Soil Properties under Organic versus Conventional Vegetable Farming Systems in Bogor District

Sifat Tanah pada Budidaya Sayur Organik Dibandingkan Budidaya Konvensional di Kabupaten Bogor

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Abstract. In term of quality, the yield of rice and vegetables of organic farming is better than conventional system. We are interested to study and to compare soil characteristics both in vegetable organic and conventional systems. The experiment was conducted in vegetable organic and conventional farming system in Bogor District from July 2012 to March 2013. Soil composites were sampled both at the sites of organic and conventional vegetable farming systems, before land preparation. Soil samples were grouped into lower, middle and upper slopes. Each soil composite group was collected from ten sampling points and mixed. These samples were analysed for chemical, physical and biological properties. The results indicated that in general the soil characteristics of organic vegetable farming were better than conventional farming systems in term of pH, C organic, total N, P and K extracted with HCl 25%. The soil pH in organic farming was 5.70 ± 0.50 and in conventional farming system was 4.79 ± 0.14. The organic C in organic system was 3.07 ± 0.28% and in conventional system was 2.19 ± 0.35%. Total N at organic system was 0.37 ± 0.03% N and in conventional faming system was 0.21 ± 0.05% N. Similarly, physical analysis was observed both in organic and conventional systems. The bulk density in organic farming was 0.70 ± 0.05 g cm^{-3} and in conventional systems was 0.75 ± 0.03 g cm^{-3}. Microbial C content in soil of organic vegetable farming and conventional farming systems statistically were not significantly different. Dehidrogenase enzyme activities were significantly different. The highest activity of dehidrogenase enzyme was in vegetable organic farming. Soil nematode population in vegetable organic and conventional farming did not show significant difference. It is suggested that soil quality in vegetable organic farming is better than in conventional system.

Abstrak. Kualitas hasil padi dan sayuran pada budidaya organik lebih baik ataupun unggul dibandingkan dengan sistem pertanian konvensional. Untuk itu, perlu dipelajari dan diungkap kualitas tanah pada sistem budidaya organik dan konvensional. Percobaan dilaksanakan pada pertanian organik dan konvensional di Kabupaten Bogor dari bulan Juli 2012 sampai dengan Maret 2013. Contoh tanah diambil pada Juli 2012 pada kedua sistem budidaya tersebut. Contoh tanah komposit masing masing dikumpulkan pada lereng atas, tengah dan bawah, dan setiap lerang diambil 10 titik, lalu dicampur dan diambil kurang lebih satu kg contoh komposit untuk setiap lereng. Contoh tanah ini kemudian dibawa ke laboraorium Balai Penelitian Tanah, Bogor untuk dianalisa sifat kimia, fisika dan biologi tanahnya. Hasil pengukuran menunjukkan bahwa secara umum karakteristik tanah pada sistem budidaya organik lebih baik dibandingkan dengan sistem konvensional meliputi pH tanah, C-organik, total P dan K yang diekstrak dengan HCL 25%. Kemasaman atau pH tanah pada budidaya sayur organik adalah 5,70 ± 0,50 dan pada budidaya konvensional 4,79 ± 0,14 C-organik pada budidaya organik 3,07 ± 0,28% dan pada budidaya konvensional 2,19 ± 0,35%. Nitrogen total pada budidaya sayur organik adalah 0,37 ± 0,03% N dan pada sistim konvensional adalah 0,21 ± 0,05% N. Hal yang sama juga terjadi pada pengamatan fisik tanahnya, dimana sistem budidaya organik lebih baik jika dibandingkan sistem budidaya konvensional. Berat Jenis tanah pada budidaya organik 0,70 ± 0,05 g cm^{-3} dan pada budidaya konvensional 0,75 ± 0,03 g cm^{-3}. Untuk aktivitas mikroba C pada budidaya organik secara statistik tidak berbeda nyata dengan sistem budidaya konvensional. Sementara untuk ensim dehidrogenase menunjukkan perbedaan yang nyata. Enzim dehidrogenase tertinggi terlihat pada sistem budidaya organik, sedangkan untuk populasi nematoda pada budidaya oragnik tidak menunjukkan beda yang nyata dengan sistem budidaya sayur konvensional. Populasi nematoda tertinggi didapat pada budidaya organik di Mega Mendung. Dapat dikatakan bahwa sistem budidaya organik cenderung lebih baik dibandingkan sistem budidaya konvensional.

