10.1071/CP24295

Crop & Pasture Science

Supplementary Material

Phosphorus buffering determines how soil properties and rainfall influence wheat (*Triticum aestivum*) yield response to phosphorus fertiliser

Craig A. Scanlan[A,B,C,*], *Raj Malik*[D], *Gustavo Boitt*[B,E], *Mark Gherardi*[F], *James Easton*[E], *and Zed Rengel*[B]

[A] Department of Primary Industries and Regional Development, 75 York Road, Northam, WA 6401, Australia.

[B] The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia.

[C] SoilsWest, Murdoch University, 90 South Street, Murdoch, WA 6150, Australia.

[D] Department of Primary Industries and Regional Development, 10 Dore Street, Katanning, WA 6317, Australia.

[E] CSBP, PO Box 345, Kwinana, WA 6966, Australia.

[F] Summit Fertilisers, 29 Ocean Street, Kwinana Beach, WA 6167, Australia.

[*]Correspondence to: Craig A. Scanlan Department of Primary Industries and Regional Development, PO Box 483, Northam, WA 6401, Australia. Email: craig.scanlan@dpird.wa.gov.au

Supplementary material

Table S1: Brief description of the Australian Soil Classification (ASC) orders at the field experiment sites. Descriptions are from Isbell R.F. and the National Committee on Soil and Terrain (2021).

ASC soil order	Description
Calcarosol	Soils that are calcareous throughout the soil profile.
Chromosol	Soils with strong texture contrast between A horizons and B horizons. The latter are not strongly acidic and are not sodic.
Kandosol	Soils that lack strong texture contrast, have massive or only weakly structured B horizons, and are not calcareous throughout.
Kurosol	Soils with strong texture contrast between A horizons and strongly acidic B horizons.
Tenosol	Soils with generally only weak pedologic organisation apart from the A horizons, excluding soils that have deep sandy profiles with a field texture of sand, loamy sand or clayey sand in 80% or more of the upper 1.0 m.

