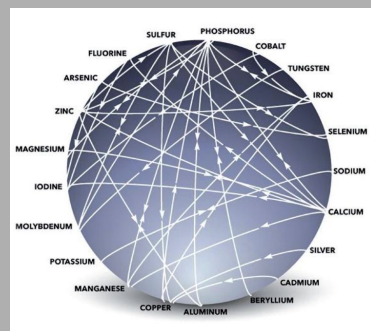
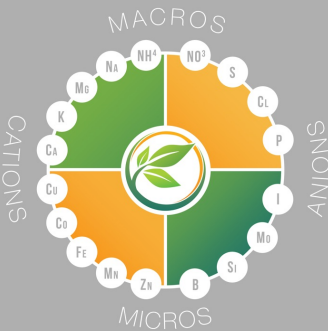
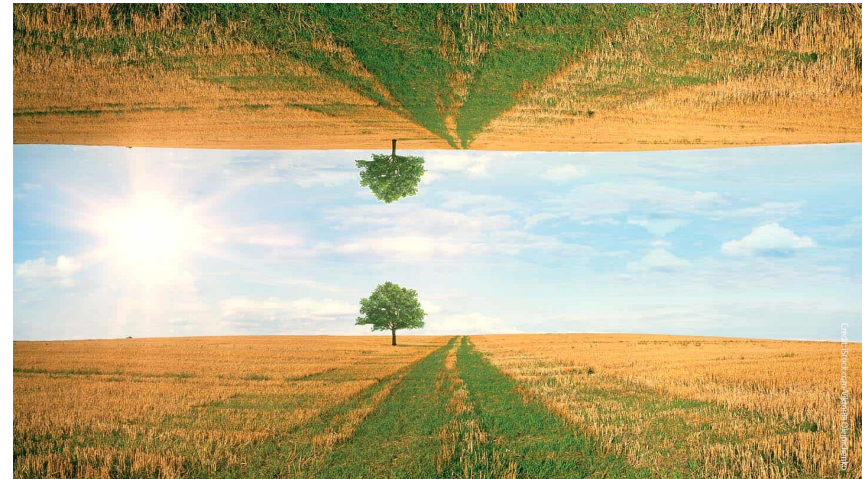


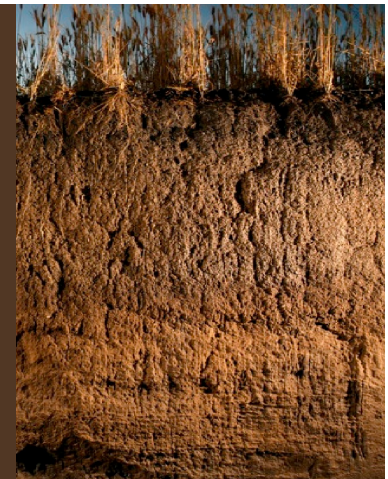
Cost-effective nutrient management and foliar feeding

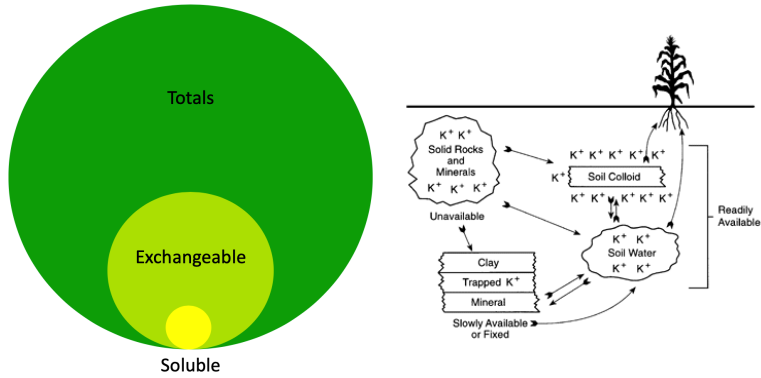
Joel Williams
www.integratedsoils.com
 @integratedsoils



Problems with Uptake?

