Assessing 'Yield Prophet®' as a tool to assist growers in determining crop nitrogen requirements in the West Midlands

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Purpose:	This trial seeks to test the Yield Prophet tool to determine its relevance and usefulness to growers of the West Midlands region in determining most efficient and effective nitrogen strategy.
Location:	Badgingarra Research Station
Rotation:	2009 canola
Soil Type:	Loamy sand with gravel
GSR:	304mm

Soil Test Results:

	Topsoil		**Subsoil (10-40cm)**	
NO_3 N	15	mg/kg	6	mg/kg
NH_4 N	3	mg/kg	1	mg/kg
P	23	mg/kg	10	mg/kg
K	100	mg/kg	103	mg/kg
S	7.2	mg/kg	11.1	mg/kg
OC	2.13	%	0.96	%
Cu	0.6	mg/kg		
Zn	2.4	mg/kg		
EC	0.08	dS/m	0.05	dS/m
pH	5.9	($CaCl_2$)	5.9	($CaCl_2$)
Gravel	15	%	15	%

BACKGROUND

Yield Prophet® does not generate recommendations or advice. Yield Prophet uses the computer simulation model APSIM together with paddock specific soil, crop and climate data to generate information about the likely outcomes of farming decisions. This tool has been widely trialled in the medium and low rainfall areas of the Northern Agricultural Region; however it has never been tested in the West Midlands region.

The trial examines and compares three Nitrogen strategies (see below) over two wheat varieties (Bonnie Rock and Mace) at two times of sowing. N strategies as follows:

- Strategy 1: Farmer Practice - growers used same decision making process as they would for their own crops to determine N strategy for each treatment. Target yield at the start of the season was 4t/ha, to be adjusted as the season developed.
- Strategy 2: Farmers used reports from Yield Prophet to assist decision making - decision made a week prior to expected time of actual application. Nitrogen to be applied when the model suggested a gap between yields from current plant available N, and that of an unlimited N situation.
- Strategy 3: Control strategy - growers determined a standard N application strategy prior to seeding, rates & timing were consistent for all treatments. This was based on soil test results with a 4t/ha yield target.

To determine 'Strategy 1' and 'Strategy 2' a working group of two farmers and two agronomists was formed, additional specialist nutrition advice was sought on an as needs basis. The working group met at 3-4 leaf and 5-6 leaf growing phase of each treatment. At these working group meetings the growers and consultants first made a decision about what N applications to apply to the Farmer strategy plots based on their observations and experience. After this they were then shown the Yield Prophet reports which they then used to determine the N application rates for the 'Yield Prophet strategy'. Post-seeding N applications for the 'Control strategy' were pre-determined at the start of the season based on consultant and grower experience.

TRIAL DESIGN

Plot size: 1.54 x 20m

Machinery: Cone seeder -25cm rows

Repetitions: 3

Crop details: EGA Bonnie Rock and Mace at 75kg/ha

Fertiliser:

TOS1- sown 24th May

N application	Date	Strategy 1 Farmer	Strategy 2 Yield Prophet	Strategy 3 Control
At seeding	24-May	Agstar Extra @ 100kg (14N)	Agstar Extra @ 100kg (14N)	Agstar Extra @ 100kg (14N)
1	22-Jun	NS41 @ 110kg (38N)	0	NS41 @ 110kg (38N)
2-part1	7-Jul	0	0	Urea @ 60kg (27N)
2-part2	14-Jul	Urea @ 50kg (22N)	Urea @ 60kg (27N)	NA
Total N Applied		**74 kg N**	**41 kg N**	**79 kg N**

TOS2- 22nd June

N application	Date	Strategy 1 Farmer	Strategy 2 Yield Prophet	Strategy 3 Control
At seeding	23-Jun	Agstar Extra @ 100kg (14N)	Agstar Extra @ 100kg (14N)	Agstar Extra @ 100kg (14N)
1	10-Aug	NS41 @ 70kg (25N)	NS41 @ 70kg (25N)	NS41 @ 110kg (38N)
2	NA	NA	NA	NA
Total N Applied		**39 kg N**	**39 kg N**	**52 kg N**

Chemical:

Products and rates	TOS 1 Dates	TOS 2 Dates
Dominex @ 100ml + Treflan @ 1.5Lt + Sprayseed @ 1.5Lt + Talstar @ 200ml	24-May	22-Jun
Triple @ 1Lt (Cu10%, Zn 25%, Mn 30%)	22-Jun	19-Jul
Barracuda @ 0.8Lt	19-Jul	28-Jul

Sowing and Seasonal Conditions

- The crops sown at the first time of sowing (TOS 1) were planted into good soil moisture conditions after nearly 30 mm of rain had been received over the previous 3 days (21-23 May; Figure 1).

