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BRIEF REPORT

Comparing organic versus conventional soil management on soil respiration

[version 1; peer review: 2 approved]

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Abstract
Soil management has great potential to affect soil respiration. In this study, we investigated the effects of organic versus conventional soil management on soil respiration. We measured the main soil physical-chemical properties from conventional and organic managed soil in Ecuador. Soil respiration was determined using alkaline absorption according to Witkamp. Soil properties such as organic matter, nitrogen, and humidity, were comparable between conventional and organic soils in the present study, and in a further analysis there was no statically significant correlation with soil respiration. Therefore, even though organic farmers tend to apply more organic material to their fields, but this did not result in a significantly higher CO2 production in their soils in the present study.

Keywords
soil respiration, conventional soil management, organic soil management

This article is included in the Agriculture, Food and Nutrition gateway.

Open Peer Review

Approval Status ✓ ✓

	1	2
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Any reports and responses or comments on the article can be found at the end of the article.

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Author roles: Mátyás B: Conceptualization, Investigation, Methodology, Supervision, Validation, Writing – Original Draft Preparation, Writing – Review & Editing; **Chiluisa Andrade ME**: Investigation, Methodology, Writing – Original Draft Preparation; **Yandun Chida NC**: Investigation, Methodology, Writing – Original Draft Preparation; **Taipe Velasco CM**: Investigation, Methodology, Writing – Original Draft Preparation; **Gavilanes Morales DE**: Investigation, Methodology, Writing – Original Draft Preparation; **Miño Montero GN**: Project Administration, Supervision, Writing – Original Draft Preparation; **Ramirez Cando LJ**: Data Curation, Formal Analysis, Validation; **Lizano Acevedo RX**: Conceptualization, Project Administration

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Introduction

Research related to the benefits of organic management[1] has become increasingly important in sustainable agriculture. Organic soil management can contribute to meaningful socio-economic and ecologically sustainable development. Kilcher states that "Organic agriculture reduces the risk of yield failure, stabilizes returns and improves the quality of life of small farmers' families"[2]. Soil management has great potential to affect soil respiration, which is an important qualitative indicator of soil microbial activity[3]. Soil respiration is released as a result of soil organic matter decomposition. The present study aims to investigate the effects of organic versus conventional management on CO_2 production of some Northern Ecuadorian agricultural soils. Our hypothesis was that major soil respiration will be observed in soils under organic management due to the increased amount of applied organic materials.

Methods

Sampling sites

Soil samples from 23 organic farms and conventionally managed neighbouring farms were analyzed. In total, 17 sampling sites were located in organic farms, while 6 sampling sites were located in chemical fertilizer-treated areas. The sampling sites were chosen according to proximity of organic and conventionally managed farms in which the same crops are produced. Further details about each of the sampling sites can be found in Table 1. Approximately 1000 g of soil samples of 0–20 cm depth were taken. The following crops were produced in the examined areas: broccoli, potato, tomato and carrot.

Soil properties

Soil moisture content was determined gravimetrically, drying the soil at 105°C for 24 hours according to Fernández *et al.* (2008)[4]. Soil texture was measured using sodium hexametaphosphate ($(NaPO_3)_6$) according to Bouyoucos (1962)[5]. To measure the soil chemical properties, the samples were sieved through a 2mm mesh and pre-incubated at 25° for 72 hours. Soil pH in distilled water (soil/water, 1/2.5, w/w) was determined according to Karkanis (1991)[6]. In addition, we measured the electrical conductivity (EC) using a glass electrode according to Karkanis (1991)[6]. Cylinder volume was determined according to Agostini *et al.* (2014)[7]. Soil organic matter was determined according to Walkley and Black (1934)[8]. We measured the phosphorous content according to Olsen (1954)[9]. The Sand/Silt/Clay ratio was determined by Bouyoucos's method (1936)[10], while the cation exchange capacity was determined according to ISO 11260 (1994)[11] protocol.

Soil respiration

The experiment was applied at $25°C$. 0, $1M$ NaOH ($10ml$) was placed in laboratory bottles ($250ml$), a sterile gauze pad were filled with 10 g of soil sample according to Witkamp (1966)[12]. After 10 days, the amount of CO_2 was subsequently measured by standardized titration against $0.1N$ HCl using firstly phenolphthalein and then methyl orange indicator according to Witkamp (1966)[12].

