8. Fertiliser and Crop Management of Areas at Risk of Flooding

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KEY MESSAGES

- Wheat was surprisingly tolerant of continuous flooding for nearly 4 months, yielding up to 2.8 t/ha with the best combination of nutrients tested.
- Despite the extended flooding there was a 13% response to P at a starting Colwell P of 29 mg/kg, with an economic optimum application rate of 7 kg P/ha.
- Canola was intolerant of extended flooding, producing no harvestable yield.
- In-crop application of urea shortly before flooding showed no grain yield response in wheat, while there was a negative response of 9% to applying S as in-crop sulfate of ammonia.
- Ideally in-crop applications of fertiliser should be made at least a week prior to flooding to allow time for the crop to take up the nutrients.

Background

Little is known about whether soil test interpretation criteria developed under low and medium rainfall conditions also apply to the high rainfall zone (HRZ), where there is both a higher yield potential (McCaskill et al. 2016), but also challenges of waterlogging and inundation. A nutrient omission experiment with wheat at Bool Lagoon in 2016 found that relative to a treatment fully supplied with all nutrients (N, P and S), omitting P led to a 24% yield penalty, omitting S a 17% penalty, and omitting in-crop N a 56% penalty (Pearce et al. 2017). A similar magnitude of response was found for canola. In these experiments non-limiting quantities of nutrient were supplied. However, for fertiliser decisions, a nutrient response relationship is also required to determine the most economic application rate. This report presents results from nutrient response experiments conducted on wheat and canola at Bool lagoon in 2017.

Activities

Two adjacent trials were sown at the Bool Lagoon site on 15 May 2017, one with wheat (cv. Beaufort), the other with canola (cv. Pioneer® 45Y91). These were located close to the site of the 2016 trials. The soil was a Calcarosol consisting of 10 cm of black clay, overlying limestone. Topsoil soil tests indicated the soil was deficient in P, with a Colwell P of 29 mg/kg, which is below the critical value of 34 mg/kg for Calcaresols (Armstrong et al. 2014), but had adequate K, S, Cu and Zn (Table 1). Both trials had a design of 7 different P rates x 2 N rates, all with a basal of 20 kg S/ha, plus an additional treatment of no added S at the highest P rate. The P was applied in a separate pass prior to sowing as MAP at rates of 3, 6, 13, 25, 50 and 100 kg P/ha plus a nil P treatment, with the N balanced by urea. The N rates were intended to supply either 60% or 100% of N requirements (60N or 100N), but due to the site being inaccessible, actual amounts applied were only 63 or 101 kg N/ha comprising 46 kg N/ha at sowing and the balance in-crop. Had the site been more accessible, rates of N would have been similar to 2016, when the 60N received 63 kg N/ha and 100N 149 kg N/ha. Insecticide and snail bait were spread on 14 June, after which the site became inundated until late July. Sulfate of ammonia (SOA) was hand spread to supply the S treatments at GS31 on 31 July, along with urea during a brief period without surface water, after which further rain caused the site to remain flooded until mid-November (Figure 1). Growing season rainfall (April to November) at the site was 698 mm, which was 54% higher than the long-term average of 453 mm (Table 2), and in the 10th decile. The wheat experiment was harvested on 18 December, but there was so little yield from the canola that it was not harvested.

Data from the experiment was analysed by the REML and FITCURVE procedures in Genstat 18th Edition, and treatment differences are reported at the 5% level. The economic optimum rate of P was assessed for a wheat price of $220/t, $15/t for freight, $25/t for harvest, and MAP at $680/t and $15/t for freight.

Table 1: Initial soil mineral N (nitrate + ammonium) prior to sowing the 2016 and 2017 wheat experiments at Bool Lagoon, and topsoil (0-10 cm) available P (Colwell), K (ammonium acetate, calculated as equivalent to a Colwell K extract) and S (KCl-40), and critical values at which 90% of maximum grain yield would be expected for Calcaresols (Armstrong et al. 2014) and micro-nutrients Cu and Zn (DTPA – extractable) and critical values (Peverill et al. 1999).

Site	N	P	K	S	Cu	Zn
	mg/kg					
2017	40	29	1275	6.4	1.3	1.2
2016	22	24	1050	7.2	0.5	0.3
Critical Value		34	40	4.5	0.3	0.8

Figure 1: The Bool Lagoon experiment on 12 September 2017.

Table 2: Rainfall (mm/month or mm/year) recorded at the site by the Dryland Probe Network relative to long-term records for Bool Lagoon.

