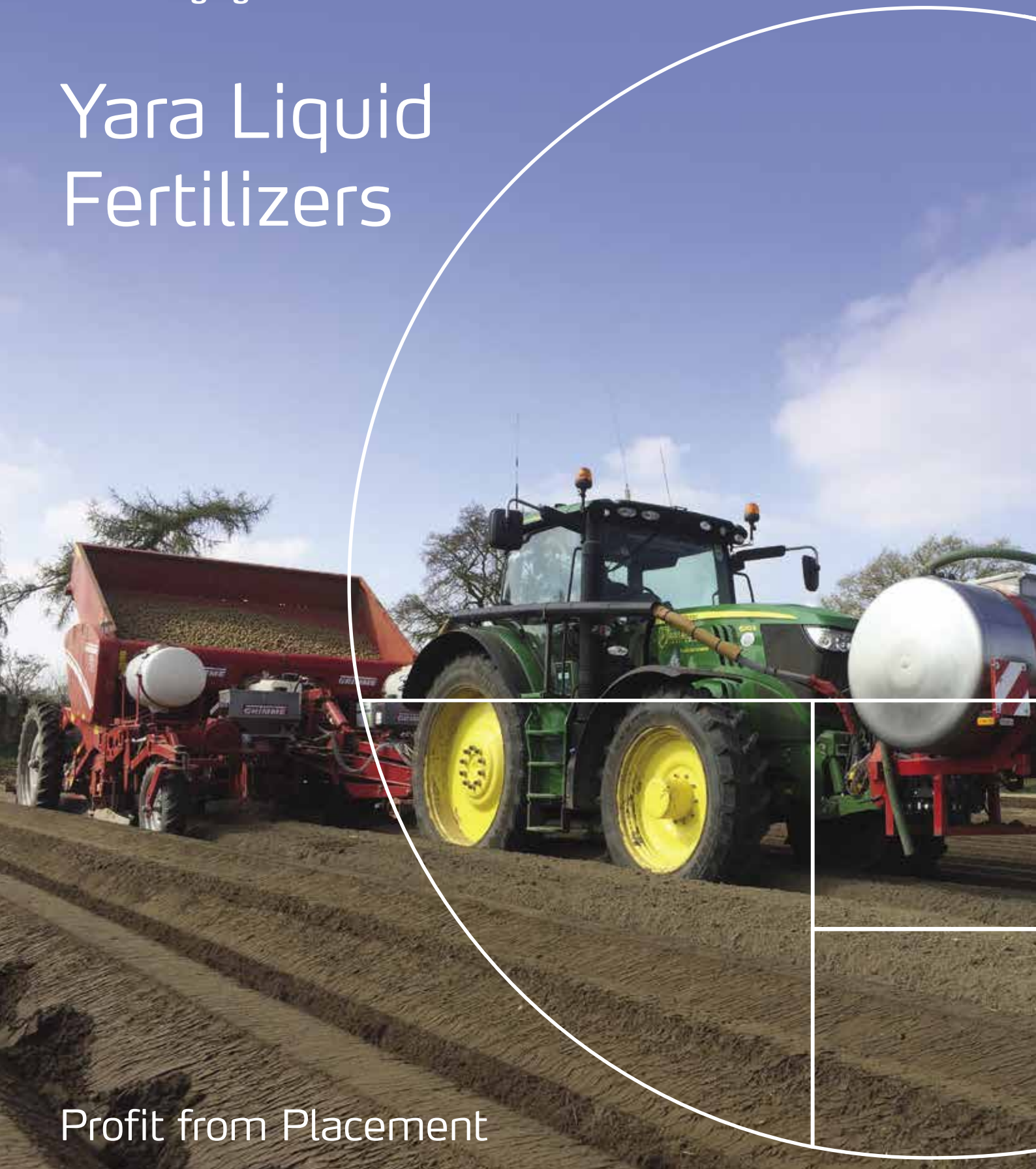
Knowledge grows

Yara Liquid Fertilizers



Profit from Placement

Potato Fertilizer Placement

During the last 40 years the Yara liquid fertilizer placement technique has become 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 polyphosphates (used in Yara liquid fertilizers), 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.