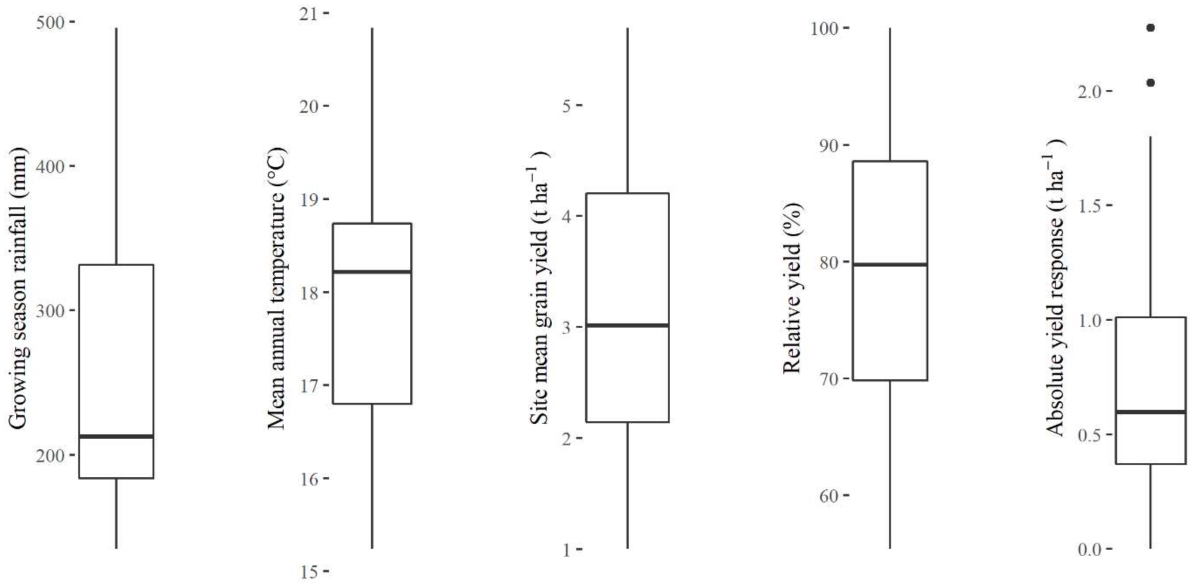

Fig. S1: Summary of growing season rainfall, mean annual temperature, site mean grain yield, relative yield and yield response to phosphorus fertiliser at the 40 field experiments with wheat. The lower and upper boundary of the boxes are the 25th and 75th percentiles, respectively, and the line between these is the median. The whiskers show the minimum or maximum value, limited to 1.5 *x* the interquartile range beyond the 25th or 75th percentile. Data beyond the whiskers are shown as dots.