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Introduction

By definition, the term of organic agriculture refers to a process that uses methods respectful of the environment, from production stages through the handling and processing. Thus, it is not merely concerned with a product, but the whole system used to produce and deliver the product to the ultimate consumers (Anonymous 2004). Consequently, organic farming systems avoid applications of chemical fertilisers and pesticides, rely on organic inputs and recycling for nutrient supply, and emphasize on cropping system design and biological processes for pest management (Rigby and Cáceres 2001). They may thus reduce some negative effects attributed to conventional farming (Oehl *et al*. 2004; Mäder *et al*. 2002; Reganold *et al.* 1987). The term of sustainable is defined as capable of being maintained at a steady level without exhausting natural resources or causing severe ecological damage (Anonymous 1992). In soil science, this term refers to capability of soil function to keep its good productivity.

Recently, soil quality assessment have become more fashionable responding to environmental concerns particularly in developing country that has claimed significant effects of land degradation on their agricultural production and food security. Therefore, soil quality assessment including chemical, physical and biological properties has become a model to determine soil function (Sukristiyonubowo *et al.* 2011). According to Doran and Parkin (1994) soil quality is defined as the capacity of the soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental productivity, and promote plant and animal health. Sharma *et al.* (2008) reported that in the past soil quality is understood as inherent soil capacity to supply essential plant nutrients. Consequently, profitable and sustainable agriculture management should be addressed at supplying sufficient nutrients for optimum crop growth and development as well as farmers income, with keeping losses to environments at the minimum level. Inputs addition for right amount nutrient through fertilisers should be based on characteristic soil fertility status and crop being planted. Combined uses of mineral and organic fertilisers (recycling rice straw, crop residues, compost, and manures) are also recommended in conventional or non organic farming system (Fenning *et al*. 2002; Hasegawa *et al*. 2005; Khai *et al*. 2007; Yang *et al*. 2007; Sukristiyonubowo and Tuherkih 2009). Spesifically, Yan *et al*. (2007) and Haynes (2005) stated that soil organic matter is considered to be a key attribute of soil quality because of its role on chemical, physical and biological properties and process in soil. Therefore, basically soil quality is the ability of a soil to perform the functions necessary for its intended use. Thus, indicators include dynamic soil properties or management, chemical (nutrients and carbon cycling), physical (aggregate stability, available water capacity, bulk density, infiltration, slaking, crust, soil structure and macrospores) and biological (respiration, enzyme, microbial community, and phospholipids fatty acids) aspects (USDA 2009; Herrick. 2000; Doran and Zeiss (2000). Specifically, according to Amalia (2011) soil quality in paddy field is combining among soil organic carbon (SOC) and total N content with enzyme dehydrogenase, β-glucosaminidase activity and microbial biomass C (MBC) as well as phospholipids fatty acids (PLFA) are suitable indicators, while in vegetables field PLFA is not considered as suitable parameter.

In the past, during the green revolution technology, combination between high external input and high yielding variety are promising way to achieve rice promising yields (Sukristiyonubowo and Tuherkih. 2009; Min *et al*. 2003; Cho *et al*. 2002; 2000; Soepartini 1995; Adiningsih. 1992; Adiningsih *et al*. 1989; Prawirasumantri *et al*. 1983; Cooke 1970; Uexkull 1970). In vegetable growing areas, the application of inorganic fertilizers are also tremendously significant, for instance the use of N fertilizers in leafy vegetables, K in tuber crops both are very high. However, this technology is considered not sustainable for the long term. In much conventional rice growing centres are showing a levelling-off, even a decline or loss in productivity. Now in Indonesia , there are organic faming and conventional systems both for rice and vegetables. The yield of rice and vegetables of organic farming is better than conventional system. This paper discusses several soil quality parameters in organic versus conventional farming systems.

