



## 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 CO<sub>2</sub> production in their soils in the present study.

## Keywords

soil respiration, conventional soil management, organic soil management

## 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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## Introduction

Research related to the benefits of organic management<sup>1</sup> 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”<sup>2</sup>. Soil management has great potential to affect soil respiration, which is an important qualitative indicator of soil microbial activity<sup>3</sup>. 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)<sup>4</sup>. Soil texture was measured using sodium hexametaphosphate ( $(NaPO_3)_6$ ) according to Bouyoucos (1962)<sup>5</sup>. 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)<sup>6</sup>. In addition, we measured the electrical conductivity (EC) using a glass electrode according to Karkanis (1991)<sup>6</sup>. Cylinder volume was determined according to Agostini *et al.* (2014)<sup>7</sup>. Soil organic matter was determined according to Walkley and Black (1934)<sup>8</sup>. We measured the phosphorous content according to Olsen (1954)<sup>9</sup>. The Sand/Silt/Clay ratio was determined by Bouyoucos’s method (1936)<sup>10</sup>, while the cation exchange capacity was determined according to ISO 11260 (1994)<sup>11</sup> 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)<sup>12</sup>. 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)<sup>12</sup>.

The below formula was applied to calculate soil respiration:

$$m(CO_2) = V \times N \times 22 \text{ } CO_2$$

And  $CO_2$  production (for 10 days):

$$mg(CO_2) * 100g - 1 * 10 \text{ day} - 1 = \\ \text{methyl orange factor} * HCl - \text{phenolphthalein loss} * \\ NAOH \text{ factor} * 2, 2 * \text{Moisture multiplication factor}$$

where

$$\text{Moisture multiplication factor} = \frac{(\text{moisture content} \% + 100)}{100}$$

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 ( $kg/CO_2/ha/day$ ), 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 an 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 Kendall’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).

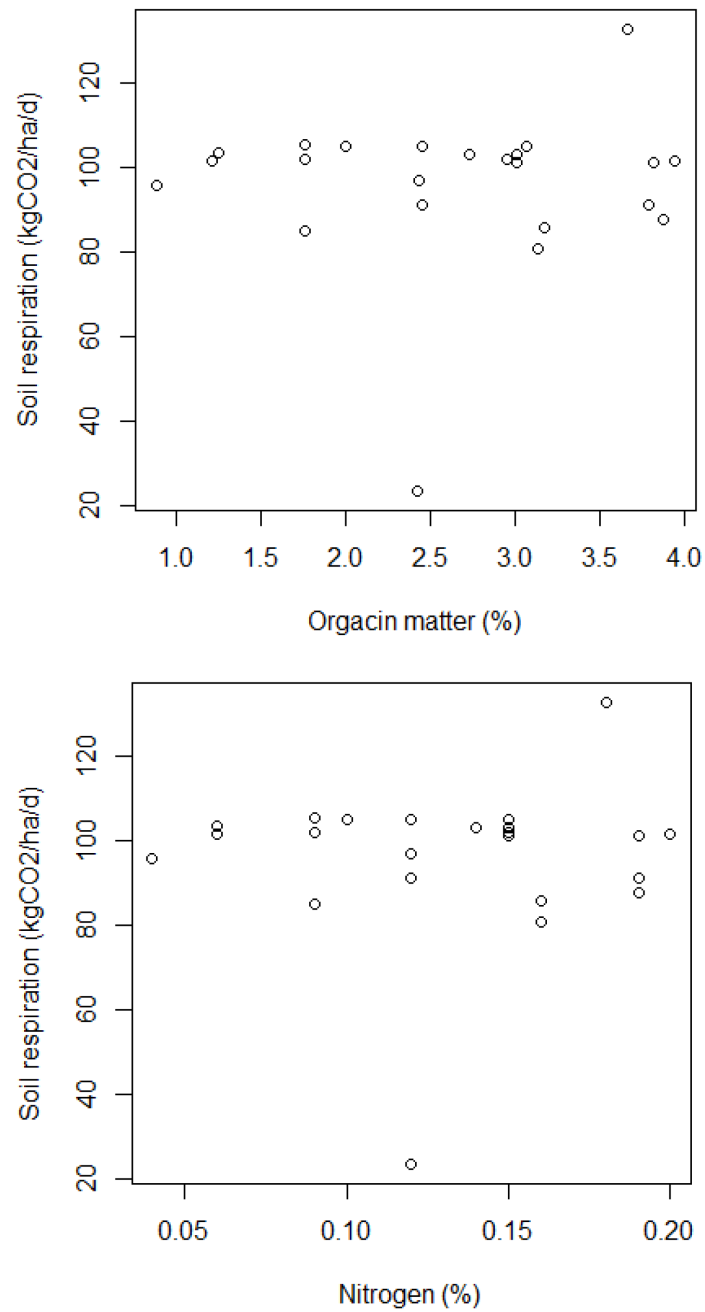
There were statistically significant differences between group means as determined by one-way ANOVA ( $p < 0.05$ ), comparing crop types. Furthermore, a post hoc test (Duncan) was fixed. There was only one crop (carrot) in conventional system (odds lower than 0.05) that differs drastically from the others,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

