Soil nitrous oxide (N_2O) emission from soils treated with selected ISFM practices under maize (Zea Mays L.) cropping systems

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Introduction

- Integrated Soil Fertility Management (ISFM) has been recommended to address challenges of low soil fertility by incorporating locally available organic resources (ORs) together with inorganic nitrogen (N) fertilizers.
- Despite ISFM success in field trials, there is limited information on ORs contribution to atmospheric greenhouse gas concentrations through N_2O emission.

Objective

- To determine the relationship between nitrogen losses through nitrous oxide emission and soil nitrogen changes, under different integrated soil fertility management practices in a maize-based cropping system.

Materials and methods

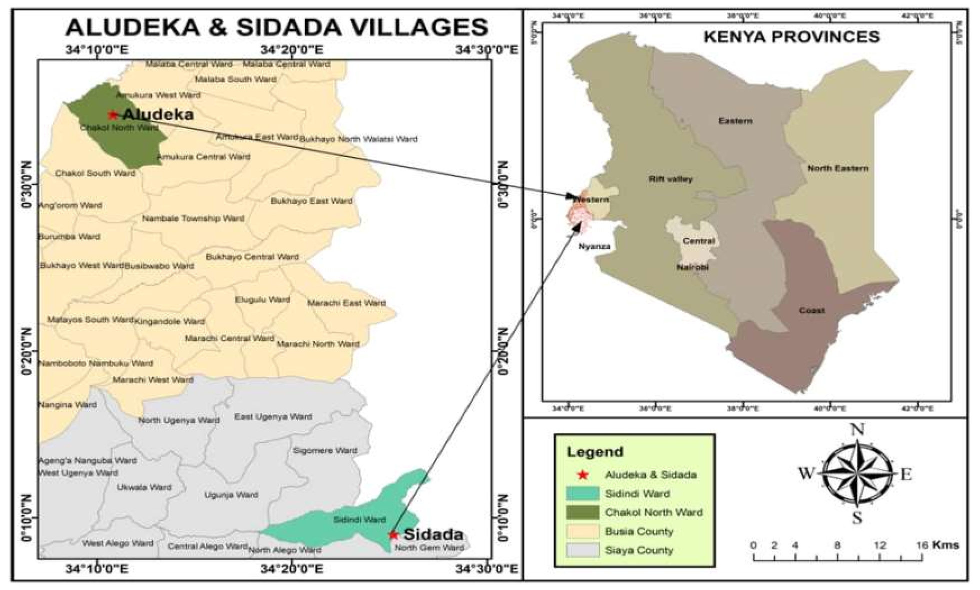

Fig. 1. Study map site, Aludeka and Sidada.

- Three OR amendments were used in this study: *Zea mays* stover, *Calliandra calothyrsus* and farmyard manure giving a total of eight treatment combinations as follows; 1. Control without inorganic N (CON –N), 2. Control with inorganic N (CON +N), 3. *Calliandra carothyrsus* without inorganic N (CL -N), 4. *Calliandra carothyrsus* with inorganic N (CL +N), 5. Farmyard manure without inorganic N (FYM -N), 6. Farmyard manure with inorganic N (FYM +N), 7. Maize stover without inorganic N (MS -N), 8. Maize stover with inorganic N (MS +N).

- Soil temporal N_2O emissions was measured using static vented chamber method collected at intervals of 0, 15, 30 and 45 minutes, between 0800 and 1300hrs.

