Effect of Farming Systems on Soil Carbon Sequestration and Crop Yield of Paddy (*Oryza sativa* L.) in Irrigated Rice Field

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ABSTRACT

Carbon sequestration is obtained from the total accumulation of the element in both soil and plants. The enhancement has the capacity to reduce greenhouse gas emissions and influence soil quality and fertility, thereby affecting plant biomass and crop yield. Therefore, this research aimed to compare the total carbon sequestration in rice field with different farming systems, determine soil characteristics, and identify the correlation between the total carbon sequestration and impact on rice yield. An exploratory-descriptive method was used through field survey and laboratory analysis. The locations were mapped by overlaying the Indonesian landform map of the Girimarto District with various rice field systems, soil types, and slopes. Furthermore, the 12 Land Mapping Units (LMU) with 3-time repetitions resulted in 36 sampling points. Data were processed by calculating total carbon sequestration and statistical tests such as one-way ANOVA and Pearson's correlation. The results showed that rice field farming systems affected the total carbon sequestration. Organic farming had the highest total carbon sequestration value of 72.49 Mg/ha and the increase had a strongly positive correlation with crop yield of paddy. Crop yield in organic farming were higher than in semi-organic and conventional systems by 8.92 tons/ha. Factors that determined total carbon sequestration were soil C-organic and microbial biomass C. The suggested improvement recommendations were the transition of conventional and semi-organic farming as well as adding a variety of organic fertilizers such as biofertilizers.

1. INTRODUCTION

The amount of carbon in the atmosphere is reported to increase due to various living activities, such as respiration, forest fires, and fossil fuel production (Welsby et al., 2021; Gonsamo et al., 2017). This can cause greenhouse gases (GHG), which increases the temperature of the earth. Therefore, different efforts are needed to reduce GHG through carbon storage by adding organic materials (Pratama, 2019). High soil organic carbon (SOC) content leads to a solid soil structure, reduces erosion risk, and maintains nutrient availability to increase soil fertility. Fertile soil due to organic additions can increase plant biomass and rice yield by 18% (Arunrat et al., 2017; Liu et al., 2021). Carbon storage occurs through sequestration, which CO_2 is absorbed from the atmosphere during photosynthesis and transferred to soil through the roots (Losada et al., 2011). As a result, CO_2 gas in the atmosphere decreases, and increased carbon sequestration can reduce GHG emissions (Takakai et al., 2020). Controlling the rate of photosynthesis increases soil carbon input. Plants that absorb high concentrations of CO_2 will fix a lot of carbon during photosynthesis. However, several challenges can be encountered due to increasing temperatures. Water availability and the rate of photosynthesis become limited during the dry season or drought conditions. Furthermore, soil carbon stores are also easily lost due to plant root respiration and the decomposition of organic matter by microbial activity. An alternative strategy used to regulate carbon uptake includes a deliberate response to rising temperatures. This comprises the introduction of organic matter into soil through land processing before planting and post-harvest. The rationale behind this method is to elevate the decomposition of SOC, leading to an increased

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production of CO_2. Subsequently, this augmented CO_2 production becomes an integral component of the ensuing photosynthesis process.

Most carbon sequestration research has been carried out in forests with tree cover on agricultural land. Rice field is notorious for emitting carbon dioxide into the atmosphere, accounting for a quarter of all anthropogenic GHG emissions (Jaiswal and Agrawal, 2020). By the last 50 years of scientific research, the agricultural sector has been exposed to climate changes in the dynamics of temperature and rainfall, causing plant stresses and decreases in production yield (Sengupta and Thangavel, 2023). Farming systems affects carbon sequestration, both adverse and beneficial impacts on the ecosystem. Arunrat et al. (2021) explained that conventional farming systems had higher GHG emissions level than organic due to excessive chemical fertilizer inputs. The intensive use of chemical fertilizers is the highest cause of soil degradation and results in poor soil carbon storage (Pahalvi et al., 2021). Conventional farming systems subjected to soil degradation often incur significant carbon losses, ranging from 25 to 75%, equivalent to approximately 10 to 30 Mg/ha (Lal, 2013). Meanwhile, organic fertilizers can increase soil carbon stock (Waqas et al., 2020). Organic farming systems enhance soil pH and hasten decomposition in humic compounds (Fitria and Soemarno, 2022). Leifeld and Fuhrer (2010) mentioned that this systems had higher soil organic carbon storage than conventional farming. Rice field with proper management practices can increase SOC by 4.85%, and support carbon sequestration in soil.

