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Prediction of available phosphorus in soil: Combined use for crop production and water quality protection

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Abstract

Optimizing phosphorus (P) application to agricultural soils is fundamental to crop production and water quality protection. We sought to relate soil P tests and P sorption characteristics to both crop yield response to P application and environmentally critical soil P status. Barley (*Hordeum vulgare* L.) was grown in pot experiments with 45 soils of different P status. Half the pots were fertilized at 20 kg P ha^{-1}, and half received no P. Soils were extracted with ammonium lactate, sodium bicarbonate (Olsen P), dilute salt (0.0025 M CaCl$_2$), and diffusive gradient in thin films. Soil adsorption coefficients were determined using the Freundlich isotherm equation, and the degree of P saturation was determined from both oxalate and ammonium lactate extracted Fe, Al, and P. All soil P analyses showed a nonlinear and significant relationship with yield response to P application, and all analyses manifested a threshold value above which no P response was observed. For the commonly used ammonium lactate test, inclusion of Al and Fe improved prediction of plant-available soil P. The threshold for yield response coincided with the environmentally critical values determined from the degree of P saturation. Results support the conclusion that soil P levels for which no P application is needed also have elevated risk of P loss to runoff.

1 | INTRODUCTION

Phosphorus (P) fertilizer is required for optimal crop yield, but there can be conflicting aims between promoting high crop yields and preventing runoff of bioavailable P (Smith, Tilman, & Nekola, 1999). As national fertilizer strategies

have matured and soil P levels have increased, fertilizer P application has decreased. The surpluses in the soil P balance in European countries have substantially decreased since 1990, but more P is still applied than removed with the crops. In Norway, the average P surplus was 26 kg P ha^{-1} in 1985 (OECD, 2017), but it had decreased to 9 kg P ha^{-1} in 2014 (Eurostat, 2017). In EU-15 area countries, the average P surplus was only 2 kg P ha^{-1} in 2014.

Efforts to minimize P application rates begin and end with soil testing. Further, soil testing may also be used to predict dissolved P concentrations in runoff (Quinton et al., 2003; Randall et al., 2005; Vadas, Kleinman, Sharpley, & Turner, 2005). Numerous extraction methods are used in

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Abbreviations: AL, ammonium acetate lactate; Al-ox, oxalate extractable aluminum; DGT, diffusive gradient in thin films technique; DPS, degree of phosphorus saturation; DPS-AL, degree of phosphorus saturation measured in ammonium acetate lactate extracts; DPS-ox, degree of phosphorus saturation measured in ammonium oxalate extracts; Fe-ox, oxalate extractable iron; P-AL, ammonium acetate lactate extractable phosphorus; P-DGT, DGT-accumulated phosphorus.

soil testing. In Norway, soil P extracted with an ammonium acetate lactate solution (P-AL; Egnér, Riehm, & Domingo, 1960) is used in fertilizer planning. A P-AL range of 50–70 mg P kg^{-1} is currently considered optimal with regard to both crop yield and environmental risk (Krogstad, Øgaard, & Kristoffersen, 2008). In this P-AL range, the P fertilizer recommendation is to apply P to meet crop removal. At P-AL >140 mg P kg^{-1}, omitting P application to cereals and grasses is recommended.

The relationship between P-AL and crop response to P application has been shown to vary between soils (Kristoffersen & Riley, 2005). Similarly, the relationship between agronomic soil tests (e.g., P-AL) and water-extractable P, a key indicator for elevated risk of P loss to runoff, varies between soils (Pote et al., 1999). Differences in P sorption characteristics are a likely cause of soil-specific relationships. In acidic soils, amorphous aluminum (Al) and iron (Fe) (hydr)oxides are important for P sorption, while P status, pH, and the content of organic matter also influence the soil's capacity to bind and release P (Bolland, Gilkes, Brennan, & Allen, 1996; Börling, Otabbong, & Barberis, 2001, 2004). However, the interaction of these factors in relation to plant response to P application is not well understood.

Previous studies looked separately at either the relationship between soil P tests and yield response to P application or at the risk of dissolved P runoff. We combine these objectives with the aim of optimizing P fertilizer practice with regard to both crop production and water quality protection. The objectives of the present study were thus (a) to relate relative yield response to P application to a range of soil P tests, P sorption characteristics, and P sorption parameters; (b) to determine the environmentally critical soil P status based on soil P tests and P sorption characteristics; and (c) to examine whether certain soil characteristics used in combination with P-AL can improve the precision of P fertilizer recommendations and the estimation of the risk of P runoff.

