Struvite as a phosphorus replacement

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Struvite, a phosphorus-rich chemical that can now be recovered from waste-water streams, has potential as a slow-release fertiliser for crops. Its removal from waste water also has significant environmental and operational benefits.

Crystal Green (CG) is a struvite fertiliser, with five units of nitrogen and 12 units of phosphorous (5:12) with 10% magnesium.

CG is manufactured from industrial and municipal wastewater streams using advanced nutrient recovery technologies. Unlike many 'recycled products' such as compost and biosolids, CG is produced as a durable white crystalline granule, with good nutrient density and excellent freight, storage, handling and application characteristics.

Purity is 99.9% and independent laboratory testing shows the levels of contaminants such as heavy metals are far below regulatory thresholds.

In the US, CG is marketed as a 5:28:0 fertiliser because phosphorus (P) value in the US is benchmarked on P_2O_5 content. In Australia it is a 5:12 product because we benchmark on elemental P content.

It has been known for many years, even as far back as the 1960s, that results from using struvite are similar to those for DAP on a unit-for-unit performance basis in terms of dry matter production, P uptake and extractable residual P(1).

In addition, struvite has a low salt index, meaning it is less likely to cause seed bed utilisation (SBU) issues than conventional TSP, DAP and MAP fertilisers in a seed-banding application (below).

Fertiliser	Salt index
CG	7.7
TSP	10
MAP	27
DAP	29

THE RELATIVE SALT INDEX OF GRANULAR FERTILISER IS A GUIDE TO THE SBU RISK.

CG is also intrinsically slow-release, remaining plant-available for 160 to 200 days(2). Struvite is not easily dissolved in water but is highly citrate-soluble. Consequently, dissolution of struvite is plant-activated, with the granules releasing nutrients when in contact with citrates produced by growing plant roots.

CRYSTAL GREEN IS A DURABLE, DUST-FREE, WHITE STRUVITE GRANULE WITH CHARACTERISTICS THAT MAKE IT WELL SUITED TO USE IN MODERN SEEDING MACHINES.

For many decades DAP and MAP have been cheaper to produce than struvite and it has only been in recent years that Ostara Nutrient Recovery Technologies, a Canadian water-management company, has commercialised an economically-viable method for struvite production from waste water (below). The struvite made using the Ostara process is branded as Crystal Green.

The cost effectiveness of the process is a result of the co-benefits for waste-water treatment and the environment.

The removal of struvite from waste water benefits the waste-water treatment plant by reducing maintenance costs and increasing throughput capacity due to a reduction in pipe blockages.

Furthermore, preventing phosphate from polluting regional waterways has a host of environmental advantages. In

OSTARA TECHNOLOGY IS IN OPERATION AT FIVE WASTEWATER TREATMENT FACILITIES IN THE US. BY THE END OF 2013 THE TECHNOLOGY WILL BE IN USE AT TWO MORE SITES, INCLUDING ONE IN SLOUGH, IN THE UK. THERE ARE CURRENTLY NO INSTALLATIONS IN AUSTRALIA.

an SA context these benefits would include improved health of sea grass in the gulf and a reduction of toxic algae blooms.

In addition, the wastewater treatment facility earns revenue sales of the CG produced.

THE BUILD-UP OF PHOSPHATE SALTS IN PIPES AT WASTEWATER TREATMENT FACILITIES IS AN ISSUE FOR PLANT CAPACITY AND MAINTENANCE.

THE RAPID GROWTH OF ALGAE DUE TO EXCESSIVE NUTRIENTS IN THE ENVIRONMENT DEPLETES THE WATER OF DISSOLVED OXYGEN, LEAVING FISH AND OTHER AQUATIC LIFE TO EFFECTIVELY SUFFOCATE.

SA trials

In light of 'peak phosphate' and the high risk of escalating phosphate prices in the future, SANTFA has assessed the performance of Crystal Green in local cropping systems.

Two trials were established in 2012 with the assistance of Zero-Waste SA and the EP NRM Board. These were a lentil trial at Hart, in which CG was compared to MAP, and a wheat trial at Wangary, comparing CG to DAP. Four randomised replicates were established at each site to ensure high data integrity, and the trials were sown and reaped by independent contractors.