- Soil nutrient supply limited by:
 - Abiotic stresses: temperature, soil moisture, salinity, pH extremes.
 - Biotic stresses: pest and disease, soil biological activity.



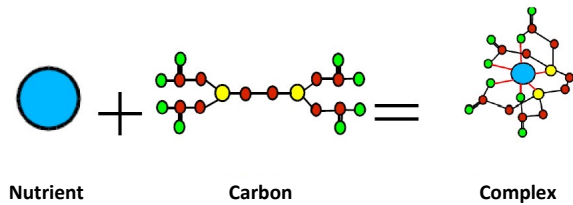


Connecting Bio-Priming Approach with Integrated Nutrient Management for Improved Nutrient Use Efficiency in Crop Species

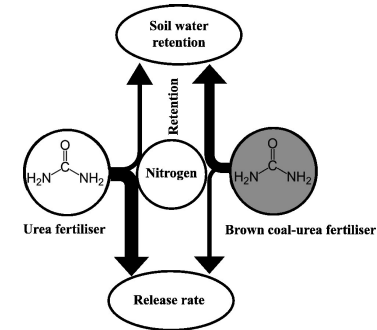
Nutrient	Efficiency (%)
Nitrogen	30-50
Phosphorus	15-20
Potassium	50-60
Sulphur	8-12
Zinc	2-5
Iron	1-2
Copper	1-2
Manganese	1-2
Boron	2-3
Molybdenum	2-5

* Sarkar et al (2021). doi.org/10.3390/agriculture11040372

Carbon Based Inputs



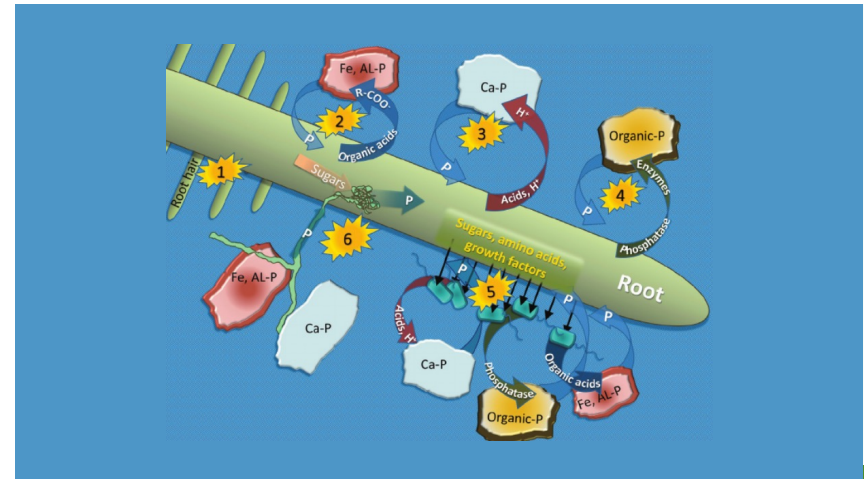
Hybrid brown coal-urea fertiliser reduces nitrogen loss compared to urea alone



* Saha et al (2017). doi.org/10.1016/j.scitotenv.2017.05.270

Application Rates

- Molasses & Sugars 5 L/ha
- Humic Acid Label rates, 3-5 L/ha
- Fulvic Acids Label rates, 1-2 L/ha
- Amino acids Label rates, 0.5-1 L/ha
- Protein Hydrolysates 2-5 L/ha
- Seaweed/Kelp Extracts 2-5 L/ha
- Plant Extracts 10+ L/ha
- Compost Extracts 10+ L/ha



Feeding Microbes

- Molasses, sugar
- Amino acids, protein hydrolysates
- Seaweed/Kelp extracts
- Fulvic Acid
- Humic Acid
- Plant Extracts
- Biostimulants



Andrew Howard
@FarmerAndyH



Mechanisms of Efficiency Gains?