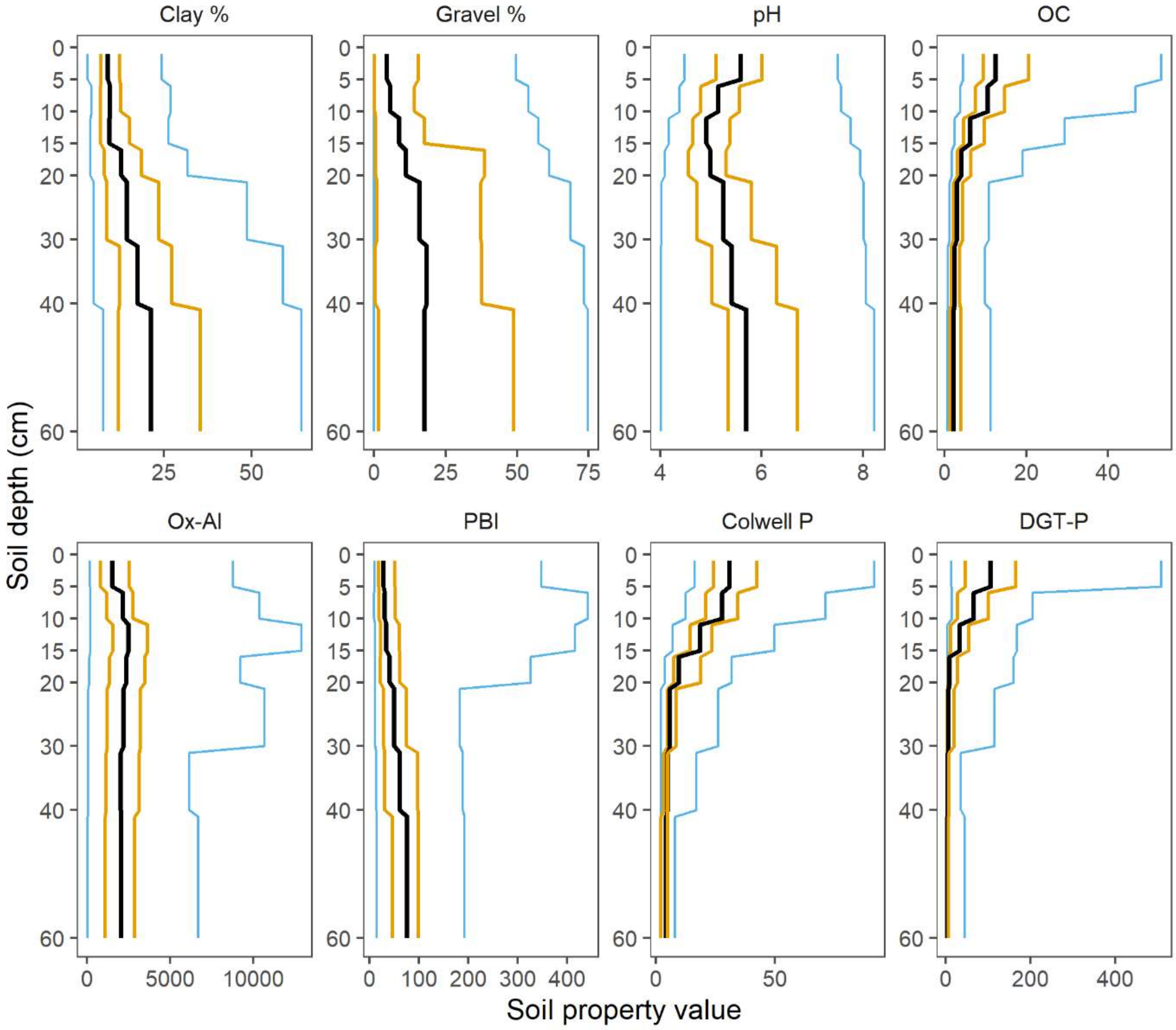

Fig. S2: Summary statistics for selected soil properties from the field experiments. Clay % = percent clay in the <2 mm fraction. Gravel % = percent gravel (≥2 mm) of whole soil by weight. pH = pH ($CaCl_2$). OC = organic carbon (g kg^{-1}). Ox-Al = oxalate-extractable Al (mg kg^{-1}). Units for Colwell P and DGT-P are mg kg^{-1} and µg L^{-1}, respectively. Blue