2 | MATERIALS AND METHODS

Pot experiments were performed with barley (*Hordeum vulgare* L. 'Helium' and 'Heder') to identify P and soil characteristics resulting in the best relationship with yield response to P application. Bulk soil samples were collected in 2011, 2012, and 2014 from the upper layer (0–20 cm) of 45 cultivated soils in southern Norway. Soils were selected to be representative of the most important soil conditions in southern Norway and had wide variations in P status. A summary of selected soil characteristics is provided in Supplemental Table S1.

> **Core Ideas**
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> - All studied soil P analyses were correlated with crop response to P application.
> - Inclusion of extractable Al and Fe may improve prediction of available soil P.
> - Values for no yield P response coincided with the environmental critical values.

2.1 | Phosphorus extractions

The P-AL test was performed with a mixture of 0.1 M ammonium lactate and 0.4 M acetic acid, at pH 3.75 (Egnér et al., 1960). Water-extractable P (CaCl$_2$-P) was extracted with 0.0025 M CaCl$_2$ in a soil-solution ratio of 1:20 (w/v) for 1.5 h. A lower CaCl$_2$ concentration than the more commonly used 0.01 M CaCl$_2$ was selected because it gives an ionic strength closer to that found in the soil solution (electrical conductivity in 0.0025 M CaCl$_2$ is 580 μS cm^{-1}). Olsen P was extracted with 0.5 M NaHCO$_3$ (pH 8.5) according to Olsen et al. (1954).

The diffusive gradient in thin films technique (DGT) was performed with a ferrihydrite [Fe(OH)$_3$] sorbent and with 48 h exposure. Standard DGT units from DGT Research Ltd., Lancaster, U.K., were used. The DGT unit was equipped with a 0.8-mm-thick diffusion membrane, and a 0.45-μm pore membrane filter was placed outside the diffusion membrane for protection. Water was added to the soil sample to give a soil paste, which was filled into a petri dish, into which the DGT unit was inserted. After 48 h of exposure, P was extracted from the ferrihydrite gels using concentrated HNO$_3$. The P concentration in the various extracts was measured using the molybdenum-blue method (Murphy & Riley, 1962), except for P-AL where inductively coupled plasma–optical emission spectrometry was used.

2.2 | Phosphorus sorption properties

Two methods for characterizing the P sorption properties of the different soils were performed: (a) the degree of P saturation (DPS) (Schoumans & Groenendijk, 2000) and (b) adsorption coefficient calculated using the Freundlich isotherm equation. The adsorption coefficient was developed by Greenwood, Karpinets, and Stone (2001) for calculating the soil's adsorption capacity as used in the PHOSMOD model. A sensitivity analysis (Kristoffersen, Greenwood, Sogn, & Riley, 2006) showed that this

parameter had a great impact on the plant's response to P fertilizer on different soil types.

2.2.1 | The degree of P saturation (DPS)

Based on the review given in Maguire, Foy, Bailey, and Sims (2001), DPS was calculated from oxalate extractable Fe, Al, and P, where P sorption capacity was estimated as a fraction (α) of the sum of oxalate extractable Fe (Fe-ox) and oxalate extractable Al (Al-ox) and DPS as the molar ratio between oxalate extractable P (P-ox) and P sorption capacity (Equation 1). We determined Fe-ox, Al-ox, and P-ox according to van Reeuwijk, (1995). Values of Al-ox, Fe-ox, and P-ox in Equation 1 are in millimoles per kilogram.

$$\text{DPS}\,(\%) = 100 \times \left[\frac{\text{P} - \text{ox}}{\alpha(\text{Al} - \text{ox} + \text{Fe} - \text{ox})} \right] \quad (1)$$

The parameter α is empirical and has sometimes been estimated to be 0.5 for noncalcareous soils (Maguire et al., 2001; Schoumans, 2009).

The DPS was also calculated with P, Al, and Fe measured in the ammonium acetate lactate (AL) extracts (DPS-AL) (all values in mmol kg^{-1}) to assess whether Norway's routine soil test (P-AL) can substitute for the more specialized and costly oxalate test:

$$\text{DPS} - \text{AL}\,(\%) = 100 \times \left(\frac{\text{P} - \text{AL}}{\text{Al} - \text{AL} + \text{Fe} - \text{AL}} \right) \quad (2)$$

Here, we elected not to include a fixed value (α) in the equation.

