Performance of SRI rice growth on soil accustomed to conventional cultivation methods

by Afik Hardanto

Performance of SRI rice growth on soil accustomed to conventional cultivation methods

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Abstract: The aims of this research are to compare actual evapotranspiration among SRI Paddy Cultivation with different treatment of fertilizer and soil amendment, and to examine SRI growth with fertilizer and soil amendment treatment in soil accustomed to conventional cultivation method. This research was conducted at the screen house of Agricultural Technology Laboratory of Universitas Jenderal Soedirman, Purwokerto, during December 2016 until April 2017. The data were collected from four experiment pots with different treatments. Soil were taken from the paddy field that usually practice conventional method (flooded irrigation, chemical fertilizer). First pot were added with organic fertilizer with dose of 100 ton ha^{-1} (SO). Second pot were added with organic fertilizer with dose of 100 ton ha^{-1} and biochar application as much as 50 kg ha^{-1} (SOA). Third pot were added organic fertilizer in amount of 100 ton ha^{-1} and chemical fertilizer during vegetative phase (SOK). The fourth pot were purely soil with chemical fertilizer (SK). Result showed actual evapotranspiration per season were higher in SOK and SK, rather than in SO and SOA. Phase per phase of crop shown sharp difference of crop coefficient (Kc) among the four treatments. The Kc were SO (0.47 - 0.57), SOA (0.44 - 0.52), and SOK (0.64-0.96), and SK (0.54-1.09). SOK and SK shows higher evapotranspiration and better growth compared to SO and SOA. SO and SOA simply recognized as 'fully organic'. The converting cultivation method from fully chemical fertilizer to fully organic fertilizer was the main hypothesis of this result.

Keywords: System of Rice Intensification (SRI), conventional cultivation method, organic fertilizer

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1 Introduction

Comparison between growing rice using conventional practice and SRI practice is widely reported. One example is mentioned that remarkable result in root number, number of effective tillers per hill, amount of days to flowering, and harvest index. It is also reported that pest and disease were minimized, stronger plant stability (due to intensive root growth) and shorter growth period However, this report showed unsignificant different from conventional practice in grain yields (Chapagain et al., 2011). Physiological aspect of SRI plant and conventional plant is reported from the point of view of evapotranspiration and photosynthesis occurrence. Higher yield in SRI is said to be influenced by higher photosynthetic rate that occur due to chlorophyl content in SRI leaves (Hidayati et al., 2016). In the vegetative stages, flowering, grain-filling phase, and mature grain stage, the photosynthetic rate marked as higher in SRI plants than conventional plants. This physiological parameters (evapotranspiration and photosynthetic rate)

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were said to be a key factor that make difference between both practices.

Rice production in SRI method were contributed by surrounding environment above the soil surface and below the surface (Hidayati et al., 2016). The effectiveness of SRI method to increase yield was reported by over 50 countries (Katambara et al., 2013) It also decrease water use and increase water use efficiency in paddy field (Mati and Nyamai, 2012; Ndiiri et al., 2012) One of the factor influencing high yield is the microbe activity. During alternate wet and drying irrigation, aerobic condition occurs and create good condition for microbe activity (Ardiansyah et al., 2012, 2016; Case et al., 2012)

The widespread of SRI practice in Indonesia is moving forward. There were not so much change in the amount of area under SRI practice since 2008 (Sato et al., 2011). It is proved in many region in Indonesia, that SRI practice shows higher yield and consequently higher income (Takahashi and Barrett, 2014). However, the difficulty on land and water management during crop practice caused SRI adopter quit the practice (Arsil et al., 2018).

