Improved crop nutrition for disease management and reduced fungicide dependency

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RESEARCH

Location
Stokes
Rainfall
Av. Annual: 450 mm
Av. GSR: 350 mm
2018 Total: 411 mm
2018 GSR: 338 mm
Yield
Potential: 6.5 t/ha (B)
Actual: 6.5 t/ha
Paddock History
2018: Wheat
2017: Canola
2016: Wheat
Soil Type
Gravelly clay loam over clay
Plot Size
2 m x 10 m x 4 reps
Trial Design
Randomised complete block
Yield Limiting Factor
Nil

Location
Wangary
Rainfall
Av. Annual: 450 mm
Av. GSR: 350 mm
2018 Total: 468 mm
2018 GSR: 406 mm
Yield
Potential: 5.5 t/ha (B)
Actual: 5.1 t/ha
Paddock History
2018: Barley
2017: Canola
2016: Wheat
Soil Type
Deep gravelly sand over clay
Plot Size
2 m x 10 m x 4 reps
Trial Design
Randomised complete block
Yield Limiting Factor
Grazing at key grain filling stages possibly reduced yield

Key messages

- **Improved crop nutrition reduced Septoria in wheat at Stokes and spot form net blotch in barley at Wangary on lower Eyre Peninsula.**
- **Improved crop nutrition did not reduce root disease at either site.**
- **At Stokes, the yield gain due to improved crop nutrition was greater under disease pressure than where disease was managed with fungicide, suggesting an interaction between nutrition and disease.**

Why do the trial?

Disease is a significant cost issue for Eyre Peninsula (EP) growers, causing yield loss and increasing management inputs such as fungicides. At the same time, many crops grown on the EP also have nutrient deficiencies, particularly copper, zinc and potassium. Previous research has demonstrated that these nutrient deficiencies not only reduce growth and yield directly, but can also affect the capacity of plants to resist or tolerate disease.

While the benefits of addressing nutritional requirements are becoming better understood and adoption by growers has increased, most research is carried out under low disease conditions. It is possible that the response to improved crop nutrition will be greater under moderate disease conditions. Addressing an underlying nutrient problem could reduce the need for some fungicide application. A two-year project has been established with funding from South Australian Grains Industry Trust (SAGIT) to assess the disease management benefits of improving crop nutrition.

How was it done?

Two field experiments were established in 2018 on lower Eyre Peninsula, at Stokes and Wangary. The Stokes site had low-marginal copper and low phosphorous status, while at Wangary, potassium was low and sulphur was marginal. At Wangary, Spartacus barley was sown on 14 May, while at Stokes, Scepter wheat was sown on 15 May. At each site, six nutrient treatments were applied at seeding either with or without fungicide to manage disease. Treatments sown without fungicide were also artificially inoculated with Rhizoctonia to ensure an even and significant amount of this root disease. The experiments were designed in consultation with a statistician (Statistics for Australian Grains Industry, SAGI) and were of a randomised, complete block design with four replicates of each of the 12 treatment combinations (Table 1).

At Wangary, nitrogen and phosphorous were balanced using di-ammonium phosphate and triple superphosphate to ensure each treatment received equal amounts of these nutrients in an available form, while at Stokes, nitrogen only was balanced (with urea), as phosphorous rate was a treatment.

Table 1 Treatment details at Stokes and Wangary in 2018

Stokes				Wangary				
P (kg/ha as DAP)	Cu (kg/ha as CuSO4)		Disease	K (kg/ha as MOP)		S (kg/ha as SOA)		Disease
0	0		Fungicide	0		0		Fungicide
15	5	×	Inoculated	30	×	20	×	Inoculated
30				60				

In 'disease-free' plots, Uniform was applied to fertiliser and soil and Vibrance was applied to the seed and Prosaro applied to foliage from late tillering stage, all at the highest label rate, to achieve relatively low levels of disease. In the 'disease' plots, soil was inoculated with Rhizoctonia and foliar diseases including Septoria and yellow leaf spot at Stokes and spot form net blotch at Wangary were allowed to develop from naturally-infected stubble present in the paddock. Weed and nitrogen management throughout the year were representative of district practice, with 225 kg/ha and 175 kg/ha of urea applied at Stokes and Wangary respectively.

Tissue tests were conducted on above-ground biomass ('whole tops') sampled at late tillering to confirm any response to nutrients. Approximately forty plants were collected from each plot, with tests conducted on a single sample per treatment, bulked across replicates.

Root diseases were assessed visually for all plots at 'late-tillering' and 'full head emergence'. Forty plants per plot were assessed by collecting four 10 cm lengths of row dug from both ends of each plot to a depth of 20 cm, the roots were washed and disease severity scored on a 0-5 scale (0 = no disease, 5 = all roots totally rotted). Foliar disease was assessed at 'booting' and 'early dough' growth stages by randomly sampling 20 leaves per plot and recording percentage leaf area affected.

