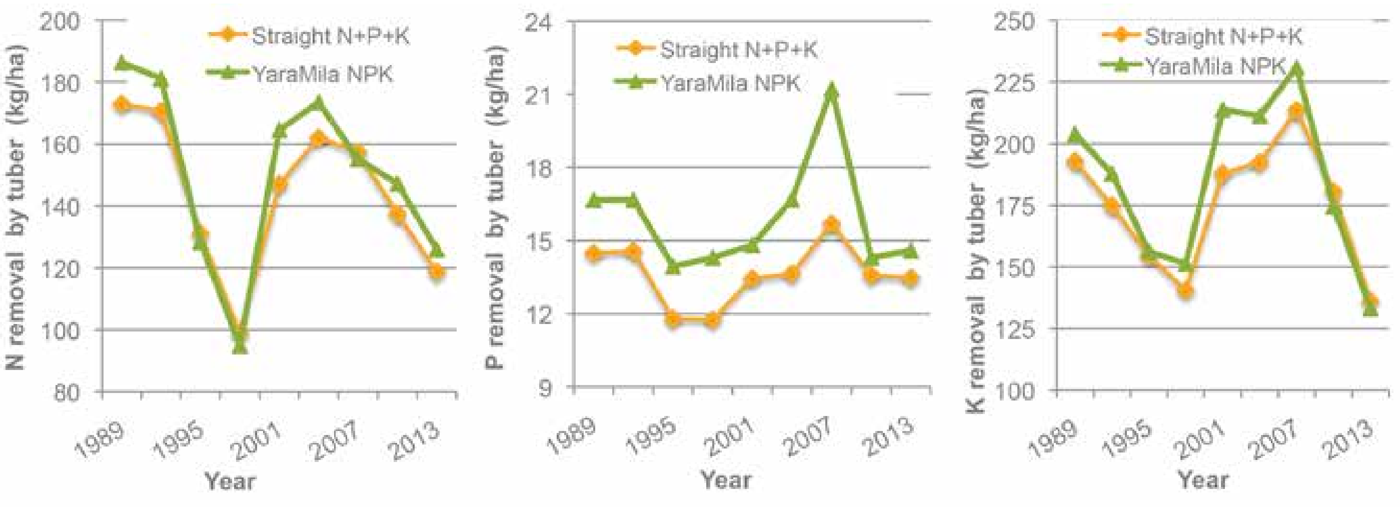
Figure 8. Average yield of potatoes (n = 9 years)




These results showed an increase in the nutrient uptake from the YaraMila grade compared to the application of straights, particularly for phosphate, which is potentially where a large proportion of the yield response came from.

# Unlocking the Maximum Yield Potential

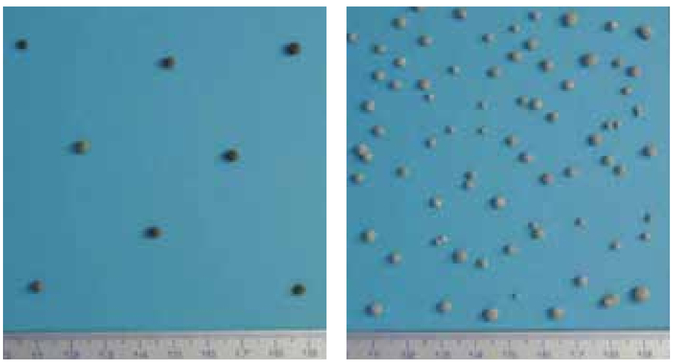
Figure 9. Nutrient removal of potato is higher with YaraMila compared to straight N, P and K (Yara field trial)




When applying the same amount of phosphate with a YaraMila grade and TSP, the required application rates of TSP are lower and there are fewer granules (landing sites) in every square metre (Fig. 9). As crops can only take up phosphate from soil solution close (within 1-2mm) to the roots this makes it more difficult for them to get hold of phosphate from TSP, as they have to grow a longer distance. This is particularly important in potato crops where the rooting is shallow and the demand for phosphate high.

The combination of water- and citrate-soluble P-forms in YaraMila grades provides a longer lasting supply of available P (Fig. 11). This is especially important for potato as it shows a strong response to P application and benefits from a constant supply of available P (Fig 12).