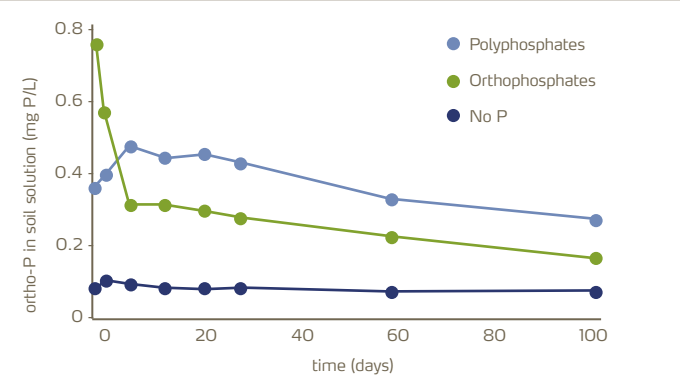
Where fertilizer is broadcast on the soil surface before planting, the mixing of the soil that occurs between fertilizer application and planting results in it being evenly distributed throughout the ridge. Some of the phosphate will inevitably be above the potato seed and some will be in the soil between the beds 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 available phosphate and a slower "lock up".

Polyphosphates

The phosphate source in Yara liquid fertilizers is predominantly ammonium polyphosphates, which enhance the availability of phosphate from soil solution, improving root growth.

Although orthophosphates are immediately available, their availablity very quickly reduces over time due to precipitation and fixation. Phosphate applied in the polyphosphate form is hydrolysed to orthophosphate increasing the P concentration in soil solution over a greater period of time than where orthophosphate alone was applied.

Polyphosphates increase P concentration in soil solution



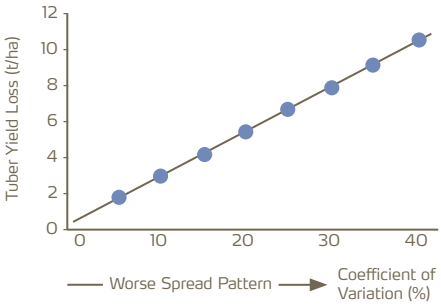
Hydrolosis of polyphosphates establishes higher P concentration in soil solution over a long peroid of time

Unbeatable Accuracy

Fertilizer can be very accurately applied using placement and achieve a very low 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.