The below formula was applied to calculate soil respiration:

$$m(CO_2) = VxNx22\ CO_2$$

And CO_2 production (for 10 days):

$$mg(CO_2) * 100g - 1 * 10\ day - 1 = \\ methyl\ orange\ factor * HCI - phenolphthaleinloss) * \\ NAOH\ factor * 2, 2 * Moisture\ multiplication\ factor$$

where

$$Moisture\ multiplication\ \ factor = \frac{(moisturecontent\% + 100)}{100}$$

We determined the volume of the examined soils (counting with 0 – 20 cm depth) using topsoil calculator tool (https://www.tillersturf.co.uk/topsoil-calculator). The results of soil respiration was then estimated in kg(CO_2)/ha/day.

Statistical analysis

To evaluate the behavior within results, two types of test were performed: i) Student's t-test for comparing means between conventional and organic crop systems in terms of soil respiration (kg/CO2/ha/day), organic matter (%) and nitrogen (%). Furthermore, Person's and Spearman's correlation were fixed in order to test data covariation and correlation. ii) ANOVA was used to compare conventional and organic crop system and the type of crop harvested in the sampling site.

Results

The results of soil respiration from areas of organic and conventional soil management are comparable (Dataset 1).

For soil respiration, conventional soil mean was 88.50 and organic mean was 98.64, showing and increment around 10%. However, there were no statistically significant differences between group means as determined by one-way ANOVA ($p = 0.15$), comparing conventional and organic systems. Pearson's and Kendell's tests have showed no correlation. Soil respiration correlation coefficient with organic matter was lower than 0.05 and with nitrogen content was lower than 0.12. This analysis did not consider the differences between conventional and organic systems (Figure 1).

There were statistically significant differences between group means as determined by one-way ANOVA ($p < 0.05$), comparing crop types. Furthermore, a post hoc test (Duncan) was fixed. There was only one crop (carrot) in conventional system (odds lower than 0.05) that differs drastically from the others, as pointed out in (Figure 2).

Considering soil characteristics (pH, CIC, K, and Electric conductivity), Student's t-test was applied to identify differences between conventional and organic systems. Only the characteristics

Table 1. Characteristics of the conventional and organic farms chosen for the present study. Variables are follows: areas of examined lands (*m2*), Name of crops, soil management (Organic/Conventional), Total crop production (kg), Applied fertilizer (kg), Type of fertilizers, Concentration of NPK, Concentration of NPK, Amount of NPK (Kg), GPS coordinates of the examined lands.

