A simple framework for profitable fertiliser use in wheat: Grain and fertiliser prices matter

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Key messages

It is important to consider fluctuations in the price of fertiliser relative to grain prices when making fertiliser decisions. Findings from farmer surveys suggest that farmers apply fertiliser amounts for a target yield but do not always take into account fertiliser and commodity prices when making decisions on fertiliser rates. A simple framework has been developed to help growers and advisers make better fertiliser decisions based on maximising profit, rather than crop yields, taking into account price of fertilisers and wheat grain.

Aims

1) To estimate Economically Optimal Nutrient Rates (EONR) of N and P for a range of potential yields and fertiliser and grain prices.

2) To perform sensitivity analysis to fertiliser and wheat grain prices and to the ratio N price: Wheat price.

Method

The bio-economic model LEAP2MPCN integrates key features of several tools and models previously developed by DAFWA, GRDC, CSIRO and Curtin University including, but not limited to, Gross Margin, Break-Even Estimator, NPDecide, Select Your Nitrogen (SYN), Navail, NutOptimiser, Optlime, APSIM, Inflation Adjusted Price Time Series, Expected Yield and Price Estimator (uses elicitation of subjective distributions) and Liebig model of the Law of the Minimum.

LEAP2MPCN determines the Economically Optimum Nutrient Rate (EONR) of N and P fertiliser for three different farm paddocks or zones. The EONR is the nutrient rates that gives maximum gross margin through optimising (rather than maximising) yield. It takes into account the target yield, the soil nutrient supply, variable costs and fertiliser and grain prices. The target yield may be anything from a realistic weighted average yield of many seasons to an expected or above-average season yield or “attainable” yield, rather than the profit maximising yield.

EONR occurs when marginal revenue for grain production from an additional unit of a nutrient equals marginal cost of that extra unit nutrient applied. EONR is the point on the yield response function that identifies the most profitable yield and nutrient rate. The Break Even Ratio (BER) is the ratio of nutrient price to grain price. The point on the yield response curve to N at which the slope equals the BER is the N rate that equals the EONR (BER = EONR). If the yield response curve to nutrient rates is known, and the BER is known, then the point on the yield response curve where the slope equals the BER is the economically optimal N rate (EONR).

Data was collected from farmer’s interviews and Planfarm Bankwest Benchmarks (Planfarm Bankwest 2015).

Results

Economically Optimum Nutrient Rate

Data from a case study in the Eastern Wheatbelt was used to illustrate the use of the LEAP2MPCN model. Input data for each zone includes target yield, available N and P in the soil top 10 cm, area of crop, grain price, input costs (other than fertilisers), N and P fertiliser prices, fertiliser expenditure limit, and minimum and maximum rates of N and P (Table 1). The LEAP2MPCN model was used to obtain the EONR of N and P for three zones or soil types in the farm

(Table 2).The EONR of P fertiliser was zero, because of the high levels of soil available P in the farm. The EONR of N ranged from 14 kg/ha in the lowest yielding zone (acidic soil) to 55 kg/ha in the best soil type or zone. Although the predicted yields for the EONR rates were lower than the target yields for each zone, these N rates maximised gross margin (Table 2). The model outputs allow for a comparison between uniform management of the whole farm and soil-specific management. Overall, uniform management with the same N rate resulted in a lower gross margin than using a specific N rate for each zone (Table 2).

Table 1. LEAP2MPCN inputs used in the case study.

	Zone A	Zone B	Zone C
Target yield (t/ha)	2.4	1.8	1.2
Available N in soil top 10 cm (kg/ha)	50	50	50
Available P in soil top 10 cm (kg/ha)	45	33	42
Annual variable costs, excluding fertilisers ($/ha)	285	285	285
N price in urea ($/kg N in urea)*	1.48	1.48	1.48
Wheat grain price (farm gate price) ($/t)	250	250	250

*Urea price of 460 $/t (CSBP, June 2015)

Table 2. LEAP2MPCN outputs for Economically Optimum Nutrient Rate (EONR) of nitrogen and phosphorus, predicted yield and gross margins.

	Zone A	Zone B	Zone C	Uniform Management
EONR of N (kg/ha)	55	38	14	38
EONR of P (kg/ha)	0	0	0	0
Predicted Yield (t/ha)	2.0	1.5	0.9	1.5
Gross Margin ($/ha)	147	21	-93	22
Gross Margin ($/farm)		7,562*		6,561

*Sum of Gross Margin for Zones A, B, C

Sensitivity analysis to N fertiliser price

The LEAP2MPCN model was used in the same case study to perform a sensitivity analysis of N rates to the price of N fertiliser (Table 3). Based on the standard urea price (CSBP, 2015), four scenarios of price variation were analysed: standard price ($1.48 /kg N, CSBP 2015), half the standard price, 1.5 times the standard price and twice the standard price. The standard price of N in urea was take from the urea price of 460 $/t in June 2015. The results show how increasing N prices, decreases the N rate that equals the EONR.

For zone A, although increasing N price decreased the N rates, all four scenarios of fertiliser price returned a profitable yield with additional N required. For zone B, all fertiliser prices returned a profitable yield with additional N required except when fertiliser was double the price. For zone C, the poorest preforming soil type, both scenarios 3 and 4 (one and half and twice the standard price) returned below break–even yields with a recommendation that no further N be applied. Based on these findings from LEAP2MPCN, assuming all other input data kept constant, both A soils (sandy) and B soils (heavy) are likely to return profitable yields with varying fertiliser price. In contrast, acidic C soils (low yielding) are heavily susceptible to fertiliser price fluctuations and when fertiliser costing is higher than 1.5 times the standard price the recommendation is not to grow a crop, if all other input data were constant.

