Potential for Foliar Applied Phosphorus in Australian Dryland Cropping: A Glasshouse Study

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Key messages

- **A yield response to foliar phosphoric acid plus adjuvant was measured in a P responsive soil type. Translocation to grain did not control the yield response but likely due to the increased ability of the tillers to survive and fill grain.**
- **Further evaluation is required of the; soil types, climatic conditions, timing, rate and formulations including adjuvants, in order to determine the best fit for foliar P fertilisation in agricultural systems having variable climate.**

Why do the trial?

It is important to apply some phosphorus (P) to the soil at the beginning of the crop growth cycle to provide essential P for early growth and to replace P exported in previous crops. With low rates of P added at sowing there may be sufficient P reserves to grow crops to tillering, but in seasons of increased yield potential a top-up application of P may be required. Foliar P application can be applied directly to the plant when required and in some cases has been shown to provide benefits for increasing P use efficiency. However, tests of foliar P fertilisation to date have had inconsistent results. Our aim was to accurately measure the ability of foliar P products to increase grain yield and contribute to grain P uptake using a radioactive tracing technique (with 33P) in the glasshouse.

How was it done?

The experiment comprised two soils, seven P fertiliser treatments with one rate of P (equivalent to 1.65 kg P ha^{-1}), replicated three times. The seven P fertiliser treatments were: control of water only, control of water only but extra 1.65 kg ha^{-1} starter P added to soil (to balance extra P applied as foliar P), ammonium polyphosphate plus the adjuvant LI700, Top Up plus LI700, Top Up only, phosphoric acid plus LI700 and phosphoric acid. Solutions were added to the foliage at a water rate equivalent to 120 L/ha. There was a treatment of ammonium polyphosphate only but this is not presented as the concentration of fertiliser was found to not match the other treatments.

After five weeks of growth, at Zadoks growth stage 39, the foliar fertiliser solutions were applied. The fertiliser solutions were labelled with 33P as a radioactive tracer. The fertiliser-33P spikes were applied to plants as 10 μL drops with 21 drops applied to each pot, with drops placed on as many leaves of each plant as possible. The spike rate is equivalent to an application of 1.65 kg P ha^{-1} in 120 L ha^{-1} total volume. The foliar fertilisers were applied mid-morning at 29.5°C and 57.9% relative humidity. Four days after the application of foliar fertiliser, the plants were rated for burn according to the methodology of Stein and Storey (1986) where 1= no effect, 2= slight surface burn on treated area, 3= moderate burn, 4= necrosis on affected area, 5= necrosis on affected area and untreated parts of plant affected. After harvest, plant parts were weighed and digested samples of grain were analysed for P content and 33P radioactivity. All statistics were undertaken using the statistical package Genstat.

What happened?

One week after adding the foliar fertiliser, the leaves were scored for scorch with a rating 1-5. The largest scorch effect was for the lowest pH fertiliser (phosphoric acid) added with adjuvant. However, as indicated in Table 2 this was the highest yielding treatment in the Koppio soil.

The grain and plant yield data indicate that plants grown in the Koppio soil yielded 1.25 times more grain when supplied with foliar P fertiliser in the phosphoric acid form added with adjuvant compared to adding the extra 1.65 kg P to the soil at sowing. Phosphoric acid only yielded similarly to adding extra P at sowing while all other treatments yielded the same as the control (Table 3).

Table 1 Soil Characteristics

Soil Characteristics	Units	Maitland	Koppio
pH	H_20	8.3	6.2
$EC_{1:5}$	dS m^{-1}	0.22	0.13
$CaCO_3$	% w/w	14	0.18
Clay	% w/w	35.2	18.1
TOC	% w/w	2.3	3.9
DGT CE_P	µg L^{-1}	964	1275
Colwell P	mg kg^{-1}	68	29

† EC-electrical conductivity, $CaCO_3$ - calcium carbonate, TOC - total organic carbon, DGT CE_P - diffusive gradient in thin film effective concentration phosphorus.

Table 2 Foliar fertiliser pH and scorch score for each treatment measured four days after application of foliar fertiliser. Significantly different treatments are appended by a different letter (P<0.001, LSD 0.81). The treatment x soil interaction was not significant.

Treatment	pH	Scorch Score
Control (water)	5.95	1.0 a
Control (water) + soil P @ 1.65kg P/ha	5.95	1.0 a
Phosphoric acid	1.26	2.8 b
Phosphoric acid + adjuvant	1.27	3.6 b
Top Up	1.88	3.3 b
Top Up + adjuvant	1.89	3.3 b
Ammonium Polyphosphate + adjuvant	6.40	1.5 a

Table 3 Grain weight (g/pot) and total plant weight (g/pot). Significantly different treatments are appended by a different letter (grain wt; soil x treatment P<0.001, LSD 2.3, total plant wt; soil x treatment P<0.001, LSD 5.3).