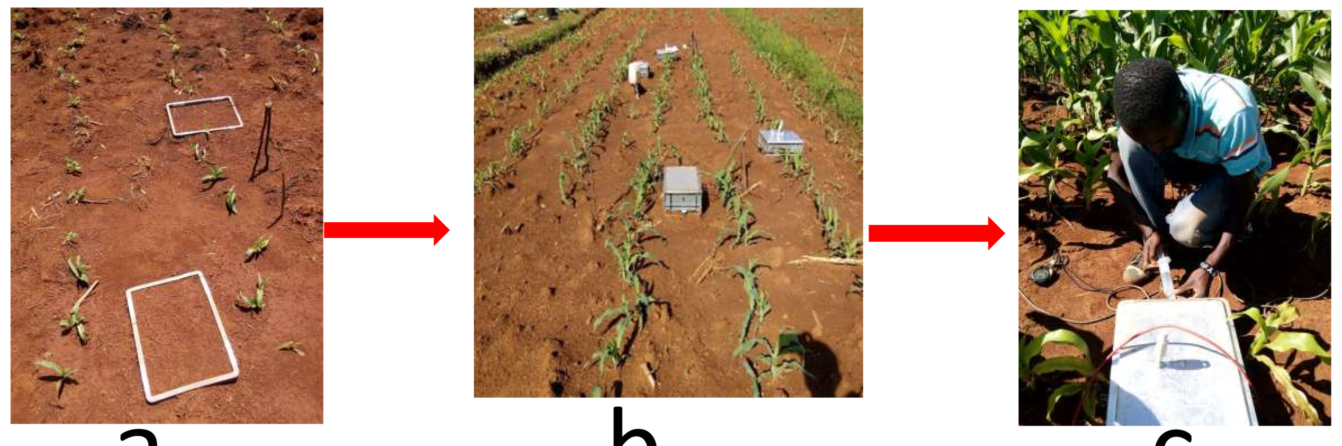

Fig. 2. Illustration of gas sampling.
a) Chamber installation b) Chamber closing c) Gas sample collection using a syringe.

Results

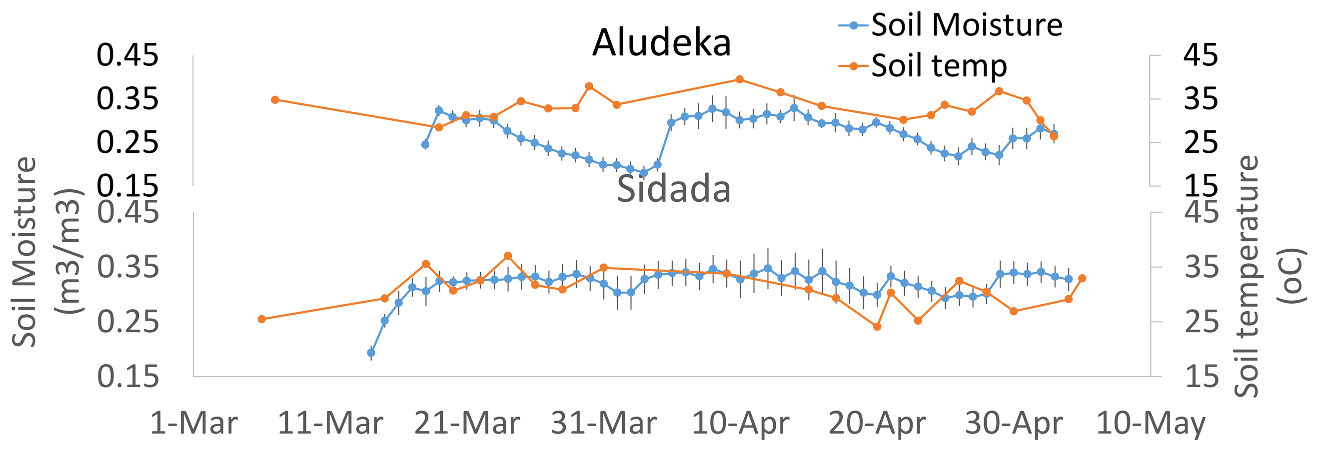

Fig. 3. Average daily soil moisture and temperature (5 cm depth) at Aludeka and Sidada sites during the study period.