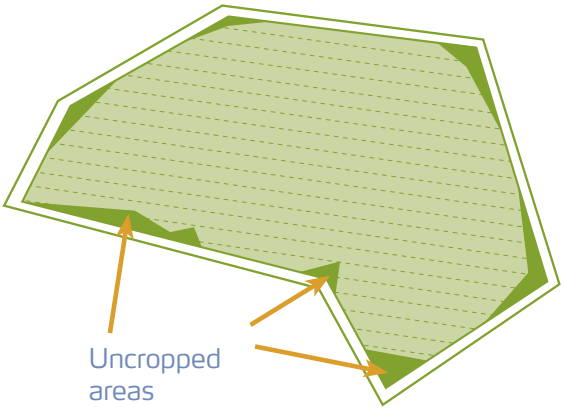
Effect of poor nutrient application

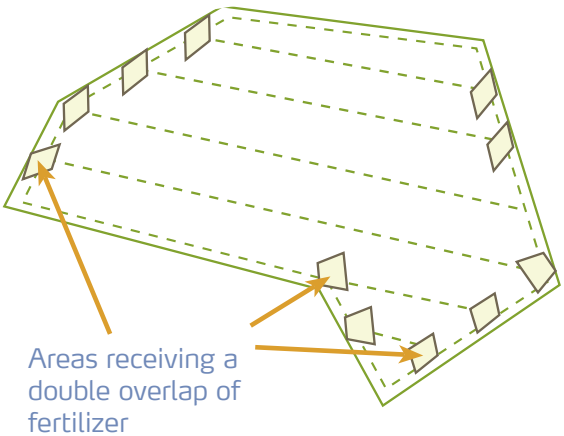


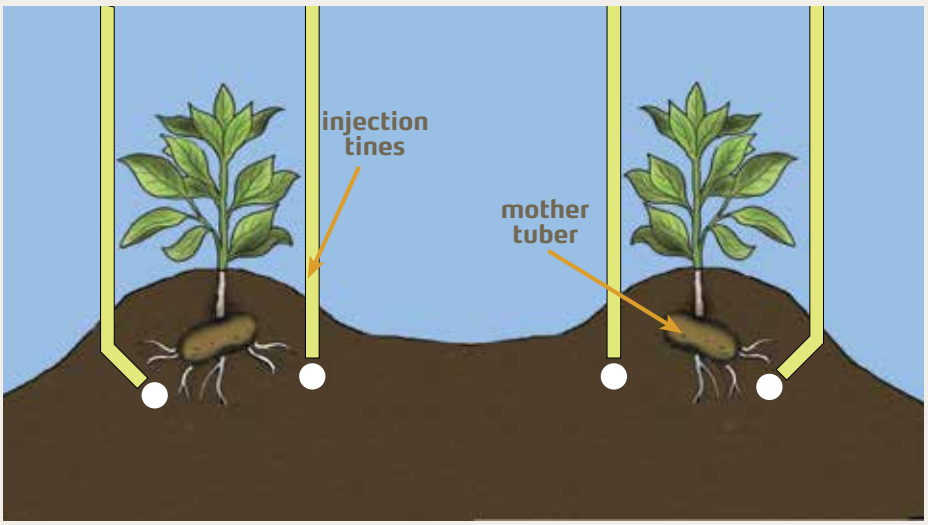
Fertilizer is only applied to cropped areas with no overlaps

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, Al 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

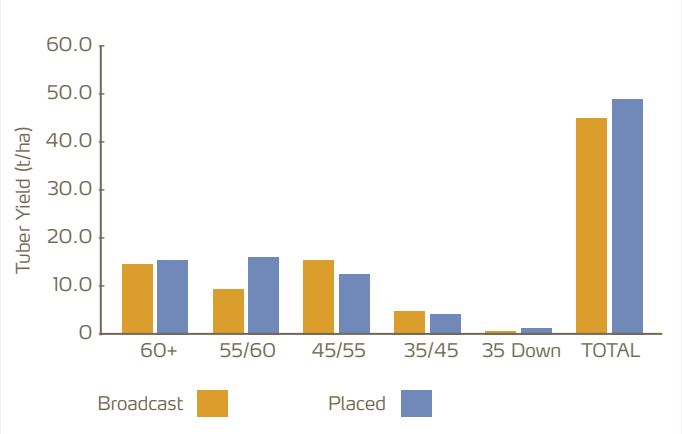
Trials carried out on behalf of Yara since the early 1990s have helped to highlight the potential yield benefits available. The Average yield increase from fertilizer placement compared to broadcast fertilizer applications was 10.8%, with increases of up to 22% being recorded.

Trial summary (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%**

The latest trial carried out in 2009, looking at the differences between fertilizer applications showed a 9.4% yield benefit from placement.

Yield – Broadcast vs Placed (2009)



Summary

- Increased Yield – average increase of trials from early 90's onwards is 10.8%
- Unbeatable accuracy
- Increased Efficiency
- All nutrients 100% water soluble (N,P,K,S)
- Ammonium polyphosphate based fertilizer
- Prescription blending – grades can be produced to match specific requirements for any market (eg seed, ware etc)

Feasibility Study

Trials carried out on behalf of Yara since the early 1990s 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.

Benefits of Potato Placement

Potato Fertilizer placement can offer many benefits, including less waste of fertilizer and increased crop yields. Trials carried out on behalf of Yara since the early 90s shows an average yield increase from placing fertilizer of 10.1% compared to broadcast applications. On top of this 3-7% of a field is not planted and 3.5-5% of a field receives a double overlap when broadcasting fertilizer, therefore Placement techniques can help cut down on wasted fertilizer.

Potato Area Grown	ha	50	**Nitrogen Cost**	£ / m3	268
Average Crop Yield	tonnes / ha	45	**Base Application of Nitrogen**	kg / ha	100
Crop Value	£ / tonne	150	**Width of Bed**	metres	1.8
Yield Increase from Placement	%	10.1	**Width of Planting**	metres	1.6

COST OF WASTED FERTILIZER

						TOTAL BENEFIT
Area fertilized but unplanted	%	5	ha	2.50	£	**£181.08**
Area of Fertilizer Overlap	%	4	ha	2.00	£	**£144.86**
Area of Bed not Utilized	%	11.1%	ha	5.56	£	**£402.40**

YIELD INCREASE

Increase in Yield	tonnes / ha	4.55	tonnes	227.25		**£34,087.50**

TOTAL BENEFIT FROM PLACEMENT	**£34,816**

Crop Specific Grades

The Yara liquid fertilizer production system is tremendously flexible enabling a wide variety of analyses to be produced. Yara are therefore able to supply an extensive and unrivalled range of Nitrogen and NPK solutions; many with the inclusion of sulphur. The number of grades we can supply is limitless. The number available for delivery to you today extends to over 300 different analyses.