Methodology

We selected three farmers in Cisarua and three farmers in Mega Mendung for vegetable organic farming and three farmers In Cisarua and three farmers in Mega Mendung for the vegetable conventional farming systems. They conducted organic farming since 2005 in Ciasarua, where as in Mega Mendung since 2007. They apply chicken manure as much as 3-5 t ha^{-1} every cropping season or only apply chicken manure one time as much as 25-30 t ha^{-1} $year^{-1}$. They plant egg plant, broccoli, carrot, French beans, cabbage, leaks, and tomato.

In vegetable conventional systems, they usually used mineral fertiliser and organic fertiliser as much as 250-30 urea kg ha^{-1}, 100-150 PONSKHA kg ha^{-1} and 15 tons chicken manure ha^{-1}. Like in organic farming system, they also cultivate egg plant, broccoli, carrot, French beans, cabbage, leaks, and tomato.

Composite soil samples of 0-20 cm in depth were taken in July 2012, before soil preparation and submitted in the laboratory for analyzing. Samples were grouped into lower, medium and upper slopes. Each soil composite group was collected from ten sampling points at every group (lower, medium and upper layers) and mixed. We took the samples in upper, middle and lower parts because the areas were sloping. These samples were submitted to the Analytical Laboratory of the Soil Research Institute at Bogor for analyses of chemical, physical and biological properties of the soils. Chemical analyses included the measurement of pH (H_20 and KCl), organic matter, phosphorus, and potassium, Organic matter was determined using the Walkley and Black method, pH (H_2O and KCl) was measured in a 1:5 soil-water suspension using a glass electrode, total P and soluble P were measured colorimetrically, extracted using HCl 25% and Olsen methods, respectively. The total K was extracted using HCl 25% and subsequently determined by flame-spectrometry. (Soil Research Institute 2009). Physical analyses included the measurement of water level, particle density (PD), bulk density (BD) and total pore space. Water level was measured by Gravimetric method, particle density was measured using Richards and Fireman method (1943), bulk density was measured by Richards method (1947) and total pores space was measured using De Boodt method (1967). All measurement of physical properties adopted from Indonesian Soil Research Institute (2009). The biological parameter includes nematode population, enzyme dehydrogenize and C microbial activities. C microbial activities were determined with fumigation incubation method (Jenkinson and Powlson 1980). Soil samples were fumigated with $CHCl_3$ free from alcohol. After fumigation, soil samples were incubated with alkali solution and then were titrated with HCl. Total microbial C was counted as number of C-CO_2 was absorbed in this solution. Dehydrogenize activities were determined according to reduction of 2.3.5 triphenyltetrazolium chloride (TTC) become triphenyl formazan (Casida *et al.* 1964; Serra-Wittling *et al.* 1995). Nematode extraction was following Cobb method. This method was used to extract active nematode in the soils and nematode in the coagulated was measured under microscope then was counted (van Bejooijen 2006). All data were statistically examined and computed using SPSS software. Means were compared using the Duncan test (5%).

