

Understanding nutrient balance in fertigation systems

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Agronomic Principles

The aim of every producer is a high yield of top-quality fruit and there are many agronomic factors which can influence this, many of which are within their control given their specific growing systems and climatic/soil conditions.



First, a question...

What did you see?

17 cows

or

10,200 kg cows



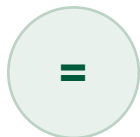
What is a mole?

A standard unit for counting extremely small particles

1 DOZEN

12

objects



same idea

1 MOLE

6.022×10^{23}

particles

Same way of
counting.
Very different scale.

A mole is the amount of substance containing exactly $6.02214076 \times 10^{23}$ elementary entities.

These may be atoms, ions, molecules or other specified particles.

PRACTICAL EXAMPLES

1 mol H^+

=

6.022×10^{23} H^+ ions

1 mol H_2O

=

6.022×10^{23} H_2O molecules

1 mmol NO_3^-

=

6.022×10^{20} NO_3^- ions

CHANGING SCALE

1 mol $\rightarrow \div 1,000 \rightarrow$ 1 mmol

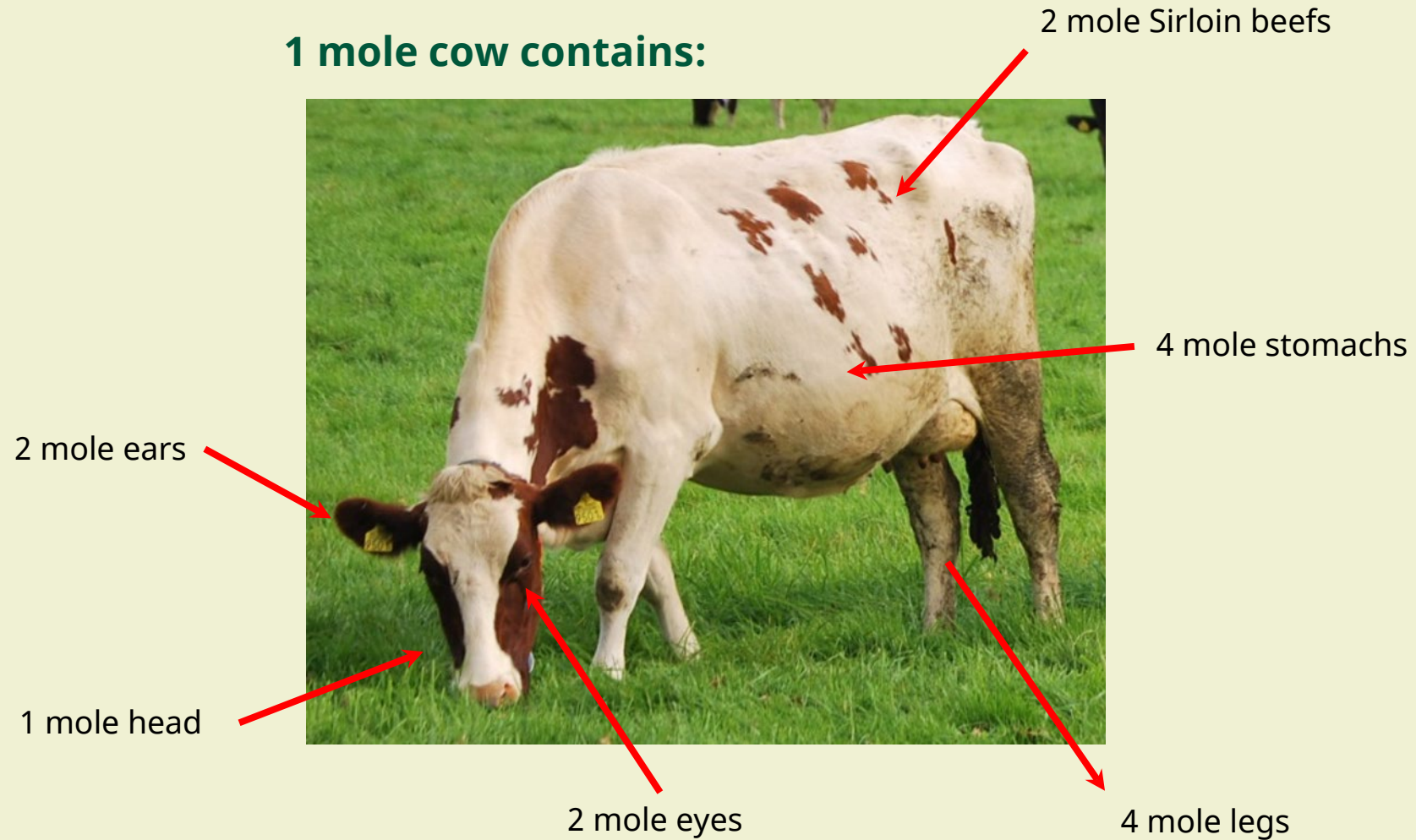
$\div 1,000 \rightarrow$ 1 μmol

A mole tells us how many particles are present, not how much they weigh.

1 mole cow

A mole is a unit for counting particles, just as a dozen is a unit for counting objects.

1 mole cow contains:



How big is a millimole?

Let's put it into beer terms.

1 mmol of beer

6.022×10^{20}
602,200,000,000,000,000 glasses

Shared across the world over an 85-year lifetime:

32 GLASSES PER PERSON
EVERY SECOND

And that is only one millimole.



A very, very large round.

mole

KNO_3 = Potassium Nitrate
 $\text{Ca}(\text{NO}_3)_2$ = Calcium Nitrate
 K_2SO_4 = Potassium Sulphate

The same principle for fertilisers:

- 1 mole KNO_3 → 1 mole K^+ and 1 mole NO_3^-