Figure 10. When applying an equal amount of P, YaraMila provides a better P distribution than TSP.



TSP 100 kg/ha $P_2O_5$ = 22.2 G/M²

YaraMila 20-7-10 100 kg/ha $P_2O_5$ = 142.8 G/M²

Figure 11. Di-calcium phosphate (DCP), the citrate soluble P fraction of YaraMila, dissolves at a constant rate providing a sustained supply of plant available P. DCP is not absorbed by Fe- and Al-hydroxides and thus protected from fixation.

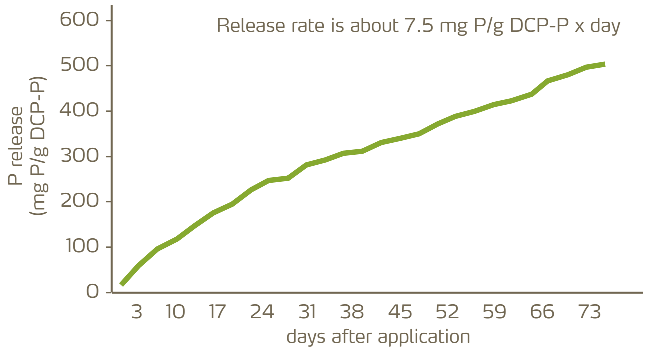
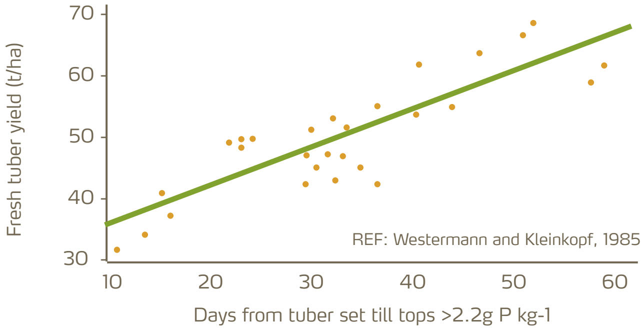



Figure 12. Keeping the leaf P content high during bulking has a positive impact on yield. Tuber yield is increased by 0.5 t/ha for each day leaf tissue P content is maintained above 0.22%.
USA - Russet Burbank (Westermann and Kleinkopf, 1985)

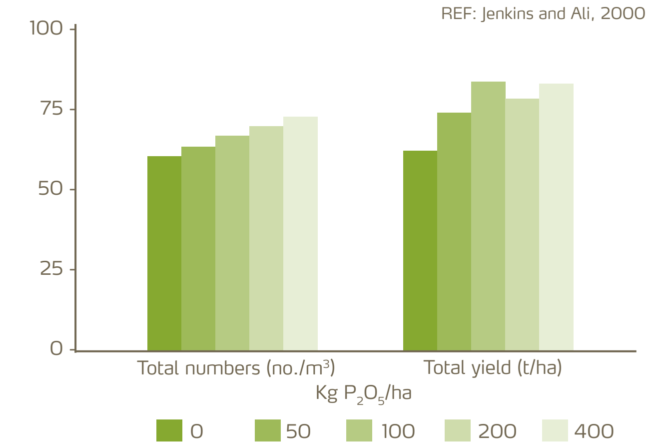



## Increasing Potato Tuber Numbers

The numbers of potato tubers produced by each potato plant is influenced by agronomy and varietal potential. A large number of tubers per hectare will produce a crop of predominately small tubers, ideal for canning, salad or seed potatoes. A relatively low tuber number provides less competition per unit area and allows the crop's energies and resources to be used to produce larger potatoes for the fresh or processing markets.