- For the second time of sowing (TOS 2) the crops were sown prior to an 8 mm rainfall event the following day (23rd June; Figure 1).
- In mid-June, at the time of the first N application for TOS 1 (3-4 leaf), zinc deficiency was identified across the trial. The whole trial was treated with an application of Copper, Zinc and Manganese.
- Total growing season rainfall was 304mm which is well below the long-term GSR average of 473mm.
- Timing of rainfall events was sporadic with an exceptionally dry finish (last significant rainfall received on 8th September- 6mm)
- The trial was harvested on 17th November.

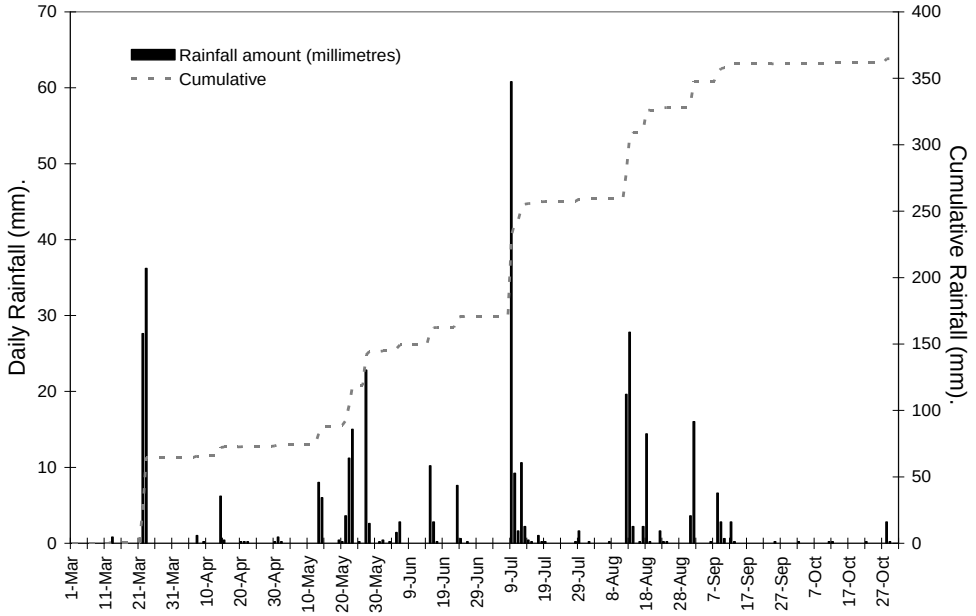

Figure 1. *Daily and cumulative rainfall for March to October at Badgingarra Research Station in 2010.*

RESULTS

Table 1. *Average grain yields (t/ha) and protein (%) for Bonnie Rock and Mace wheat. Return is farm gate grain value minus post seeding nitrogen applications and costs.*

TOS1 (24 May) N Strategy	**Variety**	**Yield (t/ha)**	**Protein (%)**	**Grade**	**Post seeding N Costs ($/ha)**	**Return ($/ha)**
Control	Bonnie Rock	2.96 a	14.2	GP1	96	734
	Mace	3.85 c	13.3	GP1	96	983
Farmer	Bonnie Rock	3.53 b	14.3	GP1	90	899
	Mace	4.25 d	13.0	GP1	90	1101
Yield Prophet	Bonnie Rock	3.28 b	14.0	GP1	39	880
	Mace	4.05 cd	13.0	GP1	39	1095
		LSD (0.05) 0.30				
TOS2 (23 June) N Strategy	**Variety**	**Yield (t/ha)**	**Protein (%)**	**Grade**	**Post seeding N Costs ($/ha**	**Return ($/ha)**
Control	Bonnie Rock	3.26 a	13.7	AUW1	59	822

	Mace	3.50 b	12.2	AUW1	59	887
Farmer	Bonnie Rock	3.13 a	13.7	AUW1	39	806
	Mace	3.52 b	11.9	AUW1	39	912
Yield Prophet	Bonnie Rock	3.23a	13.8	AUW1	42	831
	Mace	3.46b	12.1	AUW1	42	893
		LSD (0.05) 0.21				

Means followed by the same letter within a given time of sowing are not significantly different.

