



The Potato Phosphorus Challenge

Solutions for more available phosphorus

The phosphorus challenge in potato production

Potatoes are considered to have a low phosphorus (P) uptake efficiency compared to most other crops, with only about 5 to 25% of fertiliser P taken up in the year it is applied, depending on variety and conditions. Therefore, P fertiliser inputs are commonly high and costly for potato producers.

Adequate phosphorus availability is closely linked to root development and leads to greater exploration of the soil for water and nutrients. Tuber numbers, sizing and disease resistance are also enhanced when adequate phosphorus is available to the crop.

A large, healthy root system is the most important plant attribute for effective nutrient and especially P acquisition, particularly from P-fixing soils where it forms insoluble aluminium, and iron phosphates in acid soils and calcium phosphates above pH 6.4 (P-fixing). A significant proportion of Australia's potato crops are grown in these soil types.

This graph on the right shows the general distribution of P in potato plants (%) relative to total P at maturity for Russet Burbank. It illustrates the increasing P uptake requirement of the crop after planting.

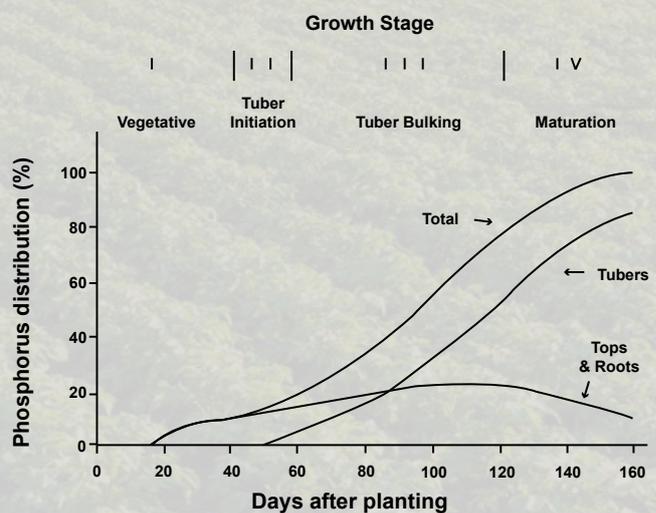
The field below in Northwest Tasmania is typical of the potato growing soils of the region. It is low in available phosphorus, pH less than 5 (CaCl) and has high levels of Al and Fe which lead to high P fixation.

These factors explain why a single preplant application of an easily fixable P-source (standard granular fertiliser) may not be suitable to provide adequate available P for the crop over the growing season.

This guide focuses on Structure® & Foundation LM™ from Loveland Agri Products.

These two technologies offer growers the ability to enhance their potato fertiliser programmes, particularly in low P and P fixing soils.

This could in turn lead to a reduction in less efficient fertiliser inputs but without compromising yield or quality, ensuring long term sustainability and ultimately profitability for Australian potato growers.





Engineered for Superior Performance

Reacted Carbon Technology™ (RCT) is a platform that encompasses a wide range of complex carbon mixtures that have been precisely designed for specific performance and agronomic benefits. Derived from leonardite, our organic matter is a complex mixture of molecules ranging in size, composition, and chemical functionality. Every product in the RCT line has a different extraction and reaction process and was developed for certain elements, nutrients, or effects on the soil.

What makes phosphorus in Structure more available and more mobile than other forms of phosphorus?

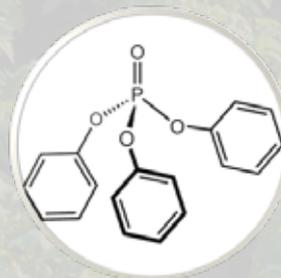
- Formation of stable water-soluble metal-organic complexes prevent the formation of insoluble metal-phosphate.
- Organic acids bind to solid phase cationic P Sorption Sites (Anion Exchange Sites) making P more available.
- Organic Acids compete with phosphate ions for adsorption sites within the soil; hence resisting P tie up.



