Biostimulant coated fertilizers prove economically significant increases in nitrogen use efficiency and subsequent crop productivity

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Losses of nitrogen and phosphorus from granular fertilisers through leaching, tie up and volatilisation are well known. By coating the granular fertilizers of urea and diammonium phosphate with a proprietary combination of organic acids, plant hormones, vitamins and minerals, these losses can be reduced, and overall productivity increased.

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Abstract:

Losses of nitrogen and phosphorus from granular fertilisers through leaching, tie up and volatilisation are well known. By coating the granular fertilizers of urea and diammonium phosphate with a proprietary combination of organic acids, plant hormones, vitamins and minerals, these losses can be reduced and overall productivity increased.

8 years of scientifically valid laboratory, greenhouse and field trials in Australia and South Africa have demonstrated that biostimulant coated urea, marketed as Black Urea®, can reduce the volume of fertilizer required to be applied by 5-35% in soil where low organic matter restricts yields. This has been reflected in productivity increases of 5.9% in irrigated cotton (A$538/ha increased profit, 1.12 bales/ha), 15.6% increases in irrigated wheat (A$165/ha increased profit, 0.66t/ha), 6.95% in irrigated corn (A$284/ha increased profit, 0.8t/ha), 20% in pasture (A$36/ha increase profit, 2t/DM/ha).

Further value is derived in dryland production by a reduction of environmental impact, at the commonly applied rate of 25% less than granular urea (yield remains the same), a 25% reduction in associated transport emissions and environmental losses is concluded.

Key Words:
biostimulants, organic acids, urea, nitrogen use efficiency, Black Urea

Introduction:

In global contexts fertiliser use is indelibly linked to food security and resource management (IFPRI) whilst ironically also linked to planet destruction costing the earth over a tonne of greenhouse gases for every tonne of fertiliser production per annum (IEA). Never more in modern farming has there been the need for enhanced efficiency fertilisers to generate win/win solutions.

Soils of low biological fertility, such as in those in semi-arid regions, are inherently inefficient in nutrient use efficiency with regards nitrogen in particular. Poor soil structure from low organic matter, low clay content, poorly balanced cations, or combinations of these, promote leaching and/or volatilisation as major loss pathways.

Late in the last century we learned roles of the different functional groups in the rhizosphere and how they were different in nutrient management within various fertility environments. We surmised that if we could build the environment similar to that of high nutrient use efficiency soils around the fertiliser granule micro site in low nutrient efficiency (low fertility) soil, we could make some improvement to the poorer soils nutrient use efficiency.