- Targeted placement directly onto crop
- Less nutrient antagonisms/competition vs soil applied
- Improved and even coverage vs sporadic granules
- Rapid uptake = less time for losses to occur
- Less off-gassing, less nitrate leaching etc
- Maintain nutrient supply during sub-optimal soil conditions
- More control over what forms of nutrients enter the plant.

Foliar versus soil phosphorus (P) application for improving P use efficiency in wheat and maize in calcareous soils

ABSTRACT
Phosphorus (P) is the most deficient nutrient in agricultural soils after nitrogen. Additionally, exogenously applied P quickly transforms into less soluble compounds through various chemo-sorption reactions resulting in poor fertilizer use efficiency (15-25%). Therefore, this pot experiment was conducted to investigate the impact of foliar P (0, 45, 90 and 135 mM KH_2PO_4) in conjunction with soil applied P (0, 10 and 20 mg $P\ kg^{-1}$) for enhanced growth and P use efficiency of maize and wheat in calcareous soils. There was a linear increase in plant height and biomass both with the increasing application of soil and foliar P in both wheat and maize crop. However, the effect of foliar P was more pronounced in P deficient condition compared to 10 or 20 mg $P\ kg^{-1}$. Soil applied P at 10 and 20 mg $P\ kg^{-1}$ increased plant dry biomass by 10.8 and 16.8% in maize and by 29.9 and 35.5% in wheat over control, respectively. Foliar P application didn't improve soil phosphorus. The interaction between soil and foliar P was significant ($p < .05$) showing that increase of either foliar or soil P application, tissue P content of both maize and wheat increased. In both seasons the higher foliar P solution resulted in higher P uptake though the increase in wheat were lower than maize. Therefore, the low recovery of soil P associated with poor soil characteristics could be corrected through its foliar application if administered at proper growth stage with suitable concentration strength and appropriate source.

Table 3. Total uptake and P use efficiency of maize and wheat crop as affected by different levels of phosphorus both soil and foliar applied P.

Treatments	Total P uptake (mg pot ⁻¹)		P use efficiency (%)	
	Maize	Wheat	Maize	Wheat
Soil applied P (mg $P\ kg^{-1}$ soil)				
0	122.62 c	45.06 b		
10	160.08 b	67.59 a	7.90	4.43
20	179.86 a	75.94 a	4.16	2.31
$LSD_{0.05}$	13.34	8.65		
Foliar P (mM KH_2PO_4)				
0	118.35 c	45.84 c		
45	148.18 b	59.44 b	37.96	19.96
90	163.68 ab	64.52 ab	19.88	10.50
135	186.52 a	81.66 a	14.21	7.92
$LSD_{0.05}$	15.40	9.98		
Interaction				
SP × FP	0.68	0.86		

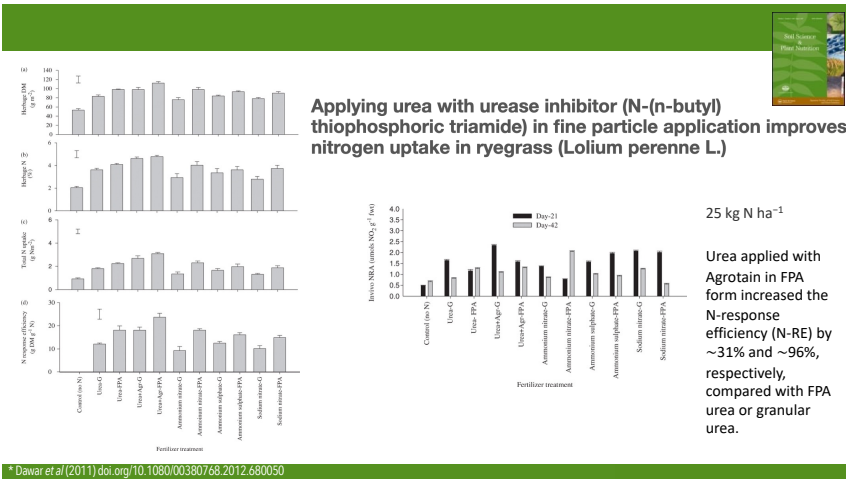
* Rafiullah et al (2021). doi.org/10.1080/01904167.2021.1871744



