

Linking Soil Acidity to P Fractions and Exchangeable Base Cations to Increased N and P Fertilization of Mono and Mixed Plantations in Northeast China

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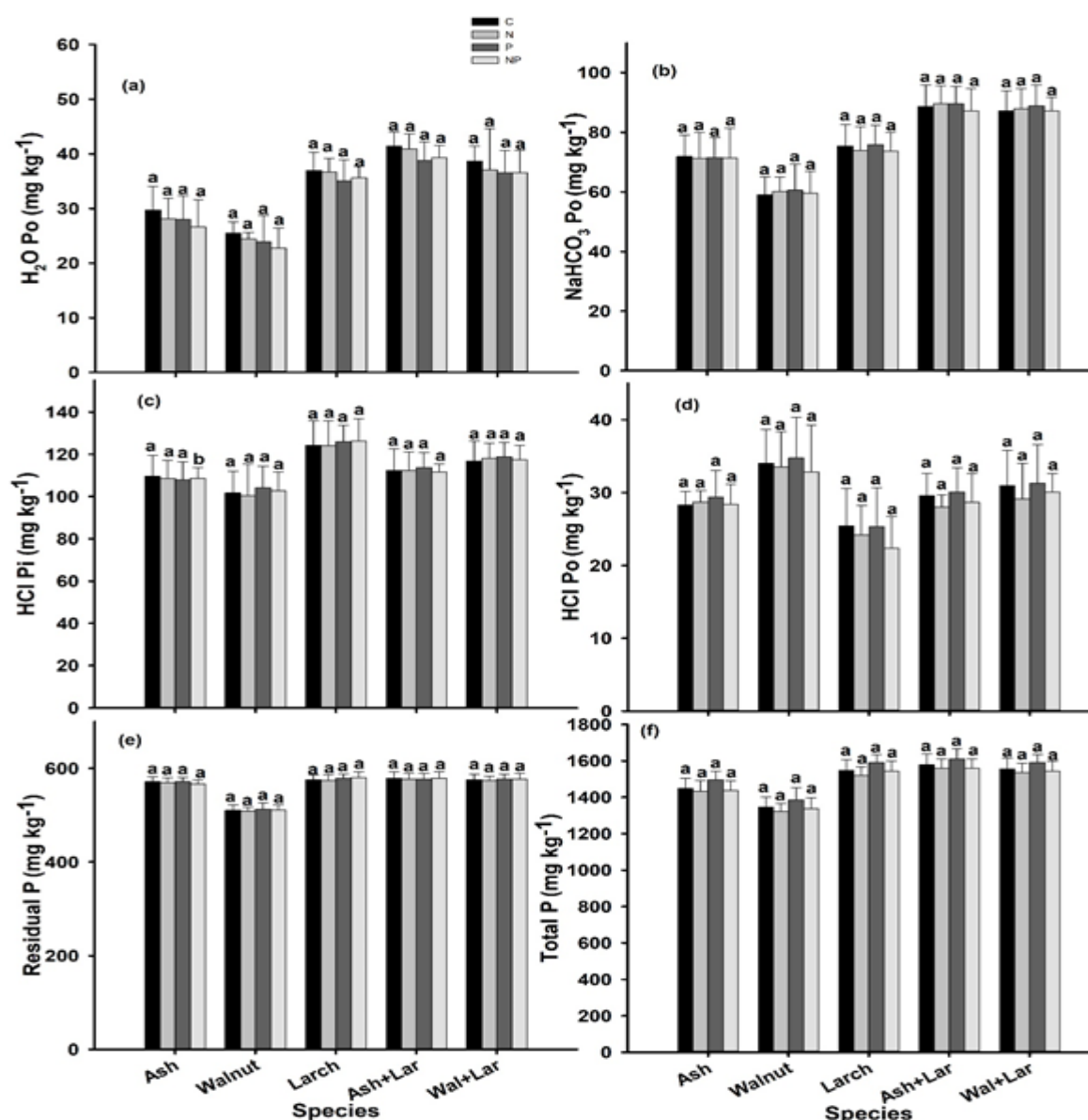