Results and Discussion

Soil chemical properties

The soil chemical parameters are presented in Table 1. Generally, the pH of soils was very acid, varying from 5.07 to 6.10 in organic farming system and from 4.63 to

Table 1. Soil chemical properties of organic and conventional vegetable farming systems at Mega Mendung and Cisarua of Bogor District (soil samples of 0-20 cm depth were taken at July 2012, Means ± SD)

Tabel 1. Sifat kimia tanah pada sistem budidaya sayur organik dan konvensional di Mega Mendung dan Cisarua, Kabupaten Bogor (contoh tanah diambil pada kedalaman 0-20 cm pada bulan Juli 2012, Rata-rata ± simpangan deviasi)

Vegetables farming system and location	pH	Organic C	N-total	P HCl 25%	K HCl 25%
		……………. %	…………….	……..……. mg $100g^{-1}$	……..…….
Organic farming at Mega Mendung					
1. Upper layer	6.10	3.52	0.39	303	56
2. Midlle layer	5.90	2.98	0.39	167	118
3. Lower layer	5.07	3.12	0.33	130	42
Mean	5.70 ± 0.5 a	3.07 ± 0.28 a	0.37 ± 0.03 a	200 ± 91 ab	72 ± 40 ab
Organic farming at Cisarua					
1. Upper layer	5.60	3.01	0.27	312	87
2. Middle layer	5.47	3.07	0.29	243	92
3. Lower layer	5.47	3.05	0.27	307	95
Mean	5.35 ± 0.07 ab	3.03 ± 0.03 a	0.28 ± 0.01 ab	287 ± 38 a	91 ± 4 a
Conventional farming at Mega Mendung					
1. Upper layer	4.90	1.83	0.16	120	53
2. Middle layer	4.90	2.18	0.22	127	39
3. Lower layer	4.90	2.52	0.26	150	26
Mean	4.90 ± 0 ab	2.19 ± 0.35 b	0.21 ± 0.05 b	152 ± 15 b	39 ± 14 b
Conventional farming at Cisarua					
1. Upper layer	4.83	3.74	0.39	188	57
2. Middle layer	4.63	3.31	0.36	140	52
3. Lower layer	4.90	3.44	0.33	150	45
Mean	4.79 ± 0,14 b	3.48 ± 0,22 a	0.36 ± 0.03 a	159 ± 25 b	51 ± 6 b
CV (%)	6.2	10.6	12.6	19.5	33.2

Note: In a column, mean followed by common letter are not significantly different at the 5% level by DMRT

4.90 in conventional system. In the organic farming system, the acidity of soils may be due to fulvic and humic acids released by organic materials (compost and manure) added in these systems, whereas in the conventional system because of application of urea, one of the inorganic fertiliser. The level of soil organic carbon (SOC) and total N were classified high both in organic vegetable farming system in Cisarua and Mega Mendung, ranging from 2.98 to 3.52% Organic C and 0.27% to 0.39% N, respectively. Meanwhile, soil organic carbon (SOC) and total N in conventional system in Cisarua were also considered high, varying from 3.31% to 3.74% Organic C and 0.33% to 0.39% N but not in the conventional system in Mega Mendung, varying between 1.83 and 2.53%. The soil organic carbon and total nitrogen in conventional considered high because the farmers also apply chicken and goat manures. According to Sommerfeldt *et al*. (1988) and Clark *et al*. (1998) observed higher soil OM levels in soils managed with animal manure and cover crops than in soils without such inputs.

For the organic vegetable farming system in Cisarua and Mega Mendung, total P or potential P extracted with HCl 25% ranged from 130 to 312 mg P_2O_5 100 g^{-1} and these values were classified as very high, suggesting that application of 3 to 5 tons compost ha^{-1} $season^{-1}$ increases the availability of P leading to soil function improvement. While, the total P or potential P extracted with HCl 25% in conventional farming system in Cisarua and Mega Mendung were also considered high, varying from 120 to 188 P_2O_5 100 g^{-1}, suggesting application of 100 to 150 kg SP-36 ha^{-1} $season^{-1}$ done by farmers increase the availability of P.

Total K was also considered high to very high in organic farming system both in Cisarua and Mega Mendung, varying from 42 to 118 mg K_2O 100 g^{-1}, indicating that application of 3 to 5 ton compost or chicken manure enough to increase the total K in the soil. It was suggesting that compost applied was rich in K content. Whereas, in conventional farming system both in Cisarua and Megamendung were considered medium to high indicating addition of 100 kg KCl ha^{-1} $season^{-1}$ also increase the total K in the soil. Clark *et al*. (1998); Rasmussen and Parton (1994) and Wander *et al*. (1994) also reported similar findings.