Carbon sequestration is important to improve soil quality, and fertility as well as reduce GHG emissions. Furthermore, carbon sequestration and soil fertility play an important role in the sustainability of agricultural land use. Soil captures and stores carbon dioxide from the atmosphere to reduce GHG emissions. In addition, SOC can promote the growth of aerobic microorganisms, which can consume CH_4 and reduce emissions. The presence can also influence other GHG emissions, such as nitrous oxide (N_2O) and methane (CH_4). SOC can increase the capacity to hold and convert nitrogen, reducing the production and release of N_2O, a potent GHG (Wiesmeier et al., 2019).

In the last two decades, climate and soil analyses have been looking at organic carbon as a strategy to minimize GHG emissions. However, many research have been conducted to identify carbon sequestration in forests, cropland, grassland, or land conversion. Agricultural land in the research area is included in the humid tropics. Basu (2014) stated that tropical areas such as Southeast Asia, specifically the humid tropics, have carbon storage capacity of 12-228 MgC/ha. Meanwhile, soil with anaerobic conditions, such as rice field, has a different amount of sequestration and depends on how systems are applied. Rice field soil conditions treated with flooding and drying affect environmental conditions in the anaerobic period. Within this context, anaerobic conditions contribute to an increased susceptibility of carbon decomposition rates to losses. The object of observation focuses on carbon sequestration in irrigated rice field with different farming systems. In addition, the defining factor concept was used to find soil characteristics (physical, chemical, and biological aspects) associated with carbon sequestration in rice field. The defining factor concept aims to formulate targeted land management strategies to maintain soil organic and carbon sequestration values, focusing on irrigated rice field. Each farming systems produce a different total carbon value related to the production of paddy crop. Land management using organic inputs shows better conditions and reduces GHG emissions. The objectives of this research were to compare total carbon sequestration in rice field with different farming systems, namely organic, semi-organic, and conventional rice field, to determine the characteristics of soil used as a basis for result determinants. Furthermore, the correlation between total soil carbon sequestration and its impact on rice yield was identified. The implications included updating data in rice field and increasing total carbon sequestration through appropriate and effective management of the defining factors to achieve optimal crop yield and sustain future agricultural land use sustainability.

2. METHODOLOGY

2.1 Research area

The research was conducted in Girimarto District, Wonogiri Regency, Central Java, Indonesia (Figure 1). The geographical location of Girimarto District is 7°45'51.4"-7°48'49.0" S and 111°01'47.6" -111°09'48.3" E with an altitude of 400 meters above sea level (m.a.s.l.), high rainfall (2,105 mm/year) at an area of 6,236.68 ha, composed of 111 hamlets. The total population is 45,569 people, with the largest livelihood in agriculture. The research was conducted on land use in rice field with organic, semi-organic, and conventional farming systems. There are two types of soil, namely Alfisols and Inceptisols, on slopes of 0 to 8% and 8 to 15%, respectively. The analysis included biological, physical, and chemical analysis of soil and plants at Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Universitas Sebelas Maret.