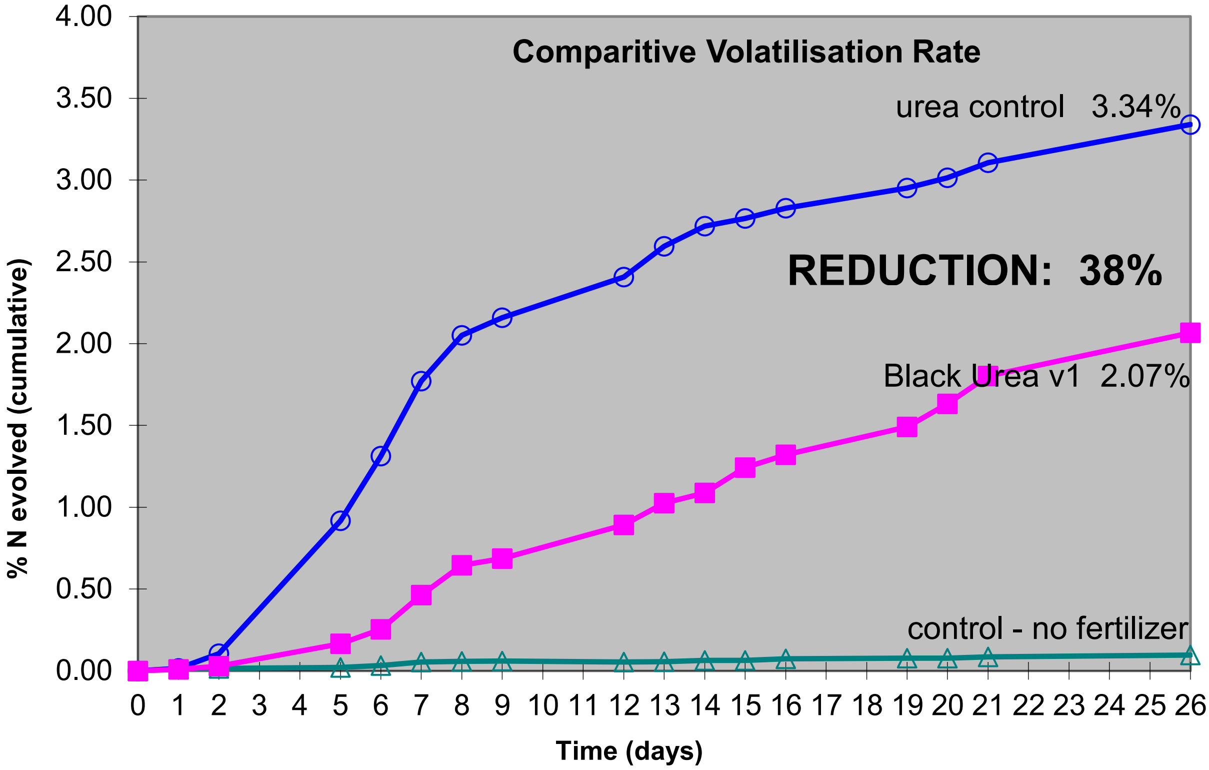
In 2001 we started laboratory tests for volatilisation and leaching with early ingredients. Followed up with greenhouse and field research through mainly a trial and error process, we learned varying combinations of the different functional groups in the rhizosphere yielded different results with varying degrees of agronomical and/or economical success.

Version 4 finally provided agronomic and economic value to the whole production chain (consumer - farmer – input supplier – production - raw material suppliers). A fertiliser coating we call LAUNCH with unique combinations of biostimulants and biocatalysts (from humate derived organic acids, plant hormones, vitamins and minerals) allowed a dual effect stabilisation process to occur, firstly by ionic exchange capacity and further by microbial activity.

Animation – To view an animation of how Black Fertiliser works go to www.advancednutrients.com.au or call 1800 244 009.

Research:

Jackson had informed us that humic molecules help stabilise soil cations which was our base priority for NH_4. After selecting and testing many humic products we agreed with Jackson but found that this was only economically and agronomically true for product base ingredients with a narrow ratio of functional groups. Our best result at that time, from a technical humic acid, was tested with the below results with scientific rigour (replicated, controlled), by an Australian fertiliser company, Incitec, in May/June 2001. The soil was taken from northern NSW, an area well known for volatilisation losses (cracking clays, pH_w8.2, CEC 31, application rate equiv. 200kgN/ha).



Motivated by our investigative work we sought other mechanisms of stabilising water soluble nutrients in the soil. The requirements of nitrogen, carbon , phosphorus etc by soil microorganisms is well known (Brock). By providing food sources and biostimulants in the coating for heterotrophic bacteria, a biological warehouse for storing of nutrients is made available around the fertiliser granule. These nutrients are made available back to the plant through the normal nitrogen cycle that is somewhat controlled by the plant via its root exudates and their effect on microbial activity to recycle nutrients.

Dr James Harkryder, Cypress College Biology Dept.
Test of biostimulants in Launch.
Heterotrophic plate count,
left petri with 2 drops of 100% bio-stimulant,
right petri 2 drops of 10% diluted bio-stimulant.

Greenhouse results are wildly mixed, 2003 QDNR greenhouse trials showed no significant difference in hydroscopicity, hydrolysis, leaching or volatilisation with coated versus non coated urea. van Vurren in South Africa however showed 28/30% increases in maize fresh/dry mass when top dressed with the commercial product, Black Urea, under greenhouse conditions. These results further demonstrated that top dressing Launch coated urea can achieve similar biomass production as the usually superior band placed fertiliser application in lime amended soils.