Therefore, it may be concluded that in the organic vegetable farming system in general soil were healthy and the chemical soil fertility were high due to very high organic matter content, and high to very high available P and K concentrations, but acidic (low in pH). These soils can function well to support vegetables to grow and yield well. Hence, the liming is very important to improve (quantity and quality) vegetable yield. Besides this, in the conventional system applications of proper mineral fertilizers to improve inherent soil fertility leading to vegetable yield is a must.

Soil physical parameters

The soil physical parameters are presented in Table 2. Generally, the bulk densities of soils were less than 1.0 both in organic and conventional vegetable farming systems, indicating that soils were very light. This soil may be classified as Andisols and the soils were managed very well. These also means that addition of manure and compost as much as 5 t ha^{-1} $season^{-1}$ in organic vegetable farming system and 15 t ha^{-1} $season^{-1}$ in conventional system were enough to maintain the soils (see the contents of C organic).

Looking at the total pores space, both in organic farming system and in conventional system the values were greater than 60. These meant that the soils were easily to be penetrated with roots of vegetable crops because of rich in organic matter or high in soil organic carbon (see Table 1). Physically, both soils in organic and conventional systems are good to support plant growth and yield.

Soil biological parameters

Biological parameters farming both in organic and conventional vegetable farming systems are presented in Table 3. Microbial C content in soil of organic vegetable farming and conventional farming systems statistically were not significantly different. In Cisarua organic farming system and in Mega Mendung conventional systems, the contents of microbial C were the highest. The values were 0.081 mg C-CO_2 day^{-1} g^{-1} soil in Cisarua organic and 0.085 mg C-CO_2 day^{-1} g^{-1} soil in Mega Mendung conventional systems. These may be due to in Cisarua they have started in organic farming system since year 2004 compare to in Mega Mendung organic farming. Whereas, in vegetable conventional system in Mega Mendung, the farmer's always use chicken and goat manures when they cultivate vegetables. This location was also considered as the central of vegetables for Bogor District. Besides these reasons, the high Microbial C also indicated that the population of microbes in these sites were considered high. The soil microbes can get the food from soil organic farming added every season.

Although the Microbial C content both in organic and conventional farming systems did not significantly different, the enzyme dehidrogenase activities were significantly different. The highest activity of enzyme dehidrogenase was in vegetable organic farming of about 23.007 ± 4.75 µg TPF.g^{-1} soil day^{-1}. The highest activities of enzyme dehidrogenase was also due to addition of organic matter sources like chicken manure resulting in improved biodegradable substrate which can increase the activity of soil micro organisms (Dinesh *et al*. 2010).

Soil nematode population in vegetable organic and conventional farming did not show significant different.

Table 2. Soil physical properties of organic and conventional vegetable farming systems at Mega Mendung and Cisarua Sub District of Bogor District (soil samples of 0-20 cm depth were taken at July 2012, Means ± SD)

Tabel 2. Sifat fisik tanah pada sistem budidaya sayur organik dan konvensional di Mega Mendung dan Cisarua, Kabupaten Bogor (contoh tanah diambil pada kedalaman 0-20 cm pada bulan Juli 2012, Rata-rata ± simpangan deviasi)