Phosphate bound in soil through tie up with cations is unavailable for the plant.



Metal-organic complexes prevent the formation of insoluble metal phosphorus (P)



Possible bonding of Ortho-P to organic substances – Cyclohexyl Dihydrogen Phosphate



More phosphate remains in an available form, able to be taken up by the plant.



Demonstrating improved phosphorus efficiency

Evaluation of Structure - a highly available and mobile form of liquid P fertiliser.

A replicated trial was conducted in Northwest Tasmania at the Forthside Vegetable Research Station during the 2020/21 season on a ferrosol soil.

The purpose of the trial was to evaluate a new liquid P fertiliser formulated with leonardite called Structure to investigate whether the yield of processing potatoes (Russet Burbank) on P-fixing soils could be maintained or improved despite a reduction in total applied phosphorus.

Treatments included five fertiliser treatments with decreasing rates of total applied phosphorus as follows: 260 – 181 – 142 – 115 – 69 kg/ha achieved via:

- Decreasing P application rates of an industry standard dry NPKS granular fertiliser blend (11-13-19-1) as follows:
 - 2000 – 1350 – 1000 – 750 – 350 kg/ha total blend.
- Increasing rates of Structure alongside the granular fertiliser as follows:
 - 0 – 50 – 100 – 150 – 200 L/ha

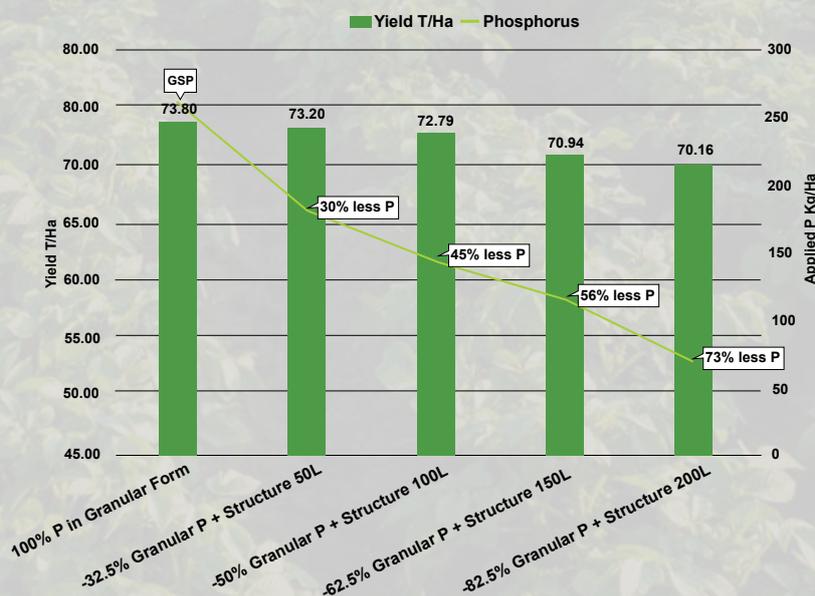
Rates of N, K, and S were kept constant at 220, 380 and 20 kg/ha respectively in all treatments; to achieve this, the required rates of a granular blend that did not contain P were applied together with the decreasing rates of the 11-13-19-1 blend.

Trial highlights:

There was no significant decline in marketable yield despite a 45% reduction in applied phosphorus when Structure was added to the granular program.

Reducing the overall P rate to 142 kg/ha via applying half of the standard granular fertiliser rate of 2000 kg/ha plus adding 100 L/ha of Structure may be a good approach in low P and P fixing soils.

This demonstrates the improved P efficiency of Structure compared to granular applied P.