Basically, decision on converting to SRI practice, especially SRI-organic is occurring due to several reason. Firstly, to reduce water use and increase efficiency. Farmers in the areas with technical irrigation might want to try SRI method, Secondly, due to movement of organic farming that increasing in developing countries. The movement of organic farming is increasing in developing countries. SRI organic as one of the options is good for the environment, however it still prone to water scarcity. Farmers conversion to organic farming in European Union, for example, supported by government policy in early 1990 (Darnhofer et al., 2011)Some farmer converted their practice into organic farming by issues related to technical aspects of agricultural production and farm structure, and personal values of practicing environmentally friendly (Darnhofer et al., 2005). Some farmers that received 'enlightment' in ecological issue of rice field tried SRI to save water. Furthermore, farmers adopt organic SRI method to save cost of pesticide and mineral fertilizer. There are personal motives and farming related motives in converting from conventional farming to organic farming (Lehmann and Kleber, 2015; Padel, 2001). Organic farming has become an important issue that not only farmers concern on the sustainability of their soil, but also government, health practitioners, environmental activist, etc do the campaign on it.

Converting paddy field from conventional cultivation method to organic SRI method is now quite common for some farmers. Some of them realize that organic matter in soil is the important part for soil (Schmidt et al., 2011), that should be increase during conversion. Several studies have reported that plant growth responses are largest when charcoal and fertilizers are combined, suggesting a synergistic relationship (Steiner et al., 2007). It was also found that pore space in soil is needed, more than organic matters (manure, etc) and other nutrient treatments (Hansen, 1996). SRI has better way to increase soil aeration that occur through alternate wetting and drying irrigation. In water filled pore space (WFP) between 30% and 70%, microbial activity increase (due to increase in aeration) (Linn and Doran, 1984), causing better soil nutrient availability. The trends of converting conventional practice into organic practice need to be address attention in the soil health point of view. Therefore, the aim of this research, are:

(1) To examine soil nutrient status during crop growth on SRI practice using soil accustomed to conventional practice

(2) To compare actual Evapotranspiration among SRI Paddy Cultivation with different treatment of fertilizer and soil amendment

(3) To examine SRI growth with fertilizer and soil amendment treatment in soil accustomed to conventional cultivation method

2 Material and methods

The experiment was done in small screenhouse with 300 cm length, 165 cm width and 200 cm height. The screenhouse were equipped with humidity sensor, temperature sensor, pyranometer and anemometer. Four pots (Figure 1), 30 cm in diameter and 30 cm in height, assembled with percolation-tap in the bottom. The bottom of the pot is given 9 cm high gravel for preventing clogging in the bottom tap (Figure 2). All pots are placed on a holder with a dimension of 90 cm long, 90 cm wide and 30 cm high. Inside each pot are placed two water content sensors and two temperature sensors with a depth of 5 cm (above) and 15 cm (bottom). These sensors are connected to the data logger.

Prior and during crop growth, treatments were given to each plot. The name of the treatments were SO, the one with organic fertilizer application with the dose of 100 ton ha^{-1} before planting. Another treatment was SOA, which is the pot with organic fertilizer and biochar application in the dose of 100 ton ha^{-1} and 50 kg ha^{-1} each. Another treatment, SOK, is the one with organic fertilizer with the dose of 100 kg ha^{-1} and chemical fertilizer during crop growth. The other, SK, has no organic fertilizer application before planting, but given chemical fertilizer during vegetative phase. Detail of treatment given in Table 1.

Table 1 Experimental treatments and fertilizer dosage

Treatment	Fertilizer Dosage	Time of Application
SO	Petrorganik (100 ton ha^{-1})	Before Transplanting
SOA	Petrorganik (100 ton ha^{-1})	Before Transplanting
	Biochar (50 kg ha^{-1})	Before Transplanting
SOK	Petrorganik (100 ton ha^{-1})	Before Transplanting
	Urea (200 kg ha^{-1})	7-15 HST (100 kg ha^{-1}), 25-30 HST (50 kg ha^{-1}) dan 40–45 HST (50 kg ha^{-1})
	SP-36 (50 kg ha^{-1})	7-15 DAT
	Phoska (100 kg ha^{-1})	25-30 DAT
	KCl (50 kg ha^{-1})	40-45 DAT
SK	Urea(200 kg ha^{-1})	7-15 HST (100 kg ha^{-1}), 25-30 HST (50 kg ha^{-1}) dan 40–45 HST (50 kg ha^{-1})
	SP-36 (50 kg ha^{-1})	7-15 DAT
	Phoska (100 kg ha^{-1})	25-30 DAT
	KCl (50 kg ha^{-1})	40-45 DAT

During crop growth, soil sample were taken, and growth variables were measured. Soil sampling schedule were given in Table 2.