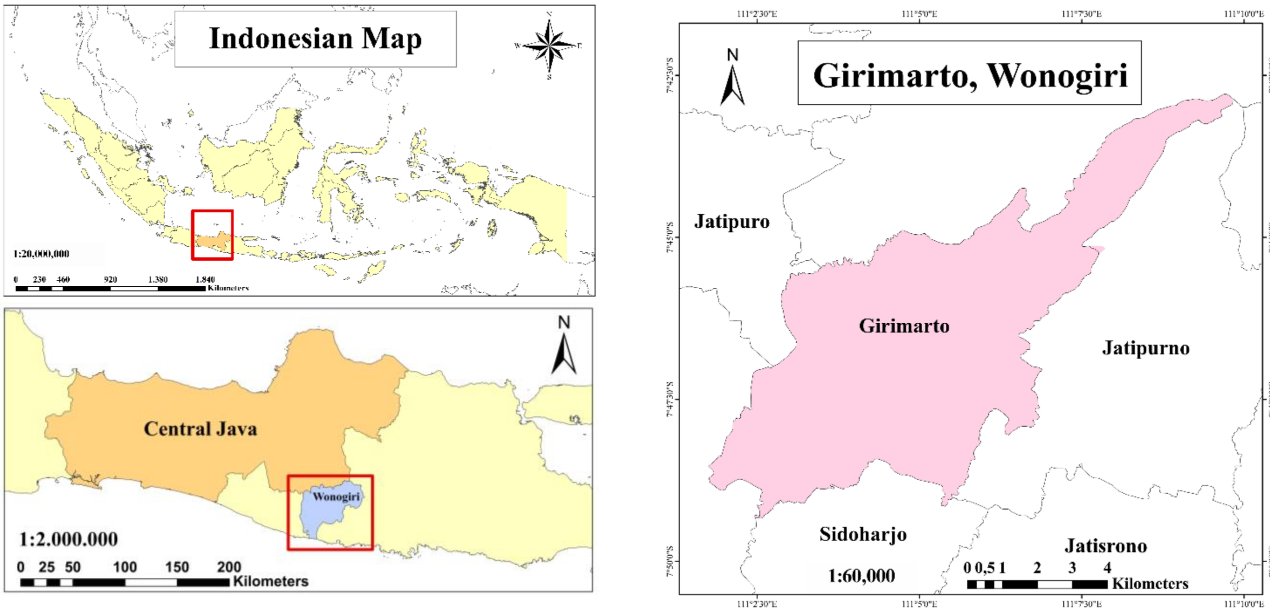

Figure 1. Research area

2.2 Soil and plant sampling

This research used an exploratory-descriptive method through field survey and laboratory analysis. Furthermore, the survey was conducted using the purposive sampling method. The land mapping unit (LMU) was carried out by overlaying the Indonesian land map (RBI) of Girimarto District, Wonogiri Regency, with a map of diverse land sources, including the type of rice field systems, soil type, and slope. The different rice field systems consist of organic, semi-organic, and conventional rice field. Soil types in the research location are Alfisols and Inceptisols, while the slope is 0-8% and 8-15%. The map overlay consists of 12 LMU, with 3 times repetitions, resulting in 36 sampling points, as shown in Figure 2. Soil samples were taken at 0 to 20 cm depth and a drill was used to carry out sampling during the maturation phase. Meanwhile, the samples taken were analyzed in the laboratory according to the method of each observation parameter during the maturation phase. The samples were oven-dried and weighed before further analysis to reduce the water content and inhibit the reaction process (Yadav et al., 2018).

2.3 Sample analysis

The parameters researched included soil volume weight by paraffin-clod method (Negro et al., 2018), texture by pipette method (Igaz et al., 2020), pH by potentiometric method (Lisak et al., 2015), soil C-organic by Walkley and Black method (Harahap et al., 2020), microbial biomass C by fumigation-extraction method (Heuck et al., 2015), C-organic of rice plants by Walkley and Black method (Gunamantha et al., 2021), rice yield (Nyamai et al., 2012) in Indonesia. This was conducted with observations of 1,000 grain weight, productive tillers, number of clumps per hectare, and number of grains per panicle (Sari, 2023), root volume by volumetric method, and root weight by gravimetric method. The calculation of total carbon sequestration was obtained from the accumulation of soil C-stock with plant C-stock. Meanwhile, soil C-stock (Bastia et al., 2013) and plant C-stock were obtained by equation (National Standardizations Agency of Indonesia, 2011).

$$Ct = BD \times \%C \times DP \qquad (1)$$

$$Cm = Bo \times \%C \qquad (2)$$

Where; Ct: soil C-stock (g/cm^3); BD: bulk density (g/cm^3); %C: soil organic carbon content (%); DP: soil depth (cm); Cm: plant C-stock; Bo: total plant biomass (kg). Total carbon sequestration was obtained from the sum of equation (1) and (2).