Assumptions:

- *Badgingarra farm gate wheat prices Dec 2010:GP1 $280/t, AUW1 $270/t*
- *Fertiliser: NS41 $490/t, Urea $530/t (Kwinana)*
- *Spreading Costs: $4.50/ha, Yield Prophet Subscription: $2.50/ha*

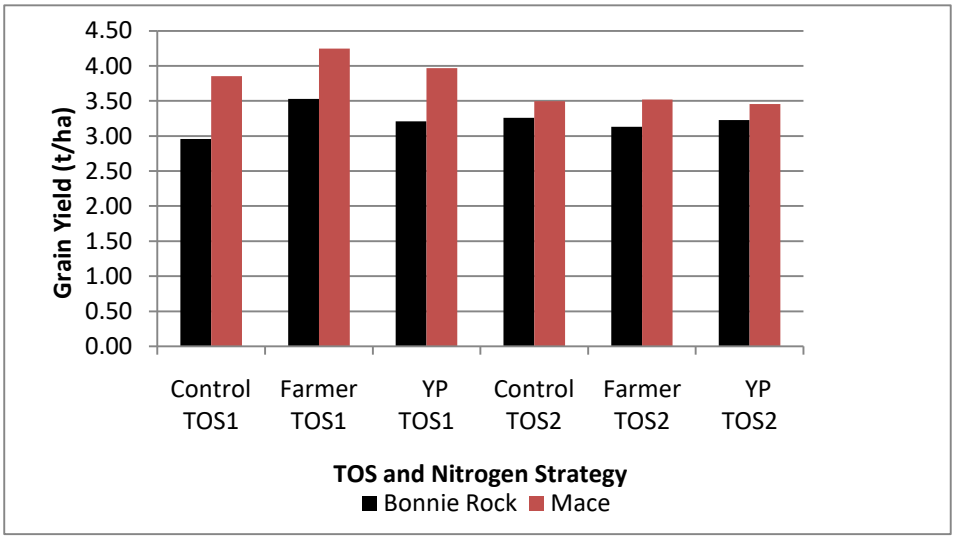

Figure 2. *Average grain yields (t/ha) for Bonnie Rock and Mace wheat. LSD (0.05) provided in Table 1.*

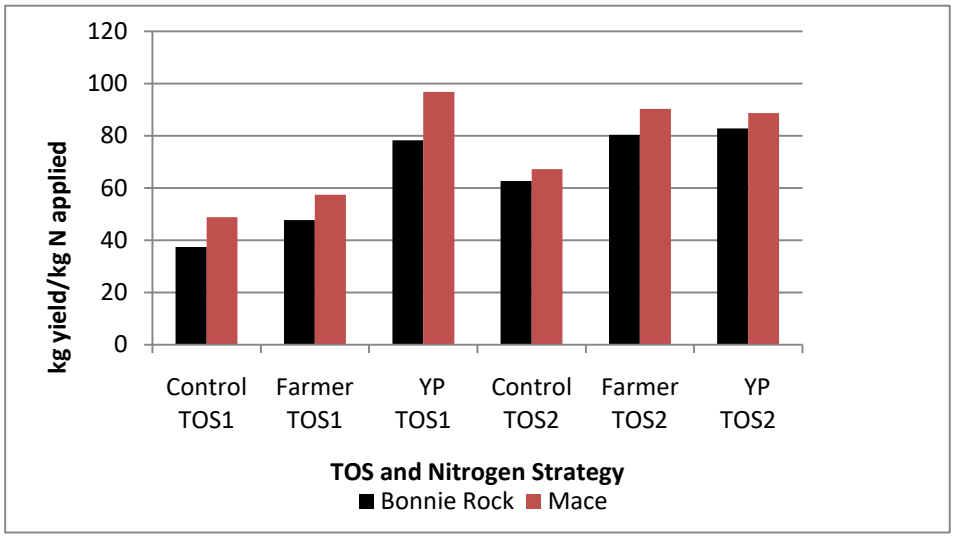

Figure 3: *Wheat yield per kg of applied N for Bonnie Rock and Mace wheat grown with three different post-seeding nitrogen application strategies for two sowing times*