Chart 1 – van Vuuren, 2006 – Fresh Mass production

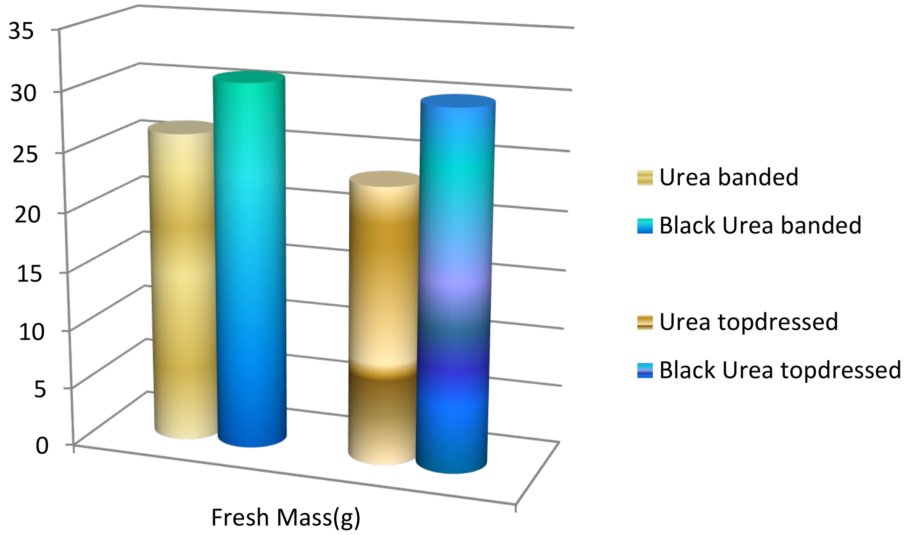
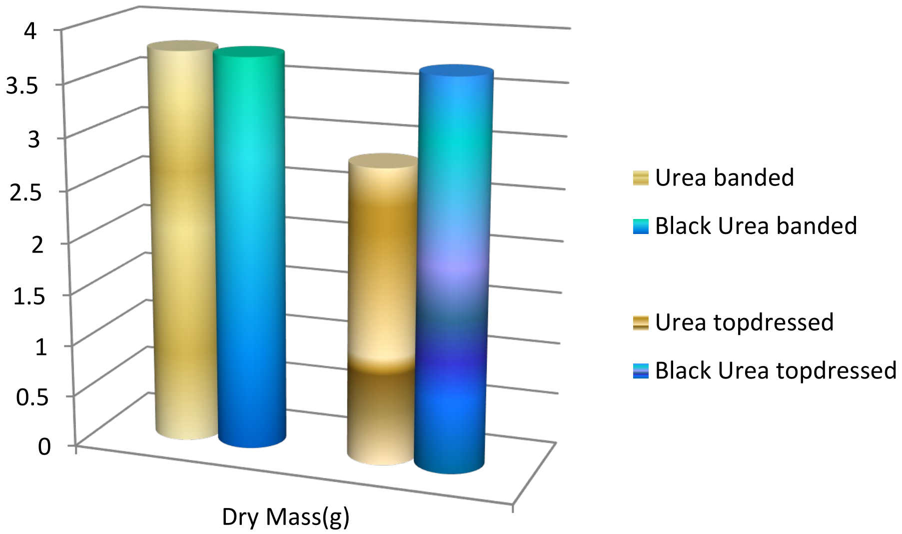


Chart 2 – van Vuuren, 2006 – Dry Mass production



Soil microbiologists Ingham and separately Knox explained that when a large diversity of microbiology are involved in a process, as we are with our coating, this diversity can only be represented in reasonably large areas, normally ½ an acre (2,200m^2) or more. This may explain the variation in pot trial results as a single pot may or may not have the same species or same “part mix” of diversity. As soil microbiology is not a well understood area of science, there are likely other mechanisms happening as well which we continue to investigate.