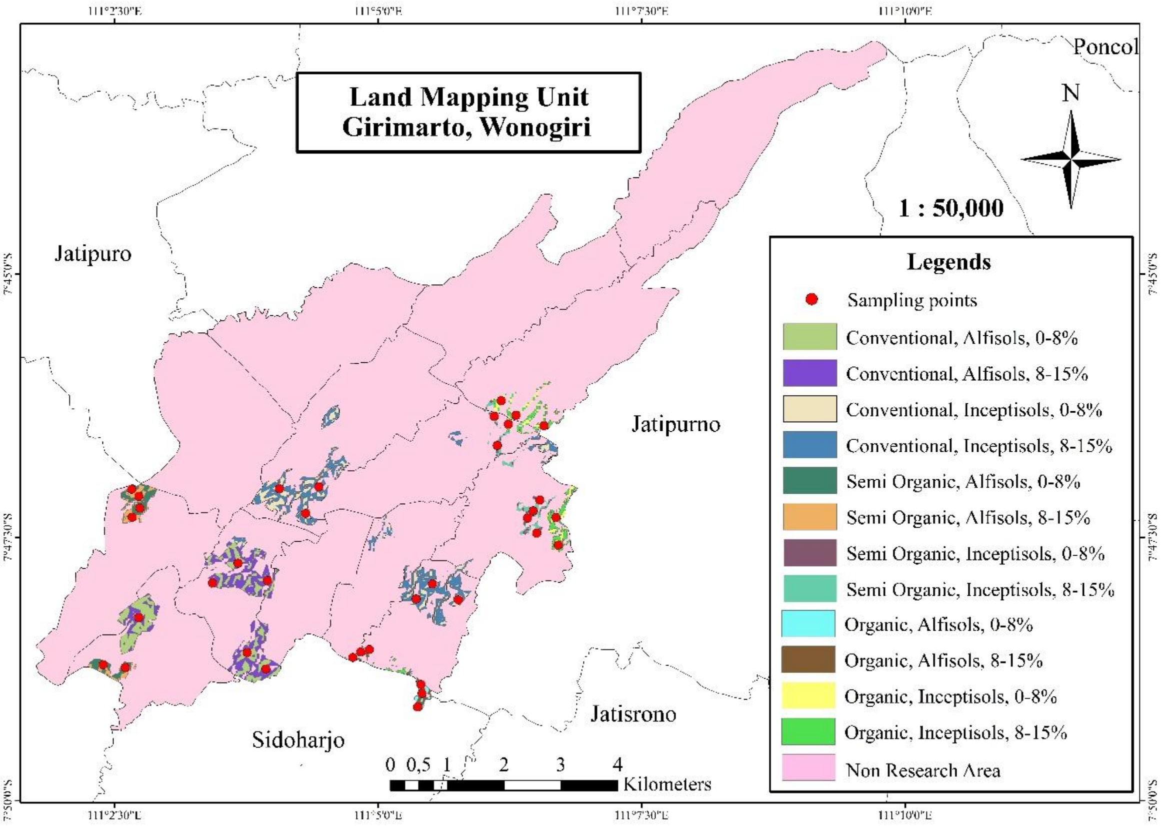

Figure 2. Observation and sampling point

2.4 Statistical analysis

Statistical tests were conducted using One-way Analysis of Variance (ANOVA) to determine effect of rice field farming systems on carbon sequestration and then Duncan's Multiple Range Test (DMRT) to determine differences in the impact of rice field farming systems. Defining factors were obtained by testing the correlation between parameters and total carbon sequestration. Defining factors were described as the most dominant factors influencing carbon sequestration and used as reference material for preparing appropriate land management recommendations to maintain soil organic carbon and sequestration.

3. RESULTS AND DISCUSSION

3.1 Soil C-stock, plant C-stock, carbon total sequestration

The C-organic at the research site is included in the medium category (2.09-2.81%), where the higher the content, the lower the bulk density. Soil C-stock content, plant C-stock, and total carbon sequestration at the research site ranged from 54.27-67.57 Mg/ha, 2.03-4.92 Mg/ha, and 56.30-72.49 Mg/ha, as shown in Table 1. The value of total carbon sequestration was highly dependent on various rice field farming systems. The results showed that rice field farming systems affected the total carbon sequestration value, as shown in Table 2.

Table 1. Value of soil C-stock, plant C-stock, and carbon total sequestration

Farming systems		C-Org (%)	BD (g/cm^3)	Soil c-tock (Mg/ha)	Biomass weight (g)			Plant C-Org (%)			Plant C-stock (Mg/ha)	Carbon total sequestration (Mg/ha)
					Stems	Root	Grain	Stems	Root	Grain		
FS	C	2.09	1.30	54.27	23.44	13.48	32.18	43.78	5.60	5.39	2.03	56.30
	SO	2.49	1.23	61.41	29.87	13.72	41.62	48.49	6.47	6.16	2.88	64.29
	O	2.81	1.20	67.57	44.27	27.06	53.54	55.51	6.81	7.93	4.92	72.49

Remark: FS=Farming systems; C=Conventional; SO=Semi organic

Table 2. Effect of farming systems on total soil carbon sequestration

	Farming systems
Carbon total sequestration p-value (sig.)	0.000**

Remark: **=highly significant (p-value<0.01)

Soil C-stock, plant C-stock, and total carbon sequestration in organic rice field farming systems had higher values than in conventional and semi-organic rice field farming systems (Figure 3).

3.2 Rice productivity

Rice yield was obtained by observing the weight of 1,000 grains, productive tillers, number of clumps/ha, and number of grains/ha of rice yield (22). Yield of rice crop at the research location ranged from 4.14 to 8.92 tons/ha (Table 3).