Below is a list of popular fertilizer grades for potatoes:

Suitable for pre-emergence top dressing

Fertilizer Grade	%N	$\%K_2O$	$\%SO_3$
Chafer 19.8-0-9.4 + 5 SO_3	19.8	9.4	5
Chafer 20-0-10	20	10	0
Chafer Nuram 30.3 + 10.8 SO_3	30.3	0	10.8
Chafer Nuram 35 + 7 SO_3	35	0	7
Chafer Nuram 37	37	0	0

Suitable for foliar application

Fertilizer Grade	%N	$\%SO_3$
Chafer Nufol 20	20	0
Chafer Nufol 20 + S	20	4.2

Suitable for placement at planting

Fertilizer Grade	%N	$\%P_2O_5$	$\%K_2O$	$\%SO_3$
Chafer 4-12-12	4	12	12	0
Chafer 4.7-11.3-11.3 + 5 SO_3	4.7	11.3	11.3	5
Chafer 05-15-10	5	15	10	0
Chafer 6-9-12	6	9	12	0
Chafer 6.6-13.7-9.9 + 5 SO_3	6.6	13.7	9.9	5
Chafer 7-16-10	7	16	10	0
Chafer 7-21-0	7	21	0	0
Chafer 7-21-09	7	21	9	0
Chafer 8-0-12	8	0	12	0
Chafer 8-4-12	8	4	12	0
Chafer 8.5-7.5-11.3 + 5 SO_3	8.5	7.5	11.3	5
Chafer 9-9-12	9	9	12	0
Chafer 9-11-11	9	11	11	0
Chafer 9-18-09	9	18	9	0
Chafer 9-27-0 + 6 SO_3	9	27	0	6
Chafer 9.4-8.5-11.3 + 5 SO_3	9.4	8.5	11.3	5
Chafer 10-5-12	10	5	12	0
Chafer 10-15-10	10	15	10	0
Chafer 10-18-7	10	18	7	0
Chafer 10.5-12.5-10.5	10	12.5	10.5	0
Chafer 11-8-11	11	8	11	0
Chafer 11-11-11	11	11	11	0
Chafer 11.5-3-11.5	11.5	3	11.5	0
Chafer 12.2-0-11.3 + 5 SO_3	12.2	0	11.3	5
Chafer 12.5-15-9	12.5	15	9	0
Chafer 12-17-9	12	17	9	0
Chafer 12-18-0	12	18	0	0
Chafer 12-18-0 + 5 SO_3	12	18	0	5
Chafer 13-13-6.5	13	13	6.5	0
Chafer 14-17-0	14	17	0	0
Chafer 16-16-0	16	16	0	0
Chafer 18-14-0	18	14	0	0
Chafer 20-10-0	20	10	0	0

[1] Alternatively apply MOP
[2] Apply either CHAFER NURAM or TROPICOTE
[3] Other Grades are available
* Over 300 NPK or NPK+S grades available
** Rate depends on SNS and NMP recommendation