Farmer's code		Crop	Solid fertilizers	Area of land m2	Total crop production (Kg)	Fertilizer application rate on total crop production (Kg)	Concentration of NPK (%) in each fertilizer solid			Amount of NPK in kg			liquid fertilizer	Fertilizer application rate on total crop production (Kg)	Concentration of NPK (%) in each liquid fertilizer			Amount of NPK in Kg			GPS coordinates	
							N	K	P	N	K	P			N	K	P	N	K	P	latitude	length
OB1		Agroecological	Compost	60.38	315	95.25	0.53	0.6345	1.322	0.504825	0.60436125	1.259205	Biol	2.63975	0.2428	0.8183	0.3061	0.00640931	0.02160107	0.008080275	O804800	OOO3519
OB2		Agroecological	Bocashi	118.2	576	268.03	0.17	0.4013	0.071	0.455651	1.07560439	0.1903013	Biol	185	0.2	1.0816	0.0148	0.37	2.00096	0.02738	O809419	OOO6402
OB3		Agroecological	Compost	9	79.2	20.2	0.3	0.3891	0.1221	0.0606	0.0785982	0.0246642	biol	30	0.14	0.0075	0.467	0.042	0.00225	0.1401	O809136	OOO3476
OB4		Agroecological	Bocashi	144	600	300	0.5	0.8667	0.1271	1.5	2.6001	0.3813	Biol	211.18	0.24	0.4033	0.0958	0.506832	0.85168894	0.20231044	O804806	OOO3527
OB5	Broccoli	Agroecological	Bocashi	56	326.7	101	0.43	0.4427	0.5081	0.4343	0.447127	0.513181	Biol	150	0.2202	0.2862	0.0735	0.3303	0.4293	0.11025	O811423	OOO3176
CB1		Conventional	18460	2511.6	8316	82.21654	18	0	46	14.7989772	0	37.8196084									O805608	OOO1169
			OO60			33.33904	0	60	0	0	20.003424	0										
			Triple 15			44.4521	15	15	15	6.667815	6.667815	6.667815										
			UREA			2.1	46	0	0	0.966	0	0										
OT1		Agroecological	Gallinaza	322.766	0.0322766	1550	0.59	0.6815	0.8673	9.145	10.56325	13.44315	Biol	78.51387307	1.09	1.5659	0.5374	0.85580122	1.22944874	0.421933554		
			Compost			1550	0.89	2.5875	0.6949	13.795	40.106	1.077									0811193	0006955
OT2		Agroecological	Humus 1	202.4	0.02024	2470	1.24	2.9429	1.0828	30.628	72.68963	26.74516	Biol	2086.4584	0.26	0.3443	0.2216	5.42479184	7.18367627	4.623591814		
			Humus 2			2470	0.66	0.7458	0.5232	16.302	18.42126	12.92304										
			Bocashi			2470	0.8	1.2478	0.6486	19.76	30.821	16.02										
			Bocashi negro			2470	1.29	1.0581	0.2705	31.863	26.135	6.681									0809214	0003617
OT3		Agroecological	Compost	250.912	0.0250912	6.38	0.39	0.8731	0.2064	0.024882	0.05570378	0.001316832	Biol	11964.3692	0.220045	0.073448586	0.2859998	26.3269962	8.78766	34.218072		
	Tomato		Bocashi			6.38	0.43	0.5081	0.4427	0.027434	0.033	0.028									0811429	0003184
CT1		Conventional	Nitrogen Magnesium	847.132	0.0847132	41.32	10.7	0	0	3.79	0	0									0809021	0002732
			Ultrasol K			41.32	13	46	0	5.3716	19.0072	0										
CT2		Conventional	8-20-20	4827.69	0.482769	99.43	8	20	20	7.95	19.89	19.89										
			MAP			99.43	12	0	61	11.93	0	60.65										
			EC FERTILIZER			41.43	15.5	0	0	5.14	0	0									0805316	0001139
CT3		Conventional	Florone	1234.865	0.1234865	5.668635843	1	9.5	5	0.056686358	0.538520405	0.283431792										
			Nitrofoska foliar			40.49025602	8	24	12	3.24	9.71766145	4.8588307									0805312	0001138
OP1		Agroecological	Compost	116	408.16	1360	0.53	0.6345	1.322	7.208	8.629	17.979	Biol	1.0559	0.2428	0.8183	0.3061	0.00256373	0.00864043	0.00323211	804851	3376
OP2		Agroecological	Gallinaza	88.2	136	50	3.14	4.3752	6.0922	1.57	2.1876	3.0461										
			Cal Agrícola			9.0719	x	x	x	x	x	x	Biol	84.472	0.17	0.4013	0.071	0.1436024	0.33898614	0.0599712	809414	6481
OP3													Biol 1	12.6708	0.22	0.3619	0.013	0.02787576	0.04585563	0.001647204		
		Agroecological	Bocashi	69.9	181.4	1500	0.38	0.7695	0.4772	5.7	11.5425	7.158	Biol 2 microorga.	6.3354	0.13	0.2065	0.0065	0.00823602	0.0130826	0.000411801	808161	3438
OP4	POTATO	Agroecological	Compost	13.17	45.35	4.5359	0.91	0.4283	0.865	0.04127669	0.01942726	0.03923554	Biol	1.58385	0.18	0.224	0.0387	0.00285093	0.00354782	0.00061295	808225	3496
CP1		Conventional	Harvest waste	10 000	13610	3000			x	x	x	x										
			103010			750	10	10	30	75	75	225										
			18460			250	18	46	0	45	115	0										
			Stimufolk			4	11	38	5	2.2	7.6	1										
			Agricare			4	19	19	19	9.5	9.5	9.5									810311	5670