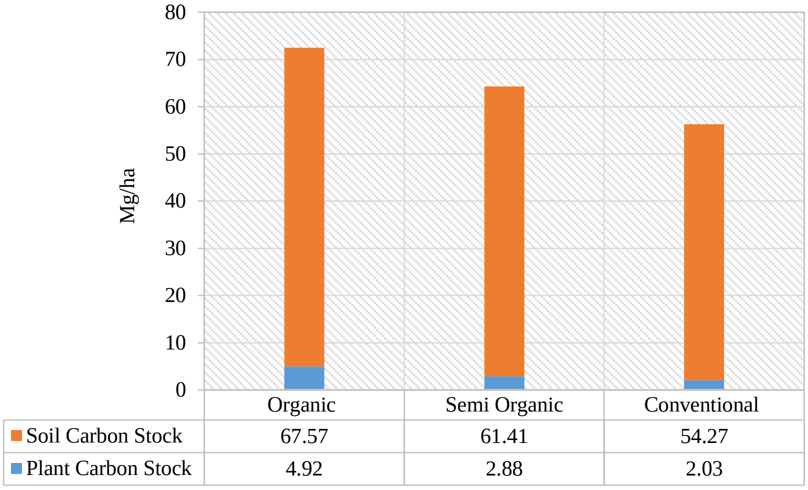

Figure 3. The average of C-stock soil, carbon of paddy crop, and carbon total sequestration under different farming systems

Table 3. Rice productivity

Land characteristics		1,000 grain weight (g)	Productive tiller	Number of clumps/ha	Number of grains/ panicle	Rice yield (tons/ha)	Carbon total sequestration (Mg/ha)
Farming systems	Conventional	32.50	8.67	160,000	91.75	4.14	56.30
	Semi Organic	32.75	9.92	160,000	100.42	5.22	64.29
	Organic	33.08	15.17	160,000	111.08	8.92	72.49
Soil type	Alfisols	32.50	10.94	160,000	100.61	5.64	63.04
	Inceptisols	32.75	11.56	160,000	101,56	6.15	65.68
Slope	0-8%	32.59	11.83	160,000	101.33	6.25	65.04
	8-15%	32.96	10.67	160,000	100.83	5.67	63.67

The results showed that rice field farming systems affected yield. Conventional, semi-organic, and organic farming systems have significantly different results, where organic systems has the highest yield at 8.92 tons/ha (Figure 4).

3.3 Defining factor of total C sequestration and the correlation between carbon sequestration and rice productivity in farming systems

Defining factors are important to provide recommendations for improving carbon sequestration in the research area. These factors are obtained through correlation tests between carbon total sequestration and various parameters (Table 4).

Table 4. Defining factor of carbon total sequestration

Parameter	Carbon total sequestration
Bulk density (g/cm^3)	-0.272^{ns}
pH	0.136^{ns}
Sand (%)	0.053^{ns}
Silt (%)	-0.096^{ns}
Clay (%)	0.035^{ns}
Soil C-organic (%)	0.923**
Microbial biomass C (µg/g)	0.829**

Remark: ns=not correlated; *=significantly correlated at p-value≤0.05; **=significantly correlated p-value≤0.01

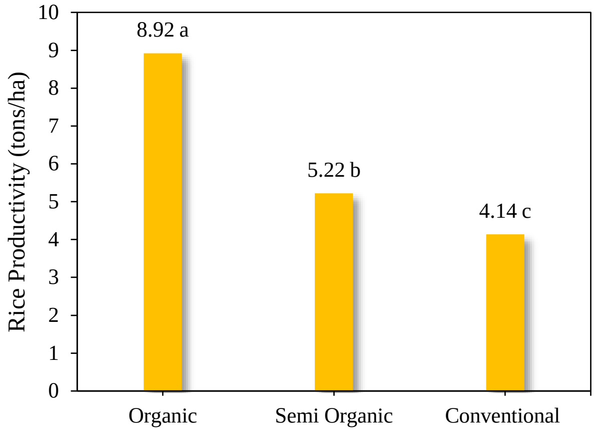

Figure 4. The average rice productivity under different farming systems

There are two defining factors of total carbon sequestration (Table 4), namely soil C-organic (r=0.923**) and microbial biomass C (r=0.829**). Figure 5 shows that organic rice field farming systems have the highest soil C-organic and microbial C biomass.

The results (Figure 6) of carbon total sequestration correlation test with rice yield showed a significant positive relationship (r=0.759**). Organic rice field farming systems had the highest root volume (113.33 mL) and weight (27.06 g).