YARA

Knowledge grows

Potato Crop Programme





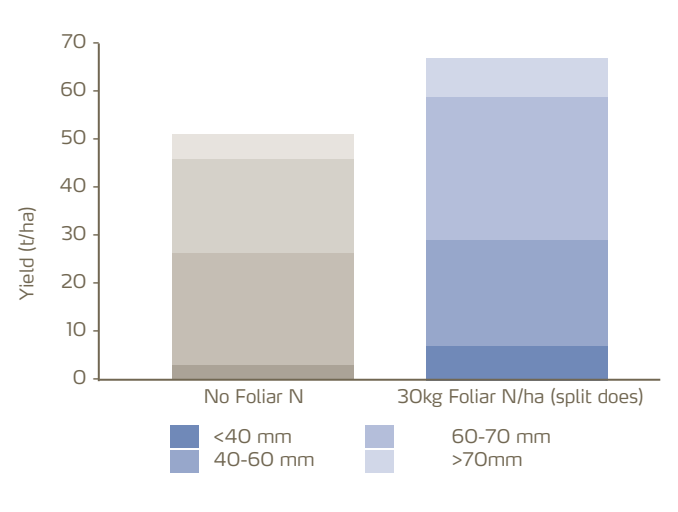
Crop Stage	Pre-planting	Planting	Vegatative growth	Tuber initiation	Early tuber bulking	60% of tubers final size
Yara Liquid	Yara Liquid[1] e.g. 0N-0P_2O_5-180K_2O	Yara Liquid* ** e.g. 160N-200P_2O_5-120K_2O	Pre-emergence: CHAFER NURAM 37[2,3]** e.g. 60N-0-0		CHAFER NUFOL 2x25 l/ha	CHAFER NUFOL 2x25 l/ha
YaraLiva™				TROPICOTE[2]** e.g. 60N-0-0 + 100Ca		
YaraVita™			MAGFLO 300 2-4 l/ha MANTRAC PRO 1 l/ha	MAGPHOS K for tuber number 10 l/ha	MAGPHOS K for tuber size 2x5 l/ha	

This programme shows a typical programme for maincrop potatoes. Rates for additional markets may need adjusting from those shown in this example.

Maximising Returns from Nitrogen

NUFOL™ - Recommendations for Potatoes

The potato crop is an inefficient utilizer of soil nutrients. Opportunities therefore exist for supplementing basal dressings with foliar treatments. Additional nitrogen can be supplied using dilute applications of Nufol to help maintain a green leaf canopy and increase tuber size. When compared with soil applied top-dressings significant improvements in nitrogen utilisation are usually achieved.



N-Sensor™

Although there is a calibration for variable rate nitrogen applications developed specifically for the potato crop, this may be of limited use if not applying a nitrogen top-dressing to the crop. There are however alternative uses for the N-Sensor in potatoes, for example as an agronomy tool.

Although the Yara N-Sensor operates as a standalone 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.

Potato Haulm Desiccation Module

An additional module for the N-Sensor has been developed and was released in 2007 by Plant Research International, Wageningen in the Netherlands for site specific dosing of potato desiccants. By measuring the reflectance of a potato canopy it is possible to pick up differences in colour significantly in advance of the naked eye, therefore applying higher dose rates to the 'greener' canopies to improve the uniformity of action and help reduce overall herbicide use.

N-Sensor™ - Potato Haulm Killing Herbicide Module

Recent developments in precision agriculture make variable rate application systems of pesticides on farms possible.

Plant Research International has developed decision rules for site specific dosing of haulm killing herbicides in potatoes (Minimal Lethal Herbicide Dose for Potato Haulm Killing = MLHD PHK).

With the integration of the PHK module in the N-Sensor software in 2007 a practical solution for site-specific optimization of potato haulm killing is now available.

Main steps in MLHD PHK

The N-Sensor measures light reflectance of the potato canopy while driving through the crop.
Areas with 'greener' canopies, that give higher reflectance parameters, require a higher herbicide dose for potato haulm killing (Fig. 1)

The farmer selects the appropriate decision rule for his field by setting a few calibration parameters: chosen herbicide, risk level, single or split application.

The MLHD PHK module translates the reflectance data into a site-specific dose (Fig 2).

Figure 1. Example of a minimum effective dose curve

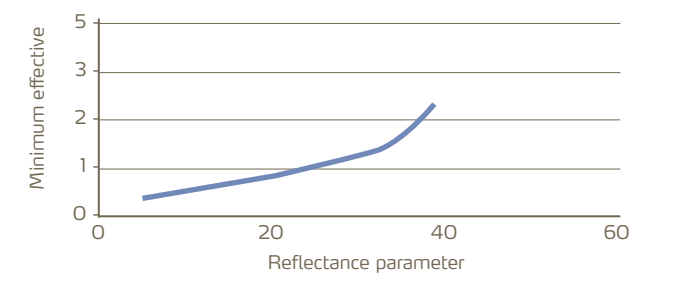
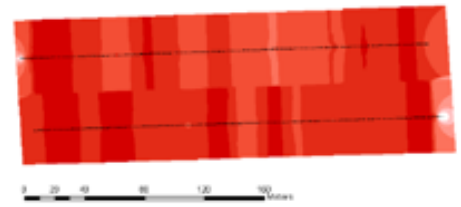


Figure 2. Example of a dose map of a relatively green potato crop. Two spray tracks and agent doses ranging from 1.5 – 3 l/ha in this crop.