Growing more with less phosphorus

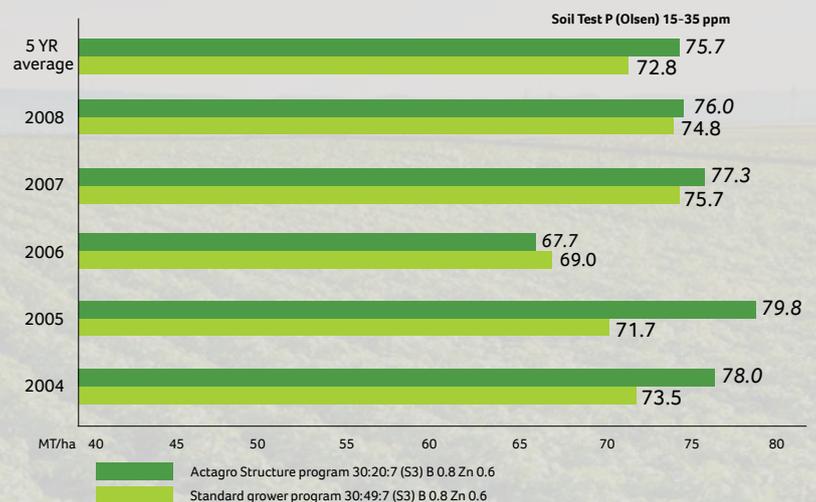
Structure has been part of potato fertiliser programs in North America for many years. Adoption by American potato growers is a result of Structure providing a more efficient form of phosphorus that has led to improvements in local potato production.

In 2004-2008, Western Farm Services Agronomist for Nutrien Ag Solutions, Dave Barta conducted a replicated trial at 11 different potato growing sites over 5 years, throughout the Washington Basin in North America.

The trial compared 236L/ha of Ammonium Polyphosphate (APP) to 160L/ha of Structure and all other inputs remained the same. This represented a 60% reduction in applied phosphorus as Structure.

Despite less phosphorus being applied, yields from the Structure treatments outperformed the APP treatments by an average of 2.91T/Ha.

Source: Nutrien Ag Solutions, USA



Increased mobility of phosphorus

Dr. Husein Ajwa et. al, of University of California Davis, USA evaluated the availability and movement of available soil phosphate in four fertiliser treatments over three months.

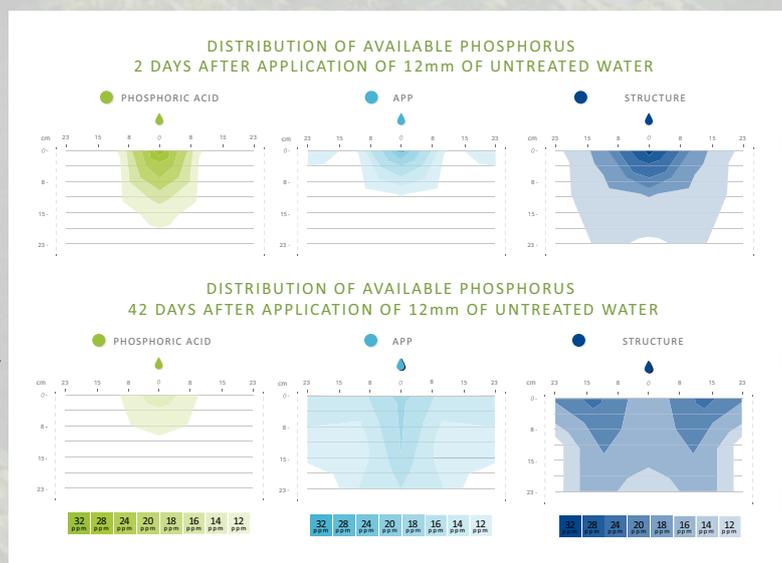
Soil type was clay loam with pH of 7.8. Each treatment was replicated four times. The experiment design was a randomised complete block with a final plot size of one, 1.524m wide, 60.96m long bed (a total plot size of 2,000m²). Fertilisers were applied through a single low flow drip irrigation tape (1 lpm/30.48m) with 101mm emitter spacing, placed in the middle of the bed surface. Fertilisers were applied over a span of six hours.

Beds were pre-irrigated and additional irrigation water was applied to ensure high fertigation uniformity. Irrigation occurred twice weekly to replace water lost to evaporation. No crops or weeds were allowed to grow.