Urease inhibitor reduces N losses and improves plant-bioavailability of urea applied in fine particle and granular forms under field conditions

A field lysimeter/mini plot experiment was established in a silt loam soil near Lincoln, New Zealand, to investigate the effectiveness of urea fertilizer in fine particle application (FPA), with or without the urease inhibitor N-(n-butyl) thiophosphoric triamide (NBPT – "Agrotain"), in decreasing nitrogen (N) losses and improving N uptake efficiency. The five treatments were: control (no N) and ¹⁵N-labelled urea, with or without NBPT, applied to lysimeters or mini plots (unlabelled urea), either in granular form to the soil surface or in FPA form (through a spray) at a rate equivalent to 100 kg N ha⁻¹. Gaseous emissions of ammonia (NH₃) and nitrous oxide (N₂O), nitrate (NO₃⁻) leaching, herbage dry-matter (DM) production, N-response efficiency, total N uptake and total recovery of applied ¹⁵N in the plant and soil varied with urea application method and with addition of NBPT. Urea with NBPT, applied in granular or FPA form, was more effective than in application without NBPT: N₂O emissions were reduced by 7–12%, NH₃ emissions by 65–69% and NO₃⁻ leaching losses by 36–55% compared with granular urea. Urea alone and with NBPT, applied in FPA form increased herbage DM production by 27% and 38%, respectively. The N response efficiency increased from 10 kg DM kg⁻¹ of applied N with granular urea to 16 kg DM kg⁻¹ with FPA urea and to 23 kg DM kg⁻¹ with FPA urea plus NBPT. Urea applied in FPA form resulted in significantly ($P < 0.05$) higher ¹⁵N recovery in the shoots compared with granular treatments and this was improved further when urea in FPA form was applied with NBPT. These results suggest that applying urea with NBPT in FPA form has potential as a management tool in mitigating N losses, improving N-response efficiency and increasing herbage DM production in intensive grassland systems.

* Dawar et al (2011) doi.org/10.1016/j.agee.2011.08.007



* Dawar et al (2011) doi.org/10.1080/00380768.2012.680050

Foliars Enhance Soil Uptake?

- Foliar NH₄⁺ increased soil N uptake (cotton)
- Foliar K promoted soil K uptake (potato)
- Foliar urea enhanced soil N and P uptake (potato)
- Mechanism?
 - Foliar nutrients can be translocated to roots and increase root biomass and hence soil uptake.
 - Enhanced root exudation.

* Niu et al (2021), doi.org/10.1007/s42729-020-00346-3

Soil vs Foliar

- **Soil dominant nutrients**
 - Major minerals
 - Immobile nutrients
- **Foliar dominant nutrients**
 - Trace minerals
 - Mobile nutrients
 - Any at all, with realistic goals

Avoiding the 'spray and pray' approach



Plant response depends on...



Formulation



Application



Crop



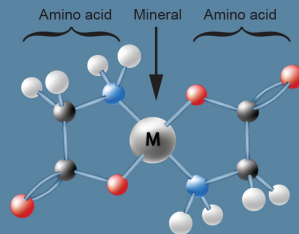
Environment

Plant Response: Formulation

- Formulation
 - Water quality
 - pH (<6)
 - Carbon or chelation
 - Electrical charge (cations vs anions)
 - Solubility
 - Molecular size
 - EC (electrical conductivity: 1.5-3 mS/cm)
 - Surface tension (spreading capacity)

Chelation

- Chelated minerals generally have:
 - Neutral charge
 - Better absorption (by root or foliar)
 - Better translocation within the plant
 - Lower salt index/less burning
 - Slower release rate (varies)
- Amino chelates are particularly useful.
 - Fish etc