Plots were harvested on 16 November at Wangary and 4 December at Stokes, and yields were recorded. Yield data at Wangary could have been affected by sheep grazing the site late, during key grain formation stages.

Data were analysed using Genstat (19th Edition) in consultation with a statistician from SAGI with all treatment differences tested using ANOVA at the $\alpha = 0.05$ significance level.

What happened?

Both sites received good early rainfall around 3 May, allowing good establishment in both trials. Growing season rainfall totalled 338 mm at Stokes and 406 mm at Wangary (Cummins median GSR = 315 mm).

Tissue tests conducted on whole above-ground biomass confirmed phosphorous and copper deficiency at Stokes. All nil phosphorus treatments had low tissue P, with marginal P in the 15 kg/ha treatments and sufficient P in 30 kg/ha. Copper was deficient in plots where copper was not added, except in the nil phosphorous plots. At Wangary, all treatments had sufficient potassium but sulphur was marginal.

Root disease

Nutrient treatments did not affect root disease score at either site (Table 2), however the differences in root disease score between inoculated (no fungicide) and fungicide treatments demonstrate that the inoculation was highly effective, but the fungicide treatment was only partially effective. Inoculation with Rhizoctonia and use of fungicides was effective at creating low and high Rhizoctonia levels.

Leaf disease

At Stokes, in late July, Septoria tritici blotch (*Zymoseptoria tritici*) and some yellow leaf spot (*Pyrenophora tritici-repentis*) began to develop in all plots including those treated with fungicide, however disease pressure was low overall. Nutrient treatments had a significant, but minor effect on early leaf disease development in the fungicide-treated plots ($P = <0.001$) (Table 3).

Table 2 Average root disease scores of fungicide treated or inoculated treatments on crown and seminal roots at late tillering and full head emergence at Stokes and Wangary in 2018

Site	**Late tillering**				**Full head emergence**	
	Crown		**Seminal**		**Crown**	
	Fungicide-treated	**Inoculated**	**Fungicide-treated**	**Inoculated**	**Fungicide-treated**	**Inoculated**
Stokes	0.67	4.04	0.83	1.65	0.86	2.87
Wangary	2.09	4.05	1.77	2.95	1.56	3.36

Table 3 Early leaf disease percentage at Stokes in 2018

Nutrient treatment	Leaf Disease (%)	
	No Fungicide	Fungicide
P0C0	1.18e	0.82de
P0C5	1.11de	0.74cd
P15C0	0.96de	0.34bc
P15C5	1.21de	0.27ab
P30C0	0.94de	0.16ab
P30C5	0.85de	0.07a

Table 4 Early leaf disease percentage at Wangary was generally low but was affected by nutrient treatments without fungicide

Nutrient treatment	Leaf Disease (%)	
	No Fungicide	Fungicide
K0S0	7.25g	0.10a
K0S20	4.88e	0.32b
K30S0	3.43d	0.11a
K30S20	3.82d	0.20ab
K60S0	5.99f	0.10a
K60S20	1.24c	0.11a

Table 5 Late leaf disease percentage at Wangary was affected by nutrient treatment for no fungicide treatments

Nutrient treatment	Leaf Disease (%)	
	No Fungicide	Fungicide
K0S0	26.97cd	1.49a
K0S20	16.89b	1.17a
K30S0	25.83bcd	0.89a
K30S20	19.35bc	1.02a
K60S0	30.32d	1.44a
K60S20	16.92b	1.34a

By the second assessment, no nutrient effects on leaf disease were evident. The disease level in the no fungicide treatment was low, approximately 2.5% leaf area, and less than 0.01% in the plus fungicide treatments.

At Wangary, spot form net blotch began to develop in the no fungicide treatments in late July. Disease levels were low and were affected by nutrient inputs ($P<0.001$). The highest level of disease was in the nil added potassium and sulphur treatments. All combinations of sulphur and potassium reduced spot form net blotch, with the highest rates of both nutrients limiting disease to 1.24% compared to 7.25% in the nil added nutrient treatments (Table 4).

At the second assessment, nutrient treatments significantly reduced leaf disease percentage ($P<0.001$), however results were inconsistent. Potassium alone at either rate did not reduce diseases compared to the control treatment. Sulphur reduced disease from 27% to 17% and the combination of sulphur 20 kg/ha and potassium 60 kg/ha reduced disease to 17%. The combination of sulphur (20 kg/ha) and potassium at the lower rate (30 kg/ha) did not reduce leaf disease percentage below the nil treatment, although did reduce disease below one other treatment without sulphur.