Trial highlights:

- Phosphoric acid initially moved, but was mostly tied up before 42 days.
- APP initially moved, but was largely tied up before 42 days.
- Structure moved throughout the soil and remained available for uptake for all 42 days.

Source: University of California Davis, USA



Introducing solutions to improve phosphorus efficiency



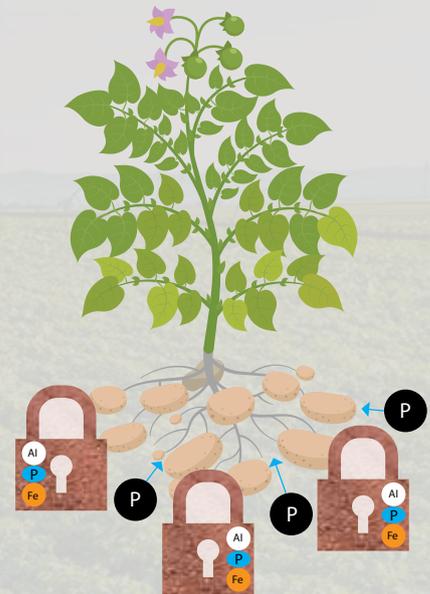
Structure has been developed to provide more mobile and significantly more available phosphorus to the root zone.

Features

- Analysis: 9.1 : 11.9 : 00 + 0.26% Zinc
- 7.8% Reacted Carbon Technology
- Low salt index

Benefits

- Reacted Carbon formulation keeps phosphorus in an available form for longer.
- Helps buffer the salt effect from other fertilisers when applied in combination.
- Phosphorus is less prone to tie up with calcium & magnesium in high pH soils, and iron & aluminium in low pH soils.



The image above describes phosphorus tied up with Al and Fe, compared to Structure where the phosphorus in the Reacted Carbon formula is less prone to fixation and more available to the plant.



Foundation LM contains concentrated biochemistry; the by-product of a biological system – specifically for use with liquid fertiliser applications, in-furrow injection or broadcast application. Foundation LM improves the efficiency of applied fertilisers and helps increase the availability of tied up nutrient within the soil profile.

Features

- Contains highly diverse biochemistry; the by-product of a biological system.
- Consistent and stable formulation.
- Concentrated formula.

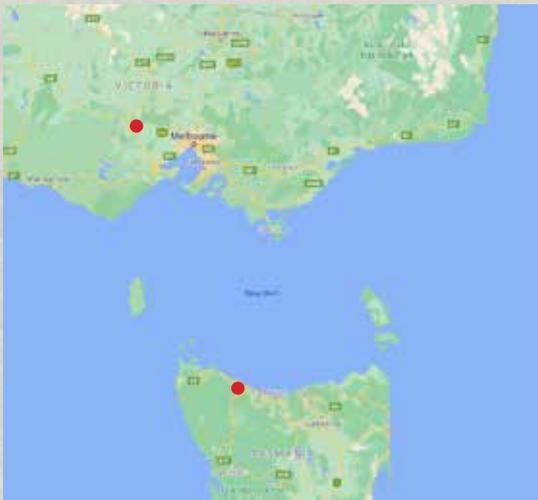
Benefits

- Increased nutrient utilisation from the soil profile.
- Improved efficiency from applied fertilisers.
- Compatible with most fertilisers, herbicides, fungicides, and insecticides.
- Better early root development.

Commercial Trials - 2020/21 Season

Trials conducted in several commercial crops around Ballarat Victoria and Northwest Tasmania showed improvements in tuber set and yield when Structure & Foundation LM was included in the fertiliser programme.

The Ballarat trials described in detail on pages 9 & 10, showed increased yield and tuber set over GSP. These were replicated trials and the yield responses were statistically significant. The Northern Tasmanian trial described on page 11, was a side-by-side demonstration and achieved yield gains compared to the granular only programme.



