Labile carbon fraction, humic acid, and fulvic acid on organic and conventional farming of rice field in Imogiri and Berbah

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Abstract. Organic farming provides many benefits. It can improve soil fertility such as carbon fraction. Carbon fraction is one of soil characteristics which can be used as soil chemistry indicator. The objective of the study was to observe the influence of organic and conventional management system of soils on soil carbon distribution. Soil samples were taken from Kebonagung, Imogiri and Kalitirto, Berbah. The results showed that there was significant change of soil carbon fraction and soil chemical properties in both organic and conventional management system. Application of organic farming systems was able to affect on carbon fraction. It was showed by increasing of humic acid, fulvic acid, C-POM (C-particulate organic matter), C-BMT (C-biomass soil microorganism), water-soluble carbon and C-mineralization. The results also showed that organic farming can improve soil chemical properties of paddy field including organic carbon, Cation Exchange Capacity, and total Nitrogen.

1. Introduction
Generally, paddy fields in Indonesia have low organic matter content. 30 locations of paddy fields in Indonesia taken randomly, 68% have carbon content less than 1.5% and 9% have carbon content less than 2%[1]. The data of land conditions that have been extensively used chemical inputs commonly called conventional agriculture. Conventional agriculture impact on decreasing C and land degradation.

Effort to maintain and increase soil productivity is used organic matter. Function of organic matter is source of nutrients that support the availability of nutrients and soil microorganisms. Organic matter should have contained 12 C/N, because can provide nutrients that are easily absorbed by plants and this will affect the physics, chemical and microbial activity while compared to paddy fields have less organic material input. Therefore, carbonised as indicator to determination of soil quality due to the important role of carbon in agriculture.

Carbon used as an indicator of sustainable index of agricultural system. The index means carbon efficiency in field. Sustainable agriculture systems not only require crop productivity, but also to controlling carbon input and loss carbon. Sustainable index provides information on the direction of changes organic soil carbon content. Trend of organic carbon from critical level to be an indication to improve the management systems paddy fields. The objective of this study was to investigate the effect of organic and conventional systems on soil content carbon.
2. Materials and Methods

2.1. Site description
The study was located in paddy field area in Kebon Agung Village, Imogiri, Bantul and Pusat Inovasi Agroteknologi (PIAT) UGM Kalitirto, Berbah, Sleman. Area samples were obtained from two farming systems in Imogiri and Berbah with comparisons of organic and conventional farming in May 2016. Organic farming in Kalitirto, Berbah were applied at least one year and eight years in Imogiri. Organic farming were categorized as either manure, straw and house waste depending on the primary sources of fertility used whereas conventional farming systems using synthetic fertilizer on paddy.

2.2. Soil sampling
Soil samples were collected from each soil horizon for analysis of chemical properties in Soil Science Laboratory and Chemistry and Soil Fertility Laboratory, Agriculture Faculty, Universitas Gadjah Mada, Yogyakarta.

2.3. Soil chemical analysis
Soil pH was measured in distilled water (1:2.5, soil:distilled water) soil solution ratio for air-dried sample by the glass electrode method. Carbon organic was measured with Walkley and Black titration method: oxidation of organic matter by potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$)-sulfuric acid mixture followed by back titration of the excessive dichromate by ferrous ammonium sulfate ($\text{Fe(NH}_4\text{)}_2\text{(SO}_4\text{)}_2\cdot6\text{H}_2\text{O}$) [2].

Particulate organic matter was separated from sample collected from the soil layer by dispersing 20 g soil samples with sodium hexametaphosphate solution (5 g L$^{-1}$ H$_2$O). The suspensions were shaken at high speed on a reciprocal shaker for one hour and rinsed through a 53-µm sieve. The material collected on the sieve was retained and dried at 80°C. The resulting dried POM fraction was ground with a disk mill [3]. Soil microbial biomass C was estimated using the chloroform fumigation method [4]. To determine water-soluble C, soil suspension (1:2, soil:distilled water) were shaken for 30 minutes at 150 rev min$^{-1}$, centrifuged for 5 min at 2500 rev min$^{-1}$ and filtered through Whatman No.42 filter paper that had been rinsed with distilled water. Carbon in the extract was determined following Nelson and Sommers (1982) by the Walkley and Black [5]. Mineralizable C was measured by incubated-titration [6]. Humic and fulvic acid was measured by dispersing soil samples with NaOH and shaken for 24 h, added saturated NaCl for 24 h and filtered through Whatman No.42 filter paper, pH ranged from 2–3, water bath and filtered. The extract fulvic and material collected on the sieve is humic. It was determined by the Walkley and Black [7].