DISCUSSION

TOS1 Nitrogen Management and Results

- The trial established well, and apart from the setback caused by the early Zn deficiency the Farmer and Control strategies continued to target a yield of around 4t/ha as the crop developed. The decision was made to test the Yield Prophet model and assumptions by only applying in-crop N when the model indicated that there would be an economic response. Due to the high level of simulated soil N in the model, the first opportunity to apply N in-crop was after the large rainfall event in mid-July.
- The target yield was achieved in all Mace treatments, and although the crop showed no obvious signs of moisture stress, high grain protein across all treatments (Table 1) suggested that the yield potential for both varieties may have been slightly curtailed by the dry finish.
- Both variety and nitrogen strategy had significant impacts on grain yield (Table 1). For any given N strategy Mace yielded more than Bonnie Rock with an average increase in grain yields of 790 kg/ha (25%). While Bonnie Rock tended to have more heads/m2 than Mace the average head weight for Mace was higher (data not shown). For both Mace and Bonnie Rock the Farmer N strategy gave the highest yield, significantly more than the Control strategy (Table 1). Grain yields for the Yield Prophet strategy sat in between these two.
- At the time of nitrogen application decision making (3-4 leaf and 5-6 leaf) the Yield Prophet reports showed little difference between varieties thus both varieties were treated the same. Figure 3 shows that Mace was more successful in converting applied Nitrogen to yield, for example in the Yield prophet strategy Mace yielded 97kg grain per 1 kg N applied and Bonnie Rock yielded 78kg grain per 1 kg N applied.
- Yield Prophet Reports suggested no economic response to applied nitrogen until after the large rainfall event on 9-12 July (Fig.1). To test the model, no nitrogen was applied until the model suggested a response (hence the split second applications in the trial design).
- The Control strategy yielded less than the Farmer strategy despite receiving very similar amounts of N fertiliser. The Control strategy received 60 kg/ha urea in the second post-seeding N application on 7 July, just prior to 82 mm of rainfall which fell between the 9-12 July (Fig. 1). By contrast the second post-seeding N application for the Farmer strategy (50 kg/ha urea) and the first post-seeding N application for the Yield Prophet strategy (60kg/ha urea) were applied one week later on 14 July after these large rainfall events, and with a small rainfall event forecast . It is likely that the urea applied earlier to the Control strategy was poorly utilised due to N lost via leaching, while the more flexible Farmer and Yield Prophet strategies allowed for N application after this large rainfall event, which provided very good N utilization.
- The crops at the time of the 2nd N applications were at early stem elongation (Zadocks 31). Despite the difference in apparent N utilisation and its impact on grain yield there was no impact on total shoot biomass, which averaged 8.7 t/ha for the TOS1 and 6.8 t/ha for TOS2 (data not shown). There was no significant effect of variety or N strategy on total shoot biomass at either sowing time. The N strategy did not alter grain protein of a given variety either although total N uptake by the grain was greater for those strategies that had higher yields. Grain protein did differ with variety with Bonnie Rock having higher grain protein than Mace at both times of sowing (Table 1).

- The grain from all TOS1 Treatments would have been downgraded to GP1 at delivery, due to screenings between 5 and 10%.

TOS2 Nitrogen Management and Results

- The trial established well, however due to the later sowing time the decision was made to reduce the first N application for the Farmer strategy, compared to the Control, as it was felt that the target yield was more likely to be around 2.5-3t/ha. Tiller counts from 13th September supported the yield target (data not shown) and it was decided that a higher target yield could be achieved with an application of UAN in the event of a wet August/September.
- Final yields ended above the expected target, with Mace significantly out yielded Bonnie Rock across all N strategies, by an average of 287 kg/ha (9%) (Table 1).
- Nitrogen strategy had no impact on yield for TOS2 (Table 1, Figure 2). This is indicative of the limited opportunity for altered N strategies to impact on crop performance with later sowing, particularly in a season with a dry finish.
- The limited opportunity to alter N applications is reflected in the fact that the Farmer and Yield Prophet strategies had the same N applications. The Control strategy had the highest applied N (52kg N compared to 39kg N for Yield Prophet and Farmer) and as this was not converted to yield, this strategy was shown to be much less efficient at converting applied N to yield (Figure 3).
- Mace was much more sensitive to sowing date with consistently lower yields TOS2 for all of the N strategies. In contrast, yields of the shorter season Bonnie Rock for the TOS2 were variable relative to TOS1, with lower yield for Farmer, similar yield for the Yield Prophet and higher yield for the Control strategy (Table 1).
- The grain from all TOS2 Treatments would have been downgraded to AUW1 at delivery, due to screenings above 10%.

Yield Prophet Accuracy and Issues

Table 2. *Yield Prophet model forecast yields compared to actual harvest results*

Variety and TOS	**Yield Prophet forecast as at 13 September (probability of exceeding a given yield)**				**Yield Prophet forecast at Harvest (t/ha)**	**Actual Yield (t/ha)**
	100%	**80%**	**50%**	**20%**		
Bonnie Rock TOS1	3.1	3.6	3.6	3.6	3.1	3.3
Mace TOS1	3.1	3.6	3.6	3.6	3.1	4.1
Bonnie Rock TOS2	1.7	2	2.7	3.8	1.7	3.2
Mace TOS2	1.7	2	2.7	3.8	1.7	3.5

- An example of a Yield Prophet Crop Report is contained in Appendix 1 of this book. This report was generated on September 13th and was used to compile Table 2.
- Yield Prophet relies heavily on plant available water and N availability calculations which are dependent on good soil and rooting depth characterization. This information is coupled with planting information and historical weather records determine a range of likely yield outcomes (excluding the effects of other nutrients and disease). In this instance, apart from soil nutrient testing, the soil at the site had not been fully characterized, without an accurate estimate of the plant available water holding capacity of the soil. Instead, a previously characterised similar soil in the Yield Prophet database (Wongan Hills- Duplex Sandy Gravel) had to be used

instead. This will impact on the accuracy with which Yield Prophet can predict likely yield outcomes. For the 2011 growing season the soil will be fully characterized so this issue will be resolved.