Trial locations Ballarat VIC & Wynyard TAS

Soil Analysis	Northern Tasmania	Ballarat Victoria
pH CaCl	4.88	4.68
Phosphorus mg/kg	10.9*	92*
Fe mg/kg	174.1	110
Al saturation %	15	5.1
PBI	861	298
Organic Carbon	5.88	2.31

Soil test results from each region

*Mehlich 3 extraction #Colwell extraction



Very little difference was apparent above ground between the Structure & Foundation LM section (Right) compared to the Grower Standard Programme (Left).



Rob Wilson, Nutrien Ag Solutions agronomist at Wynyard Tasmania inspecting a commercial trial.

Observations in commercial demonstrations

Northern Tasmania

4 weeks after planting



More fibrous root systems in the Structure & Foundation LM section (Right) compared to plants in the Grower Standard Programme (Left).

7 weeks after planting



Increased root biomass and improved tuber set in the Structure & Foundation LM section (Right) compared to plants in the Grower Standard Programme (Left).

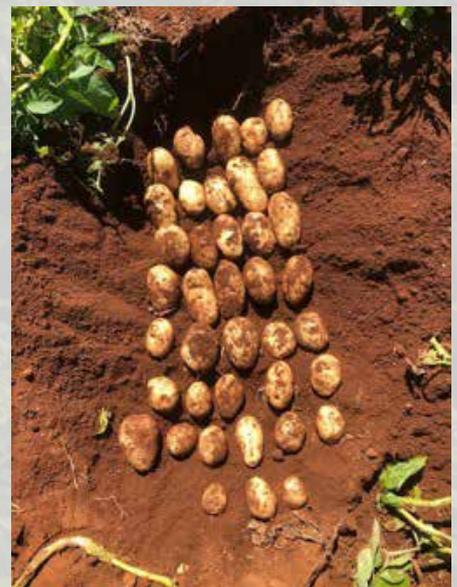
Tuber counts from 3 plants and 8 stems



23 tubers
Grower Standard Programme



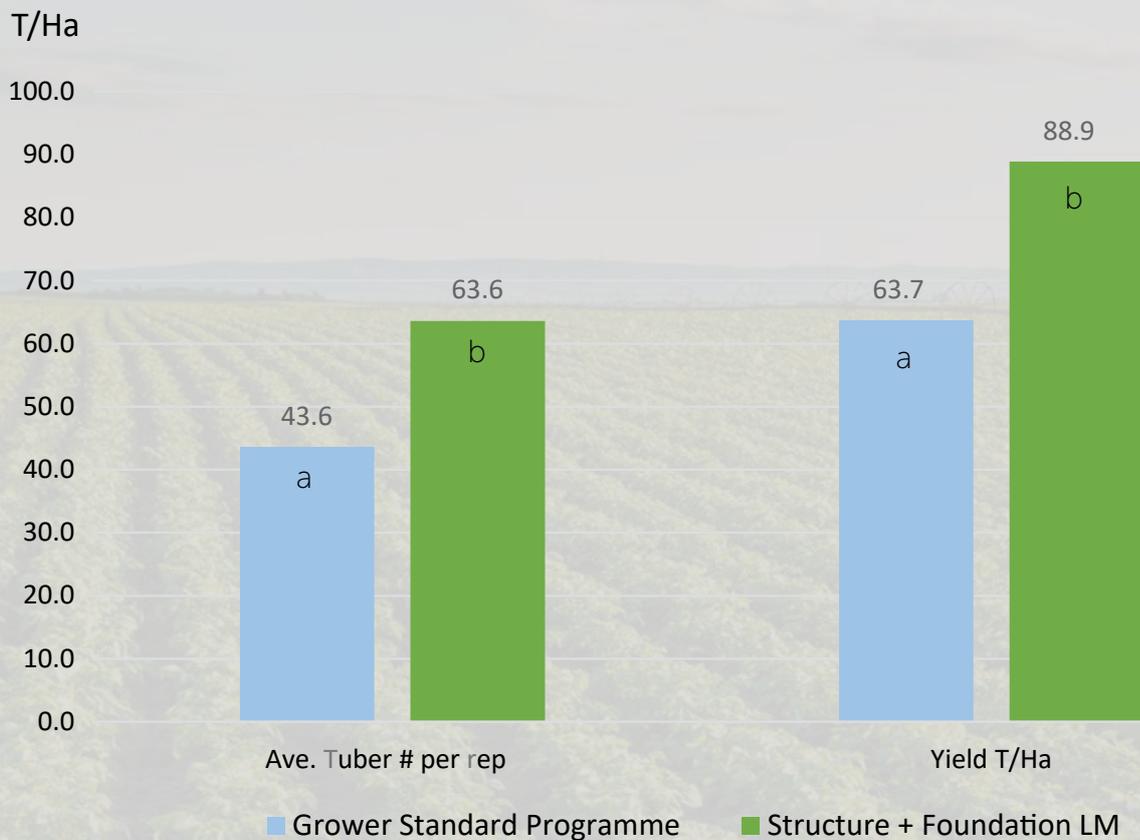
29 tubers
Foundation LM 10L/ha
(+26%)