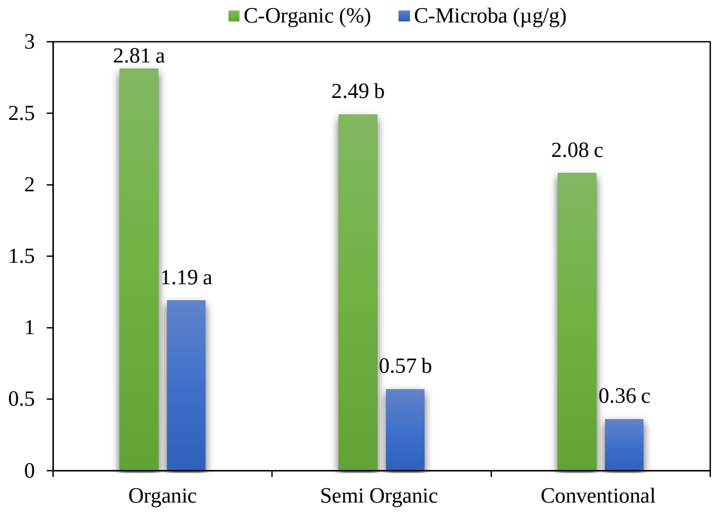

Figure 5. Defining factor of carbon total sequestration

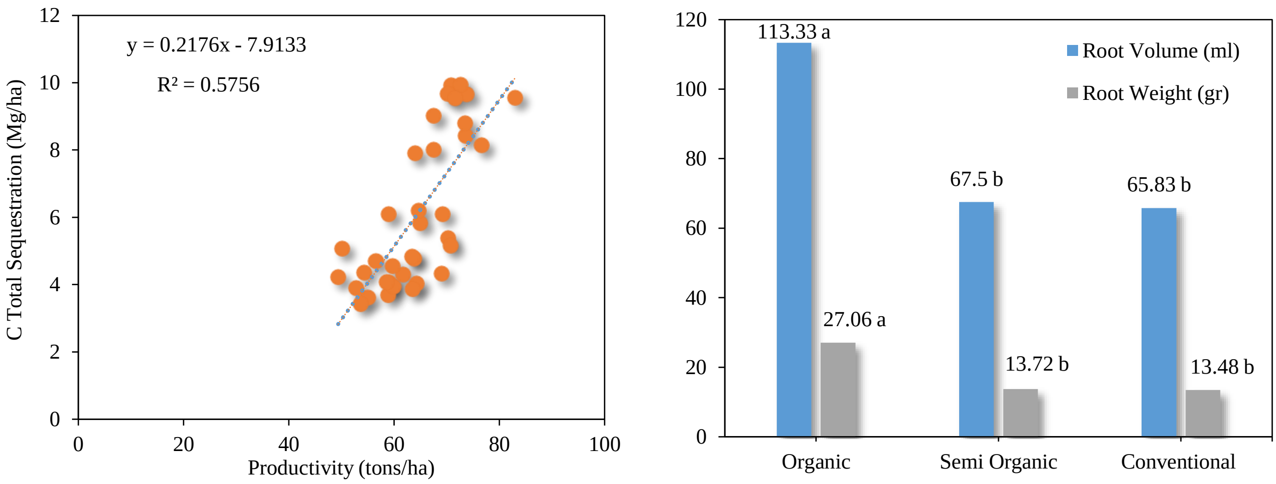

Figure 6. Correlation between C total sequestration and rice productivity

4. DISCUSSION

4.1 Carbon total sequestration

Carbon sequestration (Table 2) was influenced by farming systems (p-value<0.01) and rice field was a significant source of methane. Therefore, management practices such as water management (wetting and drying), fertilizer application, and tillage methods play a crucial role in reducing methane emissions and enhancing carbon sequestration. Meanwhile, rice field cropping affects total carbon sequestration due to tillage. Before and after planting, soil tillage disturbs soil aggregates, causing organic carbon loss during soil mineralization. Different dosages and fertilizer types in each rice field farming method affect total carbon sequestration (Singh et al., 2018). Organic rice field is managed using fertilizer such as compost during tillage, where CH_4 and N_2O emissions decrease by up to 50% compared to rice field with urea fertilizer (conventional rice field) (Gupta et al., 2021).

Carbon total sequestration (Figure 3) in conventional farming has the lowest value compared to other systems. This is because conventional agriculture does not use organic fertilizer, but has the lowest soil organic C content (Table 1) compared to organic and semi-organic rice, namely 2.09%. Furthermore, organic C content in semi-organic farming systems is 2.49%, and the total carbon absorption is higher than in conventional systems. Soil carbon levels are determined by the balance between inputs, such as plant residues and organic matter, and C losses owing to organic matter decomposition. To enhance SOC, carbon must be added to soil and this can be accomplished by improving crop yield to increase crop residue or retaining more residue in cropping systems (Hu et al., 2018). A previous research by Gupta et al. (2021) stated that rice field was the main contributor to CH_4, and flooded soil conditions increased N_2O emissions in large amounts. The results from nitrification activities by microbes contribute to up to 70% of total N_2O emissions. Synthetic N fertilization produces up to 77% N_2O, and the application of synthetic NPK fertilizer produces high total NO emissions. Meanwhile, organic fertilization such as compost, green manure, and plant litter only produces N_2O ranging from 1% to 6% (Bordoloi et al., 2018; Gupta et al., 2021).