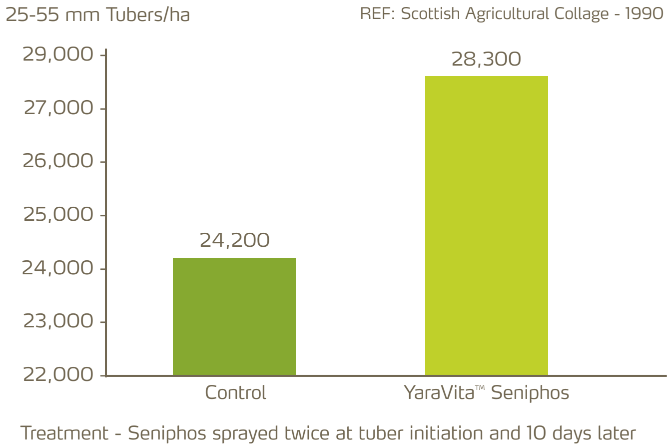
Phosphate availability at tuber initiation is important to ensure maximum tuber set, especially if tuber numbers need to be increased for certain varieties, or where the market demands a large number of smaller tubers (e.g. seed production).

Figure 13. Phosphorus and yield
Wales - Desiree




Study from Wales showing the effect of phosphorus on increasing total tuber numbers and overall yield.

Figure 14. Foliar Phosphorus - Effect on tuber number
Scotland - Estima




Study from Scotland showing the effect of foliar phosphorus on increasing total tuber numbers.

Because phosphorus is relatively immobile in the soil it is important that fertilizer –P is placed close to the tuber, banding the fertilizer usually works better than broadcasting, especially on soils with the potential for very high phosphorus lock-up.

While potatoes are very responsive to fresh phosphate, the economic optimum rate is often difficult to define. Rates will depend on soil type and soil test results. Where sufficient soil phosphate is not available for growth, foliar phosphate ensures rapid availability.

**YaraVita™ MAGPHOS K**

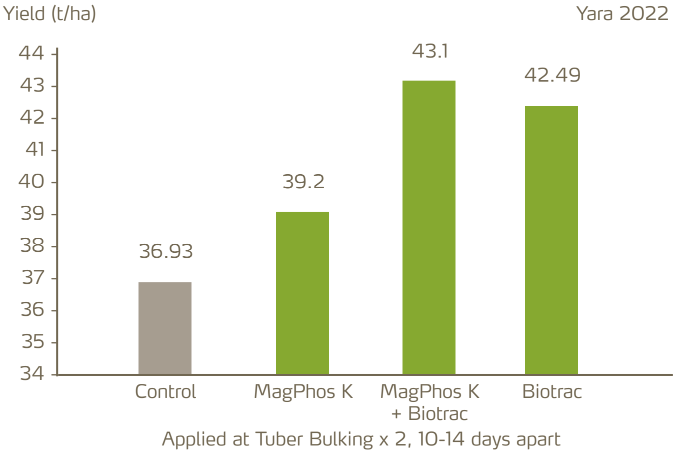
To increase tuber number, 10 l/ha at tuber initiation (when 50% of the tip swellings are twice the diameter of the rest of the stolon).

## Increasing Potato Tuber Size

Tuber size and uniformity is critical for every market, whether it is fresh potatoes, seed or processing crops. Anything that the grower can do to prolong a healthy leaf canopy will increase the average tuber size.

Foliar phosphate, applied after tuber initiation, increases tuber size and so increases tuber yields. However, foliar phosphate is not a substitute for soil applied phosphate and without adequate soil phosphate early season growth is sub-optimal.

Figure 15. Effect of MagPhos K, MagPhos K + Biotrac and Biotrac, on marketable yield.




These trials conducted independently in England show a consistent yield increase from applications of foliar phosphate after tuber initiation resulting in an increase in tuber size and so overall yield.

### YaraVita™ MAGPHOS K

To increase tuber size a minimum of 2 applications of 5 l/ha during tuber bulking (as soon as first formed tubers are 10 mm in diameter). Allow 10-14 days between applications. Water rate: 200 l/ha.

Foliar phosphorus application promotes root development. Plant on left received a typical YaraVita “phos” input (10 l/ha MagPhos K) a few weeks before these pictures were taken. Note the increase in root density which will help nutrient uptake from the soil

### YaraVita™ BIOTRAC

To enhance tolerance to abiotic stresses, extreme temperatures or drought, 2-3 litres applied at vegetative growth, tuber initiation and early tuber bulking. Water rate: 200l/ha.

Untreated

Biotrac x 2

BIOTRAC contains bioactive compounds and nutrients that are involved in various mechanisms of the plant. UK trials have shown YaraVita BIOTRAC increased both tuber numbers and tuber weight, resulting in a higher market value. A return on investment of 4:1, or 158kg of additional yield is needed to cover the cost of BIOTRAC.