Table 2 Soil sampling schedule

Sampling Time	Growth Phase
Before Treatment	-
10 DAT	Early Stage
57 DAT	Vegetatif Stage
85 DAT	Maturation
120 DAT	Harvesting

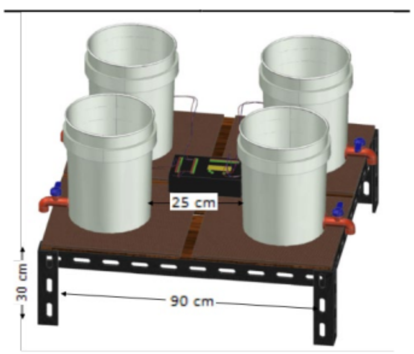

Figure 1 Pot experiment setting

The variables observed and measured in this study are: soil organic matter, crop evapotranspiration, and growth parameters (plant height, no. of leaves, and no. of tillers). To obtain soil organic matter, soil sampling was carried out four times during crop growth period. Sampling time were done before treatment, at the beginning of planting (10 days after transplanting/DAT), at the time of plant development level (57 DAT), during panicle initiation (85 DAT), and during harvest (120 DAT).

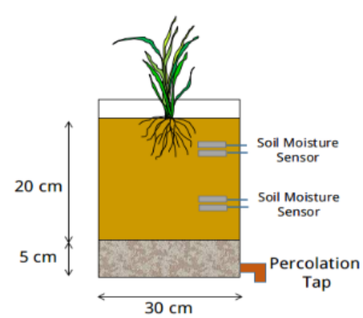

Figure 2 figure title

3 Result and discussion

3.1 Soil organic content

Figure 3 shows that the overall value for organic-C content is low. This is caused by the soil used obtained from rice fields which generally use mineral fertilizer and low input of organic fertilizer. Initial soil organic content in soil is small (1.7%). Activity of soil organisms that use carbon compounds for the formation of its body cells and some are released in the form of CO_2 during the decomposition process so that organic-C is reduced. Figure 3 is also shows that the average of organic-C dynamics shows increase during the vegetative period and a decrease in the formation of grains and maturation. The increase in organic-C value in the vegetative period is caused by the activity of soil microorganisms.

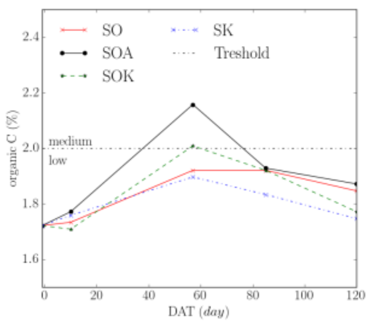

Figure 1 Organic-C content during crop growth

Organic-C reduction occurs in the formation of grains and ripening. This phase required more nutrients for forming and filling grains. In this phase, more organic-C will be modified to be simpler compounds by microorganisms. As soon as the organic matter is overhauled, it will require more organic-C for the reshuffle process. The decrease of organic-C microorganism decomposition. Granting charcoal and organic fertilizer can increase the most effective organic-C value. Carbon is a food source for soil microorganisms. Therefore, with the addition of charcoal in the soil, it will be more available and indirectly will add microorganisms in the soil. Consequently, organic materials will be more decomposed and mineral becomes more available (Deenik et al., 2010).

In this research, SO (Organic SRI) and SK (Chemical SRI) treatments have the lowest organic-C values. The low value of organic-C content is caused by the input of nutrients in the paddy field only in the form of mineral fertilizer without being balanced with organic fertilizer.