Carbon total sequestration in organic rice field farming systems is significantly different and has the highest value compared to semi-organic and conventional rice field farming systems (Figure 3). This is because organic rice field farming can improve soil fertility and increase plant biomass to enhance carbon sequestration. Applying organic fertilizers enhances the physical, biological, and chemical conditions of soil by improving aggregates that facilitate root penetration and provide a place for microorganisms. Therefore, nutrients and organic carbon are efficiently circulated among soil aggregates (Anshori et al., 2016; Wicaksono et al., 2014). Nutrients are used by plants for growth, including their roots. Growing and developing roots can optimally absorb water as photosynthetic material (Hodge, 2014). Increased photosynthesis can increase the results of photosynthesis in the form of acylates translocated to grain and all parts of the plant to increase biomass (Khoerunnisa et al., 2022). The amount of carbon stored in plant biomass shows carbon dioxide (CO_2) absorbed from the atmosphere. The dynamics of climate, such as increasing temperatures in rice field, affect the microbial activity of soil and the number of organic matter decompositions, as well as alter methane production and oxidation balance. High temperatures lead to higher methane emissions, reducing the potential carbon sinks of rice field. According to Keenan et al. (2014), carbon uptake from photosynthetic activity shows an increase and a higher value compared to plant respiration in some areas. In addition, high photosynthesis leads to increased uptake and storage of carbon in plants and soil, balancing methane emissions. Water management conservation measures and soil cover in organic rice field farming systems can prevent organic carbon loss (Meena et al., 2020). High levels of soil and plant organic carbon result in increased total carbon sequestration.

4.2 Rice productivity

Farming systems affected rice yield (p-value<0.01**) due to the provision of organic fertilizer with different doses. Fertilization aims to improve soil conditions by adding nutrients to support plant growth and development (Ekawati et al., 2021). Yield of rice crop in various rice field farming systems was significantly different, with the value of yield in organic rice field farming being higher (8.92 tons/ha) compared to conventional (4.14 tons/ha) and semi-organic (5.22 tons/ha) (Figure 4) systems. Applying organic fertilizer in cow manure can increase nutrients completely and improve soil structure, enhancing the capacity to hold nutrients and water. Meanwhile, cow manure provides soil nitrogen, phosphorus, potassium, and calcium nutrients. Organic fertilizers also increase microbial activity, resulting in the release of nutrients into soil (Tashi and Wangchuk, 2015). Conventional farming systems that continuously apply inorganic fertilizers can degrade soil and reduce yield (Chen et al., 2017).

Field management significantly affected productive tillers and the number of grains per panicle.

The number of productive tillers and grains per panicle of rice crop in organic rice field was higher than in semi-organic and conventional field farming systems. This is consistent with Siavoshi et al. (2011), where organic fertilizers give balanced nutrients, such as micronutrients, to enhance tillers, grains per panicle, and 1,000-grain weight. Micronutrients function as activators of the enzyme systems in the photosynthesis process to increase the conversion of carbon dioxide into carbohydrates (Sherefu and Zewide, 2021).

The pH ranged from 6.47 to 6.89 at the research location, which is slightly acidic to neutral. The increase in pH value in organic rice field farming is due to the application of organic fertilizers and the inundation process. In addition, inundation causes an increase in pH due to a change in oxidation to reduction, where the $Fe(OH)_3$ compound is reduced to $Fe(OH)_2$ and liberates OH^- ions. A neutral pH reaction is an optimum condition for the availability of macronutrients needed for plant growth (Supriyadi et al., 2020).

4.3 Defining factor of carbon total sequestration

Understanding the determinants for formulating recommendations aimed at enhancing carbon sequestration in the Girimarto District is important. There are two determinants of carbon sequestration (Table 4), namely soil C-organic and microbial C-biomass. Rice field farming systems significantly affected both determinants (p-value<0.01**) due to the application of different types and doses of fertilizers. Fertilization activities aim to add macro and micronutrients needed by plants (Hayati et al., 2012).

The use of inorganic fertilizers offers a substantial quantity of specific nutrients. Due to their water-solubility, these fertilizers facilitate rapid absorption. However, prolonged and consistent use leads to soil degradation since the nutrients are prone to be fixed and leached, resulting in a gradual reduction in fertility. Meanwhile, applying organic fertilizers improves the physical, chemical, and biological conditions of soil (Nurmalasari et al., 2021). Organic fertilizers improve soil structure and have a more balanced macro and micronutrient content, resulting in increased soil fertility but require a larger input volume (Bhatt et al., 2019).