Hart lentils

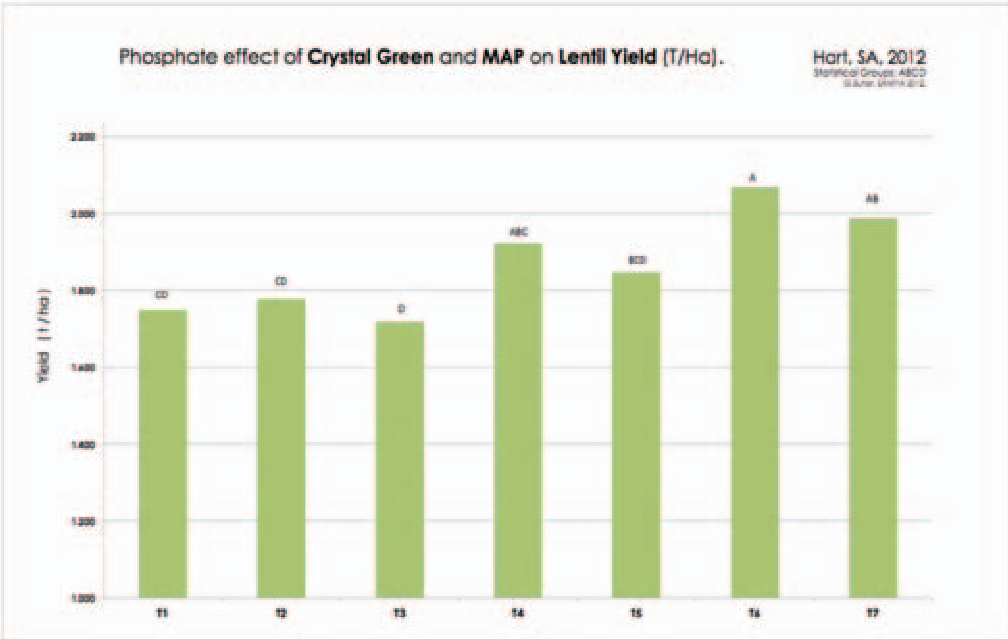
At Hart two rates of CG – 25 kg/ha and 75 kg/ha – were compared to MAP on a weight-for-weight basis. In a separate treatment, additional N was applied with CG so the total units of N applied matched the N applied via MAP (Graph 1).

The 75kg/ha rate of CG produced a 17% yield benefit compared with the yield from the control, which received no fertiliser. The high rate of MAP increased yield by 6%.

The low rate of MAP produced a 2% yield benefit but in the plots with the low rate of CG the yield was 2% lower than the nil control. However, the addition of urea, to match the amount of supplied N with the N added in the MAP, resulted in a yield benefit of 10%; statistically similar to the 6% yield benefit from the high rate of MAP.

Based on this performance it appears CG could be readily used in place of MAP fertiliser in grain legume production.

GRAPH 1: THE YIELD OF LENTILS RELATIVE TO FERTILISER TREATMENT.



	Treatment	Products Applied (kg/ha)			Units Applied (kg/ha)		Wheat Yield	
		DAP	CG	Urea	N	P	t/ha	% of T1
T1	Nil (seed only)				0	0	3.42	100
T2	DAP (18:20) LR	35			6.3	7	3.94	115
T3	Crystal Green (5:12) LR		35		1.75	4.2	4.49	131
T4	Crystal Green (5:12) with Urea (N-compensation) LR		25	12	6.3	3	3.90	114
T5	DAP (18:20) HR	100			18	20	5.67	166
T6	Crystal Green (5:12) HR		100		5	12	4.40	112
T7	Crystal Green (5:12) with Urea (N-compensation) HR		71	34	18	8.5	5.17	151

Source, SANTFA 2012

Wangary wheat

At Wangary, two rates of CG – 35 kg/ha and 100 kg/ha – were compared to DAP on a weight-for-weight basis.

Additionally, the CG was supplemented with urea in a separate treatment so the total units of N applied were consistent with the DAP (Graph 2).

The high rate of DAP was the best-performing treatment, with a yield benefit of 66% over the nil treatment control. The high rate of CG produced a significantly lower yield benefit of 12%. However, when the high rate of CG was supplemented with urea the yield was significantly improved to 51% of the control; similar to the high rate of DAP.

It is important to note that while the N units were consistent with the applied DAP in this treatment, the P units applied in the CG were less than half of the DAP, indicating that the P-use efficiency with CG may be better than with DAP.