2.2.2 | Adsorption coefficient calculated by Freundlich isotherm equation

Two grams of soil was added to 40 ml 0.0025 M $CaCl_2$ containing 0, 0.5, 1.5, 10, 30, and 40 mg P L^{-1} as KH_2PO_4 for soils from pot experiments 1 and 2. For soils from pot experiment 3, the P concentrations were 0, 0.5, 1, 2, 4, 8, and 16 mg P L^{-1}. The suspensions were shaken for 22 h, centrifuged at 12,900 × g for 10 min and filtered through 0.45-μm membrane filters. Phosphorus concentrations in the solutions were measured using the molybdenum-blue method (Murphy & Riley, 1962). The difference between the amount of P applied and the remaining in the solution was considered to be that adsorbed by the soil. The sorption data were then fitted to the Freundlich isotherm equation (Equation 3):

$$Q_e = Kc^a \quad (3)$$

where Q_e is the amount of adsorbed P per unit of weight, c is the equilibrium concentration of P, and K and a are empirical Freundlich coefficients.

The adsorption coefficient (AC) was determined by Equation 4 developed by Greenwood et al. (2001):

$$\text{AC} = B_d Ka \,(\text{Olsen} - \text{P}/K)^{[(a-1)/a]} \quad (4)$$

where the parameters B_d (bulk density), K, a, and Olsen-P were specific for each individual soil, and B_d was estimated according to formula of Riley (1996) (Supplemental Material, section "Soils").

2.3 | Pot experiment

Three pot experiments were conducted in a greenhouse in 2011, 2013 and 2015, respectively, with different soils each time, collected in 2011, 2012, and 2014. The experimental design was a factorial design with three replicates. The factors were soil types, soil P-AL levels, and P fertilization.

Three kilograms of air-dried soil was placed in 5-L plastic pots. In half the pots, 10 mg P kg^{-1} soil, corresponding to 20 kg P ha^{-1} (P20), was given as triple superphosphate, applied 5 cm below the seeds. The other half of the pots received no P fertilizer (P0). Basal doses (120 mg kg^{-1} soil) of N (ammonium nitrate) and K (potassium sulphate) were applied to all pots in granular form 5 cm below the seeds. Soils were compacted by hand to a relative degree of compactness of 75% (Kristoffersen & Riley, 2005).

Twelve seeds of barley (*Hordeum vulgare* L. 'Helium' [2011], 'Heder' [2013, 2015]) were sown per pot and thinned to 10 once germinated. At the start of the trials, the mass wetness in the pots was adjusted to 30% and maintained at that level by regular watering with tap water. The loss of water was determined by weighing pots before each watering. As the soils were of varying texture and pore size distribution, soil moisture tensions varied among soils, but the total amounts of water in each pot were the same. The temperature was kept at 13 °C by day/10 °C by night and the light period was 14 h in all three trials. In addition to natural daylight, light at a fluence rate of 184 μmol quanta m^{-2}s^{-1} was provided by a mixture of SonT and incandescent lamps.

The plants were harvested at the onset of heading, growth stage 49 (Zadoks, Chang, & Konzak, 1974). The plants were cut 0.5 cm above ground, dried at 60°C and their dry biomass was recorded.

Responses to P application are presented as relative yield responses, which were calculated as the yield difference

between no P fertilizer (P0) and 20 kg P ha^{-1} (P20) relative to the yield at P0 (Equation 5).

$$\text{Relative yield response} = \frac{\text{Yield P20} - \text{Yield P0}}{\text{Yield P0}} \times 100$$

$$(5)$$

2.4 | Statistical methods

The statistical model used is a split-line model, where the expectation function of the response variable y is given by $E(y) = \alpha + \beta \bullet x$ when $x \leq \tau$ and $E(y) = \alpha + (\beta - \delta) \bullet \tau + \delta \bullet x$ when $x > \tau$. x is the regressor, α, β, δ, and τ are parameters to be estimated, where τ is the threshold value; β and δ are the slopes of the lines below and above τ, respectively. Minitab (version 18) was used for all statistical analyses.

3 | RESULTS

Soils included in the pot experiments represented a wide range of mineral soils with texture ranging from 3 to 50% clay and soil organic matter ranging from 1.2 to 10.0% (Supplemental Table S1). The pH (H_2O) ranged from 5.5 to 7.0 and therefore in a range where P binding to Al and Fe (hydr)oxides dominates over binding to calcium (Ca). Oxalate extractable Fe ranged from 2.1 to 10.1 g kg^{-1}, whereas oxalate extractable Al ranged from 0.5 to 5.3 g kg^{-1} (Supplemental Table S1). There was also a large variation in extractable P. Consequently, the degree of soil P saturation also varied widely: 16–73% for DPS measured in ammonium oxalate extracts (DPS-ox) and 4–59% for DPS measured in ammonium acetate lactate extracts (DPS-AL). The Freundlich isotherm-derived adsorption coefficient varied from 6 to 974 (Supplemental Table S1).