3.2 Crop evapotranspiration

Actual evapotranspiration higher in SOK and SK (373 mm and 406 mm per season, respectively), rather than in SO and SOA (203 mm and 223 mm per season, respectively) (Figure 4). The portion of evaporation and transpiration is given by (Ashktorab et al., 1994) that E/ET lies between 0.28 and 0.05 at crop cover 43% and 85% respectively. It means, during phase of growth development until harvesting, amount of transpiration increase, showing increase in leaf area. In the case of the experiment, SOK and SK showing higher seasonal transpiration of 317 mm and 345 mm (using value of E/ET of 0.15). Crop coefficient calculated shows different value between SO-SOA and SK-SOK. SO and SOA has quite similar result compared to SK and SOK (Figure 5). However, both pattern are smaller than crop coefficient introduced by FAO.

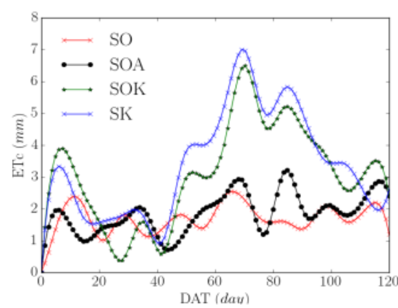

Figure 2 Crop evapotranspiration pattern

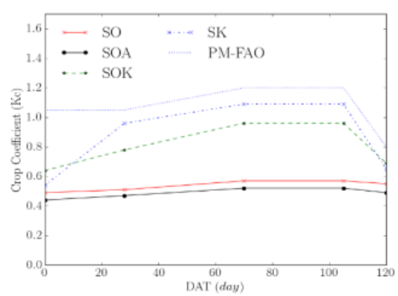

Figure 3 Crop coefficient

3.3 Growth variables

Observations were also made on plant height, number of leaves, and number of tillers. Plant height, number of leaves, and number of tillers are growth parameters that examine in the experiment. Figure 6 shows that growth variable clustered into two groups. SO and SOA in one group and SOK and SK in the other group. For all three parameters, SOK and SK show remarkable difference on growth, compared to SO and SOA. The result strengthens the hypothesis that the soil with chemical fertilizer input give better result. In other words, crop was not ready for purely organic practice in the beginning of conversion.

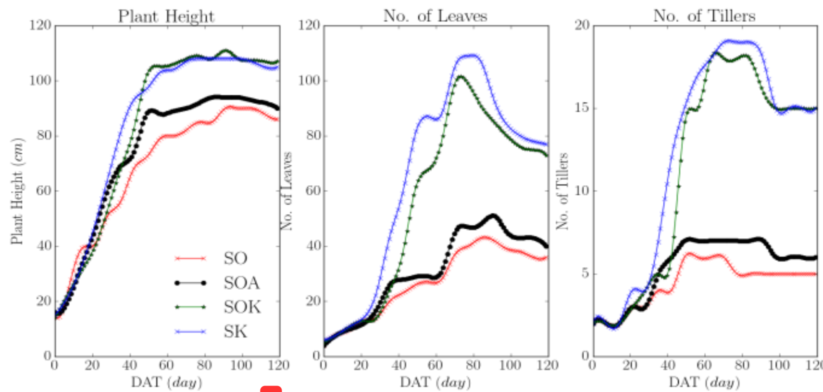

Figure 4 Plant height, No of leaves, and No. of tillers

SRI method shows observable difference on plant organs development, above (straw) and below soil surface (root) compared to Non-SRI method. Water management of alternate wetting and drying contributed to this result (Ardiansyah et al., 2018).

Table 3 Yield in each treatment

Treatments	Amount of Grain			Dry Weight			TOTAL
	Empty (g)	Filled Out (g)	Total (g)	Empty (g)	Filled Out (g)	Total (g)	(ton ha^{-1})
SO	495	360	855	1.91	7.56	9.47	1.04
SOA	254	485	739	1.27	9.83	11.01	1.21
SOK	677	451	1128	1.64	10.85	12.49	1.37
SK	1090	582	1672	3.31	9.57	12.88	1.41

The productivity of Ciherang variety cultivied with SRI method from previos studies that have been done before, has a high enough result (Subardja et al., 2016). For example, the research using the SRI method of Ciherang variety in the saline soil and produced 8.2 tons ha^{-1}. While the research conducted by (Wangiyana and Laiwan, 2018) using Ciherang variety using the SRI method to produce harvested dry rice of 9.4 tons ha^{-1}. The result of this research can be seen in Table 3 which shows a very low yield. The average productivity generated when compared to the reference only resulted in an average of 16% with failure reaching 84%. The lack of productivity is thought to be due to 60 HST rice plants began to develop leaf blight disease. The plants affected by leaf blight disease could reduce or fail its grain filling. In these conditions the yield loss reaches 50%-70%.