- 1 mole $\text{Ca}(\text{NO}_3)_2$ → 1 mole Ca^{2+} and 2 mole NO_3^-
- 1 mole K_2SO_4 → 2 mole K^+ and 1 mole SO_4^{2-}



Plants take up ions, not fertiliser by weight

Fertilisers → **Dissolves in water** → **Ions in solution** (cations & anions)

- Roots absorb nutrients as ions from the soil solution.
- Uptake must maintain electrical charge balance within the plant and rhizosphere.

The number, charge and ratio of ions are more informative for plant nutrition than mass concentration alone.

Moles make nutrient ratios simple

The chemical formula tells us the number and ratio of nutrient ions.



1 mmol HPO_4^{2-}

One phosphorus atom per phosphate ion



1 mmol P



1 mmol NO_3^-

One nitrogen atom per nitrate ion



1 mmol N



1 mmol K_2SO_4

The subscript sets the molar ratio



2 mmol K^+ + 1 mmol SO_4^{2-}

Equivalent nutrient content: 2 mmol K + 1 mmol S

Moles reveal the number and ratio of nutrient particles, not just their mass.

Converting between moles and mass

Molar mass is the bridge between particle amount and weight.

WORKED EXAMPLE

$$\text{Molar mass} \quad 39.10 + 14.01 + (3 \times 16.00) = 101.1 \text{ g/mol}$$

Potassium nitrate (KNO_3)

$$1 \text{ mmol/L KNO}_3 \times \frac{101.1 \text{ mg}}{1 \text{ mmol}} = 101.1 \text{ mg/L KNO}_3$$

mg cancels mmol

In a dilute aqueous solution:

$$101.1 \text{ mg/L} \approx 101.1 \text{ ppm KNO}_3$$

Same concentration expressed as mass per litre or mass per kilogram*

QUICK RULE

$$\text{moles} \times \text{molar mass} = \text{mass}$$

Mole weight

Al	26.98	Mg	24.31
B	10.81	Mn	54.94
Br	79.90	Mo	95.94
C	12.01	N	14.01
Ca	40.08	Na	22.99
Cl	35.45	O	16.00
Cu	63.55	P	30.97
Fe	55.85	S	32.06
H	1.01	Si	28.09
K	39.10	Zn	65.38

*The mg/L $\approx$ ppm relationship assumes a dilute aqueous solution with density close to 1 kg/L.