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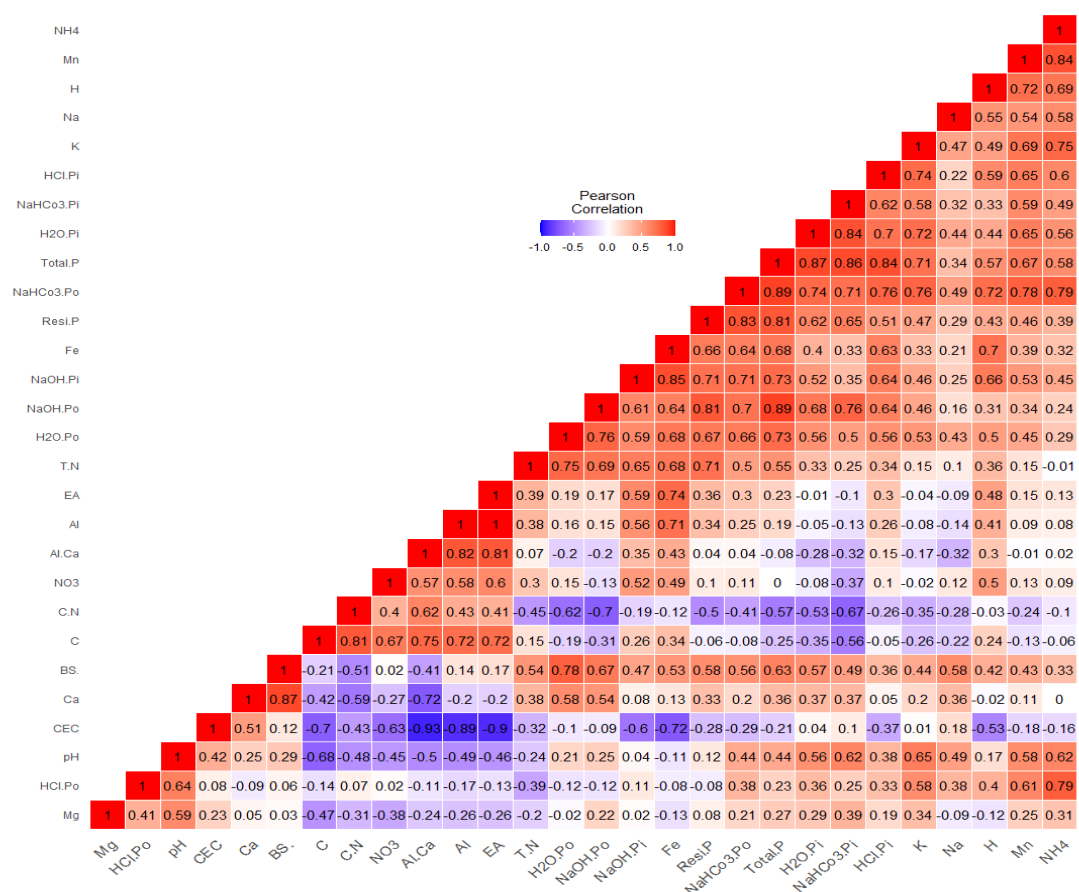
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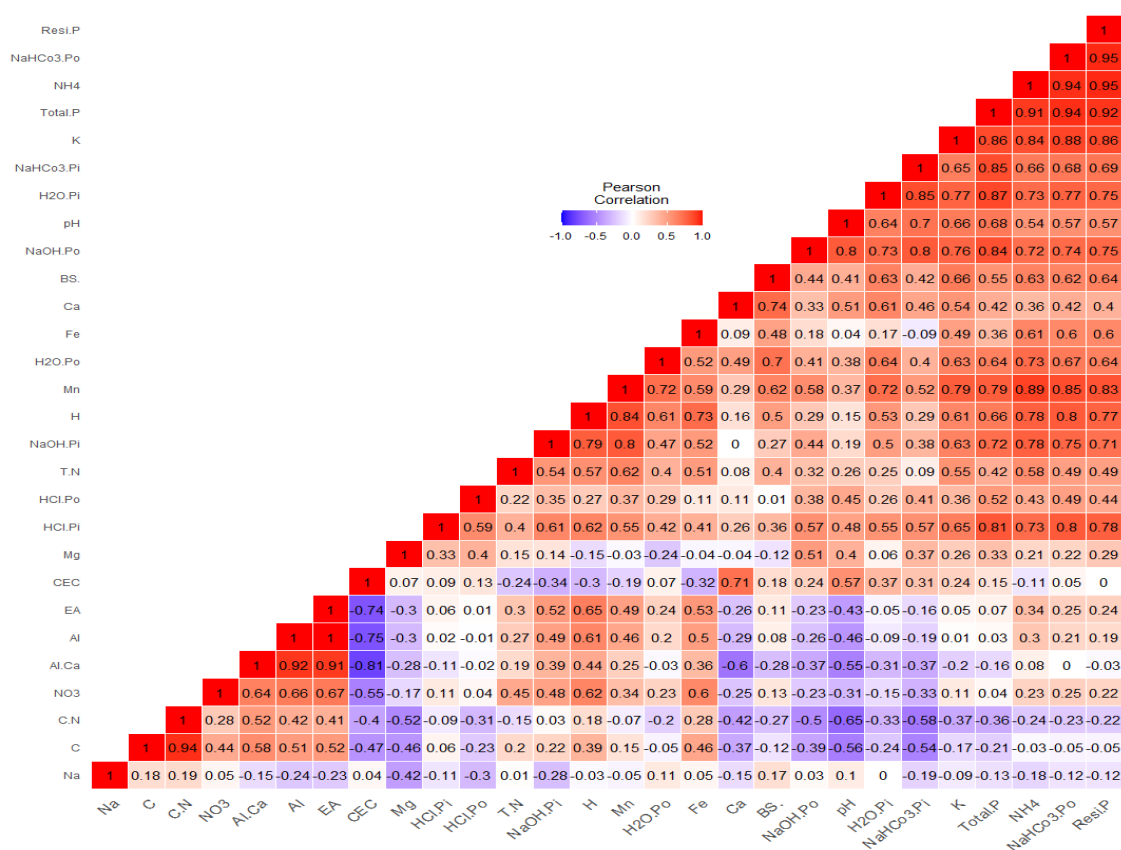
Supplementary Materials