# Zinc

Zinc acts as a binding agent in enzyme reactions and protects proteins from denaturation. Therefore, it plays a role in nitrogen metabolism. Yield effects of zinc application can be expected on soils low in zinc and with a high or low soil pH.

Zinc deficiency shows in younger leaves as interveinal chlorosis and necrosis which occurs in irregular patches. Whitish spots develop within the brown necrotic tissue. Symptoms may also start on older leaves. Deficiency is made worse by organic and high pH soils. Soils rich in phosphorus or those receiving high phosphorus application can also induce zinc deficiency, as can cold wet conditions.

Zinc is used to suppress powdery scab, but only soil applications provide sufficient zinc to have an effect on powdery scab.

Figure 16. Effect on yield - Effect of Zinc on total yield (t/ha) of potatoes, 2014

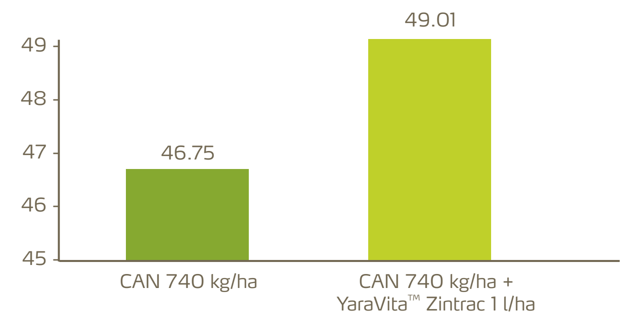
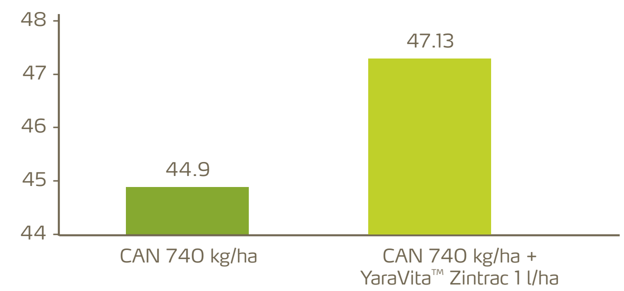



Figure 17. Effect on marketable yield - Effect of Zinc on marketable yield (t/ha) of potatoes, 2014




# Solid Fertiliser Crop Programmes

Knowledge grows

## Potato Crop Nutrition
## Seed Potatoes
## Solid Fertiliser Programme

| | Pre-Planting | Planting | Vegetative Growth | Tuber Initiation | Early Tuber Bulking | Maturity |
|---|---|---|---|---|---|---|
| YaraMila™ | | ACTYVA S * 525 - 650 kg/ha<br>COMPLEX * 700 - 875 kg/ha<br>MAINCROP * 600 - 750 kg/ha | | | | |
| YaraLiva™ | | | | TROPICOTE 200 - 300 kg/ha | | |
| YaraVita™ | | | MAGFLO 300 4 l/ha<br>MANTRAC PRO 1 l/ha | MAGPHOS K - for tuber numbers 10 l/ha | | |
| Analytical Tools | Broad Spec Soil Analysis - to identify limiting nutrients | | Petiole and Tissue Analysis - to identify limiting nutrients | N-Sensor - to variably apply nitrogen and increase N use efficiency (if applying a top dressing) | | N-Sensor - for desiccation |

*Read label before application of any YaraVita product*

* Alternative products are available, depending on P&K requirements

Soil applied products | Foliar applied products | Analytical tools

Knowledge grows

## Potato Crop Nutrition
## Early Potatoes
## Solid Fertiliser Programme

| | Pre-Planting | Planting | Vegetative Growth | Tuber Initiation | Early Tuber Bulking | Maturity |
|---|---|---|---|---|---|---|
| YaraMila™ | | ACTYVA S * 750 kg/ha<br>COMPLEX * 1000 kg/ha<br>MAINCROP * 850 kg/ha | | | | |
| YaraLiva™ | | | | TROPICOTE 300 - 400 kg/ha | | |
| YaraVita™ | | | MAGFLO 300 4 l/ha<br>MANTRAC PRO 1 l/ha | MAGPHOS K - for tuber numbers 10 l/ha | MAGPHOS K - for tuber size 2 x 5 l/ha | |
| Analytical Tools | Broad Spec Soil Analysis to identify limiting nutrients | | Petiole and Tissue Analysis - to identify limiting nutrients | N-Sensor - to variably apply nitrogen and increase N use efficiency (if applying a top dressing) | | N-Sensor - for desiccation |