The lowest C-organic content in conventional rice field was 2.08%, as shown in Figure 5. The low level was due to the continuous application of inorganic without being balanced by the application of organic fertilizers. The reduction in soil fertility inhibits the regeneration of crop, leading to the unsustainability of agricultural practices (Agegnehu et al., 2017). Low levels of C-organic matter in field will affect the physical, chemical, and biological properties of soil, inhibiting plant growth and production (Rina, 2020). Low organic matter causes high soil density, making it difficult for roots to penetrate soil and causing microorganisms to decline due to the lack of organic matter (Costantini and Mocali, 2022). Carbon sequestration in conventional rice field farming systems was lowest at 56.30 Mg/ha. The lower soil C-organic content resulted in a decrease in soil C-stock.

Soil microbial C biomass plays an important role in fertility acting as an agent of biochemical processes and nutrient cycling, determining soil quality and yield (Brar et al., 2015). Decreased microbial C biomass reduces the rate of nutrient cycling in soil. Therefore, nutrient uptake by plant roots is disrupted to inhibit photosynthesis. Conventional rice field farming had the lowest microbial C biomass at 0.36 μg/g. There was a significant positive correlation between microbial biomass C and C-organic (r=0.837**). Micro-organisms use C-organic as a food source, and with a decrease in this variable also inhibit the activity.

4.4 Correlation of C total sequestration with rice yield

Statistical test results show that carbon sequestration has a very significant positive correlation with rice yield (r=0.759**). Based on Figure 6, organic rice field farming has the highest carbon sequestration and rice yield of 72.49 Mg/ha and 8.90 tons/ha. Photosynthesis is the process of converting carbon dioxide (CO_2) from the atmosphere and water (H_2O) from soil and water vapor into oxygen (O_2) and glucose ($C_6H_{12}O_6$) (Nagy et al., 2010). This process increases the need for photosynthetic materials by absorbing carbon dioxide (Daud et al., 2021). The increased photosynthesis followed by nutrient uptake by plants can improve products in glucose, which is translocated and accumulated into the grain (Hidayati et al., 2016).

In conventional rice field farming, the total carbon sequestration value and rice yield are 56.30 Mg/ha and 4.14 tons/ha. The lower carbon sequestration result, the lower rice yield. This is because the use of inorganic fertilizers causes soil C-organic to be lower than in other management systems. The low soil C-organic makes soil C-stock also low. High doses of chemical fertilizers containing certain nutrients do not meet the needs of others, specifically micro-nutrients required by plants. The role of micronutrients in plants functions for protein synthesis, chlorophyll formation, and enzyme activators in the photosynthesis process. Therefore, the lack of micronutrients inhibits plant metabolism, such as photosynthesis, decreasing the absorption of CO_2 from the atmosphere.

Root weight and volume play an important role in plant carbon content. In the research location, conventional and semi-organic rice field used the IR 64 rice variety, while organic rice field used the Menthik Wangi variety. Root characteristics play an important role in dealing with drought stress conditions. This means that IR 64 rice is more sensitive to drought stress than Menthik Wangi rice. In conventional rice field farming systems, the variety has a lower root weight than the Menthik Wangi rice (Maisura et al., 2017). In contrast, Menthik Wangi varieties are better able to absorb water than IR 64 because the roots have better growth and elongation to reach deeper layers. In organic management systems, the variety has higher root weight and volume than conventional rice field, resulting in increased carbon sequestration. The observation results (Table 3) show that Menthik Wangi has a higher number of tillers, grain weight per panicle, and total grain number per panicle than the IR 64 variety.

5. CONCLUSION

In conclusion, farming systems was reported to influence carbon total sequestration due to differences in applying organic fertilizers. Organic rice field had higher carbon total sequestration than semi-organic and conventional rice field systems, which amounted to 72.49 Mg/ha. These results showed that carbon total sequestration significantly correlated with rice yield. Furthermore, organic rice field farming systems had the highest rice yield of 8.92 tons/ha. Soil characteristics that determined the total carbon sequestration in soil were soil C-organic, microbial biomass C, root volume, and root weight. Based on the results, the most feasible alternative to be implemented was converting conventional rice field to organic with a gradual reduction in the application of chemical fertilizers according to the conservation stage. Improvement could be given by using other variations of organic fertilizers to increase C-organic levels and total carbon sequestration, as well as reduce carbon dioxides in the atmosphere. The long-term impact of implementing this recommendation was an increase in carbon storage in soil and a contribution to the preservation of sustainable agriculture. This was due to the non-use of chemicals in agricultural businesses, as well as increased soil fertility and quality to increase rice productivity. Future research was also expected to compare carbon sequestration with the calculation of emissions released by agricultural businesses in organic, semi-organic, and conventional rice field.

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