3.1 | Relationships between yield response, soil P tests, and P sorption characteristics

All the soil P tests and P sorption characteristics of DPS-ox and DPS-AL exhibited nonlinear relationships between the soil P and relative yield response to P application (Figure 1). The threshold values, together with their confidence intervals, obtained with the split-line models, where the response to P application increased rapidly, for the soil P tests and the sorption characteristics are given in Table 1. The split-line models described the relative yield response and threshold values well for all the soil P tests and for DPS-AL. The relationship was poorer for DPS-ox, giving

a large confidence interval. The relative yield response at the threshold values varied from 2 to 18%, depending on different soil tests.

## 3.2 | Soil analyses for evaluating vulnerability to dissolved P release to runoff

The soil P tests P-AL and Olsen P were related with a split-line model to readily releasable soil P (CaCl$_2$-P), to evaluate their ability to estimate environmental risk (Figure 2). For P accumulated with DGT (the diffusive gradient in thin films, P-DGT), it was not possible to relate a split-line model with CaCl$_2$-P, while DPS-ox and DPS-AL were also related to CaCl$_2$-P with the split-line model. The threshold values with confidence intervals are given in Table 1. For DPS-ox, the threshold value had a large confidence interval and the threshold was hardly visible. The threshold value was estimated slightly better with Olsen P and DPS-AL.

The capacity of soil to bind applied P fertilizer is important for the risk of P loss to runoff. The Freundlich isotherm–derived adsorption coefficient showed nonlinear relationships with P-AL, CaCl$_2$-P, Olsen P, DPS-AL, and DPS-ox (Figure 3). The split-line model was used to estimate threshold values for the soil P parameters. Below the threshold values, the soil adsorption coefficient increased rapidly, while above them, the adsorption coefficient was low. The threshold values with confidence intervals are given in Table 1. The threshold values were determined most precisely for CaCl$_2$-P and DPS-AL. For P-DGT, it was not possible to relate a split-line model with the adsorption coefficient.

Table 1 summarizes threshold values with 95% confidence intervals for soil P tests, DPS-ox, and DPS-AL related to relative yield response, soil adsorption coefficient, and CaCl$_2$-P. For DPS-AL, the threshold values for relative yield response, soil adsorption coefficient, and CaCl$_2$-P are quite close, whereas there are larger differences in these threshold values for DPS-ox and the soil P tests.