The link to microbiological function is as critical to laboratory testing as it is to greenhouse testing. In most laboratory protocols for leaching and volatilisation experiments, crushing, grinding, drying, sterilising are usual soil preparation steps, this is course changes the living component of the soil and thereby tainting real comparison to real world applications. Yara showed this in 2007 studies at Hanninghoff were testing the effects of Black Urea in sterilised, or highly prepared, media against instructions to the contrary produced few results seen repeatedly in field experiments.

With no economically real solution to the possible conflicts in laboratory or greenhouse studies, our focus is largely on commercial on-farm demonstrations sites that the larger scale can provide replicated real world results preferred by our customer base.

Ferguson was commissioned by a wholesale customer independently of our involvement, who wanted to evaluate the product for distribution. Moisture is often associated with nitrogen loss potential, Fergusons work showed generally increased losses as moisture increases but with a far higher retention of nitrogen in the soil with Launch coated fertiliser.

Ferguson, J. NITROGEN RETENTION in SOIL (% Total N)					
Low Moisture					
	2 weeks	4 weeks	6 weeks	8 weeks	10 weeks
Coated Urea	95%	84%	75%	70%	62%
Uncoated Urea	55%	30%	15%	3%	1%
Low - Medium Moisture					
	2 weeks	4 weeks	6 weeks	8 weeks	10 weeks
Coated Urea	93%	85%	70%	63%	52%
Uncoated Urea	66%	45%	28%	10%	4%
Optimum Moisture					
	2 weeks	4 weeks	6 weeks	8 weeks	10 weeks
Coated Urea	90%	80%	65%	52%	46%
Uncoated Urea	75%	42%	26%	8%	5%
Moderately High Moisture					
	2 weeks	4 weeks	6 weeks	8 weeks	10 weeks
Coated Urea	90%	76%	65%	50%	45%
Uncoated Urea	68%	40%	15%	4%	3%
Very High Moisture					
	2 weeks	4 weeks	6 weeks	8 weeks	10 weeks
Coated Urea	85%	70%	60%	52%	48%
Uncoated Urea	60%	35%	10%	2%	1%

The most important performance indicator for sustainability is profitability. All farm inputs must contribute to the overall financial success of the enterprise. Enhanced Efficiency Fertilisers hold a greater benefit in their ability to resolve issues at niche level providing flexibility to consumers with higher returns on investment and adding value along the whole supply chain. Launch coated fertilisers have demonstrated this value in many regions and cropping systems.

Examples include;

Crop and Location:	Irrigated Cotton - "Tundunna", Mungindi
Application:	Ground rig, September 2005, 390kgs/ha
Trial Conditions:	Replicated 2.4ha plots over three fields. Black Urea applied at only 5% less (390kgs/ha) than normal practice (410kg/ha) giving an increased application cost for Black Urea of $22/ha. Heavy cracking clay with a 8.1 pH and a CEC of 40. Average rainfall 550mm.
Result:	Granular Urea: averaged 12.67 bales/ha Black Urea : averaged 13.79 bales/ha The additional 1.12 bales (@ A$500/bale) less the increased application costs (A$22/ha) provides **a net profit increase to the grower of $538/ha**

Crop and Location:	Dryland Wheat - “Mayfield”, Quirindi
Application:	Applied by air in crop, July 2004, 50kgs/ha.
Trial Conditions:	Urea is usually applied at 80kgs/ha in crop but is difficult to maintain to be economically viable. Black Urea™ is tried at 50kgs/ha to determine if overall economics improve over an area of 200ha. A black basalt soil with a 6.5 pH and a CEC of 28. Two good rain events through the season with a wetter than normal harvest.
Result:	Urea average yield: 4.23 t/ha at nutrition cost of $28/ha = 151kgs yield per $1.00 spent. Black Urea™ av. yield 4.89 t/ha, at a nutrition cost of $23/ha = 212kgs yield per $1.00 spent. Black Urea™ delivered an increase in the overall yield economics of over 40%. **A yield increase of 0.66t/ha and reduced input cost increase net margin by $165/ha.**