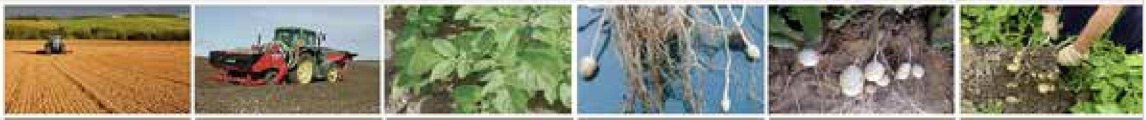
*Read label before application of any YaraVita product*

* Alternative products are available, depending on P&K requirements

Soil applied products | Foliar applied products | Analytical tools

Knowledge grows

# Potato Crop Nutrition
## Maincrop Potatoes
## Solid Fertiliser Programme



| | Pre-Planting | Planting | Vegetative Growth | Tuber Initiation | Early Tuber Bulking | Maturity |
|---|---|---|---|---|---|---|
| YaraMila™ | | MAINCROP * 850 - 1100 kg/ha<br>ACTYVA S * 750 - 1000 kg/ha<br>COMPLEX * 1000 - 1250 kg/ha | | | | |
| YaraLiva™ | | | | TROPICOTE 375-500 kg/ha | | |
| YaraVita™ | | | MAGFLO 300 4 l/ha<br>MANTRAC PRO 1 l/ha | MAGPHOS K - for tuber numbers 10 l/ha | MAGPHOS K - for tuber size 2 x 5 l/ha | CROPLIFT PRO 5 kg/ha ** |
| Analytical Tools | Broad Spec Soil Analysis - to identify limiting nutrients | | Petiole and Tissue Analysis - to identify limiting nutrients | N-Sensor - to variably apply nitrogen and increase N use efficiency (if applying a top dressing) | | N-Sensor - for desiccation<br>N-Tester - to monitor N status of canopy |

*Read label before application of any YaraVita product*

* Alternative products are available, depending on P&K requirements
** Rate depends on N-Tester

Soil applied products | Foliar applied products | Analytical tools

## Yara's Potato Range of Products


12-11-18+ 20%$SO_3$


16-15-15 +6.5%$SO_3$


14-14-21


15.5%N +26.3%Ca

# YaraVita™

## Magflo 300

2-4 l/ha 1 week after 100% emergence and following petiole analysis during tuber bulking. For moderate to severe deficiency, repeat applications at 10-14 day intervals.

## Mantrac Pro

1 l/ha 1 week after 100% emergence. For moderate to severe deficiency, repeat applications may be necessary at 10-14 day intervals. A further application may be made following petiole analysis, during tuber bulking. Water rate: 200 l/ha.

## Magphos K

To increase tuber number, 10 l/ha at tuber initiation (when 50% of the tip swellings are twice the diameter of the rest of the stolon). To increase tuber size a minimum of 2 applications of 5 l/ha or 1 to 2 applications of 10 l/ha during tuber bulking (as soon as first formed tubers are 10 mm in diameter). Allow 10-14 days between applications. Water rate: 200 l/ha


## Croplift Pro

2.5 to 5 kg/ha. Repeat at 10 to 14 day intervals as necessary.
Water rate: 200 l/ha.

## Biotrac

2-3 l/ha 3-4 applications applied 7 to 14 days after 100 percent emergence. Water rate: 200 l/ha minimum.

## Zintrac 700

1 l/ha one week after 100% emergence. For moderate to severe deficiency, repeat applications may be necessary at 10 to 14 day intervals. Also, 1 l/ha following petiole analysis, during tuber bulking. Water rate: 200 l/ha.