Supplementary Figure S1. H₂O Po (mg kg⁻¹) (a), NaHCO₃ Po (mg kg⁻¹) (b) HCl Pi (mg kg⁻¹) (c) HCl Pi (mg kg⁻¹) (d) (extracted by H₂O, NaHCO₃, and HCl) and Residual P (mg kg⁻¹) (e), Total P (mg kg⁻¹) (f) at control (C; no additional deposition; black bars), and after (N; 20 g N m⁻² yr⁻¹; light grey), (P; 10 g P m⁻² yr⁻¹; dark grey), (NP; 30 g NP m⁻² yr⁻¹; off white) fertilization in Ash, Walnut, Larch, Ash Larch and Walnut Larch plantations in three replications at 0-20cm soil depth in NE China. Within species significant differences between treatments are indicated by different lower-case letters (Tukey's HSD post hoc; $P < 0.05$; mean $\pm$ SE)



Supplementary Figure S2. Heat map for Pearson's correlation coefficients of soil acidification, P fractions, and other soil chemical properties in mono cultures at three replications. The P fractions and other chemical properties were identified in each sample by colours deduced from blue to red (-1.0 to +1.0). Abbreviations: phosphorus (Pi & Po) fractions (extracted by H₂O, NaHCO₃, NaOH, and HCl), Residual P (Resi P), Hydrogen ions (H⁺), Potassium ions (K⁺), Magnesium ions (Mg²⁺), Manganese ions (Mn²⁺), Sodium ions (Na⁺), Calcium ions (Ca²⁺), Aluminium ions (Al³⁺), Iron ions (Fe³⁺), Effective cation exchange capacity (CEC), Base saturation percentage (BS%), Effective acidity (EA), Aluminium calcium ratio (Al:Ca), Ammonium (NH₄⁺-N), nitrate (NO₃⁻-N), Total nitrogen (TN), Soil organic carbon (SOC), Carbon nitrogen ratio (C:N ratio), Soil pH (pH) and Total phosphorus (T P).