Why use moles in fertigation?

A simple way to describe what is happening around the roots.

Plants do not read fertiliser labels.

They meet nutrients as dissolved ions around their roots.

Moles help us see...

How many ions are present

The balance between those ions

The concentration available to the crop

Think in ions. Mix in kilograms.

Moles describe the recipe. Weight tells us how to deliver it.





Fertiliser

From mole to kg fertigation fertilisers

Yara Liva Calcinit



Krista range: Straight ws-fertilisers



Kristalon Range: Water Soluble NPK



Rexolin: Chelated micro nutrients



From mmol to kg fertilisers in stock solution.

Tank size	1,000	Litre
Concentration	100	x
total nutrient solution	100,000	Litre

Fertiliser		Tank	mmol fertiliser / l 1 mmol/l = .. kg kg fertiliser				density	litre fertiliser	Recipe in mmol and mmol/l distribution							
									NH ₄ ⁺	K ⁺	Ca ²⁺	Mg ²⁺	NO ₃ ⁻	SO ₄ ²⁻	H ₂ PO ₄ ⁻	H ⁺
Calcinit		A	4,00	21,6	86,4	-	-		1,25	8,00	4,00	1,37	16,00	1,37	1,25	
Krista K plus		A / B	6,75	10,1	68,1	-	-		0,80		4,00		8,80			
Krista SOP		B		17,4		-	-			6,75			6,75			
Krista MKP		B	1,25	13,6	17,0	-	-								1,25	
Krista MAP		B		11,5		-	-			1,25						
Krista MgS		B	1,37	24,6	33,7	-	-					1,37		1,37		
Krista MAG		A / B		25,6		-	-									
Magnesium nitrate	Liquid	A / B		40,0		1,35	-									
Ammonium nitrate	Liquid	A / B	0,45	15,6	7,0	1,24	-	5,7	0,45				0,45			
Nitric Acid 38%	Liquid	A / B		16,7		1,24	-									
Phosphoric acid 59%	Liquid	B		16,7		1,42	-									
Rest									-	-	-	-	-	-	-	-

Out of convenience, using a “Full Bag program”

Fertiliser	Tank	kg recipe	kg “full bag”
Calcinit	A	86.4	100
Krista K plus	A / B	68.1	75
Krista MKP	B	17	12.5
Krista MgS	B	33.7	37.5
Ammonium nitrate	A / B	7 kg = 5.7 L	5 L = 6.2 kg