Vegetables farming system and location	Soil physical parameters				
	Bulk density	Particle density	Total pores space	Fast pores drainage	Slow pores drainage
	……………. g cm^{-3} …………….		…………………..……… % ………………..…………		
Organic Farming at Mega Mendung					
1. Upper Layer	0.65	1.92	66.50	33.70	4.60
2. Middle Layer	0.69	1.92	63.87	29.33	4.36
3. Lower Layer	0.75	2.03	63.10	28.17	4.46
Mean	0.70 ± 0.05 a	1.96 ± 0.11a	64.49 ± 1.78 b	30.40 ± 2.92 b	4.48 ± 0.12 a
Organic farming at Cisarua					
1. Upper Layer	0.74	1.94	61.87	25.56	4.76
2. Middle Layer	0.83	1.90	56.53	22.60	4.70
3. Lower Layer	0.81	2.02	59.17	23.40	4.67
Mean	0.79 ± 0.04 b	1.62 ± 0.06 a	59.19 ± 2.67 a	22.85 ± 1.53 a	4.70 ± 0.04 a
Conventional farming at Mega Mmendung					
1. Upper Layer	0.76	2.15	63.73	22.10	5.53
2. Middle Layer	0.78	2.14	63.76	25.23	5.67
3. Lower Layer	0.72	1.96	63.40	24.73	5.96
Mean	0.75 ± 0.03 ab	2.08 ± 0.11 a	63.63 ± 0.20 b	24.02 ± 1.59 a	5.71 ± 0.22 b
Conventional farming at Cisarua					
1. Upper Layer	0.77	2.12	64.47	23.40	5.93
2. Middle Layer	0.76	2.11	65.70	23.47	5.50
3. Lower Layer	0.73	1.97	61.06	21.47	5.50
Mean	0.75 ± 0.03 ab	2.07 ± 0.08 a	63.74 ± 2,40 b	22.78 ± 1.14 a	5.64 ± 0.25 b

Note: In a column, mean followed by common letter are not significantly different at the 5% level by DMRT

Table 3. Biological soil parameter of vegetables organic and conventional farming systems at Mega Mendung and Cisarua Sub District of Bogor District (soil samples of 0-20 cm depth were taken at July 2012, Means ± SD)

Tabel 3. Sifat biologis tanah pada sistem budidaya sayur organik dan konvensional di Mega Mendung dan Cisarua, Kabupaten Bogor (contoh tanah diambil pada kedalaman 0-20 cm pada bulan Juli 2012, Rata-rata ± simpangan Deviasi)

Vegetables farming system and location	C microbe	Enzyme dehidrogenase	Nematode population
	mg C-CO_2 day^{-1} g^{-1} soil	µg TPF g^{-1} soil day^{-1}	$100g^{-1}$ soil
Organic farming in Mega Mendung			
1. Upper slope	0.032	13.157	255
2. Middle slope	0.004	6.071	445
3. Lower slope	0.083	6.435	317
Mean	0.040 ± 0.004a	8.555 ± 3.99 b	329 ± 110 a
Organic farming in Cisarua			
1. Upper slope	0.096	27.824	155
2. Middle slope	0.036	18.327	267
3. Lower slope	0.112	22.869	133
Mean	0.081 ± 0.04a	23.007 ± 4.75 a	185 ± 72 a
Organic farming in Mega Mendung			
1. Upper slope	0.073	7.470	467
2. Middle slope	0.060	13.655	67
3. Lower slope	0.121	14.758	100
Mean	0.085 ± 0.032a	11.961 ± 3.93 b	211 ± 222 a
Conventional farming in Cisarua			
1. Upper slope	0.007	7.005	267
2. Middle slope	0.062	8.317	167
3. Lower slope	0.055	10.206	100
Mean	0.041± 0.03 a	8.509 ± 1.61 b	178 ± 84 a

The highest population of soil nematode was at vegetable organic farming system in Mega Mendung of about 339 100 soil^{-1}. The lowest one was at vegetable conventional farming systems which seemed to be caused by the application of mineral fertilisers like urea that can inhibit the population of nematode (Farahat *et al*. 2012). It can be said that from the soil biological parameters organic system was better than the conventional one.

Conclusions

In general, the soil characteristics (soil chemical, physical and biological properties) of organic vegetable farming were better than conventional farming systems in term of pH, organic C, total N, P, and K extracted with HCl 25%, bulk density and dehidrogenase enzyme.

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