Supplementary Figure S3. Heat map for Pearson's correlation coefficients of soil acidification, P fractions, and other soil chemical properties in mixed cultures at three replications. The P fractions and other chemical properties were identified in each sample by colours deduced from blue to red (-1.0 to +1.0). Abbreviations: phosphorus (Pi & Po) fractions (extracted by H₂O, NaHCO₃, NaOH, and HCl), Residual P (Resi P), Hydrogen ions (H⁺), Potassium ions (K⁺), Magnesium ions (Mg²⁺), Manganese ions (Mn²⁺), Sodium ions (Na⁺), Calcium ions (Ca²⁺), Aluminium ions (Al³⁺), Iron ions (Fe³⁺), Effective cation exchange capacity (CEC), Base saturation percentage (BS%), Effective acidity (EA), Aluminium calcium ratio (Al:Ca), Ammonium (NH₄⁺-N), nitrate (NO₃⁺-N), Total nitrogen (TN), Soil organic carbon (SOC), Carbon nitrogen ratio (C:N ratio), Soil pH (pH) and Total phosphorus (T P).

Supplementary Table S1. Two-way ANOVA results of species, fertilizations and their interactions on soil chemical properties and P fractions (three replications) of mono culture (i.e., *F. mandshurica*, *J. mandshurica* and *L. gmelinii*), and mixed culture (i.e., *F. mandshurica* + *L. gmelinii* and *J. mandshurica* + *L. gmelinii*) in three replications at four levels of fertilization (i.e., C; no fertilizer application, N; 20 g N m⁻² yr⁻¹, P; 10 g P m⁻² yr⁻¹, and NP; 30 g NP m⁻² yr⁻¹ N and P fertilizer application) in northeast China. Phosphorus (Pi & Po) fractions (extracted by H₂O, NaHCO₃ and HCl), Potassium ions (K⁺), Manganese ions (Mn²⁺), Sodium ions (Na⁺), Effective cation exchange capacity(CEC), Ammonium (NH₄⁺-N), Total nitrogen (TN) and Total phosphorus (Total P)

Source of Variance	df	H ₂ O Po (mg kg ⁻¹)	NaHCO ₃ Po (mg kg ⁻¹)	HCl Pi (mg kg ⁻¹)	HCl Po (mg kg ⁻¹)	Residual P (mg kg ⁻¹)	K ⁺ (mmol kg ⁻¹)
Species (Spp. *)	4	<0.001	<0.001	0.027	0.05	<0.001	0.96
Fertilization	3	0.772	0.990	0.954	0.908	0.986	0.431
Spp. * Fertilization	12	1.000	1.000	1.000	1.000	1.000	1.000
Source of Variance	df	Mn ²⁺ (mmol kg ⁻¹)	Na ⁺ (mmol kg ⁻¹)	CEC (mmol kg ⁻¹)	NH ₄ ⁺ -N (mg kg ⁻¹)	Total N (g kg ⁻¹)	Total P (mg kg ⁻¹)
Species (Spp. *)	4	0.228	0.933	0.024	0.828	0.001	< 0.001
Fertilization	3	0.793	0.957	0.670	0.984	0.496	0.211
Spp. * Fertilization	12	1.000	1.000	0.999	1.000	0.999	1.000

P-values in the bold indicates significant effects

Supplementary Table S2. Soil chemical properties of mono culture (i.e., *F. mandshurica*, *J. mandshurica* and *L. gmelinii*), and mixed culture (i.e., *F. mandshurica* + *L. gmelinii* and *J. mandshurica* + *L. gmelinii*) in three replications at four levels of fertilization (i.e., C; no fertilizer application, N; 20 g N m⁻² yr⁻¹, P; 10 g P m⁻² yr⁻¹, and NP; 30 g NP m⁻² yr⁻¹ N and P fertilizer application) in northeast China. Potassium ions (K⁺), Manganese ions (Mn²⁺), Sodium ions (Na⁺), Effective cation exchange capacity (CEC), Ammonium (NH₄⁺-N) and Total nitrogen (TN)

