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Nitrous oxide emissions from pigeon pea–maize rotation in response to conservation agriculture and biochar amendments in a Ferralsol, northern Uganda

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Table S1: Soil and biochar properties. This is based on the background soil sampling (0-20 cm) taken in March 2023 for site characterisation. Soil pH was determined in a 2.5:1 water to soil suspension (Gee and Bauder, 1986). Soil C, N and δ15N were determined by Elemental Analysis-Isotope Ratio Mass Spectrometry (EA-IRMS). Plant available P, calcium (Ca), iron (Fe), potasium (K), magnesium (Mg) and zinc (Zn) were analysed using ICP-OES after extraction from soil with ammonium lactate (2 g of soil into 40 ml of P-AL) as described by Egner et al. (1960).

Parameters	Gulu	Biochar
pH	6.71	9.74
TOC (%)	1.52	50.90
N (%)	0.11	0.76
C/N	13.82	67.30
Available P (mg kg^{-1})	6	710
Ca (mg kg^{-1})	620	10133
Fe (mg kg^{-1})	56	217
K (mg kg^{-1})	210	13000
Mg (mg kg^{-1})	120	1500
Zn (mg kg^{-1})	1.1	8.53
Clay %	4	
Silt %	16	
Sand %	80	
Texture	loamy sand	

Namatsheve et al. (2025)

Table S2: Model selection and summary statistics of ANOVA for effect of treatments on hourly N_2O fluxes (μg m^2 h^{-1}). Variance and standard deviation (SD) are shown for the random effect and chi-square (χ2), degrees of freedom (df) and significance (P-value) are shown for the fixed effects

Models	AIC	BIC
mod1: N2Oflux ~ treatment × season × position + (1 | block) + (1 | chamber_ID)	4564.6	4646.3
mod2: N2Oflux ~ treatment +season + position + (1 | block) + (1 | chamber_ID)	**4558.8**	**4593.2**

Random effects	Variance	SD
Chamber ID	0	0
Block	0	0
Residual	247.48	15.732

Fixed effects	χ2	df	P-value
Treatment	11.261	3	0.010
Season	3.460	1	0.063
Position	0.855	1	0.355

$$Y_{ijk} = \beta_0 + \beta_1 \cdot \text{treatment}_{ij} + \beta_2 \cdot \text{season}_{ij} + \beta_3 \cdot \text{position}_{ij} + u_k + v_j + \epsilon_{ijk}$$

Table S3: Model selection and summary statistics of ANOVA on effect of treatments on nitrate (mg kg^{-1}). Variance and standard deviation (SD) are shown for the random effect and chi-square (χ^2), degrees of freedom (df) and significance (P-value) are shown for the fixed effects. Results are presented in Fig 2c, d.

Models	AIC	BIC
mod1: nitrate ~ treatment × season × position + (1 | block) + (1 | chamber_ID)	3188.39	3269.75
mod2: nitrate ~ treatment + season + position + (1 | block) + (1 | chamber_ID)	**3173.95**	**3212.21**

Random effects	Variance	SD
Chamber ID	0	0.000
Block	0	0.000
Residual	21.351	4.620

Fixed effects	χ2	df	P-value
Treatment	4.742	3	0.192
Season	4.833	1	0.028
Position	0.027	1	0.871

$$Y_{ijk} = \beta_0 + \beta_1 \cdot \text{treatment}_{ij} + \beta_2 \cdot \text{season}_{ij} + \beta_3 \cdot \text{position}_{ij} + u_k + v_j + \epsilon_{ijk}$$

Table S4: Model selection and summary statistics of ANOVA on treatments on ammonium (mg kg^{-1}). Variance and standard deviation (SD) are shown for the random effect and chi-square (χ^2), degrees of freedom (df) and significance (P-value) are shown for the fixed effects. Results are presented in Fig 3a.

