Comparing organic versus conventional soil management on soil respiration [version 1; referees: 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.
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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 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”. Soil management has great potential to affect soil respiration, which is an important qualitative indicator of soil microbial activity. 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 CO₂ 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). Soil texture was measured using sodium hexametaphosphate ((NaPO₄)₆) according to Bouyoucos (1962). To measure the soil chemical properties, the samples were sieved through a 2mm mesh and pre-incubated at 25°C for 72 hours. Soil pH in distilled water (soil/water, 1/2.5, w/w) was determined according to Karkanis (1991). In addition, we measured the electrical conductivity (EC) using a glass electrode according to Karkanis (1991). Cylinder volume was determined according to Agostini et al. (2014). Soil organic matter was determined according to Walkley and Black (1934). We measured the phosphorous content according to Olsen (1954). The Sand/Silt/Clay ratio was determined by Bouyoucos’s method (1936), while the cation exchange capacity was determined according to ISO 11260 (1994) protocol.

Soil respiration
The experiment was applied at 25°C. 0, 1M NaOH (10ml) was placed in laboratory bottles (250ml), a sterile gauze pad was filled with 10 g of soil sample according to Witkamp (1966). After 10 days, the amount of CO₂ was subsequently measured by standardized titration against 0.1N HCl using firstly phenolphthalein and then methyl orange indicator according to Witkamp (1966). The below formula was applied to calculate soil respiration:

\[ m(CO_2) = V_x N_x 22 \, CO_2 \]

And CO₂ production (for 10 days):

\[ mg(CO_2) \times 100 \text{g} - 1 \times 10 \text{day} - 1 = \]