- Throughout the growing season, the group responsible for the Farmer strategy felt that Yield Prophet was over estimating the amount of plant available soil N. However, given that actual yields for TOS2 were above the target values for applied N, with high grain protein (Table 1), it can be assumed that the Yield Prophet simulated nitrogen budget was reasonable.
- The variety characteristics within Yield Prophet for Bonnie Rock and Mace appear to be identical in relation to flowering dates, which accounts for the yield forecasts being the same for the two varieties. This is different to what was observed in the trial and in the area generally, with Bonnie Rock beginning to flower earlier that Mace, particularly for TOS1 (data not shown).
- Yield Prophet reports were generated on September 13th, just after what turned out to be the last rain of the growing season. These indicated that the worst case yield scenarios at the time were 3.1t/ha and 1.7t/ha for TOS1 and TOS2 respectively. This is represented in Table 2 as "100% chance of exceeding a given yield".
- For TOS1, the fact that the 80%, 50% and 20% probability yield forecasts were identical indicates that, based on historical weather data, the model expected that only a worst case scenario would have any impact on final yield.
- For TOS2, the Yield Prophet indicated that there was still significant potential for yield to be affected by ongoing weather, with an 80% chance of exceeding 2t/ha and 20% chance of exceeding 3.8t/ha. This variability was to be expected as the Yield Prophet forecast harvest/maturity date for was November 12th, compared to October 22nd for TOS1, leaving 2 months of grain fill and ripening from the report date.
- Yield Prophet reports were generated at harvest to test the accuracy of the final yield forecast to actual harvest results. Table 2 indicates that the Yield Prophet model assessed the final growing conditions as the absolute worst case scenario, and therefore yield estimates were at the extreme lower end of the possibilities suggested on September 13th (3.1t/ha and 1.7t/ha for TOS1 and TOS2 respectively). This proved to be unreasonably pessimistic, with harvest yields achieved for TOS1 and TOS2 being at the upper end of the range of probabilities indicated in the Yield Prophet reports from September 13th.
- Given the relative accuracy of the Yield Prophet model for TOS1 compared to TOS2 harvest results, and that simulated growth stage of TOS2 plots were similar to those observed in the field (data not shown), it is assumed that the model has; underestimated the amount of plant available water (PAW) in the soil; overestimated the water requirements of the crop for grain-fill; or incorrectly accounted for amount of time required for the later sown crop (TOS2) to reach maturity.
- The water budget as forecast by Yield Prophet indicated that the TOS1 crop was predicted to suffer little water stress, effectively running out of PAW at maturity, whereas the TOS2 crop was predicted to suffer significant water stress, effectively running out of PAW 2-3 weeks prior to maturity.

CONCLUSION

- The trial did re-iterate that early sowing provides more opportunity to 'play the season' and alter N management to significantly impact on crop yield outcomes compared with the late sown crops which, in the truncated 2010 season, provided little opportunity for changing N management. This suggests that focusing on getting

the N management of the earlier sown crops sown right for a given season is a good investment of time. Further testing will give a clearer picture as to whether Yield Prophet adds significant value to helping make these decisions.

- Although the Farmer group were original concerned about the Yield Prophet N budget, tt appears that the model has utilized deep soil test data to reasonably assess the supply of soil N to plants and the movement of soil and applied N through the profile. From this point of view, with the addition of an accurately characterized soil profile, the model may allow growers to better account for and manage nitrogen supply and losses from below the 0-10cm zone.
- Although yields from the Farmer strategy tended to be higher than the Yield Prophet strategy (although not significant), returns per hectare (net of Nitrogen and application costs) were very similar due to the increased costs associated with the Farmer strategy. With further soil characterization and 'ground proofing' a tool such as Yield Prophet may be a useful way to reduce the risks and more accurately quantify the benefits associated with applying in-crop nitrogen.
- This trial will be repeated in 2011, and with a more accurate soil characterization it is expected that Yield Prophet will be more accurately assessed.

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