Yield

At Stokes, both P and Cu input significantly affected yield of wheat (Table 6). Copper improved wheat yield only at the highest rate of phosphorous in the inoculated treatments and appeared to reduce yield at the lowest rate of phosphorous in the fungicide treatments. Phosphorous effects were more consistent, improving yield over the nil phosphorous treatments both with inoculation and with fungicide. However, the percentage increase in yield was consistently greater for the inoculated treatments than for the fungicide treatments, suggesting an interaction with disease.

At Wangary, nutrient inputs did not have an effect on yield of barley. Plots treated with fungicide yielded 5.1 t/ha, while diseased plots yielded 4.07 t/ha. However, barley plots were affected by unintended grazing on two separate occasions, leading to significant variability between replicates, and it is possible this the yield data does not reflect treatment effects.

What does this mean?

There were no clear benefits of nutrient inputs on root disease at either site. Root disease scores were high in inoculated plots, with generally all crown roots in all treatments at both sites displaying some disease.

Yields were still above average in disease plots, with 6 t/ha of wheat at Stokes and 4 t/ha of barley at Wangary. Visually, these plots appeared healthy throughout the growing season and only appeared affected by root disease when compared to fungicide treated plots alongside.

This is an important result as it demonstrates the difficulty of relying on top growth to indicate significant root disease effects in commercial paddocks. Plants need to be dug up and roots washed and inspected to determine the presence of root diseases.

Table 6 Yield at Stokes was affected by nutrient treatment and the percentage increase in yield was greater in disease treatments than in no-disease treatments.

Treatment	Inoculated Mean Yield (t/ha)	Increase over P0C0 'Control' (%)	Fungicide-Treated Mean Yield (t/ha)	Increase over P0C0 'Control' (%)
P0C0	3.59	-	4.15	-
P0C5	3.91	not significant (P<0.05)	3.77	-9.17
P15C0	5.27	46.45	5.95	43.49
P15C5	5.43	50.90	5.70	37.43
P30C0	5.58	55.16	6.12	47.49
P30C5	5.96	65.79	6.41	54.68
	LSD = 0.34			

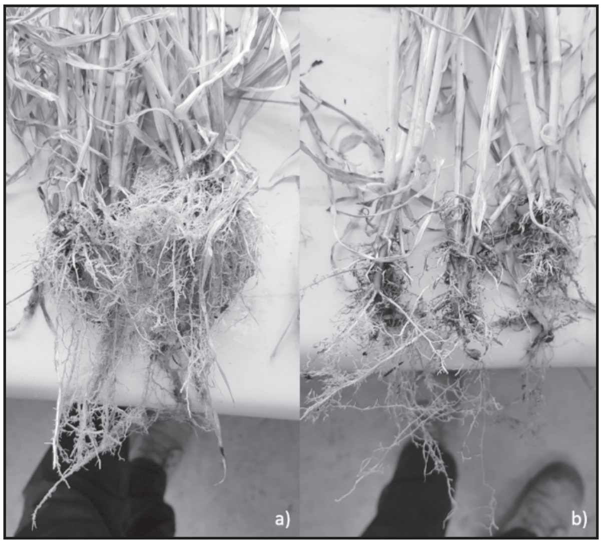

Figure 1 Example of plant roots at Wangary with a) low Rhizoctonia and b) very high Rhizoctonia infection

These effects also highlight the importance of the relationship between root disease effects and seasonal conditions. These crops did not experience significant moisture stress throughout the growing season which set up good yield potential. Even the high disease treatments produced yields likely to be accepted by many growers.

However, under low overall foliar disease levels, there was some evidence that phosphorous influenced foliar disease at Stokes, and sulphur reduced spot form net blotch at Wangary. Whilst not significant, there did appear to be a trend towards lower foliar disease percentage with the addition of copper at Stokes too.

Yield data for this site seems to support the hypothesis that nutrient inputs can compensate for reduced root systems caused by rhizoctonia, with the overall percentage increase in yield due to nutrient inputs greater in diseased treatments than in fungicide treatments. However, this additional benefit appears to be the result of improved supply to badly affected root systems (in inoculated plots), rather than due to actual disease reduction or root stimulation.

At Wangary, where the foliar disease response to sulphur was clearer, there was no yield response to any fertiliser treatment. However, it is unclear whether this is due to effects of the unintended grazing, or simply due to a lack of relationship between foliar disease and yield in this season.

The results of these experiments indicate the relationship between nutrition, root and leaf disease, and yield is highly dependent on environmental conditions, and the effect of disease on yield can be affected by nutrition. These experiments will be repeated in 2019.

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