methyl orange factor * HCl - phenolphthaleinloss) * NAOH factor * 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(CO₂)/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 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...
| Farmer's code | Crop | Soli fertilizer | 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 | Fertilizer application rate on total crop production (Kg) | Concentration of NPK (%) in each liquid fertilizer | Amount of NPK In Kg | GPS coordinates |
|--------------|------|-----------------|-----------------|---------------------------|--------------------------------------------------------|---------------------------------|------------------|--------------------------------------------------------|---------------------------------|------------------|----------------|
| OB1          | Agroecological Compost | 60.39 | 315 | 95.25 | 0.53 | 0.6345 | 1.322 | 0.524635 | 0.4036172 | 1.253905 | Biol 2.69375 | 0.24689 | 0.819309 | 0.3041 | 0.00450391 | 0.02169197 | 0.000918275 | 0.019408 | 0.0019519 |
| OB2          | Agroecological Boc ash | 118.3 | 576 | 269.03 | 0.17 | 0.4013 | 0.071 | 0.455601 | 1.0754039 | 0.1933013 | Biol 1.95 | 0.2 | 1.0194 | 0.0146 | 0.37 | 2.00296 | 0.02739 | 0.0034819 | 0.0034812 |
| OB3          | Agroecological Compost | 9 | 79.2 | 20.2 | 0.3 | 0.0699 | 0.123 | 0.0069 | 0.0716909 | 0.0346942 | Biol 30 | 0.14 | 0.0075 | 0.467 | 0.042 | 0.00235 | 0.1401 | 0.0399 | 0.03476 |
| OB4          | Agroecological Boc ash | 14.4 | 600 | 3.00 | 0.5 | 0.0667 | 0.127 | 1.5 | 2.4021 | 0.3693 | Biol 21.19 | 0.24 | 0.4033 | 0.39985 | 0.500602 | 0.816689 | 0.20231044 | 0.019066 | 0.03922 |
| OB5          | Boc ash | 15.6 | 326.7 | 1.01 | 0.4 | 0.447 | 0.0381 | 0.4434 | 0.44727 | 0.513189 | Biol 1.152 | 0.2922 | 0.5682 | 0.0735 | 0.3933 | 0.4293 | 0.1125 | 0.811423 | 0.0013176 |
| OB6          | Agroecological Compost | 25.11 | 6.376 | 82.21654 | 18 | 0 | 46 | 14.736772 | 0 | 37.6196894 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OT1          | Agroecological Gallina | 320.76 | 995.9 | 47.02 | 0.0163 | 0.06815 | 0.0873 | 9.146 | 0.156325 | 1.344.3915 | Biol 78.61387307 | 1.09 | 1.5699 | 0.5374 | 0.86560022 | 1.2944874 | 0.420930654 | 0.011193 | 0.003665 |
| CT1          | Conventional | 644.73 | 1.09732 | 33.30034 | 0 | 0 | 0 | 0 | 0.023424 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CT2          | Conventional | 472.49 | 0.98269 | 44.4521 | 15 | 15 | 15 | 6.607615 | 6.607615 | 6.607615 | UREA 2.1 | 40 | 0 | 0.906 | 0 | 0 | 0 | 0 |
| CT3          | Conventional | 250.31 | 0.0230132 | 6.39 | 0.39 | 0.673 | 0.2304 | 0.234893 | 0.23570328 | 0.001376823 | Biol 1.1168462 | 0.2234043 | 0.0734408581 | 0.8166998632 | 26.3266362 | 8.766765 | 34.2186573 | 0.011429 | 0.003194 |
| CT4          | Conventional | 934.93 | 0.09732 | 5.668.639843 | 1 | 9.5 | 5 | 0.006696399 | 0.036620405 | 0.026317922 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OP1          | Agroecological Compost | 114 | 408.16 | 13.60 | 0.53 | 0.0345 | 1.322 | 7.2089 | 8.6239 | 17.979 | Biol 1.0559 | 0.24689 | 0.819309 | 0.3041 | 0.00256373 | 0.02389453 | 0.003232171 | 0.0084511 | 0.003376 |
| OP2          | Agroecological Gallina | 68.2 | 136 | 9.0719 | x | x | x | x | x | x | x | x | x | x | 50 | 3.14 | 4.75.2 | 6.0832 | 1.57 | 2.1676 | 3.0461 | Biol 84.472 | 0.17 | 0.4031 | 0.071 | 0.1406034 | 0.33996014 | 0.009712 | 0.038441 | 0.0481 |
| OP3          | Agroecological Boc ash | 69.9 | 181.4 | 15.00 | 0.36 | 0.7695 | 0.4772 | 5.7 | 11.5425 | 7.158 | Biol 2 | 6.39541 | 0.13 | 0.206 | 0.0065 | 0.00326023 | 0.01308026 | 0.000411801 | 0.008061 | 0.003493 |
| OP4          | Agroecological Compost | 131.7 | 45.35 | 4.5599 | 0.91 | 0.4038 | 0.885 | 0.01427999 | 0.017942726 | 0.03082054 | Biol 1.580895 | 0.18 | 0.224 | 0.0387 | 0.00850903 | 0.022547602 | 0.005612595 | 0.0086235 | 0.0496 |
| OP5          | Agroecological Harvest waste | 30.00 | x | x | x | x | x | x | x | x | 30.10 | 10 | 10 | 30 | 75 | 75 | 225 | 7.5 | 18400 | 250 | 18 | 46 | 0 | 45 | 115 | 0 | 4 | 11 | 38 | 5 | 2.2 | 7.6 | 1 | 4 |
| CP1          | Agroecological Agricere | 10.00 | 13610 | 4 | 19 | 19 | 9 | 95 | 9.5 | 95 | Biol 103.12 | 9.67 | 0.567 |