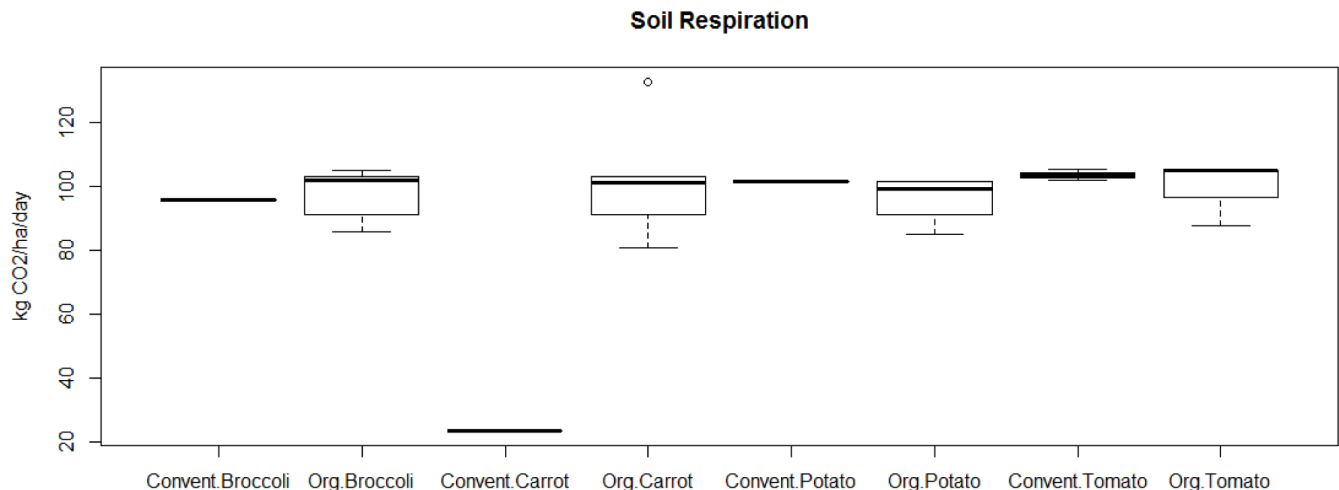
**Table 1. Characteristics of the conventional and organic farms chosen for the present study.** Variables are follows: areas of examined lands (*m*2), Name of crops, soil management (Organic/Conventional), Total crop production (kg), Applied fertilizer (kg), Type of fertilizers, Concentration of NPK, 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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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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	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.006080275	0.0060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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	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	0.0085768	0.03222298	0.01242766	17°N 08°04'05"	0003544	
OC2	Agroecological		15.645	156		0	0	0	0	0	0	Biol	2	0.23	0.007	0.0181	0.0046	0.00014	0.000382	17°N 08'11.49"	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 08°08'28"	0003066	
												Biol (2)	0.82	0.13	0.2065	0.0065	0.001066	0.0016933	0.0005533			
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 08°04'08"	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	0.001820999	17°N 08°09'136"	0003548
OC1	Conventional	Nitrato de Calcio			0.13	15	0	0	0.0195	0	0	0									17°N 08°05'383"	0001613
		Fosfato Monocamónico			0.07	11	0	52.5	0.00733333	0	0.035											
		Nitrato de Potasio			0.07	13	44	0.0066667	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**

<http://dx.doi.org/10.5256/f1000research.13852.d195529>

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/CO<sub>2</sub>/ha/day).

## Conclusions

Organic farmers tend to apply more organic material to their fields, but this did not result in a significantly higher CO<sub>2</sub> 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/CO<sub>2</sub>/ha/day). DOI, [10.5256/f1000research.13852.d195529](https://doi.org/10.5256/f1000research.13852.d195529)<sup>13</sup>

## Competing interests

No competing interests were disclosed.

## Grant information

The author(s) declared that no grants were involved in supporting this work.

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## Version 1

Reviewer Report 19 March 2018

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### Ankit Singla

Department of Industrial Microbiology, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

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<sub>2</sub>)/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<sub>2</sub>/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.**

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