lines are the minimum and maximum values. Light brown lines are 25th and 75th percentile. Black line is the median.

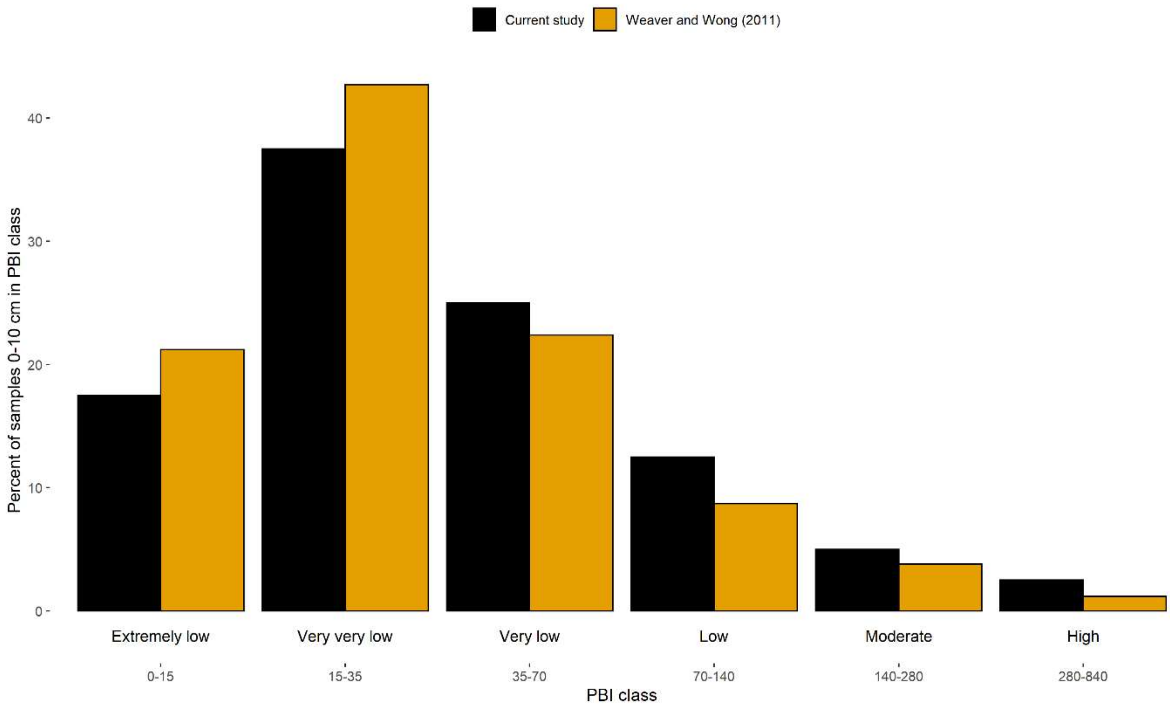

Fig. S3: Comparison of the frequency distribution of phosphorus buffering index (PBI) of the 0-10 cm soil layer in the current study [40 sites] and from Weaver and Wong (2011) [109,000 samples from Western Australia]. PBI classes are from Moody (2007).