4 | DISCUSSION

The soils included in the present study represent non-calcareous soils, with significant variation in their contents of clay, organic matter, and amorphous Fe and Al (hydr)oxides and thereby a variation in P binding properties. In pot experiments, the effects of the soil's P status and P sorption characteristics in response to P application were studied without interference from weather conditions in individual years.
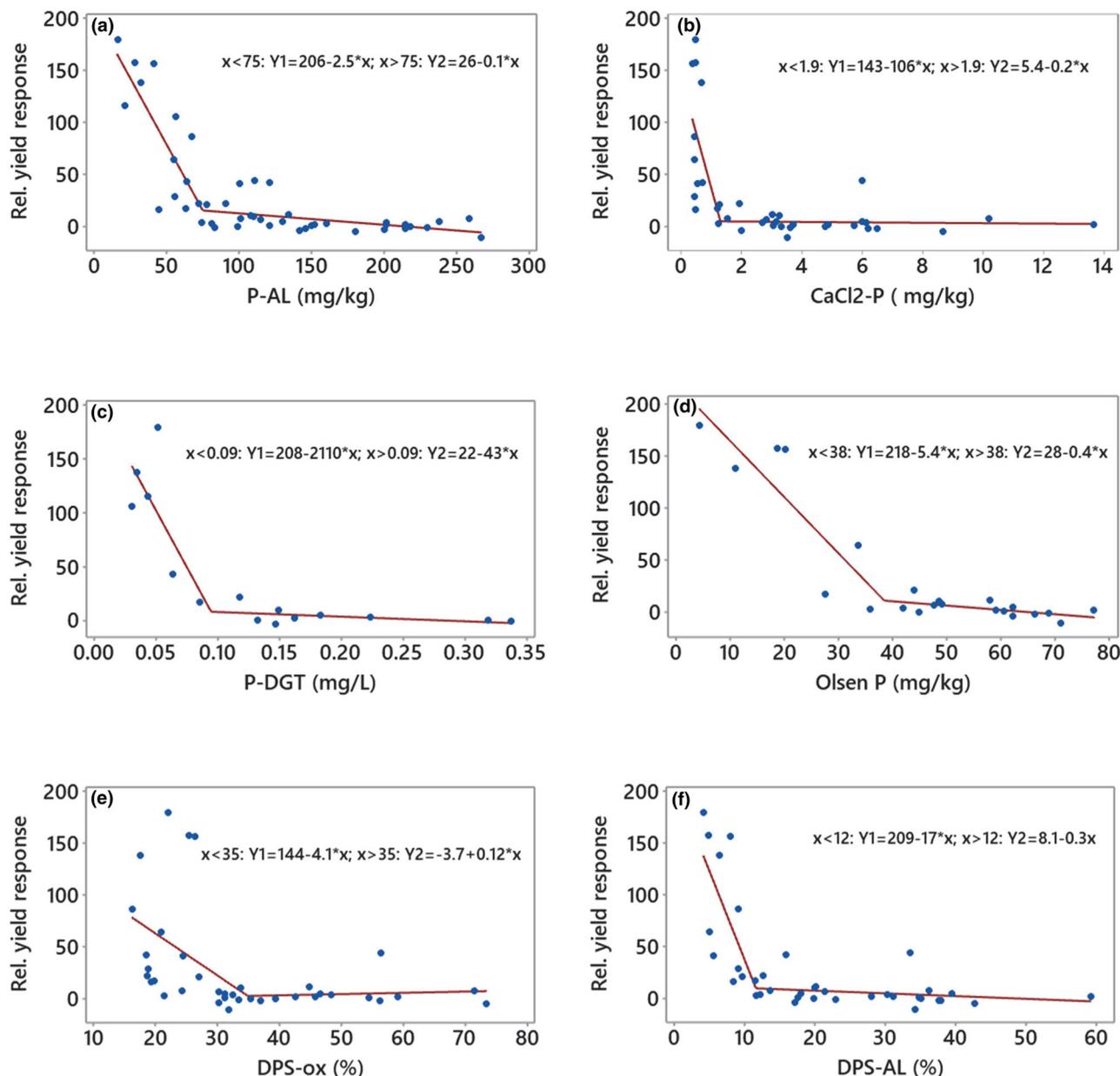
FIGURE 1 Relationships between relative yield response and (a) P-AL, (b) CaCl$_2$-P, (c) P-DGT, (d) Olsen P, (e) the degree of P saturation (DPS-ox), and (f) DPS-AL. The estimated parameters for the split-line models is given in Supplemental Table 2. DPS-AL, degree of P saturation measured in ammonium acetate lactate extracts; DPS-ox, degree of P saturation measured in ammonium oxalate extracts; P-AL, ammonium acetate lactate extractable P; P-DGT, P accumulated with diffusive gradient in thin films technique

4.1 | Soil P tests and yield responses to P application

All the included soil P tests showed similar plots for the relationship between extracted P and relative yield response to P application. Olsen P and P-DGT analyses were performed on fewer samples than those of P-AL and CaCl$_2$-P, but they nevertheless showed approximately the same pattern between P response and no P response. For Olsen P, the threshold value 38 (confidence interval

29–49) mg P kg^{-1} was in agreement with earlier results from field trials in Norway (Riley & Steenberg, 1985) where no response for P fertilization was found at Olsen P >45 mg P kg^{-1}. These results are also comparable to results from field experiments performed in different European countries (Nawara et al., 2017); testing the same soil P tests against P response to P application, the response curves showed similar shapes.