Crop and Location:	Irrigated Corn - "Goodgerwirri", Caroona
Application:	Side dress, December 2004, 160kgs/ha
Trial Conditions:	In order to evaluate any economic benefit of Black Urea on Corn compared to granular urea. Black Urea was applied to 90ha at 20% less the historical rate of granular urea (200kgs/ha)

	Black self mulching clay-Vertosol with an 8.5 pH and a CEC of 64. High rainfall in December and January with a dry harvest.
Result:	Granular Urea av. yield: 11.5 t/ha @ 142kgs per $1.00 Black Urea™ av. yield: 12.3 t/ha @ 149kgs per $1.00 **The additional 0.8t/ha netted the grower an increase of $284/ha**

Crop and Location:	Dry Land Pasture - "JNardi", Eureka
Application:	Ground spread, September 2005, 80kgs/ha
Trial Conditions:	In order to evaluate any economic benefit of Black Urea on rye grass pasture directly compared to granular urea on an intensely grazed dairy farm. Red volcanic soils with a 5.0 pH and a CEC of 18. High summer rainfall.
Result:	Granular Urea: after 21 days approx. 8 t of dry matter per ha. Black Urea : after 21 days approx. 10 t of dry matter per ha. **The additional 2t/ha dry matter netted an additional 5 days grazing giving the grower a calculated nett increase of $36/ha**

Crop and Location:	3rd Ratoon Sugar Cane - Home Hill
Application:	Applied by stool splitter, July 2009, 160kgs/ha.
Trial Conditions:	Replicated plots of varying sizes from 0.33ha – 9.75ha over six fields. Black Urea applied at only 73% less (160kgs/ha) than normal practice (220kg/ha) giving a decreased application cost for Black Urea of $44.90/ha. light sandy loam with a 6 pH and a CEC of 5. Average rainfall 1100mm.
Result:	Granular Urea: averaged 1342.04 production units per ha Black Urea : averaged 1404.47 production units per ha The additional income per ha of $4/unit less the increased application costs (A$44.90/ha) provides **a net profit increase to the grower of $294/ha**

Continuous Improvement:

The challenges to a sustainable future are growing. All those involved in food and fibre production must be of a continuous improvement mindset to meet these challenges and develop new opportunities. We are continuously trying to improve our understanding of our products and improve their value proposition. van Vuuren in South Africa is researching improvements by adding lime and microorganisms to the coating, promising signs of significant improvements (see Chart 3 and 4) have led to further field and commercial studies currently ongoing. Where DAP improved over the control (SSP) 5.2% in fully replicated studies, further gains over DAP by Black DAP of 11.3% and even further gains by Black DAP++ of 17.9% over Black DAP, an aggregate of 37.8% gain over the standard practice control.