## Bortrac 150

One application of 1 to 2 l/ha applied one week after 100% emergence. A second application may be made 10 to 14 days later. A further application may be made following petiole analysis, during tuber bulking. Water rate: 200 l/ha.

## Stopit

2 to 3 applications of 5 to 10 l/ha commencing at tuber initiation (when 50% of the tip swellings are twice the diameter of the rest of the stolon) with 10 to 14 day intervals between applications. Water rate: 200 l/ha.

## Safe N 300

10 to 20 l/ha before tuber set and at onset of flowering. Also, apply 10 to 20 l/ha, if required, following petiole analysis. Water rate: 100 to 200 l/ha.

## Foliar Potash

10 to 20 l/ha before tuber set and at onset of flowering. Also, apply 10 to 20 l/ha, if required, following petiole analysis. Water rate: 100 to 200 l/ha.

## Seniphos

Apply Seniphos at 15 l/ha in 200 litres of water, at the onset of tuber initiation. The application may be repeated at bulking, using 5 l/ha in 200 litres of water repeated at 2-3 week intervals.

## Coptrel 500

0.5 l/ha applied 7 to 14 days after 100% emergence and following petiole analysis during tuber bulking.
Water rate: 200 l/ha.

## Mancozin

1 l/ha at one week after 100% emergence and following petiole analysis during tuber bulking. For moderate to severe deficiency, repeat applications at 10-14 day intervals.
Water rate: 200 l/ha.

# Placement

Fertilizer placement techniques have over the last few decades, become widely accepted as best practice by the UK's leading growers. A controlled supply of nutrient produces both increases in marketable yield and a more even sample size.

## Improved Agronomy

The use of ammonium phosphates increases the amount of phosphate available to the plant by local acidification. This results in a higher early growth response. It is also known that this early response to applied phosphate increases with the amount of water soluble phosphate available to the plant. The precision placement of fertilizer below the potato crop provides all of the phosphate, in the water soluble form, in a continuous band and is therefore provided in the form and in a position that allows maximum usage by the crop.

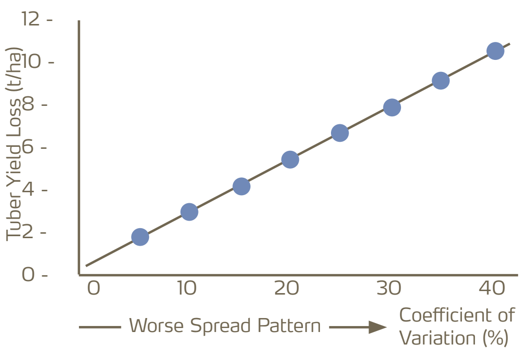
Where fertilizer is broadcast on the soil surface before planting, the mixing of the soil that occurs between fertilizer application and planting results in it being evenly distributed throughout the ridge. Some of the phosphate will inevitably be above the potato seed where it cannot be utilised. This mixing of fertilizer and soil leads to rapid "lock up" of water soluble phosphates. In contrast the placing of fertilizer at least 5cm below and to the side of the seed leads to a high concentration of phosphate and a slower "lock up".

## Unbeatable Accuracy

### Reduced CV

Fertilizer can be very accurately applied using placement and achieve a coefficient of variation (CV%) of 5%. The CV of broadcast applications is typically 10-15% when carried out properly. Therefore placement of fertilizer provides greater accuracy to achieve the target nutrient rates advised by your potato agronomist.

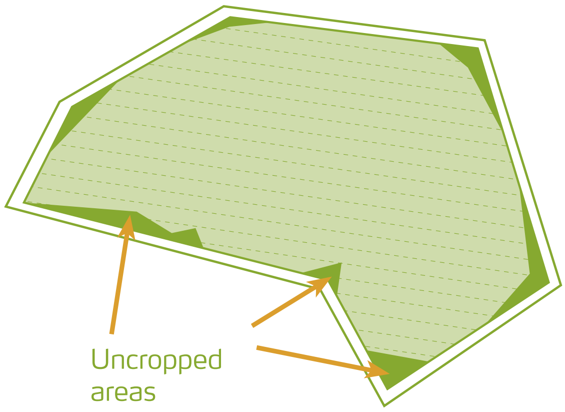
Figure 18. Effect of poor nutrient application