Benefits of MLHD PHK with N-Sensor™

- Site-specific optimization of potato haulm killing herbicides is now possible.
- Reduction in use and costs of crop desiccants (42 % reduction in 2006 with an injection sprayer).
- Reduced application rates on sparse canopies may improve potato quality and reduce environmental impact.
- N-Sensor and PHK are compatible with most sprayers.
- A Windows terminal in the sprayer cabin allows easy choices of strategy and herbicide. Special dosing rules for high-risk situations are available.
- Websites: www.mlhd.nl or www.sensoroffice.com.

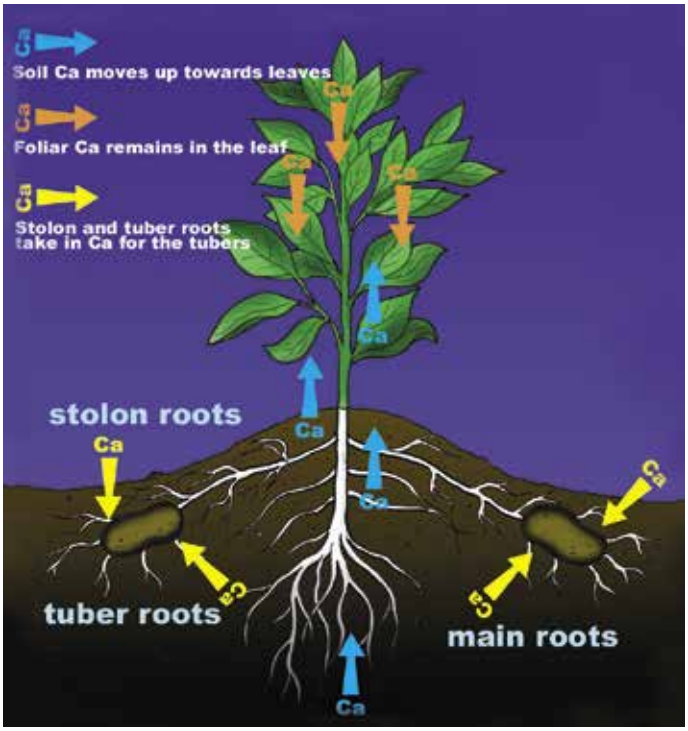
Nutrition is also important for plant health, improving resistance or tolerance to disease. Shortages in any nutrient (particularly potassium, calcium, boron, manganese, copper or zinc) could lead to an increase in disease levels, which if not controlled effectively through fungicides can also decrease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

Are your potatoes getting enough Calcium?

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.

Calcium uptake and movement



Internal Rust Spot

a recognised calcium deficiency disorder.

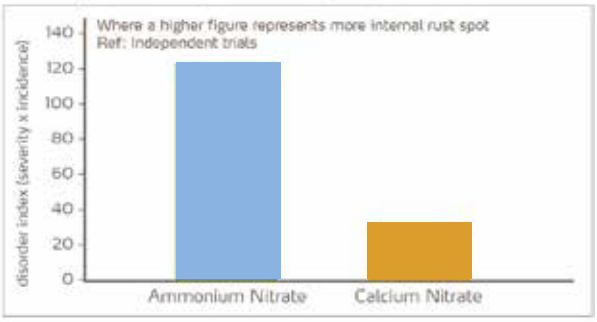
Improve skin finish

addition of calcium promotes strong cell walls.

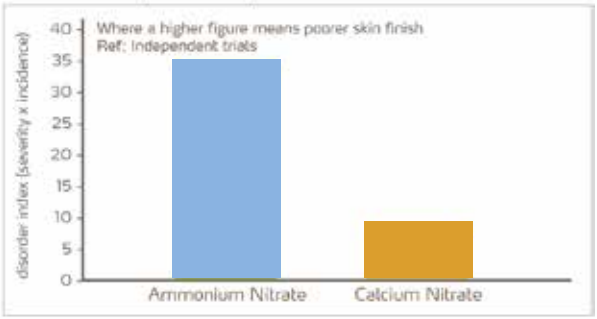
Resist bacterial soft rot invasion

improve tuber cell wall calcium pectate content.