Species/ Fertilizer		K ⁺ (mmol kg ⁻¹)	Mn ²⁺ (mmol kg ⁻¹)	Na ⁺ (mmol kg ⁻¹)	CEC (mmol kg ⁻¹)	NH ₄ ⁺ -N (mg kg ⁻¹)	TN (g kg ⁻¹)
Ash	C	16.6±0.9 a	6.0±0.5 a	46.9±2.7 a	252.2±7.6 a	4.6±0.7 a	6.9±0.4 a
	N	16.4±0.6 a	6.4±0.5 a	46.7±3.1 a	250.7±8.8 a	4.4±0.7 a	7.0±0.4 a
	P	16.2±0.9 a	6.4±0.5 a	46.4±2.9 a	248.5±8.0 a	4.5±0.7 a	6.6±0.6 a
	NP	16.0±0.9 a	6.2±0.5 a	45.8±2.1 a	253.0±6.5 a	4.6±0.7 a	6.9±0.4 a
Walnut	C	16.1±0.8 a	5.9±0.5 a	46.0±2.3 a	239.5±11.4 a	4.4±0.5 a	5.9±0.4 a
	N	16.4±0.5 a	6.2±0.5 a	45.7±2.8 a	240.2±12.3 a	4.4±0.7 a	6.4±0.3 a
	P	16.0±0.9 a	6.3±0.5 a	45.5±2.4 a	240.1±13.5 a	4.3±0.9 a	5.8±0.4 a
	NP	16.1±0.5 a	6.1±0.7 a	44.9±2.5 a	246.8±13.8 a	4.4±0.7 a	6.0±0.4 a
Larch	C	16.7±0.8 a	6.3±0.3 a	45.9±2.3 a	272.9±7.5 a	4.2±0.6 a	7.6±0.2 a
	N	16.1±0.9 a	6.2±0.5 a	45.7±2.8 a	254.5±13.0 a	4.2±0.7 a	8.0±0.1 a
	P	16.4±0.8 a	6.4±0.4 a	45.4±2.2 a	263.2±7.3 a	4.0±0.7 a	7.7±0.1 a
	NP	15.7±0.8 a	6.0±0.4 a	45.1±2.9 a	264.2±8.1 a	4.2±0.6 a	7.1±0.3 a
Ash+Larch	C	16.4±0.8 a	5.8±0.4 a	45.4±2.7 a	257.1±7.6 a	4.6±0.6 a	6.8±0.4 a
	N	16.0±0.8 a	6.3±0.4 a	45.2±2.0 a	247.3±8.2 a	4.5±0.5 a	7.0±0.4 a
	P	16.3±0.8 a	6.2±0.5 a	45.0±2.9 a	250.6±5.8 a	4.5±0.6 a	6.8±0.5 a
	NP	15.9±0.8 a	6.3±0.3 a	44.5±3.1 a	253.4±6.6 a	4.5±0.7 a	6.7±0.4 a
Walnut+Larch	C	16.3±0.7 a	5.4±0.5 a	45.4±2.6 a	248.7±7.4 a	4.2±0.7 a	6.7±0.2 a
	N	16.0±0.8 a	5.8±0.6 a	44.9±2.5 a	248.9±9.6 a	4.0±0.7 a	6.9±0.4 a
	P	16.3±0.9 a	5.4±0.6 a	44.5±3.1 a	248.5±3.9 a	3.9±0.6 a	6.3±0.5 a
	NP	15.6±0.9 a	5.5±0.5 a	44.8±3.1 a	250.2±4.2 a	4.3±0.6 a	6.7±0.4 a

Note: Significant differences between per species are indicated by different lower-case letters (Tukey's HSD post hoc; P<0.005; mean±SE).



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