For the soils analyzed with DGT, there was a very close relationship between P-DGT and relative yield response to
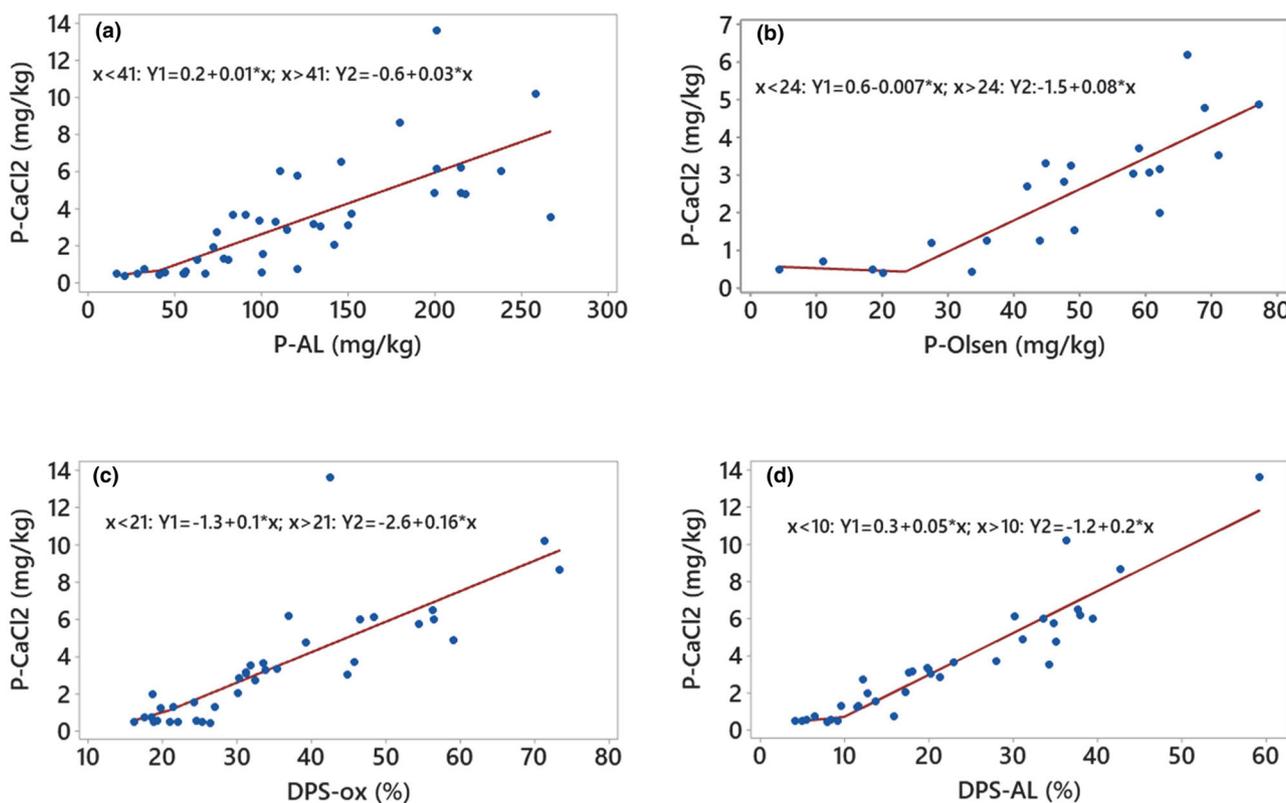
TABLE 1 Threshold values with 95% confidence intervals (CI) for soil P tests, DPS-ox (degree of P saturation measured in ammonium oxalate extracts), and DPS-AL (degree of P saturation measured in ammonium acetate lactate extracts) related to relative yield response, soil adsorption coefficient, and $CaCl_2$-P

| | Threshold values related to: | | |
	Relative yield response (CI)	Adsorption coefficient (CI)	$CaCl_2$-P (CI)
P-AL (mg kg^{-1})	75 (63–87)	88 (13–163)	41 (2–80)
$CaCl_2$-P (mg kg^{-1})	1.3 (0.8–2.2)	0.8 (0.6–1.2)	–
P-DGT (mg L^{-1})	0.09 (0.07–0.18)	–	–
Olsen P (mg kg^{-1})	39 (29–48)	51 (35–69)	24 (1–47)
DPS-ox (%)	35 (23–70)	39 (19–59)	21 (1–93)
DPS-AL (%)	12 (9–15)	12 (10–20)	10 (2–18)

Note. P-AL, ammonium acetate lactate extractable P.

P application (Figure 1c); this is in accordance with results from Almås, Sævarsson, and Krogstad (2017). The DGT adsorbs P in soil solution and mimics roots, which maintain soil P concentration low close to the roots due to P uptake (Nawara et al., 2017). However, the results also indicate that the classical soil P extractions can satisfactorily predict yield response to P application. Even though soil extractions only provide a snapshot of a certain P fraction, our results indicate that they also reflect the soil's P supplying power. Weak or strong extraction was not crucial

for predicting P response to P application for the soil tests included here. With the AL extraction, 2–20% of total P was extracted, whereas for 0.0025 M $CaCl_2$, only 0.03–0.94% of total P was extracted. However, P-AL and $CaCl_2$-P were positively linear-related (R^2 = .55), showing that in noncalcareous soils, the most readily releasable soil P fraction is buffered from the fraction extracted with stronger extraction solutions. This corresponds to the findings of Djodjic, Börling, and Bergström (2004) and Øgaard (1995). A study of P desorption from noncalcareous soils in 0.01 M