Farmer's code		Crop	Solid fertilizers	Area of land m2	Total crop production (Kg)	Fertilizer application rate on total crop production (Kg)	Concentration of NPK (%) in each fertilizer solid			Amount of NPK in kg			liquid fertilizer	Fertilizer application rate on total crop production (Kg)	Concentration of NPK (%) in each liquid fertilizer			Amount of NPK in Kg			GPS coordinates	
							N	K	P	N	K	P			N	K	P	N	K	P	latitude	length
OC1	Carrot	Agroecological	Compost	92.97	2045	146.66	0.53	0.6345	1.322	0.777298	0.9305577	1.9388452	Biol	4.06	0.2428	0.8183	0.3061	0.00985768	0.03322298	0.01242766	17N 0804805	0003544
OC2		Agroecological		15.645	156		0	0	0	0	0	0	Biol	2	0.23	0.007	0.0181	0.0046	0.00014	0.000362	17 N0811449	0003795
OC3		Agroecological	Bocashi	9	72	1.35	0.38	0.7695	0.4772	0.00513	0.01038825	0.0064422	Biol (1)	1.64	0.22	0.3619	0.013	0.003608	0.00593516	0.0002132	17 N 0808284	0003066
													Biol (2)	0.82	0.13	0.2065	0.0065	0.001066	0.0016933	0.0000533		
OC4		Agroecological	Bocashi	11.2	246	23.3	0.5	0.8667	0.1271	0.1165	0.2019411	0.0296143	Biol	16.425	0.24	0.4033	0.0958	0.03942	0.06624203	0.01573515	17 N 0804808	0003504
OC5		Agroecological	Compost	60	1500	134.6	0.3	0.3891	0.1221	0.4038	0.5237286	0.1643466	biol	200	0.14	0.0075	0.467	0.28	0.015	0.934	17 N O809136	0003548
CC1		Conventional		176.56	108								Biofertilizante (lombriz)	60	0.32	0.3963	0.4595	0.192	0.00126816	0.001820999	17 N 0805383	0001613
			Nitrato de Calcio			0.13	15	0	0	0.0195	0	0										
			Fosfato Monoamonico			0.07	11	0	52.5	0.00733333	0	0.035										
			Nitrato de Potasio			0.07	13		44	0.00866667	0	0.02933333										

