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N BUDGETING TO MEET YIELD POTENTIAL

Harries et al. estimate

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INTRODUCTION

Equations to support N budgeting and yield potential

Estimating crop nitrogen(N) requirements is key to developing an effective fertiliser strategy, balancing agronomic performance and financial return. This relies on accurately estimating yield potential and aligning nitrogen inputs accordingly.

Several tools have been used over time to estimate yield potential, including the French and Schultz equation (1984), the Sadras and Angus formula (2006) (used in Yield Prophet Lite®).

More recent work by Harries et al. (2022) introduced a method based on water use (WU) of commercial crops grown in Western Australia to estimate water-limited potential yield (PYw). This represents the best yield achievable under best management, best cultivar and high water use efficiency, and can be used as a benchmark target.

This estimate is then adjusted using economic yield percentage (EY), which accounts for diminishing returns as input levels (e.g. N/urea) increase. A common rule of thumb is to target around 80% of PYw to maintain profitability.

Review during the growing season and after harvest

There are many reasons why a crop might not reach its yield potential, such as time of sowing, frost, heat and moisture stress. As the season progresses, climate outlooks generally become more reliable. Consider reviewing your yield potential throughout the growing season and especially prior to applying urea. A review after harvest, to consider any discrepancies between actual and estimated yields, is useful to identify areas for improvement in subsequent years.

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STEP 1. ESTIMATING CROP WATER USE (WU)

Crop water use (WU) has three components to calculate:

a. Calculate soil plant available water (PAW) at 1 April (prior to the start of growing season).

Rule of Thumb: If you haven't measured soil water prior to sowing, a rule of thumb is approximately 25% of summer fallow rainfall is available to the following crop, assuming no weeds.

b. Calculate the growing season to date if making in-season estimates. This is the rainfall since 1 April in mm.

c. Estimate rainfall for the rest of the growing season (31 Oct in low or medium rainfall zones or 30 Nov in high rainfall zones). This can be based on climate outlooks, historical records, apps such as CliMate.

The formula for calculating crop water use is:

$$WU(mm) = (0.25 \times \text{Nov-Mar rainfall}) + \text{Apr-Oct rainfall}$$

Tip: Rather than using one estimate for growing season rainfall, conduct a sensitivity analysis by selecting a range of outcomes: low, medium and high (or decile 2, 5 and 7) to calculate a range of yield outcomes for your crop.

STEP 2: CALCULATE WATER LIMITED YIELD POTENTIAL

The yield potential calculation for different crop types uses the Harries et al estimate. This equation for wheat is based on top performing crops, where about 25kg of grain is produced per mm of water after ~ 45mm is lost to evaporation and early crop use, which does not contribute to grain yield.

$$\text{Wheat } PY_w = (WU - 45) \times 25$$
$$\text{Barley } PY_w = (WU - 50) \times 24$$
$$\text{Canola } PY_w = (WU - 80) \times 15$$

STEP 3: CALCULATE N REQUIREMENTS

Calculate N requirements using the following guides of how much N is needed to produce one tonne of grain per hectare:

Wheat - 40kg N/ha
Barley - 35kg N/ha
Canola - 80kg N/ha

To work out the amount of urea (kg/ha) to apply, divide the N requirement by 0.46 which is the component of N in urea.

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Worked example: Estimating yield potential for a wheat crop growing at Beulah on 1 July.

Table 1. Beulah monthly rainfall tallies (mm) actual or estimate.

Month	Rainfall (mm)	Actual or estimate
Nov	28	Actual
Dec	10	Actual
Jan	13	Actual
Feb	38	Actual
Mar	89	Actual
Apr	10	Actual
May	25	Actual
Jun	35	June
July	36	Estimate
Aug	39	Estimate
Sept	37	Estimate
Oct	35	Estimate

Step 1: Estimate crop water use (WU)

a. Calculate soil PAW at 1 April. Using your records or a nearby weather station.
= 0.25 X (28 + 10 + 13 + 38 + 89)
= 0.25 x 178mm
= 44.5mm

b. Calculate the growing season rainfall to date. Using your records or a nearby weather station.
= 10 + 25 + 35
= 70mm

c. Estimate rainfall for the rest of the growing season (climate outlook, historical BoM records, gut feel etc)
= 36 + 39 + 37 + 35
= 147mm
WU (mm) = (44.5 + 70 + 147)
= **261.5mm**

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Worked example continued:

Step 2: Calculate PYW using Harries et al. estimate.
Wheat PYW is calculated as (WU – 45) x 25
= (261.5 – 45) x 25
= 5 412 kg/ha

Wheat EY is calculated as PYW x 0.8
= 5 412 x 0.8
4 330 kg/ha
Wheat EY = 4.3 t/ha

Step 3: Calculate N requirements
4.3 t/ha wheat yield potential, with a starting soil N supply of 60 kg N/ha and 7 kg N/ha applied via MAP at sowing, requires:

4.3 x 40 kg N/ha = 172 kg N/ha
172-60- 6 kg N/ha = 106kg N/ha
106 ÷ 0.46 = **230 kg urea/ha**

COST SCENARIO (see the factsheet "Assessing profitability with current high input costs" for more information)

Can I profitably grow a 4.3t/ha APW wheat crop, at $300/t market price, with 230 kg urea/ha, at $1500/t, with a 20 l/ha fuel rate, at $3/l diesel, in the LRZ?

= $1 290/ha (gross income) minus $345/ha (urea) minus $60/ha (diesel) minus $285 (other variable costs)
= $600/ha gross margin

Reference Harries M *et al.* (2022) *Crop & Pasture Science*, **73**(10), 1097-1117.

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