FIGURE 2 Relationships between readily releasable soil P, $CaCl_2$-P, and (a) P-AL, (b) Olsen P, (c) DPS-ox, and (d) DPS-AL. The estimated parameters for the split-line models is given in Supplemental Table 2. DPS-AL, degree of P saturation measured in ammonium acetate lactate extracts; DPS-ox, degree of P saturation measured in ammonium oxalate extracts; P-AL, ammonium acetate lactate extractable P
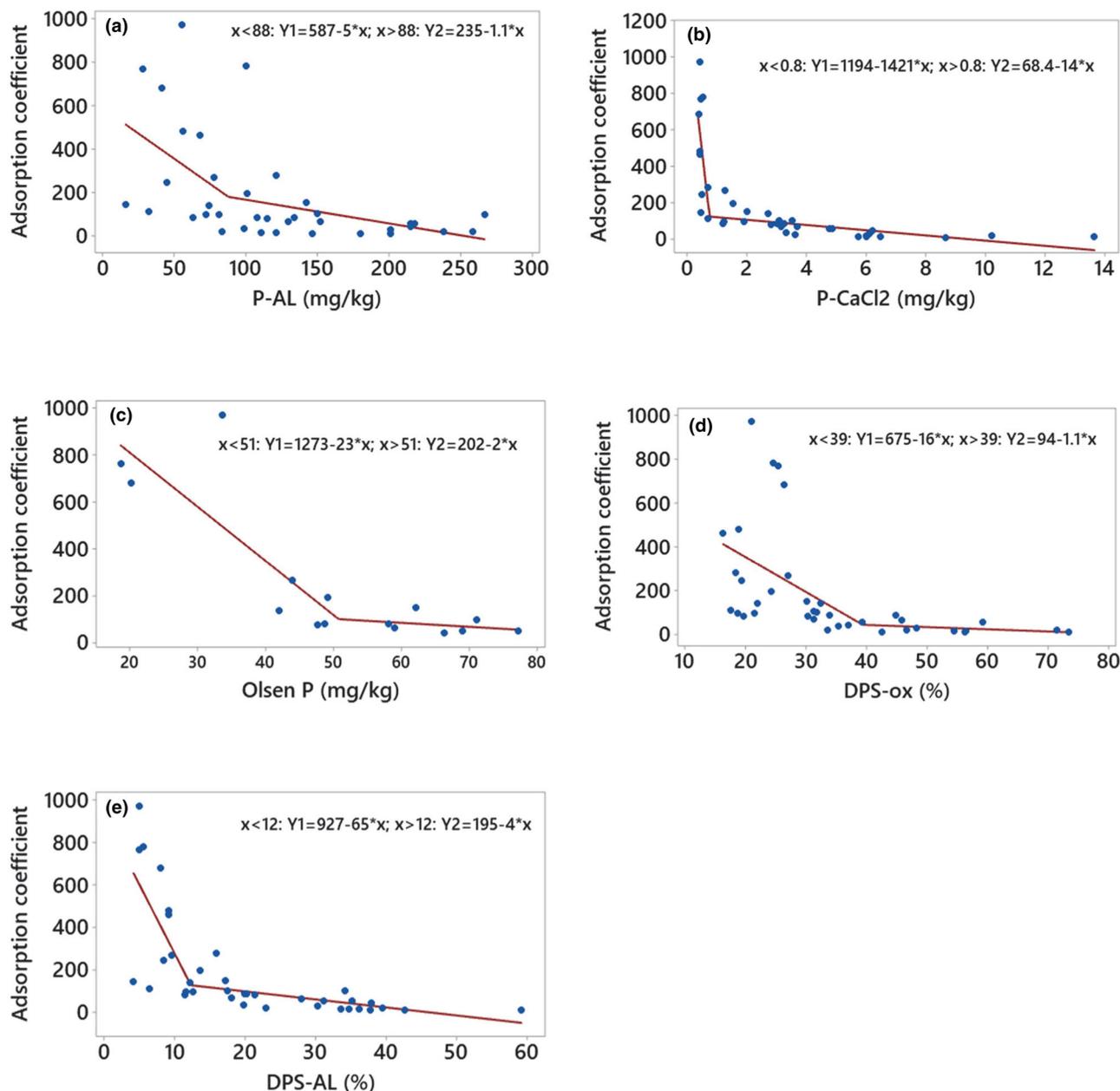
FIGURE 3 The relationships between the soil adsorption coefficient and (a) P-AL, (b) P-CaCl$_2$, (c) Olsen P, (d) DPS-ox, and (e) DPS-AL. The estimated parameters for the split-line models is given in Supplemental Table 2. DPS-AL, degree of P saturation measured in ammonium acetate lactate extracts; DPS-ox, degree of P saturation measured in ammonium oxalate extracts; P-AL, ammonium acetate lactate extractable P

CaCl$_2$ increased the solution/soil ratio up to 2,000 and revealed that increasing P-AL in soil increased P desorption and P concentration in the solution at all solution/soil ratios, confirming that P-AL reflects both the P concentration in soil solution and the P buffering capacity (Øgaard, 1995). Both factors are important for P supply to the crop. Our results also showed that the prediction of the need for P application using AL extraction could be somewhat improved by measuring Fe and Al in the extracts, in addition to P, and by using the calculated DPS-AL value in the prediction (Figure 1f).