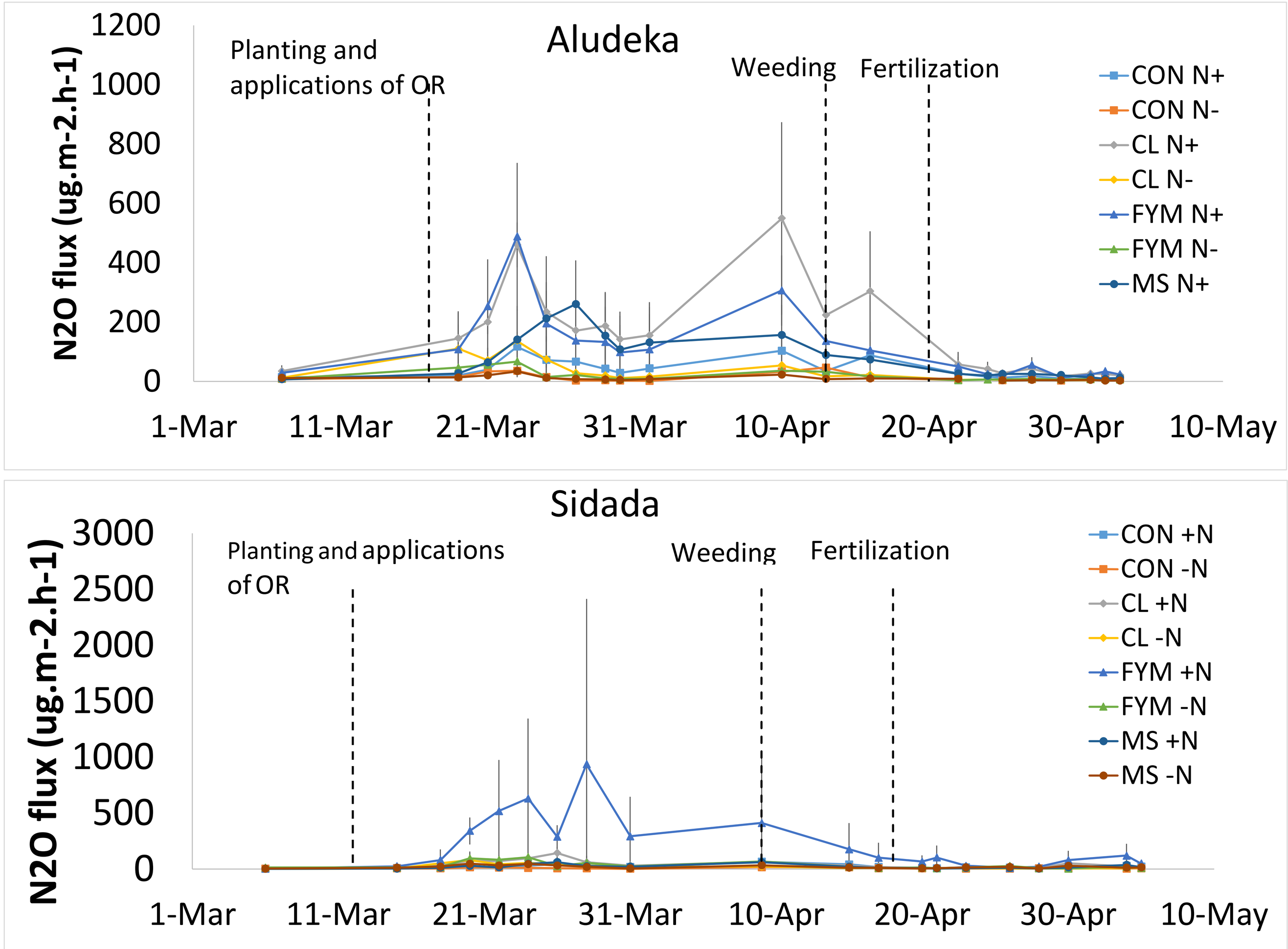

Fig. 4. Temporal soil N_2O fluxes from CON, CL, FYM and MS treatments with and without mineral N fertilizer. Error bars represent SD. Dotted vertical lines indicate different farm management activities.