Models	AIC	BIC
mod1: ammonium ~ treatment × season × position + (1 | block) + (1 | chamber_ID)	5142.6	5224.0
mod2: ammonium ~ treatment + season + position + (1 | block) + (1 | chamber_ID)	**5127.5**	**5161.7**

Random effects	Variance	SD
Chamber ID	0	0
Block	7.062	2.657
Residual	819.64	28.63

Fixed effects	$\chi2$	df	P-value
Treatment	9.694	3	0.021
Season	7.900	1	0.004
Position	0.916	1	0.338

$$Y_{ijk} = \beta_0 + \beta_1 \cdot \text{treatment}_{ij} + \beta_2 \cdot \text{season}_{ij} + \beta_3 \cdot \text{position}_{ij} + u_k + v_j + \epsilon_{ijk}$$

Table S5: Model selection and summary statistics of ANOVA on effect of total mineral N on N2O. Variance and standard deviation (SD) are shown for the random effect and chi-square (χ^2), degrees of freedom (df) and significance (P-value) are shown for the fixed effects. Results are presented in Fig 4.

Models	AIC	BIC
mod1: totalN~ treatment × season × position + (1 | block) + (1 | chamber_ID)	5098.5	5179.9
mod2: totalN ~ treatment + season (1 | block) + position + (1 | chamber_ID)	**5083.8**	**5118.1**

Random effects	Variance	SD
Chamber ID	0	0
Block	6.94	2.635
Residual	755.14	27.480

Fixed effects	$\chi2$	df	P-value
Treatment	8.643	3	0.034
Season	10.805	1	0.001
Position	0.942	1	0.332

$$Y_{ijk} = \beta_0 + \beta_1 \cdot \text{treatment}_{ij} + \beta_2 \cdot \text{season}_{ij} + \beta_3 \cdot \text{position}_{ij} + u_k + v_j + \epsilon_{ijk}$$

Table S6: Model selection and summary statistics of ANOVA on effect of WFPS on N_2O. Variance and standard deviation (SD) are shown for the random effect and chi-square (χ^2), degrees of freedom (df) and significance (P-value) are shown for the fixed effects. Results are presented in Fig 4.

Models	AIC	BIC
mod1: WFPS ~ treatment × season × position + (1 | block) + (1 | chamber_ID)	4764.6	4785.0
mod2: WFPS ~ treatment + season + position + (1 | block) + (1 | chamber_ID)	**4746.3**	**4846.3**

Random effects	Variance	SD
Chamber ID	0	0
Block	0.296	0.544
Residual	348.317	18.663

Fixed effects	$\chi2$	df	P-value
Treatment	3.498	3	0.321
Season	12.807	1	0.0003
Position	0.447		0.504

$$Y_{ijk} = \beta_0 + \beta_1 \cdot \text{treatment}_{ij} + \beta_2 \cdot \text{season}_{ij} + \beta_3 \cdot \text{position}_{ij} + u_k + v_j + \epsilon_{ijk}$$

Table S7: Model selection and summary statistics of ANOVA for effect of treatments on cumulative N_2O emissions (kg N_2O-N ha^{-1}). Variance and standard deviation (SD) are shown for the random effect and chi-square (χ^2), degrees of freedom (df) and significance (P-value) are shown for the fixed effects. Results are presented in Fig 3a, 3b, S3.

Models	AIC	BIC
mod1: cumN2O ~ treatment × season × position + (1 | block)	-30.766	8.093
mod2: cumN2O ~ treatment + season + position (1 | block)	**-37.688**	**-20.417**

Random effects	Variance	SD
Block	0.000	0.029
Residual	0.021	0.145

Fixed effects	$\chi2$	df	P-value
Treatment	22.320	3	<0.0001
Season	5.536	1	0.019
Position	1.541	1	0.463

$$Y_{ijk} = \beta_0 + \beta_1 \cdot \text{treatment}_{ij} + \beta_2 \cdot \text{season}_{ij} + \beta_3 \cdot \text{position}_{ij} + u_k + v_j + \epsilon_{ijk}$$

Table S8: Model selection and summary statistics of ANOVA for effect of treatments on scaled N2O emissions (kg N_2O-N ha^{-1}) for both seasons. Variance and standard deviation (SD) are shown for the random effect and chi-square (χ^2), degrees of freedom (df) and significance (P-value) are shown for the fixed effects. Results are presented in Fig 3c, S3c.