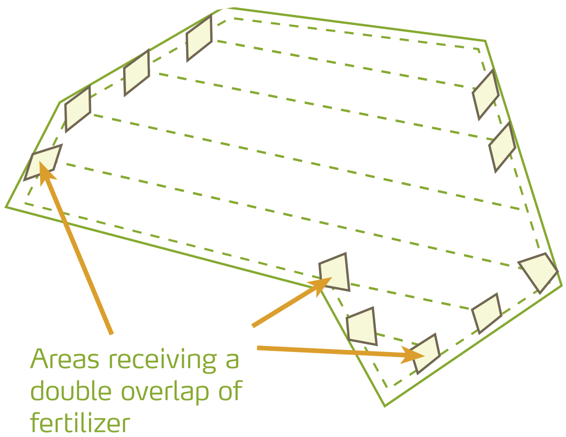



### Fertilizer is only applied to cropped areas with no overlaps

3-7% of a potato field is NOT planted to allow for harvesting, irrigation and spraying headlands. Fertilizer placement at planting only places fertilizer where the crop requires it.

This saves fertilizer and reduces the risk of leaching of nutrients into ground water supplies. Areas being cropped will reduce leaching risk as active plant growth will keep both nitrate and water levels in the soil at low levels during the growing season. On irrigated land there could be increased risk of leaching on uncropped areas.

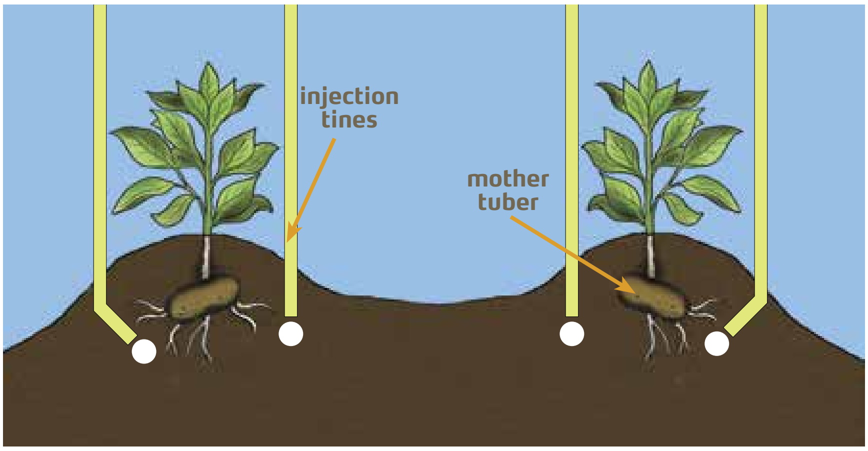


## Increased Efficiency

Increased concentrations of fertilizer in narrow bands reduces lock-up of phosphate with free cations in soil (eg $Ca^{2+}$, $Al^{3+}$ etc) keeping the phosphate available for plant uptake.

Because the fertilizer is accurately placed below the soil surface into the moist root zone at a controlled distance from the seeds the nutrients are immediately available to the crop even in dry periods, without the risk of scorching.



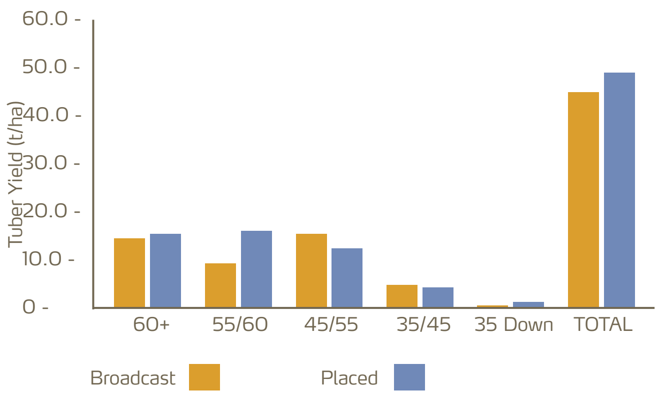

## Trials Results

Trials carried out on behalf of Yara since the early 1990's have helped to highlight the potential yield benefits available. The average yield increase from fertilizer placement compared to broadcast fertilizer applications was 10.8%, with increases of up to 22% being recorded.