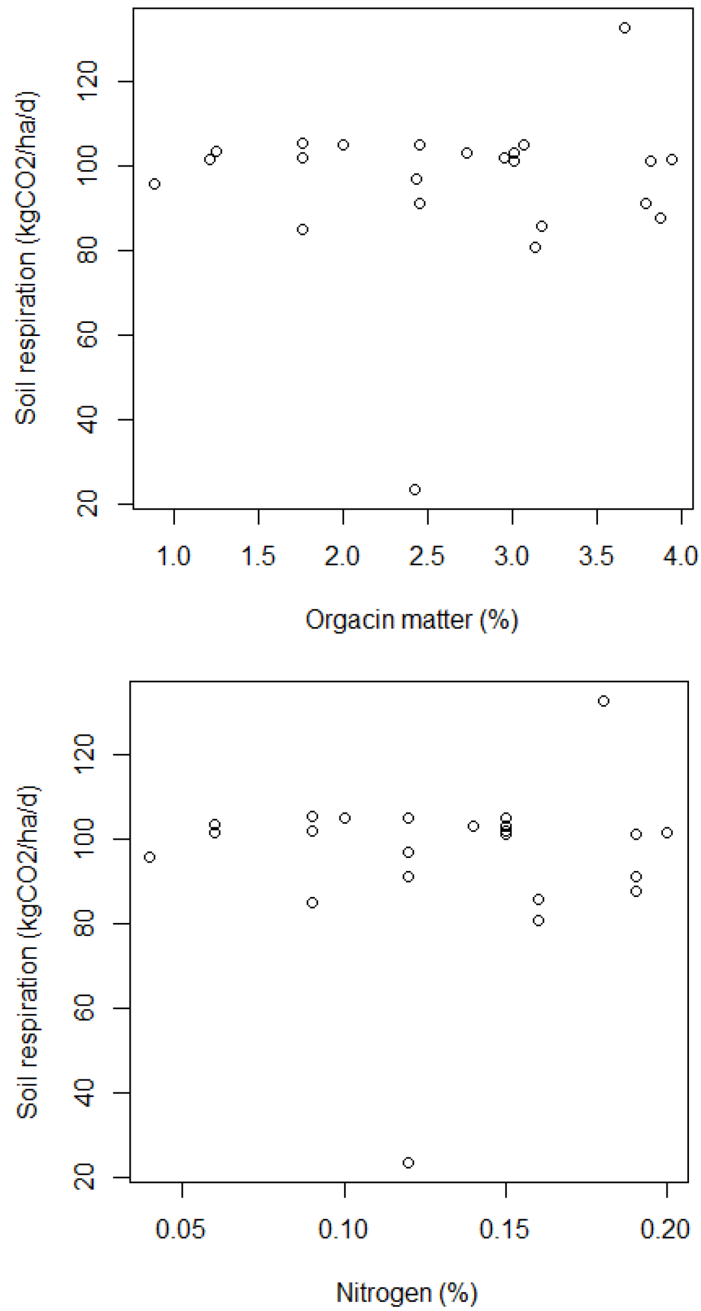

Figure 1. **Soil respiration compared with organic matter and nitrogen in soil.**

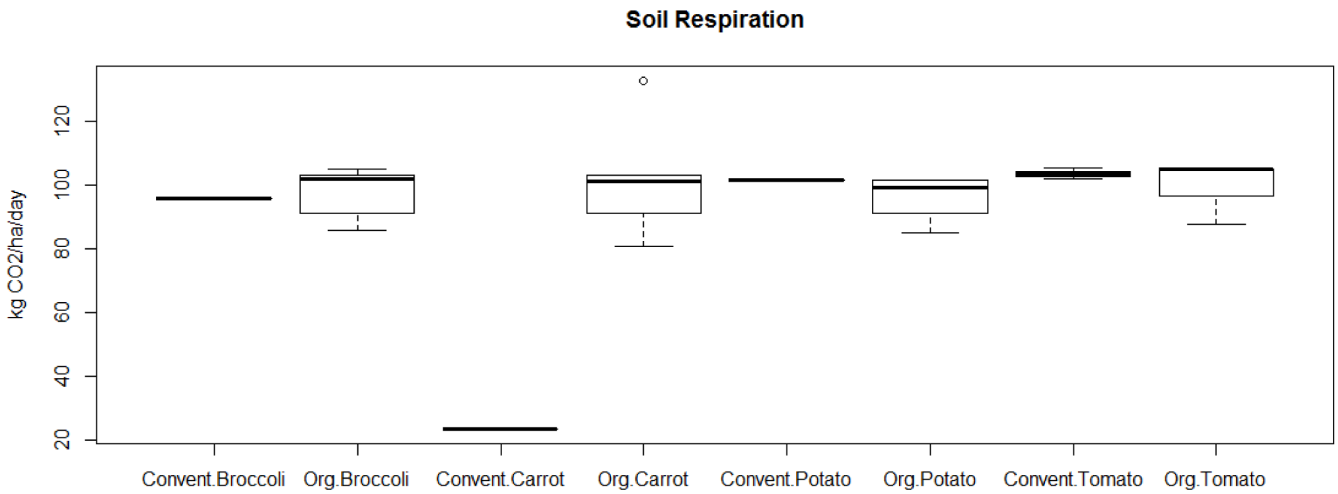

Figure 2. Boxplots showing alterations within crop systems and crop harvested in the zone.

from carrot crop systems (conventional or organic) have shown differences in terms of means ($p < 0.05$). Furthermore, the mean of conventional crop system was lower in every characteristic evaluated. Besides, these results were in congruence with Figure 2, leading us to believe that the cropping system has no influence on soil respiration, which is in contrast to the influence that soil characteristics have over soil respiration in this study.

Dataset 1. Raw data for various parameters calculated in conventional and organic managed soils

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Parameters as follows: pH, Organic material (percentage), Total Nitrogen (percentage), Match (mg/kg), Potassium (cmol/kg), Electrical conductivity (dS/m), CIC (cmol/kg), Soil moisture content (percentage), Sand (percentage), Silt-limo (percentage), Clay (percentage), Texture (class), Soil respiration (kg/CO2/ha/day).