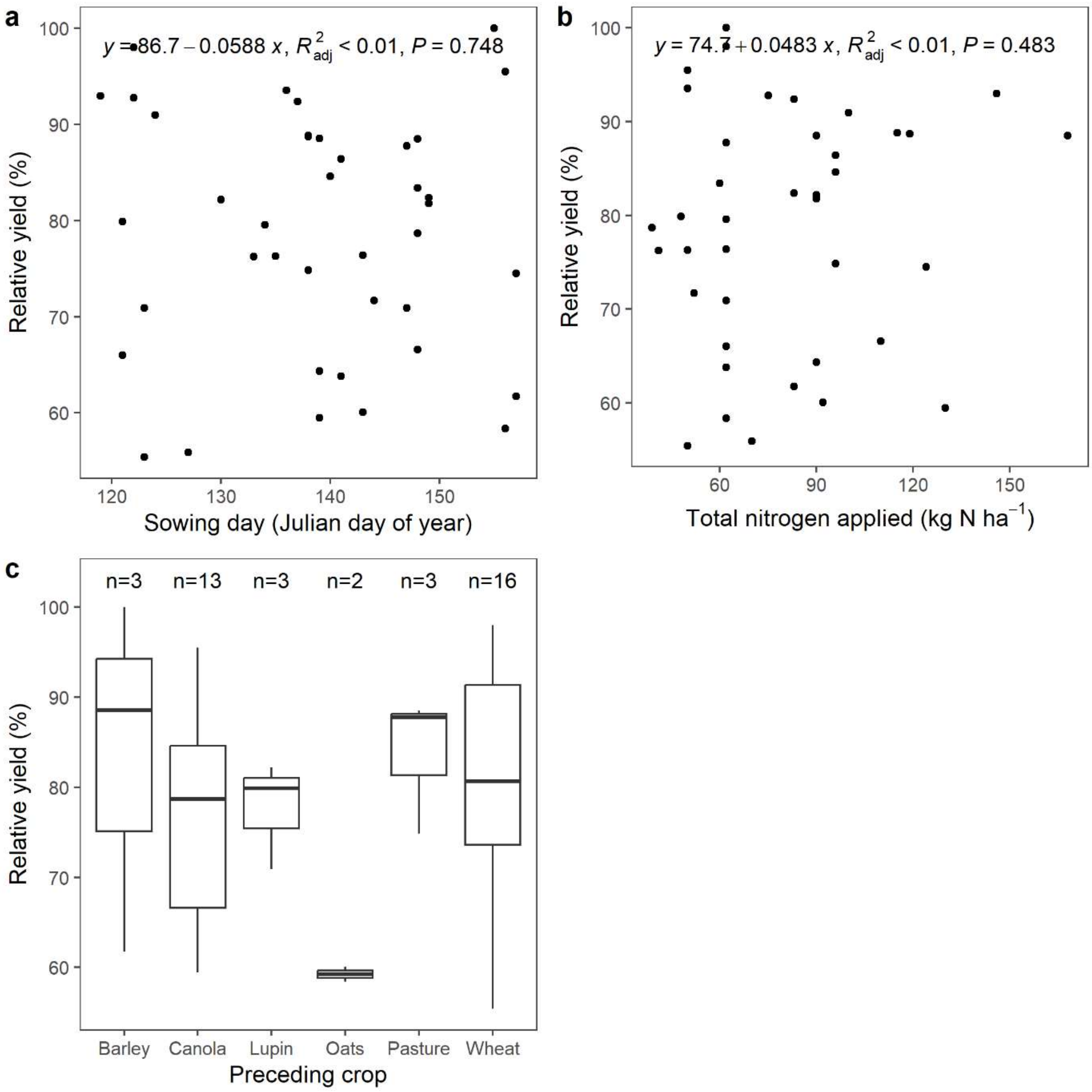

Fig. S4: Relationship between relative yield and (a) sowing day, (b) total nitrogen applied and (c) preceding crop. Analysis of variance for preceding crop (c) showed a non-significant effect (p=0.31). Values shown in (a) and (b) are outputs from the linear regression.