Month	2017	Long-Term Average
Jan	43	31
Feb	5	21
Mar	57	28
Apr	103	32
May	99	50
Jun	25	66
Jul	130	83
Aug	137	87
Sep	89	57
Oct	35	41
Nov	79	38
Dec	15	35
Year (mm/year)	817	559
Apr-Nov (mm/year)	698	453

Results & Discussion

The highest yield achieved was 2.8 t/ha for a nil-S treatment at 100 kg P/ha (Figure 2). There was a positive response to P of 13%, a negative response of added S of 9%, and no significant difference between N60 and N100. The response to P was described by the relationship $y=2.52-0.3337(0.8961^{x})$. Using this relationship, the economic optimum for a 1:1 benefit cost ratio was 7 kg P/ha, which corresponded to 94% of maximum yield.

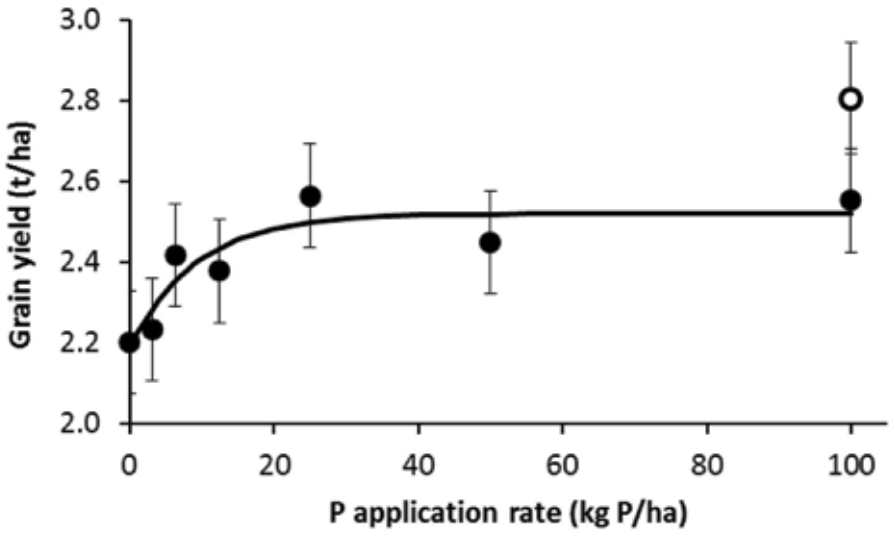

Figure 2: Grain yield response to added P and S at Bool Lagoon for nil S (open circle) and 20 kg S/ha at sowing (closed circles), and a curve fitted to the +S data. Values are the mean of 60N and 100N. Error bars show ±SE.

The previous season in 2016 also had growing season rainfall in the 10th decile, but the duration of inundation was shorter and intermittent (early August to late October) (Pearce et al 2017), whereas in 2017 inundation was continuous from mid-July to mid-November. In 2016 there was opportunity to apply urea on 29 August 2016 prior to flooding, and on 28 October 2016 once the surface water had drained away. However, in the 2017 season there was little opportunity to apply in-crop N fertiliser, and even that applied during a brief period without flooding on 31 July may have had reduced effectiveness because the site received 60 mm of rain in the week following application, which led to a return of flooded conditions The wheat yield of 2.8 t/ha in 2017 was similar to the 3.0 t/ha achieved by the 60N treatment in 2016 (68 kg N/ha), whereas the 100N treatment in 2016 achieved 4.4 t/ha. This suggests that yield limitations in 2017 were primarily because of limitations of getting N into the plant, and that apart from the N uptake process wheat is surprisingly tolerant of inundation.

The risks of prolonged waterlogging in low-lying parts of the region would be greater in years following above average rainfall, because high groundwater levels mean there is little capacity in the landscape to absorb surplus water. In such years, canola is a higher-risk crop, potentially yielding nothing harvestable, whereas wheat produced a yield consistent with the amount of N that could be fed into the crop.

The 9% yield depression through adding S as SOA may have been because of the formation of mildly toxic hydrogen sulphide under waterlogged conditions shortly after application. Nevertheless, positive responses to S such as the 17% achieved in 2016 are likely to offset negative effects of S over the longer term.

Conclusions

For this soil that was marginally deficient in P, the most effective preparation for inundation risk was starter P at sowing at the rate of 7 kg P/ha. In-crop application of SOA and urea during a brief period without surface water in late July were ineffective, the S causing a yield depression and the N no increase in grain yield. To avoid complications of flooding and nutrient uptake, in-crop applications should be timed at least a week prior to flooding to ensure there is sufficient time for the crop to take up the nutrients.

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