38 tubers
Structure 50L/ha
(+65%)

Ballarat Victoria - Trial 1

Variety: Innovator (Processing)



Yield LSD 11.25 P= 0.05
Tuber # LSD 13.9 P=0.05

In this replicated trial, Structure and Foundation LM (treated area) were applied with fungicide at planting to compare with the growers' standard granular fertiliser programme. A significant increase in tuber numbers and more even tuber sizing was observed during the growing season. A significant yield increase was achieved in the treated area compared with the grower standard programme along with a positive return on investment with Innovator priced at \$320.00/tonne.

Treatments	Granular NPKS fertiliser kg	Yield T/Ha	Ave tuber # per rep	\$ / tonne	Approx. Gross \$	Approx. ROI
Grower Standard Programme	2200	63.7	43.6		\$20,348.00	-
Structure 50L + Foundation LM 20L	1900	88.9	63.6	\$320.00	\$28,448.00	-
Difference	-300	+39.55%	+45.9%		\$8,064.00	21 : 1

Ballarat Victoria - Trial 2

Variety: Atlantic (Processing)



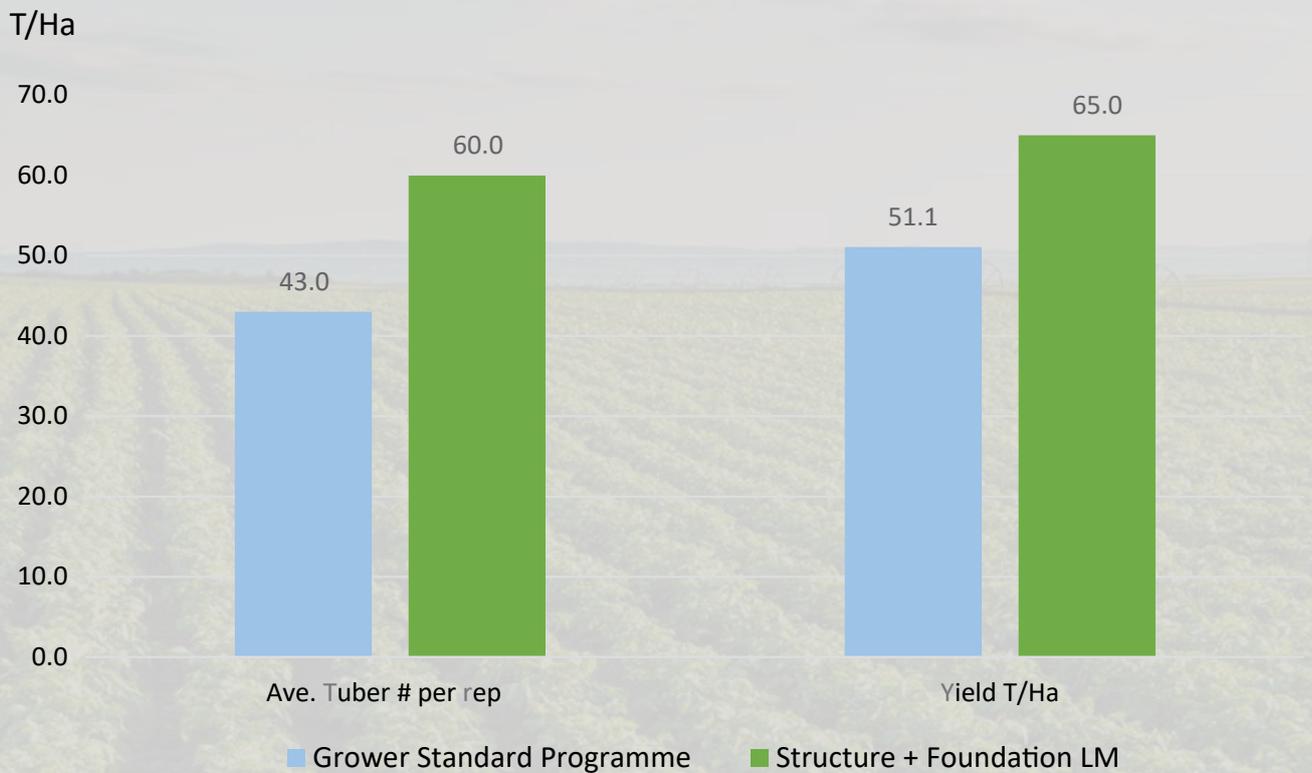
Yield LSD 7.39 P= 0.05
Tuber # LSD 11.19 P= 0.05