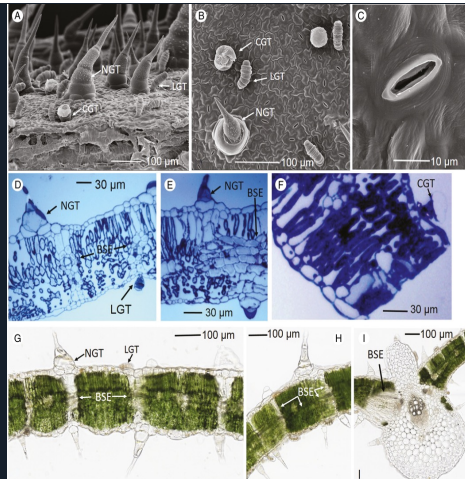


Plant Response: Application

- Nozzle
- Droplet size
- Pressure
- Droplet deflection
- Runoff
- Drift
- Surface area coverage
- Forward speed

Plant Response: Crop

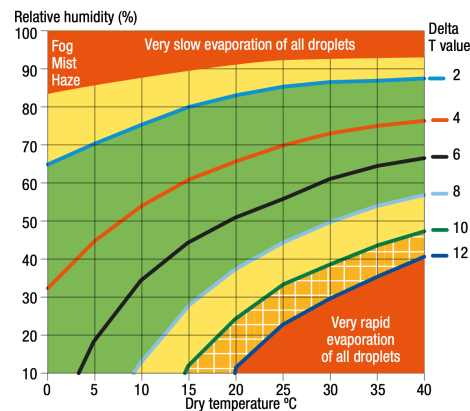
- Crop stage
- Canopy Structure
- Leaf Area Index
- Leaf Chemistry
- Leaf Shape
 - Cuticle
 - Surfaces waxes
 - Leaf hairs, spines etc
- Abiotic and biotic stresses



Plant Response: Environment

- Humidity
 - Time of day (stomata & pores open)
 - 70%+ humidity is ideal
 - Rapid drying can lead to re-crystallization
- Temperature
 - Max 28 C (~25 C)
- Wind
 - 3-15 km/h
- Drought
 - Early vs Late plant stress

- Preferred Delta T conditions for spraying
- Marginal Delta T conditions for spraying
- Conditions are marginal for COARSE or greater spray quality and unsuitable for medium or finer spray quality
- Unsuitable Delta T conditions for spraying



* https://grdc.com.au/_data/assets/pdf_file/0023/142583/grdc_fs_spray-practical-tips_low-res.pdf.pdf

1. **Use plant/sap analysis**
 - Determine nutrient imbalances/limitations and which nutrients need addressing
2. **Nutrient source(s)**
 - Choose fertiliser source
 - Consider auxiliary nutrients
 - Consider incompatibilities
3. **Carbon source(s)**
 - C-based chelators: fulvic, molasses etc
4. **pH adjustment**
 - Optimum spray pH (5-5.5)
5. **Wetter Sticker**

Designing Foliar Mixes



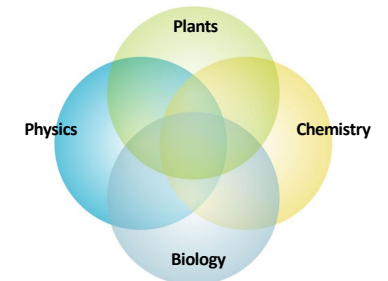
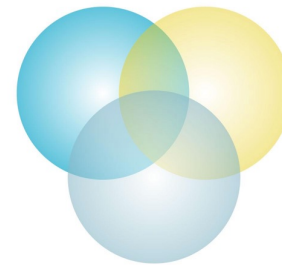
Sap vs Tissue

Sap Testing:

- Leaf sap/juice
- Nutrients + pH, EC, sugars
- Real-time nutrient status
- More predictive
- More variable/snapshot
- Very good for N quality

Tissue Testing:

- Whole leaf
- Nutrients
- Cumulative nutrient status
- More widely accepted
- Comprehensive
- Target ranges more robust



Thank you, Questions?

Mailing List, Resources, More info:

www.integratedsoils.com

[@integratedsoils](https://twitter.com/integratedsoils)