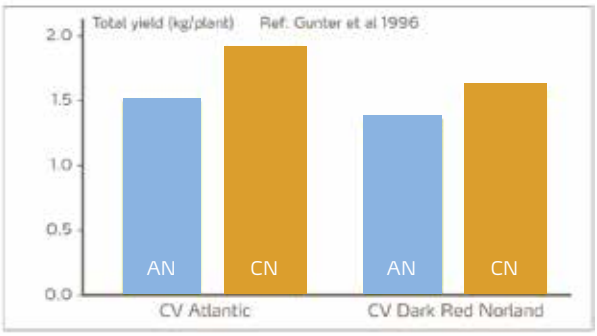
YaraLiva™ TROPICOTE
can help reduce Internal Rust Spot



YaraLiva™ TROPICOTE
improves skin finish



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).

Interpretation of potato petiole analysis

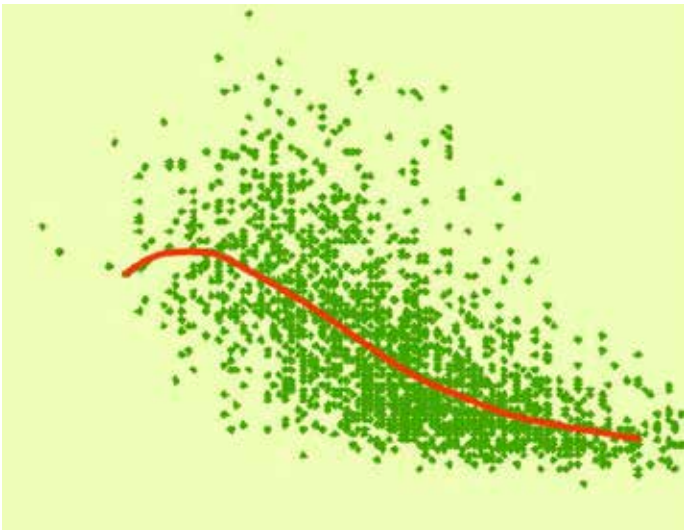
Independent research has demonstrated the importance of phosphorus for tuber bulking - the longer it is maintained at a high level in the crop, the greater the yield potential. Yield potential is increased by around 0.5 t/ha for each extra day that the phosphorus level in the petiole is kept above 0.22%.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

Megalab potato petiole programme

Since 1993 Lancrop Laboratories have been analysing petiole samples from UK potato crops and our database currently stands at over 5,000 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 on the graph below).

The Yara petiole Megalab system is therefore much more PROACTIVE because we are able to establish if the crop will 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.

Decline in petiole phosphorus level. Target level is shown in red.



Other nutrients

Independent research has demonstrated the importance of phosphorus for tuber bulking - the longer it is maintained at a high level in the crop, 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. The phosphorus level normally reaches 0.22% around 100 to 110 days after planting. Any "premature deficiency" incurs a yield penalty of 0.5 tonne per hectare per day.

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 immediately.

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). Do not sample fields within 3-5 days after being sprayed with pesticides or foliar nutrients.

Increasing Potato Tuber Numbers

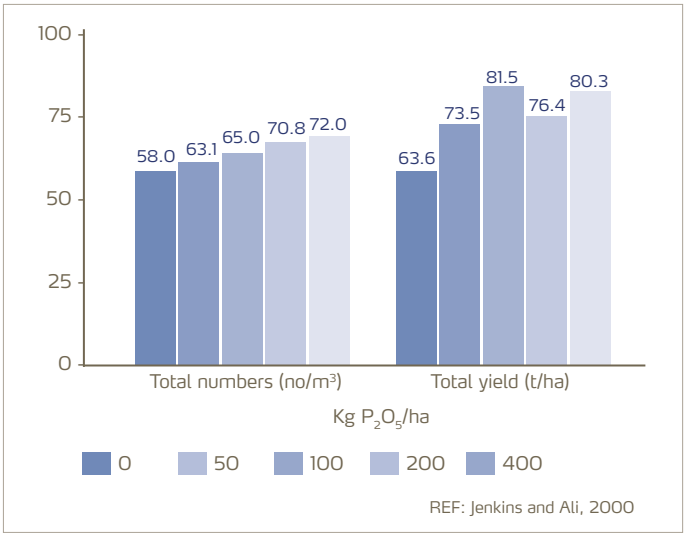
The numbers of potato tubers produced by each plant is influenced by agronomy and varietal potential. A large number of tubers per hectare will produce a crop of predominately small tubers, ideal for canning, salad or seed potatoes. A relatively low tuber number provides less competition per unit area 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).