Treatment	Grain Weight (g/pot)	Total Plant Weight (g/pot)
Koppio		
Control (water)	15.7 c	47.0 d
Control (water) + top up soil P	16.9 bc	53.7 bc
Phosphoric acid	19.0 ab	58.7 ab
Phosphoric acid + adjuvant	21.2 a	64.0 a
Top Up	15.0 c	45.6 d
Top Up + adjuvant	15.4 c	48.3 d
Ammonium Polyphosphate + adjuvant	15.1 c	50.6 cd
Maitland		
Control (water)	7.4 d	23.1 e
Control (water) + top up soil P	7.8 d	24.7 e
Phosphoric acid	6.3 d	20.9 e
Phosphoric acid + adjuvant	6.6 d	21.4 e
Top Up	7.8 d	24.8 e
Top Up + adjuvant	6.1 d	20.4 e
Ammonium Polyphosphate + adjuvant	6.1 d	22.5 e

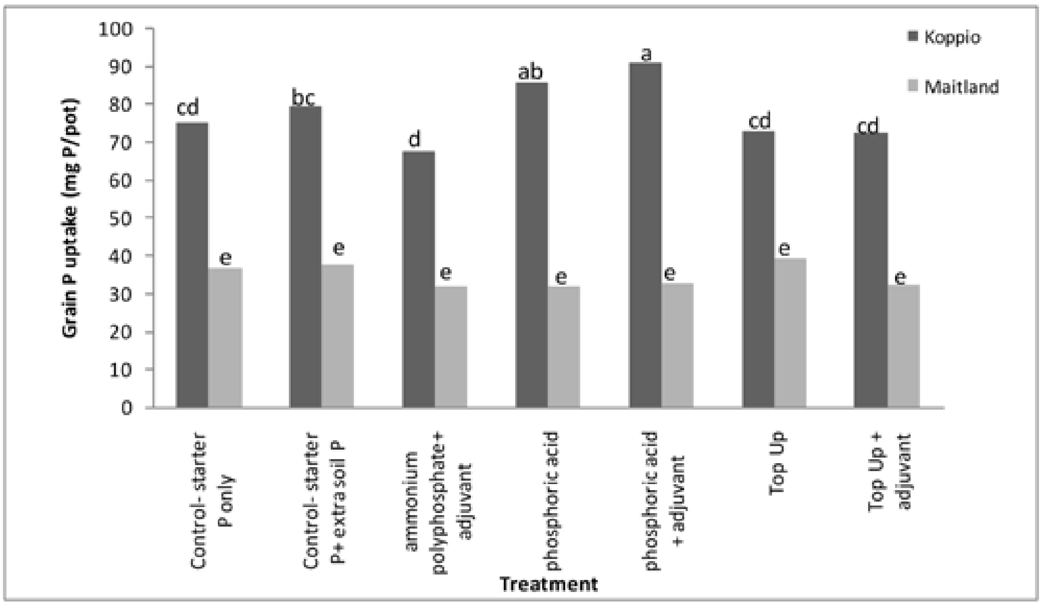

***Figure 1** Phosphorus in grain derived from the foliar fertiliser (mg P/pot). Significantly different treatments are appended by a different letter (treatment P=0.042, LSD 0.61).*

Despite also having a marginal soil P test value (DGT-P), the Maitland soil did not respond to foliar P application, demonstrating the importance of pre-screening for responsiveness to soil and foliar nutrient of a range of application rates. This lack of responsiveness to foliar P despite low initial soil test results was also observed by Mosali et al. (2006). The reliability of soil P testing methodology is vital for appropriate site selection and P testing is being researched by Mason and McNeill (2008).

The P in grain derived from the foliar fertiliser is a small amount of P (mg) and did not significantly differ between treatments (Figure 1). These data indicate that the foliar P addition does not have a function of loading the grain with P but rather supports the ability of the tillers to fill grain.

In-season P fertilisation prior to the emergence of the head allowed the plant to produce a higher number of fertile tillers per unit area resulting in a higher yield in a number of studies (Batten et al. 1986; Elliott et al. 1997; Goos 1995; Romer and Schilling 1986). In comparison, a P-deficient crop will conserve sufficient P to sustain the survival of just one fertile tiller on each plant (Romer and Schilling 1986).

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Top Up – registered product of SprayGro Liquid Fertilizers.

LI700 - registered product of Nufarm Australia Ltd.

Genstat tenth edition is a registered product of Lawes Agricultural Trust.

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