Total N was measured with Kjeldahl method: soil samples boiled in 0.01 N H$_2$SO$_4$ solution to get ammonium sulfate solution, followed by distillation process which is adding excess base to the acid digestion mixture to convert NH$_4^+$ to NH$_3$ followed by boiling and condensation of the NH$_3$ gas in receiving solution and titration of the excessive ammonia in the receiving soltion by 0.01 HCl [2]. Exchangeable cation was extract with NH$_4$Ac at pH 7 followed by reciprocal shaking and filtration. Then, the pellet was washed with 96% ethanol to remove the salt excess. The ammonium was extracted with 10% NaCl solution. The ammonium ion content was determined as cation exchange capacity by distillation process with Kjeldahl method.

2.4. Statistical analysis
Soil chemical data was statistically analyzed for correlations to detect significant relationships among them. Statistical test was performed in SPSS version 16.0 for Windows.
3. Results and Discussion

3.1. Organic and conventional farming
Organic farming in Imogiri was implemented by farmers beginning in 2008 and 2015 in Berbah. Commonly, rice variety planted are menthik and ciherang. Irrigation on paddy fields from Oyo and Opak river. Fertilization using manure, straw and household waste. Conventional farming used synthetic fertilizers. In Imogiri used compost fertilizer too with low dose. Rice varieties are begendhit and mikonga. Imogiri organic has five horizons, Imogiri conventional has 4 horizon, Kalitirto organic has six horizons and Kalitirto conventional has five horizons.

3.2. Soil chemical properties

3.2.1. pH, organic carbon, cation exchange. Soil pH (H2O) ranged from 6.31 to 7.08 (mean 6.84) and increased gradually with depth in most soil profiles (figure 1). The soil pH was neutral. In general, optimum nutrient availability and absorption was under neutral pH conditions, pH H2O in organic and conventional farming in Imogiri ranged from 6.31–6.86 (mean 6.67) and 6.62–7.08 (mean 6.92). pH H2O in organic and conventional farming in Berbah ranged from 6.84–7.07 (mean 6.95) and 6.39–7.04 (mean 6.83). There were no significant differences in IO, IC, KO and KC. Soil organic carbon ranged from 0.47 to 2.03% and decreased gradually with depth in all soil profiles. Soil organic carbon in Imogiri ranged from 0.55–2.03 % (mean 1.04%) and 0.47–1.89% (mean 0.91%). Soil organic carbon in Berbah ranged from 0.70–1.49% (mean 0.86%) dan 0.72–1.37% (mean 0.91%). Soil organic carbon in Imogiri Organic (IO) was moderate than Imogiri conventional, Kalitirto organic, Kalitirto conventional was low. Organic farming in Imogiri and Berbah have content soil organic carbon higher than conventional caused application organic matter higher than conventional. Organic matter effects on soil nutrient and content organic carbon. Cultivation by utilizing organic materials can significantly increase content soil carbon.

![Figure 1](image-url) Vertical distribution of soil pH H2O, organic carbon, cation exchange capacity, total nitrogen in each of the soils.

Cation exchange capacity ranged from 4.65 to 26.21 cmol kg⁻¹ and decreased gradually with depth in all soil profiles. CEC organic and conventional farming in Imogiri ranged from 7.20–26.21...
cmol(+)kg\(^{-1}\) (mean 19.01 cmol(+)kg\(^{-1}\)) and 4.65–22.00 cmol(+)kg\(^{-1}\) (mean 13.34 cmol(+)kg\(^{-1}\)). CEC in Berbah ranged from 12.19–22.13 cmol(+)kg\(^{-1}\) (mean 17.75 cmol(+)kg\(^{-1}\)) and 14.23–17.44 cmol(+)kg\(^{-1}\) (mean 15.90 cmol(+)kg\(^{-1}\)). CEC organic farming in Imogiri and Berbah higher than conventional in Imogiri and Berbah. It was caused addition organic matter. Organic matter will increase the negative charges, then it can increase soil cations. Total N content ranged from 0.01–0.47% and decreased gradually with depth in all soil profiles. Total N and cation exchange capacity in Imogiri organic 0.47% and 26.21 cmol kg\(^{-1}\) higher than Imogiri conventional, Kalitirto organic, and Kalitirto conventional.