Models	AIC	BIC
mod1: cumN2Oscaled ~ treatment × season × position + (1 | block)	-135.42	-68.744
mod2: cumN2Oscaled ~ treatment + season + position + (1 | block)	**-146.38**	**-123.303**

Random effects	Variance	SD
Block	0.000	0.021
Residual	0.010	0.101

Fixed effects	$\chi2$	df	P-value
Treatment	23.901	3	<0.0001
Season	3.873	1	0.049
Position	82.402		<0.0001

$$Y_{ijk} = \beta_0 + \beta_1 \cdot \text{treatment}_{ij} + \beta_2 \cdot \text{season}_{ij} + \beta_3 \cdot \text{position}_{ij} + u_k + v_j + \epsilon_{ijk}$$

Chamber positions

Fig S1: Fig chamber position between rows and in a basin, during the first season with pigeon pea on 11 May 2023.

Fig S2: Chamber position between rows and in a basin, during the first season with pigeon pea on 14 July 2023.

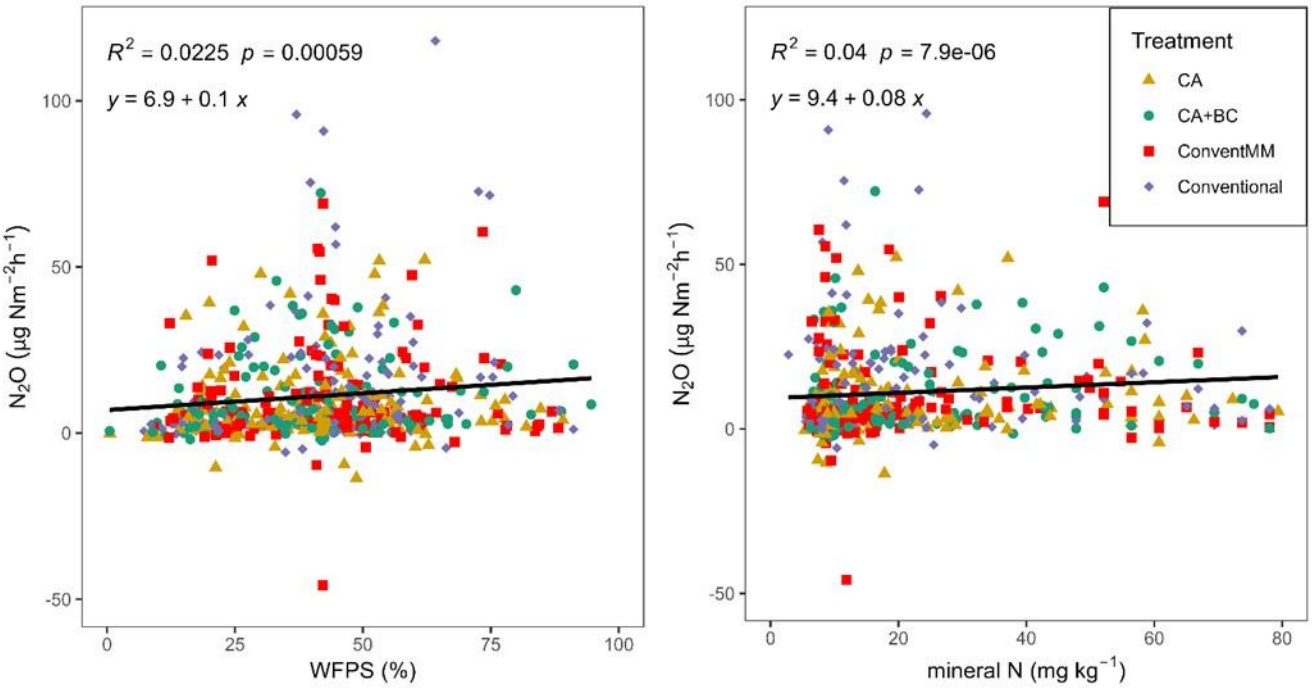

Fig S3: Relationship between hourly N_2O fluxes and water filled pore space (WFPS) and mineral N (mg kg-1) in Gulu. Data points are for 17 sampling dates.