Result in mmol



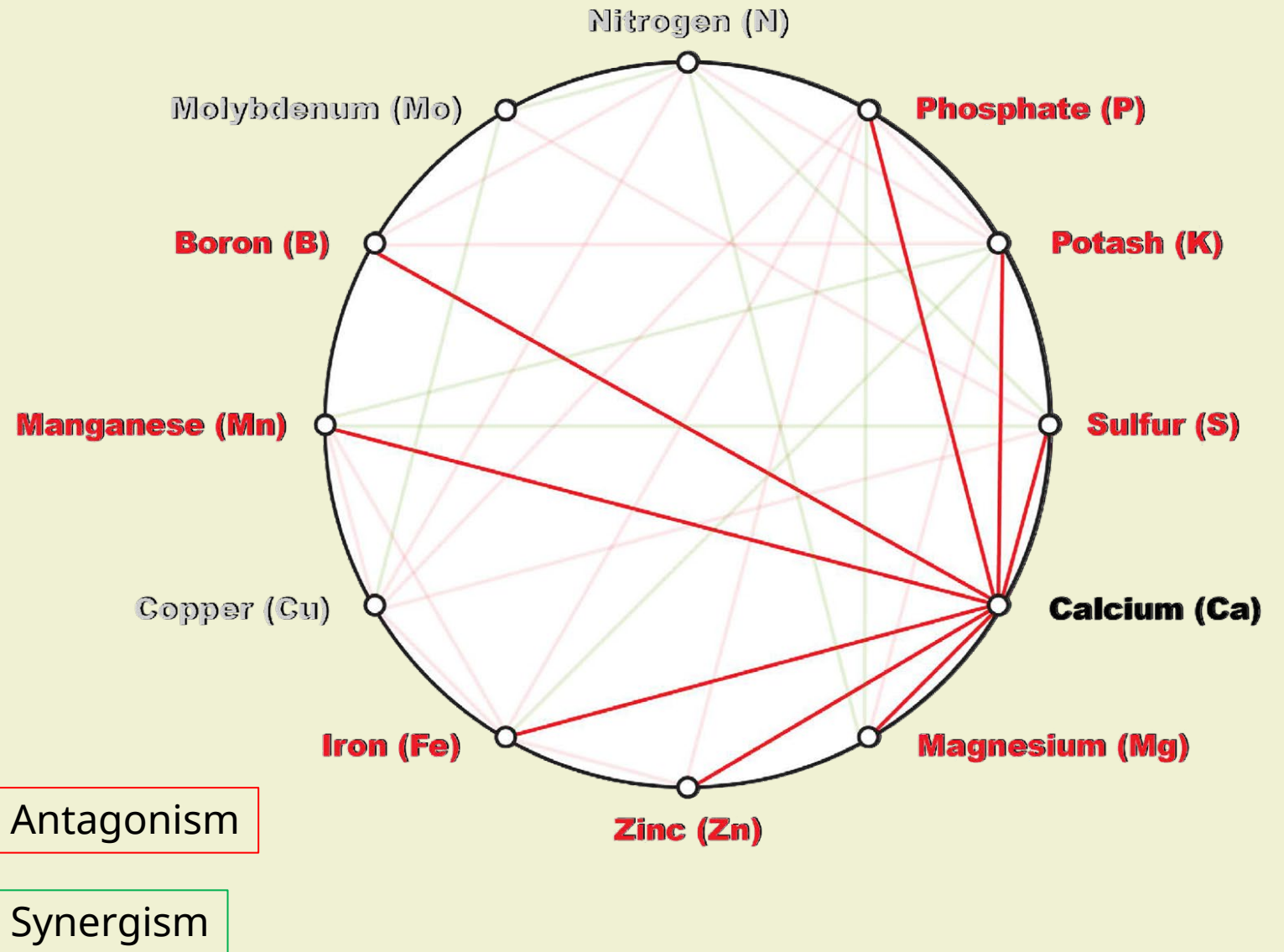
mmol	NH4	K	Ca	Mg	NO3	S	P
“full bag”	1.30	8.3	4.6	1.50	17.9	1.50	0.90
Recipe	1.25	8.0	4.0	1.37	16.0	1.37	1.25
diff	+4%	+4%	+15%	+9%	+12%	+9%	-28%



Mulders Chart

Calcium does not have any synergistic relationship with other nutrients. If calcium is overabundant, it can keep magnesium, zinc, iron, manganese, boron, phosphate, potash and sulfur from being available to the plant.

Rather than adding all of these other nutrients, be sure calcium is at the optimum level.



Role of Specific Nutrients



	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Mo	Zn	Si
Yield	^	^	^	^	^	^	^	^	^	^	^	^	^
Fruit Set	^	^	^	^*			^		^			^	
Fruit Quality	^v	^*	^	^			^				^*	^*	
Fruit Firmness	v	^	^v	^			^						^
Malformed Fruit	^		v*	v*			v					v	
Shelf Life	v		^	^			^v		^			^	
Fruit Acidity	^*		^										
Fruit TSS	v	^*	^									^*	
Fruit Vitamin C			^										
Fruit Albinism				v									
Leaf Diseases	^		v*	v*			v*	v		v			v
Fruit Diseases	^		v	v									
Root Diseases	^			v*									
Cold Tolerance	v*		^	^									

From fertiliser recipe to crop response

Three ideas to take away

1

Start with the ions

Moles make nutrient number, charge and ratio easier to compare.

2

Balance the whole system

Concentration and nutrient interactions shape what is available around the roots.

3

Convert the recipe into practice

Translate the target ion balance into fertiliser weights and a workable stock solution.

Think in ions. Mix with purpose. Grow better fruit.



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