4.2 | Soil analyses for evaluating vulnerability to dissolved P release to runoff

As CaCl$_2$-P is P released to water with a low salt concentration, this P fraction is highly relevant when evaluating the risk of release of dissolved P from soil to runoff. The close relationships between DPS-AL or DPS-ox and CaCl$_2$-P and between the soil adsorption coefficient and CaCl$_2$-P confirm that the P sorption characteristics are important for the risk of dissolved P release to runoff. Similar to the

relative yield response, the threshold values for both $CaCl_2$-P and soil adsorption coefficient were most precisely determined with DPS-AL. The threshold value for soil adsorption coefficient is the value above which added P was readily adsorbed to the soil to only a small extent, thus posing a higher risk of runoff of applied P fertilizer. The usefulness of including extracted Al and Fe when evaluating the risk of P loss to runoff from acidic soils has been shown in several studies. For example, Khiari et al. (2000) and Sims, Maguire, Leytem, Gartley, and Pautler (2002) found that DPS calculated from P, Fe, and Al extracted with Mehlich-3 solution correlated well with the risk of P loss. For AL extraction, Ulén (2006) showed a close linear relationship between dissolved P in runoff and DPS-AL in topsoil.

4.3 | Combined evaluation of required P application for crop and water quality protection

As shown above, DPS-AL was useful for determining the threshold values for relative yield response, the soil concentration of $CaCl_2$-P, and soil adsorption coefficient. Thus, use of DPS-AL will make it possible to perform a combined evaluation of required P application for optimizing both crop growth and water quality protection in fertilizer planning. That these threshold values were determined more precisely with DPS-AL than DPS-ox (Table 1) indicates that a weaker extraction of Al and Fe than that obtained by oxalate extraction better mirrors the P sorption/P release properties of the soils. The correlation between ammonium acetate lactate extractable Al and Al-ox was very good ($R^2 = .85$), but the AL-extraction only released 20% of the oxalate extractable Al. The ratio of ammonium acetate lactate extractable iron to Fe-ox was even lower (5%) and the correlation was less good ($R^2 = .48$). A higher Al/Fe ratio in the AL-extract compared with the oxalate extract may explain why DPS-AL has a closer relationship with the P sorption/P release properties of the soils. In slightly acid soils, Al (hydr)oxides are more important for P sorption than are Fe (hydr)oxides (Penn & Camberato, 2019). This is reflected in previous findings showing that the P concentration in the soil solution had a stronger negative correlation with Al than with Fe extracted by ammonium oxalate (Achat, Pousse, Nicolas, Brédoire, & Augusto, 2016; Singh, Krogstad, Shivay, Shivakumar, & Bakkegard, 2005). Therefore, using DPS-AL as an additional parameter in fertilizer planning has the potential to increase the precision in evaluating the need for P application to acid soils, in which available P is controlled by binding to Al and Fe rather than binding to Ca.

Table 1 shows that the threshold value for DPS-AL above which there is no need for P fertilizer in order to obtain optimal yields is approximately the same value as the environmentally critical threshold value of DPS-AL. This shows that when the concentration of readily releasable P in soil is sufficient to meet the P demand of crop, the risk of critically high dissolved P concentration in runoff is also present. Further, the threshold value obtained by relating DPS-AL to soil adsorption coefficient coincided with the threshold values for relative yield response and $CaCl_2$-P, and thus a higher risk of runoff of applied P fertilizer is expected above this level than at lower DPS-AL values. This confirms that P application when unnecessary for the crop results in a high risk of P loss to runoff. Further, it shows the importance of reducing P levels in soil when soil test P values are above the environmentally critical value.

5 | CONCLUSION

From an environmental point of view, the concentration of available P in soil should be below the values for negligible yield response to P application, and preferably as low as possible, while still sufficiently high for achieving optimal crop yields. Fields with available soil P at a level where P application is not needed have a high degree of P sorption saturation and therefore represent hotspots with regard to the risk of P runoff.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS
Annbjørg Øverli Kristoffersen: Conceptualization; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Visualization; Writing-original draft; Writing-review & editing. **Tore Krogstad:** Conceptualization; Methodology; Resources; Supervision; Validation; Writing-review & editing. **Anne Falk Øgaard:** Conceptualization; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Supervision; Validation; Writing-original draft; Writing-review & editing.

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SUPPORTING INFORMATION

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