Conclusions

Organic farmers tend to apply more organic material to their fields, but this did not result in a significantly higher CO_2 production in their soils. The difference between organic and conventional soils (10% in mean) is not enough to conclude that the soil respiration under these two systems was different, considering the analysis of their variance.

Soil properties like organic matter, nitrogen, and humidity, were comparable between conventional and organic soils in the present study, and in a further analysis there was no statically significant correlation with soil respiration. However, biological significance should be investigated in a posteriori research including microbial community profile of the soil and specific interactions in highlands (over 2500 m.a.s.l.).

Ethics

Oral consent was obtained from the farmers for the collection of soil samples from their land. Their only request was to inform them about the results of the soil characteristics, that we have already done personally on 9 November, 2017.

Data availability

Dataset 1: Raw data for various parameters calculated in conventional and organic managed soils. Parameters as follows: pH, Organic material (percentage), Total Nitrogen (percentage), Match (mg/kg), Potassium (cmol/kg), Electrical conductivity (dS/m), CIC (cmol/kg), Soil moisture content (percentage), Sand (percentage), Silt-limo (percentage), Clay (percentage), Texture (class), Soil respiration (kg/CO2/ha/day). DOI, 10.5256/f1000research.13852.d195529[13]

Competing interests

No competing interests were disclosed.

Grant information

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Data Source

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Version 1

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The submitted manuscript by Bence et al. is good work which is suitable for publication in F1000 research. Authors have compared the organic practices and conventional practices, and compared their effects on soil respiration which is very important aspect. Standard methodologies were followed which ensures reproducibility of the results. The findings were subjected to the statistical analysis and conclusion drawn nicely.

However, I have below suggestions for improvement which may be considered as minor revisions:
- "Physical-chemical" could be replaced by "Physico-chemical" throughout the manuscript.
- In abstract, word "statically" should be replaced by "statistically"
- In result, "showing and increment around 10%." should be "showing an increment around 10%."
- The discussion could be added more so that the findings of the study will become stronger.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 15 March 2018

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Anita Jakab
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This article worked at the differences between organic and conventional soil management. This research examined an important and topical issue especially the soil respiration under changing plant and soil conditions.

Introduction and methods
The research investigated 23 soil samples in Ecuador. The samples were located from organic (17 samples) and conventionally managed neighboring farms (6 samples). In the research trials broccoli, potato, tomato and carrot were applied as test plant. Soil properties were measured after 1000 g soil samples of 0-20 cm depths of soil were taken in every picked area. The soil moisture, texture, pH, electrical conductivity, cylinder volume, organic matter, phosphorus content, sand/silt/clay ratio and cation exchange capacity, and the soil respiration were analyzed in laboratory.
The values of the soil parameters are presented in a dataset, which inform about the important soil parameters especially the calculated soil respiration in kg (CO_2)/ha/day). The protocols (description of the tests) are clear and traceable, especially the formula to calculate soil respiration.
The study describes the applied type of fertilizers especially the concentration of NPK fertilizers.

Comment on the Methods
- The sampling time and vegetation status are important for the evaluation, this information is missing in the study. If it's possible, describe the followings: When the soil sampling happened? What was the state of the vegetation of test plants?
- A bit more detail of the soil properties inform us about the actual soil status. The studied soils are classified as sandy textured soil, according to the soil classification (Franco Arenoso). The most typical parameters of the samples are the following: high sandy texture, neutral pH, good/very good organic matter-nitrogen and phosphorus content, 10-20% moisture content. I suggest describing it in the Methods.

Results
The results of the study are described with sufficient statistical analysis. It also describes the statistically significant/not significant results. There were solely statistically significant differences between crop types (for soil respiration by one-way ANOVA correlation test).
- The Figure 1 contains a typographical error (Orgacin matter instead of Organic matter).
- It may be more informative, if you use a line diagram instead of dot diagrams in the first figure.
- The Figure 2 include the soil respiration values in kg CO_2/ha /day, which would be more clear with the average values.

Conclusion
The results have briefly evaluated and conclusions straightforward formulated. I quite agree with observations of the study that emphasizes the importance of further microbiological studies.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Agricultural environmental management, soil management, agricultural soil science

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.