Table 3. LEAP2MPCN outputs for Economically Optimum Nutrient Rate (EONR) (kg N/ha) of nitrogen for zones A, B and C for four fertiliser prices. Nitrogen fertiliser prices were standard price ($1.48 /kg N, CSBP 2015), half the standard price, 1.5 times the standard price and twice the standard price.

Fertiliser price	Zone A	Zone B	Zone C
Standard price N	55	38	14
N price x 0.5	95	78	55
N price x 1.5	31	14	0
N price x 2	14	0	0

Sensitivity analysis to wheat price

Sensitivity analysis to wheat price varying from $150/t to $350/t, going up in units of $10, was performed with LEAP2MPCN model, with the rest of the input data constant.

LEAP2MPCN results showed that an increase in wheat price from 150 to 350 $/t led to an almost linear increase in both the EONR of N fertiliser and gross margin (Table 4). In zone A, for example, only wheat price of $170/t or below, gave a negative gross margin. Results for zone B indicate that wheat price needs to be at least $240/t to obtain a positive gross margin, given the assumptions in this case study. For the zone C (acidic soil) to obtain a profit, given the rest of the input variables, the wheat price needs to be $350/t or higher. At this price, the predicted wheat yield is 0.9 t/ha with 14 kg/ha of N applied. Soil tests from zone C indicate that the available N in the soil ranges from 8 kg/ha to 120 kg/ha. With such high reserves of N in the soil, the farmer can achieve average yields of 1.4 t/ha with only adding 12 kg/ha of N. The limiting factor of this soil is high acidity, which prevents the crop roots accessing the soil N.

Table 4. LEAP2MPCN outputs for Economically Optimum Nutrient Rate (EONR) of nitrogen and gross margins for zones A, B and C for increasing wheat prices from 150 to 350 $/t.

	EONR (kg N/ha)			Gross Margin ($/ha)		
Wheat price ($/t)	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C
150	25	8	0	-49	-114	-171
200	42	25	1	46	-49	-133
250	55	38	14	147	21	-93
300	65	48	25	251	96	-49
350	75	58	34	358	172	-2

Sensitivity analysis to the ratio N fertiliser price: Wheat price (Break Even Ratio)

If the yield response curve to N is known, the EONR can be easily estimated with the concept of Break Even Ratio, without a computer model such as LEAP2MPCN. The point in the yield response curve to N where the slope equals the BER corresponds to the EONR (Abadi and Farre, 2015).

For the period 2000 to 2015, the BER for N in urea and wheat price in Western Australia has ranged from three in 2015 to almost eight in 2008 (Table 5). This means that in 2008, for example, for one unit of N you had to expect eight units of yield to make that investment cost effective.

For the same expected yield of 2 tonnes/hectare and a background soil N of 50kgN/ha, the EONR for N would be 70kgN/ha in 2015 and 25kgN/ha in 2008 because of the huge difference in BER between these two years.

There is always uncertainty about growing season rainfall and this will influence post-sowing nutrient applications, but other parameters being constant, the BER or relative price of nutrients to grain, will influence the fertiliser rates.

Table 5. Values of Break Even Ratio (BER), ratio of price of nutrients and price of wheat, for the years 2000 to 2015. Nutrients (Nut) Nitrogen (N) in fertilisers DAP and Urea, and Phosphorus (P) in DAP and superphosphate. Numbers in bold indicate the maximum value observed and the underlined numbers are the lowest values.

Notes: a: Sources: ABARE, CSBP and Profarmer; b: nominal prices; c: nutrient prices in the compound fertiliser DAP was calculated by proportioning the total cost of the compound fertiliser to each of the constituent nutrients on the basis of the cost of each nutrient (in its cheapest form e.g. from a single nutrient fertiliser like urea for N) as a fraction of the cost of all nutrients in the compound.

Nut: Fertiliser	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
N: DAP	3.3	2.7	<u>2.7</u>	3.5	4.0	4.4	4.3	4.4	**7.6**	5.8	5.3	6.1	3.8	3.6	4.1	3.4
N: Urea	4.7	3.5	3.3	4.4	5.8	6.0	5.3	5.2	**7.7**	6.3	5.5	7.5	4.8	4.4	5.2	<u>2.9</u>
P: DAP	8.7	7.3	<u>7.1</u>	9.2	10.5	11.6	11.5	11.8	**20.2**	15.3	14.2	16.3	10.1	9.6	10.8	9.0
P: Sup. Phos.	11.3	<u>10.5</u>	10.9	13.2	14.5	14.6	12.6	13.7	**22.6**	21.0	17.8	19.9	13.9	13.2	14.5	12.0

Conclusion

Firstly, the LEAP2MCPN model can be used to estimate the EONR of N and P. Soil tests are necessary to provide an estimate of the soil nutrient supply and usual caveats apply about limiting factors, such as seasonal conditions, risk of dry finish and additional costs of splitting nutrient applications. Secondly, If the wheat yield response curve to a wide range of fertiliser rates is known, the EONR can easily be estimated using the BER, without the use of a computer model. Finally, accounting for variations in input and commodity prices should be an integral part of fertiliser recommendations, rather than single focus on yield.
Our results suggest that accounting for variations in these prices has a significant impact on gross margin.

References

Abadi A and Farre I, 2015. A simple framework for profitable fertiliser use under risk and soil constraints. Proceedings of the Australian Agronomy Conference, September 2015, Hobart.

CSBP, 2015. CSBP Fertiliser Price List Effective15 June 2015.

Planfarm Bankwest, 2015. Planfarm Bankwest Benchmarks 2014-2015

Key words

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