The low rate of CG produced a 13% yield benefit, statistically similar to the 15% achieved with the low rate of DAP. The performance of the low rate of CG was not improved by the addition of urea, with this combination producing a yield of 14% above the control.

Based on these results it appears CG could be used as a substitute for DAP fertiliser in cereal production however blending with urea to ensure adequate N would be essential.

Summary

The look, handling and durability of the Crystal Green product means there are few practical impediments to its being adopted by farmers.

In the SA trials CG showed excellent phosphate use efficiency relative to MAP and DAP and its low salt index may provide SBU benefits in banded applications.

It provides more sustainable access to phosphate, significant environmental advantages, and the greenhouse-gas footprint of CG production is about one-fifth of that of industrial phosphate fertiliser production from natural reserves(2).

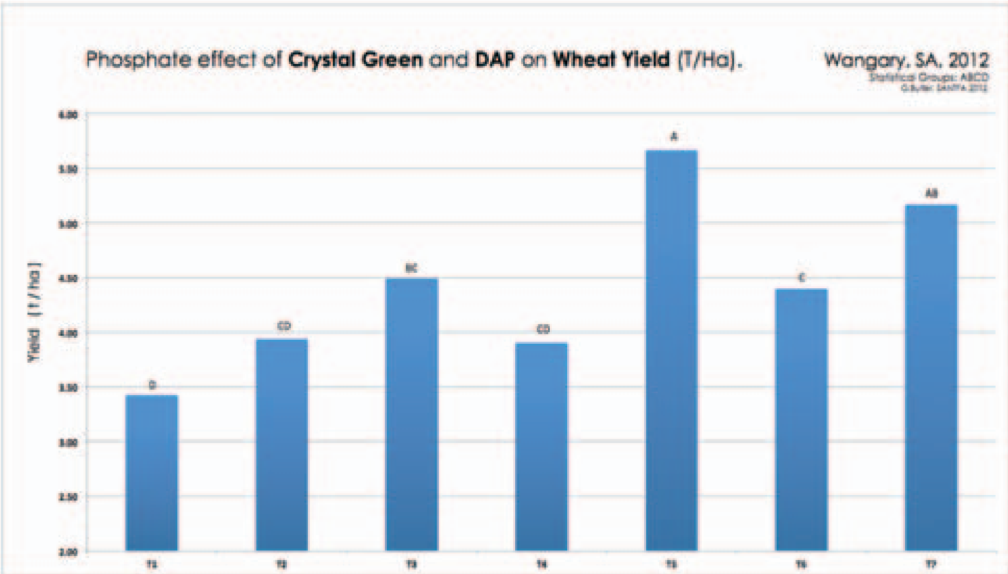
Struvite is a much slower-release fertiliser than MAP or DAP, so the carry-over benefit of CG should exceed that of MAP or DAP.

The 2012 trial site has been re-sown in 2013 without any additional phosphate, with the aim of clarifying the benefit of applying struvite as a 'rolling fertiliser', with a proportion of the nutritional benefit rolling from one season to the next.

If the Ostara waste-water technology was to be implemented in Australia by regional water-treatment authorities, CG would be available to local markets. However, the amount produced would be limited and certainly not enough to satisfy the entire demand for phosphate.

Due to this limited capacity to supply the market with phosphate from waste-water extraction, early movers seeking to secure CG supplies under longer-term contracts may gain the most benefit.

GRAPH 2: THE YIELD OF WHEAT RELATIVE TO FERTILISER TREATMENT.



	Treatment	Products Applied (kg/ha)			Units Applied (kg/ha)		Lentil Yield	
		MAP	CG	Urea	N	P	t/ha	% of T1
T1	Nil (seed only)				0	0	1.750	100
T2	MAP (10:22) LR	20			2	4.4	1.777	102
T3	Crystal Green (5:12) LR		20		1	2.4	1.717	98
T4	Crystal Green (5:12) with Urea (N-compensation) LR		15.7	2.9	2	1.9	1.920	110
T5	MAP (10:22) HR	75			7.5	16.5	1.847	106
T6	Crystal Green (5:12) HR		75		3.75	9	2.070	117
T7	Crystal Green (5:12) with Urea (N-compensation) HR		59	11	7.5	7.1	1.987	114

Source, SANTFA 2012

References:

(1) Barak and Stafford – Struvite: A recovered and recycled Phosphorous fertiliser, 2006.

(2) Nuresys, Sustainable Phosphate and resource management, 2005.

Acknowledgments:

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For more information:

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