### 3.2.2. Humic acid and fulvic acid

Soil humic carbon and soil fulvic carbon ranged from 0.15 to 1.06% and 0.18 to 1.30%, respectively, and decreased gradually with depth in all soil profiles (figure 2). Content humic and fulvic decreased caused organic C accumulation in upper layer higher than bottom layer. Humic and fulvic in Imogiri organic (1.06 and 1.10%) higher than Kalitirto organic (0.43 and 0.70%). It is because of the difference organic farming applied for eight years and one year in Kalitirto and sources organic materials. Humic and fulvic in organic farming Imogiri and Berbah higher than conventional. Humic acid contains an active functional group, a porous, and has larger surface area. Organic fertilizers produce organic acids and humification process which contributes to the source of soil acidity. pH was low caused respiratory activity of microorganisms and mineralization of organic matter produces organic acids and H\(_2\)CO\(_3\).

#### Figure 2. Vertical distribution of humic acid and fulvic acid in each of the soils.

### 3.2.3. Labile carbon fraction (c-particulate organic matter, c-soil microbial biomass, c-mineralization, water-soluble carbon)

The labile fraction has an important role to maintaining soil fertility as a source of plant nutrients that have chemical composition and fast composition levels [8]. C-particulate organic matter, c-soil microbial biomass ranged from 0.24 to 0.85% and from 0.013 to 0.062%, respectively, and decreased gradually with depth in all soil profiles (figure 3). Particulate organic matter and c-soil microbial biomass in Imogiri and Kalitirto were generally greater in soil surface. Application organic matter to be protected labile carbon from soil preparation. Conventional lower than organic because preparing for cultivation with hoeing and tractors damages soil aggregate and without organic addition stability of soil aggregate becomes low and soil macroaggregate destroyed more easily which should be stored in macroaggregate soil becomes lost or leaching [9]. Increased supply of organic materials provided increased biomass of soil microorganisms [10]. Soil microbes play a key role in immobilization and mineralization because of their ability to serve as a source and sink of soil nutrients as a “driving force” of nutrient availability [11]. Soluble-water carbon ranged from 0.18 to 0.74%. Imogiri organic was generally higher than Imogiri conventional, Kalitirto
organic, and Kalitirto conventional. It increased in sub surface because water-soluble carbon dissolved with water into the deeper layer before utilized by plants. Water-soluble carbon in Imogiri organic upper layer was low because it was utilized by soil microorganisms and can be absorbed by plant.

C-Mineralization in 10 days in Imogiri organic (5.70 mg) and Kalitirtoorganic (4.80 mg) higher than Imogiri conventional (3.90) and Kalitirto conventional (4.20 mg) and decreased gradually with depth in all soil. The addition of organic matter in the soil will increase the activity of soil microorganisms, especially the increasing process of decomposition and mineralization of organic matter.

C-POM have positively correlated with total N (r=0.731, P value=0.01), C-SMB and total N (r=0.755, P value=0.01), and water-soluble carbon and total N (r=0.609, P value=0.01). Its means an increase content C-POM, C-SMB, and water-soluble carbon in soil followed by an increase total N in soil.

4. Conclusion

Compared to conventional systems, soils under organic contained more C-POM (C-particulate organic matter), C-BMT (C-Biomass soil microorganism), water-soluble arbon, C-mineralization. Changes in soil microbial biomass are useful indicators of short-term changes in soil organic matter and soil fertility although indicators could not be explained of composition of the microbial population, frequency off addition and quality of organic residues. Application organic farming systems for a long term was able to effect on carbon fraction. It was showed by increasing of humic acid, fulvic acid and soil chemical properties (organic carbon, Cation Exchange Capacity, and total Nitrogen). Carbon fractions is useful indicator for soil quality.

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