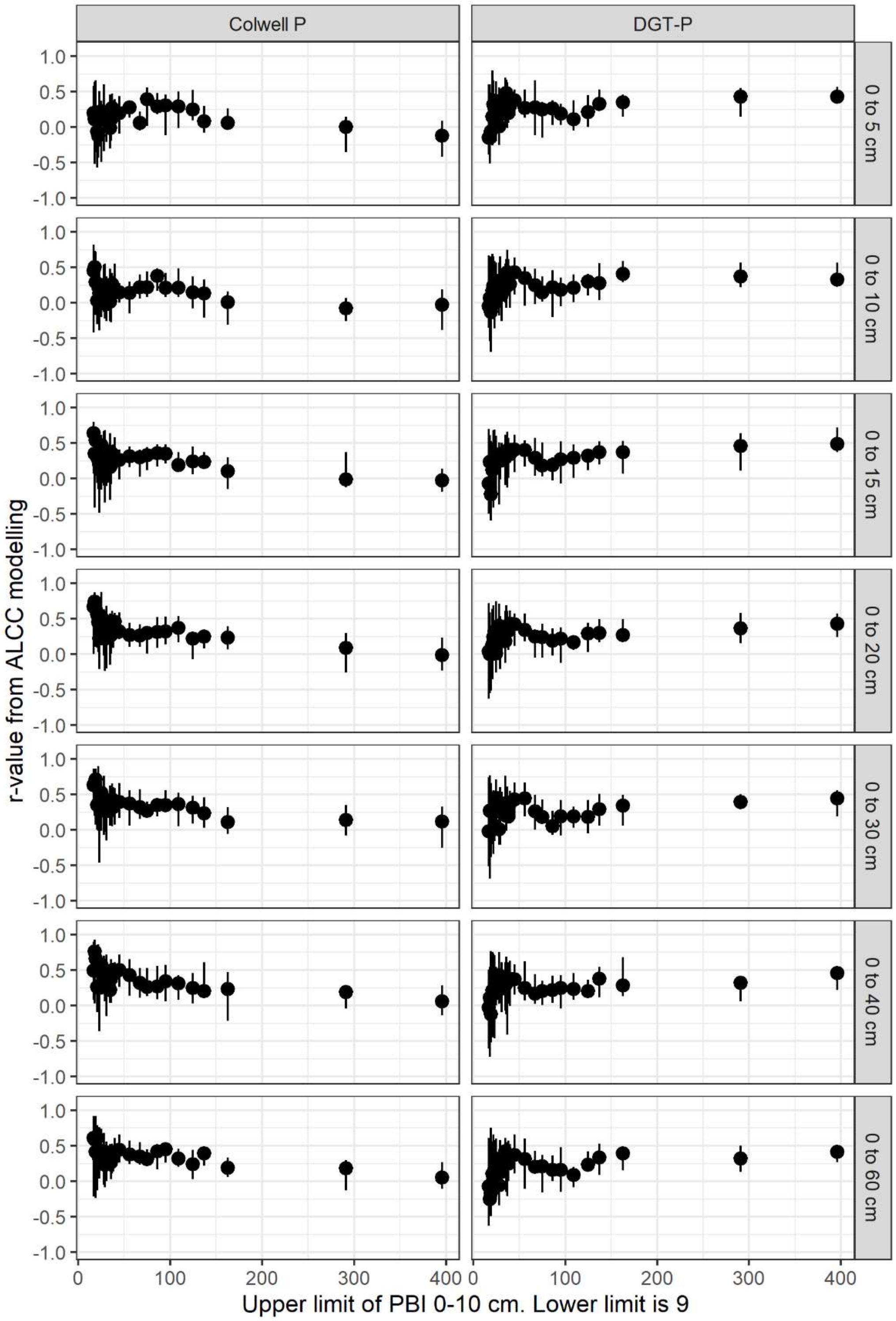

Fig. S5: Influence of the range of PBI 0-10 cm values for sites included in the calibration data, and sampling depth on the r-value for the soil test calibration curve obtained using the arcsine-log calibration curve method. Data shown here are for analysis using an *ascending* range of PBI; the lower value is fixed at 9 and the upper value increasing from 18 to 396 using the PBI values shown in the figure, and utilising bootstrapping (n=1000). Dots are the median value from the bootstrap samples, and vertical lines show the 90% confidence interval.