Table 1. Pearson correlation coefficients of linear association between soil properties and daily N_2O emissions

	Aludeka	Sidada
Soil properties	Cumulative N_2O	Cumulative N_2O
Soil pH	-0.739*	0.023
Total C	0.760*	0.605
Total N	0.820*	0.579
Soil P	-0.684	0.072
Soil C: N	-0.710*	0.177
NH_4^+-N	0.738*	0.002
NO_3^--N	0.905**	0.711*
Soil temperature	-0.563	-0.677
Soil moisture	-0.648	0.490

Table 2. Mean and cumulative N_2O fluxes, maize yield, yield scale fluxes and total N input for studied treatments at the two sites, Aludeka and Sidada. Total N input refers to input through inorganic fertilizer and organic resources.

Site	Treatment	Total N input (Kg ha^{-1})	Mean N_2O fluxes ($ug.m^{-2}.h^{-1}$)	Cumulative N_2O fluxes (Kg N_2O-N ha^{-1})	Yield (T ha^{-1})	Yield scale fluxes (g N_2O-N kg^{-1} yield)
Aludeka	CON +N	120	39.65±38.76b	0.61±0.12a	8.28±1.70cd	0.075±0.01
	CON -N	0	11.96±11.53a	0.19±0.10a	4.06±0.23ab	0.046±0.02
	CL +N	215	153.23±170.8e	2.54±1.20c	9.47±1.44d	0.272±0.14
	CL -N	95	30.77±48.27ab	0.52±0.30a	5.19±0.73b	0.103±0.06
	FYM +N	241	117.07±143.5d	1.74±0.79c	10.63±0.23d	0.163±0.07
	FYM -N	121	18.76±20.27ab	0.30±0.10a	5.42±1.17b	0.056±0.02
	MS +N	170	74.48±96.15c	1.05±0.79ab	6.66±2.98bc	0.144±0.05
	MS -N	50	9.43±9.64a	0.16±0.02a	2.36±1.71a	0.136±0.15
	P value		0.001	0.03	0.001	0.107
	LSD		22.56	1.104	2.799	0.1514
Sidada	CON +N	120	22.04±18.71a	0.36±0.12	8.43±0.42	0.043±0.01
	CON -N	0	6.82±6.27a	0.11±0.04	5.1±1.38	0.02±0.0
	CL +N	218	38.61±42.58a	0.54±0.20	7.86±0.98	0.071±0.03
	CL -N	98	22.18±26.99a	0.28±.05	6.24±1.07	0.046±0.01
	FYM +N	237	212.32±425.1b	3.13±3.62	9.23±0.58	0.356±0.43
	FYM -N	117	30.39±39.41a	0.45±0.19	8.81±0.98	0.05±0.02
	MS +N	170	21.08±23.23a	0.33±0.04	7.47±0.95	0.045±0.0
	MS -N	50	16.58±23.44a	0.23±0.26	7.8±3.29	0.026±0.02
	P value		0.001	0.149	0.052	0.194
	LSD		52.84	2.206	2.509	0.2616

Discussion

- High emissions from treatments with inorganic N fertilizer took place for about 15 days after fertilization. This was closely linked with the rainfall events that occurred within the same period.
- High emissions were higher in the silt loam soils at Aludeka than the silty clay soils of Sidada suggesting that soil texture plays a role in N_2O emissions.
- Better quality OR (CL and FYM) with inorganic N resulted to higher cumulative N_2O emissions compared to poor quality (MS).
- Inorganic N fertilizer was the major source of N_2O emissions due to high concentration of available N.

Conclusions and Outlook

- SOC level had a greater impact on N_2O emissions, being most significant where SOC was low, implying that less N from mineralized SOC than from inorganic N fertilizer was lost as N_2O emissions.
- The cumulative emissions at Aludeka under OR treatments were in the order of CL>FYM>MS which suggest that N_2O emissions is dependent on the OR quality, producing higher emissions with lower C: N ratio.
- The effect of FYM to N_2O emissions when supplemented with inorganic N fertilizer was not consistent across the sites, meaning that its interactive effect on N_2O emissions needs to be assessed further.

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