In this replicated trial, Structure and Foundation LM (treated area) were applied with fungicide at planting to compare with the growers' standard fertiliser programme which included both granular fertiliser and liquid ortho phosphate. A statistically significant increase in tuber numbers and yield was achieved in the treated area compared with the grower standard programme along with a positive return on investment with Atlantic priced at \$350.00/tonne.

Treatments	Granular NPKS fertiliser kg	Yield T/Ha	Ave tuber # per rep	\$ / tonne	Approx. Gross \$	Approx. ROI
Grower Standard Programme	1550	61.8	57.2		\$21,630.00	-
Structure 50L + Foundation LM 20L	1250	70.4	69.00	\$350.00	\$24,640.00	-
Difference	-300	+13.9%	+20.6%		\$3,010.00	12 : 1

Northern Tasmania - Trial 3

Variety: Innovator (Seed)



A commercial demonstration was conducted where the addition of Structure and Foundation LM (treated area) was applied at planting in addition to the growers standard granular fertiliser programme. An increase in tuber numbers and yield was achieved in the treated area compared with the grower standard programme resulting in a positive return on investment with Innovator seed priced at \$600.00/tonne.

Treatments	Granular NPKS fertiliser kg	Yield T/Ha	Ave tuber # per rep	\$ / tonne	Approx. Gross \$	Approx. ROI
Grower Standard Programme	1500	51.1	43		\$30,660.00	-
Structure 50L + Foundation LM 20L	1500	65.0	60	\$600.00	\$39,000.00	-
Difference	-	+27.2%	+39.5%		\$8,340.00	22 : 1

PRODUCT SPECIFICS

STRUCTURE®

Contains	(N) 9.1%, (P) 11.9%, (Zn) 0.26% + 7.8% Reacted Carbon
Use Rate	Refer to product label
pH	6.3
Specific gravity	1.307
Compatibility	Not compatible with calcium or magnesium liquid fertilisers. Seek professional advice prior to tank mixing with other fertilisers or pesticides.
Available pack size	20L & 1000L

FOUNDATION LM™

Contains	Concentrated biochemistry from a microbial manufacturing system
Use Rate	Refer to product label
pH	8.0
Specific gravity	0.994
Compatibility	Highly compatible. Avoid mixing with highly acidic tank mixes.
Available pack size	20L & 1000L



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