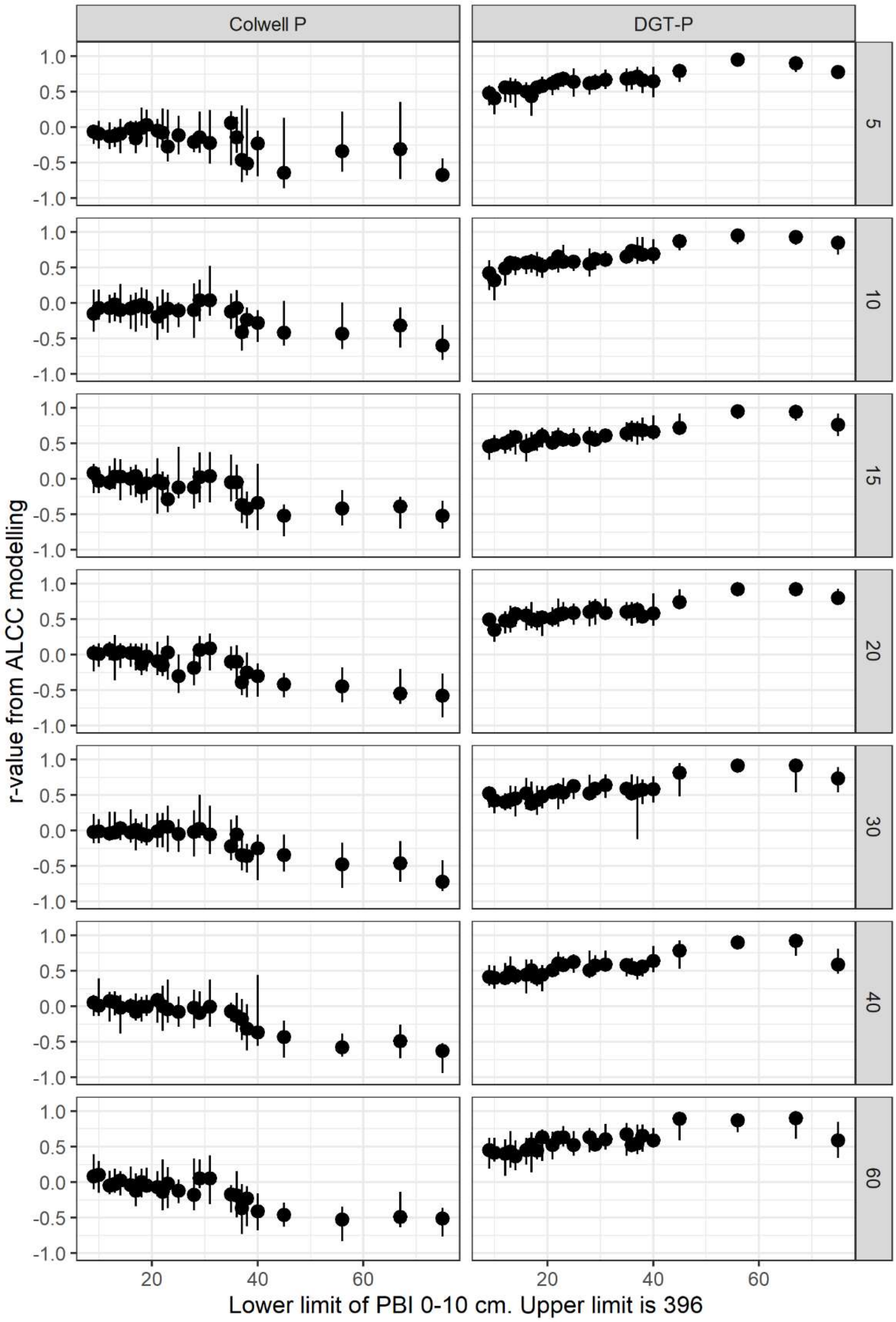

Fig. S6: Influence of the range of PBI 0-10 cm values for sites included in the calibration data, and sampling depth on the r-value for the soil test calibration curve obtained using the arcsine-log calibration curve method. Data shown here are for analysis using a *descending* range of PBI; the upper value is fixed at 396 and the lower value decreasing from 75 to 9 using the PBI values shown in the figure, and utilising bootstrapping (n=1000). Dots are the median value from the bootstrap samples, and vertical lines show the 90% confidence interval.

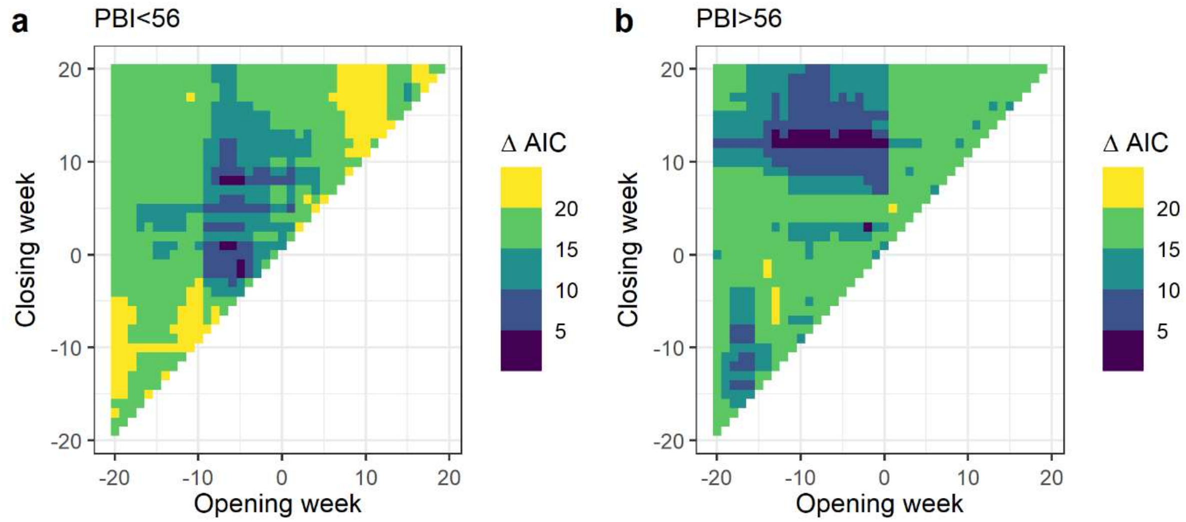

Fig. S7: Matrix plot of ΔAIC for the quadratic model fitted to relative yield – rain data for each time-based window in the sliding window analysis, in comparison to the window with the lowest AIC value. Sites were grouped by phosphorus buffering index (PBI) 0-10 cm for the analysis of relative yield-rain data, shown in (a) PBI <56, and (b) PBI>56.

Isbell R.F. and the National Committee on Soil and Terrain (2021) 'The Australian Soil Classification.' (CSIRO Publishing: Melbourne)

Moody, PW (2007) Interpretation of a single-point P buffering index for adjusting critical levels of the Colwell soil P test. *Soil Research* **45** (1), 55-62. http://dx.doi.org/10.1071/SR06056