Table 1. Characteristics of the conventional and Agroecological 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) | 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 |
|---------------|------|------------------|------------------|---------------------------|---------------------------------------------|-------------------|-----------------|---------------------------------------------|---------------------------------------------|------------------|-----------------|
| OC1           | Agroecological | Compost         | 92.97            | 20.45                     | 146.66                                     | 0.53              | 0.6345          | 1.322                                      | 0.777389                     | 0.9330577       | 1.93818462       | N | K | P | N | K | P | 2.42 69     | 0.6183 | 0.3061 | 0.039679 | 0.33323238 | 0.01242756 | 171408344825 | 00035444 |
| OC2           | Agroecological |                | 15.645           | 1.56                       | 0                                           | 0                 | 0               | 0                                          | 0                                          | 0                | 0               | N | K | P | N | K | P | 0.02 93     | 0.0071 | 0.0081 | 0.00014   | 0.000262  | 00037956 |
| OC3           | Agroecological | Bocashi         | 9                | 72                        | 1.35                                        | 0.39              | 0.7665          | 0.4772                                    | 0.003513                     | 0.01630623      | 0.0064427        | N | K | P | N | K | P | 0.22       | 0.3619 | 0.013   | 0.003409 | 0.00039516 | 0.0002132 | 171408306214 | 00030606 |
| OC4           | Agroecological | Bocashi         | 1.2              | 2.46                      | 0.5                                         | 0.8667           | 0.1271          | 0.5165                                    | 0.2019411                     | 0.02065743      | 0.01642766       | N | K | P | N | K | P | 0.13       | 0.3565 | 0.005   | 0.001066 | 0.00206423 | 0.00757305 | 171408304493 | 0003504 |
| OC5           | Agroecological | Compost         | 6.0              | 15.00                     | 1.346                                       | 0.3               | 0.3991          | 1.0221                                    | 0.4038                        | 0.5237296       | 0.6014466        | N | K | P | N | K | P | 0.14       | 0.0075 | 0.467   | 0.003691 | 0.003608    | 0.00593516 | 171408306916 | 00035448 |
| OC6           | Carrot         | Bocashi         | 1.7              | 1.08                      | 1.72                                        | 0.13              | 0.15            | 0                                          | 0                                          | 0                | 0               | N | K | P | N | K | P | 0.32       | 0.3993 | 0.4595  | 0.003618     | 0.0012099 | 0.003603183 | 1714083063 | 0001613 |
| OC7           | Conventional   | Biofertilizante (lombriz) | 6.0              | 1.08                      | 6.0                                        | 0.13              | 0.15            | 0                                          | 0.0195                        | 0                | 0               | N | K | P | N | K | P | 0.32       | 0.3993 | 0.4595  | 0.003618     | 0.0012099 | 0.001603183 | 1714083063 | 0001613 |

**OC1**
- **Crop**: Carrot
- **Solid fertilizers**: Agroecological Compost
- **Area of land (m²)**: 92.97
- **Total crop production (Kg)**: 20.45
- **Concentration of NPK (%) in each fertilizer solid**: 0.53
- **Amount of NPK in kg**: 0.6345
- **Liquid fertilizer**: N, K and P
- **Fertilizer application rate on total crop production (Kg)**: 1.322
- **Concentration of NPK (%) in each liquid fertilizer**: 0.777389
- **Amount of NPK in Kg**: 1.93818462
- **GPS coordinates**: N 17 408344825, K 00035444

**OC2**
- **Crop**: Carrot
- **Solid fertilizers**: Agroecological
- **Area of land (m²)**: 15.645
- **Total crop production (Kg)**: 1.56
- **Concentration of NPK (%) in each fertilizer solid**: 0
- **Amount of NPK in kg**: 0
- **Liquid fertilizer**: N, K and P
- **Fertilizer application rate on total crop production (Kg)**: 0
- **Concentration of NPK (%) in each liquid fertilizer**: 0
- **Amount of NPK in Kg**: 0
- **GPS coordinates**: N 17 408306214, K 00030606

**OC3**
- **Crop**: Carrot
- **Solid fertilizers**: Agroecological
- **Area of land (m²)**: 9
- **Total crop production (Kg)**: 72
- **Concentration of NPK (%) in each fertilizer solid**: 1.35
- **Amount of NPK in kg**: 0.7665
- **Liquid fertilizer**: N, K and P
- **Fertilizer application rate on total crop production (Kg)**: 0.4772
- **Concentration of NPK (%) in each liquid fertilizer**: 0.003513
- **Amount of NPK in Kg**: 0.01630623
- **GPS coordinates**: N 17 408306214, K 00030606
Figure 1. Soil respiration compared with organic matter and nitrogen in soil.
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.

**Conclusions**

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. 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.

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/CO2/ha/day). DOI, 10.5256/f1000research.13852.d195529

**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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Open Peer Review

Current Referee Status: ✔ ✔

Ankit Singla
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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.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.
I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Referee Report 15 March 2018

doi:10.5256/f1000research.15056.r31652

Anita Jakab
National Agricultural Research and Innovation Centre, National Agricultural Research and Innovation Centre, National Agricultural Research and Innovation Centre, Újfehértó, Hungary

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.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

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

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

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