3.4 General discussion

The related issue on converting from conventional practice of paddy farming to organic farming is the expected yield. Reports showed in the converting process, rice yield from conventional field are still higher (about 23%) compared to organic field during first five year of converting process (Hokazono and Hayashi, 2012). The cause of the lower yield is reportedly the result of lower nutrient availability, even though there is an improvement is soil quality (Ceesay et al., 2011; Dixit and Gupta, 2000; Zhang et al., 2012). However, it has been also said that farmer's experience can make yield better, even in the first year of the conversion process (Martini et al., 2004).

Comparing conventional practice and organic practice requires various case and year-to-year field experimental observation (Mäder et al., 2002; Pimentel et al., 2005; Reganold et al., 2001). The distinguishable improvement could be observed after three to five years (Drinkwater et al., 1995; Martini et al., 2004). Conversion from conventional practice to organic practice will stabilize with the higher nutrition after 4 to 8 years after establishment. During the conversion, common practice such as crop rotation is applied as well as give higher input of organic fertilizer or manure (Clark et al., 1998)

What happened in the result of the experiment also showed that the quality of the soil taken from area that accustomed to common practice is didn't meet the requirement of the plant to grow maximal. Amount of evapotranspiration, and growth variables are lower in the soil that has purely organic treatments. Even though the soil has higher organic-C, the nutrition dynamic is not fulfilling the good process of mineralization. Availability of mineral nutrition in soil cannot be separated from the role of microorganism. It decomposes organic matter to provide plant nutrition pool. Thus, availability of mineral nutrition varies depending on the activity of decomposition (Ardiansyah et al., 2012; Renny and Supriyanto, 2018)

In paddy cultivation using SRI, the key factor for higher growth lies on the water management. Alternate wetting and drying irrigation that become main characteristic of SRI forming certain root traits, especially in nodal root number, and dry weight at 22 and 30 days after transplanting. The root traits are strongly related to increasing productivity (Sandhu et al., 2017). In this research, the alternating soil condition from wet (anaerob) and dry (aerob) creates good environment for nitrogen supply. Nutrition, radiation, and water are responsible for total biomass of the crop (Ardiansyah et al., 2018). The nitrogen uptake, key for biomass growth, is depend on the availability of nitrogen in the soil and the evapotranspiration rate. The higher evapotranspiration rate, the higher water uptake and thus nitrogen uptake (Ardiansyah et al., 2016). The plant biomass development concept (Ardiansyah et al., 2018) put the biomass development as the result of higher nutrient uptake (higher evapotranspiration) and good radiation efficiency (higher LAI).

4 Conclusion

The dynamic of total organic-C during the rice planting period in the SRI method is indicated by its difference on each growth phase. The maximum level of organic-C during crop growth lies on the treatments of combination of organic and inorganic fertilizers with levels of 2.2% (SOA) and 2.0% (SOK). They are relatively higher compared to the treatment of using only organic or unaorganic without combination treatment. Both lies in the level of 1.9% (SO) and 1.9% (SK).

Availability of unorganic substance may be the cause of the high yield in SOK and SK. Chemical fertilizer provided the inorganic substance on both treatments. Evapotranspiration is higher in SK and SOK, where additional available mineral exist. It's allegedly related to the leaf growth (and further transpiring surface) that shows higher in both treatments.

To conclude the result of the research, it is clearly shows that converting common practice of paddy cultivation into organic SRI method cannot be done immediately. The soil needs to be conditioned to provide adequate nutrient for paddy to grow. Thus, mineral fertilizer should be added into the soil in the transition to SRI-Organic method.

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