Table 1. Data Set (1991-2009)

| Site | Year | Variety | Ware Yield (t/ha) Placed | Ware Yield (t/ha) Broadcast | % Increase |
|---|---|---|---|---|---|
| Telford | 1991 | Dell | 59 | 52 | 13.5% |
| Ramsey | 1992 | Piper | 76 | 63 | 20.6% |
| Northwich | 1994 | Piper | 43 | 45 | -4.4% |
| Keelby | 1995 | Broddick | 56 | 47 | 19.1% |
| Flint | 1995 | Estima | 47 | 52 | -9.6% |
| Whittlesey | 1995 | Sante | 46 | 44 | 4.5% |
| Telford | 1995 | Estima | 44 | 36 | 22.2% |
| Whittlesey | 1996 | Sante | 59 | 56 | 5.4% |
| Ormby | 1996 | Edward | 52 | 53 | -1.9% |
| Telford | 1996 | Dell | 40 | 33 | 21.2% |
| JSR | 2002 | Nadine | 104 | 86 | 21.2% |
| Wragby | 2003 | Marfona | 47 | 44 | 6.7% |
| Wragby | 2005 | Melody | 56 | 48 | 16.0% |
| East Yorkshire | 2007 | Dell | 65 | 55 | 17.3% |
| East Yorkshire | 2009 | Carlita | 49 | 45 | 9.4% |
| Average | | | | | 10.8% |

Figure 19. Yield – Broadcast vs Placed (2009)




## Application Systems

Various machinery manufacturers can supply and fit conversion kits enabling planters to simultaneously place fertilizer while planting. Placement kits are available to fit a wide range of planter and tractor combinations. Modern electronic rate controllers and GPS technology allows highly accurate application, with very little wastage to be achieved. The increased marketable yields give a very good return on capital employed from the equipment required.

The N-Sensor is being used to map potato canopy growth and development through the colour and biomass measurements as well as for 'scouting' to identify early problem areas in the field. This ability to track senescence enables it to be used for variable crop dessication resulting in a more effective kill.

## Fertilizer Placement Summary:

- Placement trials have shown on average a 10.8% yield increase
- Unbeatable accuracy
- Increased efficiency
- Polyphosphate based fertilizers

Sulphur is very important in plants, it is a building block of protein and therefore a vital nutrient. Sulphur improves a plant's nitrogen uptake and, therefore, nitrogen use efficiency (NUE) due to the relationship between sulphur and nitrogen in the plant. With sufficient levels of sulphur the plant can take up and utilise the nitrogen more effectively, thereby increasing yield. Potatoes require 40-50kg/ha $SO_3$, applied in the seedbed application.

# Yara N-Sensor™

The Yara N-Sensor has a potato specific variable rate nitrogen application module for use when top-dressing the crop with nitrogen. There are also other uses for the N Sensor, for example as an agronomy scouting tool.

Although the Yara N-Sensor operates as a stand alone system, in that GPS is not essential, this is usually supplied as part of the package to enable customers to create biomass and nitrogen application maps for each field scanned. These maps can be useful as a general agronomy tool highlighting areas of low biomass which enable the users to go back and gather more information as to the cause of the problems.

## About Yara

Yara grows knowledge to responsibly feed the world and protect the planet. Supporting our vision of a world without hunger and a planet respected, we pursue a strategy of sustainable value growth, promoting climate-friendly crop nutrition and zero-emission energy solutions. Yara's ambition is focused on growing a climate positive food future that creates value for our customers, shareholders and society at large and delivers a more sustainable food value chain.

To achieve our ambition, we have taken the lead in developing digital farming tools for precision farming, and work closely with partners throughout the food value chain to improve the efficiency and sustainability of food production. Through our focus on clean ammonia production, we aim to enable the hydrogen economy, driving a green transition of shipping, fertilizer production and other energy intensive industries.

Founded in 1905 to solve the emerging famine in Europe, Yara has established a unique position as the industry's only global crop nutrition company. We operate an integrated business model with around 17,000 employees and operations in over 60 countries, with a proven track record of strong returns. In 2020, Yara reported revenues of USD 11.6 billion

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