Because phosphorus is relatively immobile in the soil it is important that fertilizer phosphate 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.

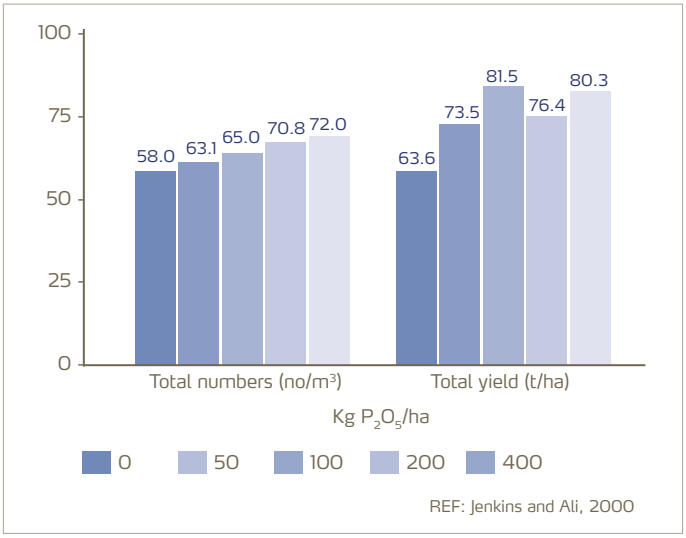
While potatoes are very responsive to fresh phosphate, the economic optimum rate is often difficult to define. Rates will depend on soil type and soil test results. Where sufficient soil phosphate is not available for growth, foliar phosphate ensures rapid availability.

Phosphorus and yield (Wales - Desiree)



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

Foliar phosphorus - Effect on tuber number (Scotland - Estima)



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

YaraVita™ MAGPHOS K

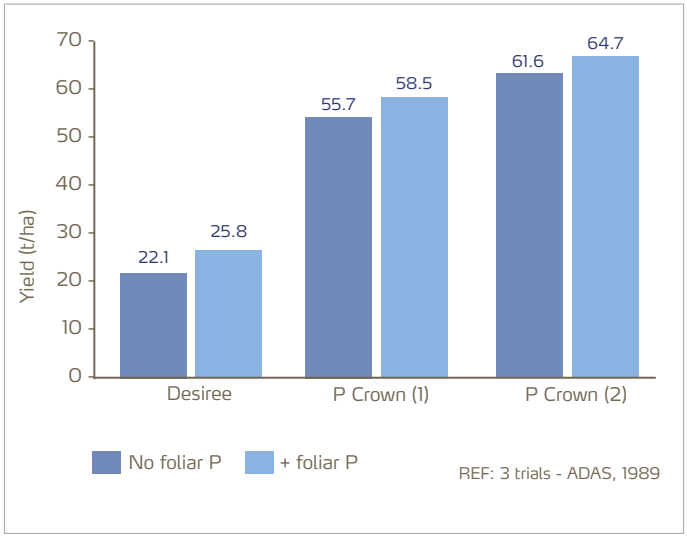
To increase tuber number, 10 l/ha at tuber initiation (when 50% of the tip swellings are twice the diameter of the rest of the stolon).

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 yields, however, foliar phosphate is not a substitute for soil applied phosphate and without adequate soil phosphate early season growth is sub-optimal.

Foliar phosphorus - Effect on yield (England)



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 bilking (as soon as first formed tubers are 10mm in diameter). Allow 10-14 days between applications. Water rate: 200 l/ha.

Yara UK Limited
Pocklington Industrial Estate,
Pocklington,
York
YO42 1NR

Customer Services - Tel: 01472 889301

Yara UK Limited
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@Yara_UK Yara UK 01472 889301 agronomy.uk@yara.com www.yara.co.uk