Chart 3 – van Vuuren 2009, Fresh Mass production

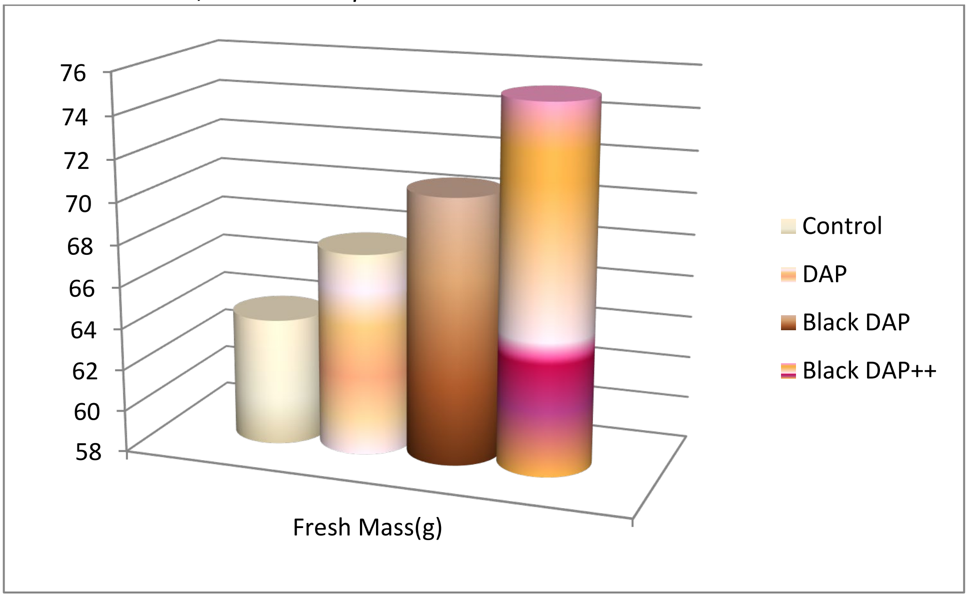
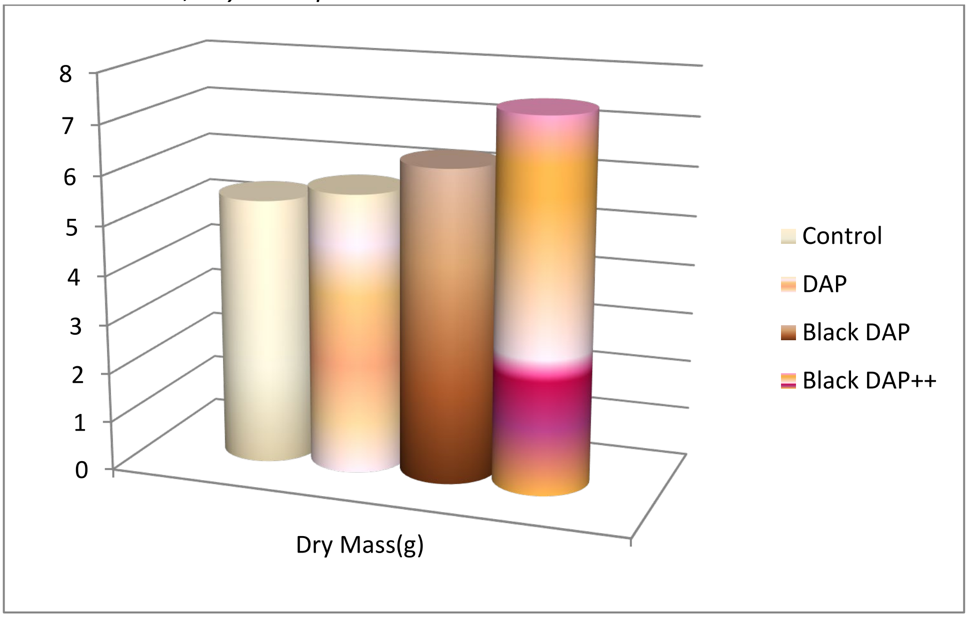


Chart 4, van Vuuren 2009, Dry Mass production



Environment Impact:

A simplistic view of environmental benefit tells us a 20-30% reduction in coated fertiliser application reduces environmental impact from production and transport also 20-30% in regions that are agronomically suited.

Norton concluded significantly reduced nitrification and N_2O emissions under cool, moist conditions with Launch coated fertiliser in laboratory tests. Whilst providing us insight, the test soil was of a type where this fertiliser is marginally suited (>2% SOM) and Norton could only measure the effects of chemical interactions and so limiting results compared to commercial field conditions where biological mechanisms of the product are suited. Field plot trials on N% retention at different moisture levels conducted by Ferguson support a probable wider range of applicable soils and environments.

Conclusion:

We agree with many of our learned colleagues that enhanced efficiency fertilisers have niche places in crop production depending on product mechanism, soil type, environment, etc. Launch coated fertilisers niche is in low biologically fertile soils (<2%SOM), where nutrient loss pathways are high, particularly when top dressing is prevalent. Whilst we admit we do not fully understand the complete mechanisms and some theories lack depth, our research continues to be focussed on commercially relevant outcomes and a lower priority on pure scientific endeavour. Delivering economically and environmentally sustainable outcomes is our priority in a world of declining food security and natural resources.

Resources:

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