AJAB

Original Article

Effect of compost application on organic Fe composition in the soil, Fe uptake, and rice yield at Inceptisols in Meko, Indonesia

Ita Mowidu*, **Kamelia Dwi Jayanti, Yulindatanari Ridwan, Dolfie Tinggogoy**
Faculty of Agriculture, Sintuwu Maroso University, Poso, Indonesia

Received:
March 10, 2019
Accepted:
October 17, 2019
Published:
December 05, 2019

*Corresponding author email:
itamowidu@unsimar.ac.id

Abstract

Iron can be in form of crystalline, amorphous and organic in the soil. The objective of this research was to study the effect of compost application on soil organic Fe composition, Fe uptake and the plant content as well as rice yield at Inceptisol, in Meko. The treatment used was the application of 5 t ha^{-1} compost that was mixture of rice straw and cocoa pods with various composition. The treatments were K0: without compost, K1: 100% straw compost, K2: 75% straw compost + 25% cocoa peel (CP), K3: 50% straw compost + 50% CP, K4: 25% straw compost +75% CP, and K5: 100% CP compost. Observations regarding Fe-p (Iron-organic) were recorded using selective solvents 0.1 M Na-pyrophosphate, likewise, Fe uptake; and rice yield were also estimated. The results showed that the application of compost had a significant effect on Fe-p at 40 and 70 days after planting (DAP), the Fe content in rice at 14, 40, 75 days and harvest time, as well as on Fe uptake at 40, 75 DAP and harvest time; However, it had no significant impact on grain weight per clump. The peak of Fe-p formation occurred at 40 DAP because of high Fe reduction. Rice Fe levels > 500 mg kg^{-1} during observation followed by Fe uptake which continued to increase with increasing plant age. The yield of rice increased by 7.90-27.30% compared to control and 2.60-21.04% compared to the average yield according to the description of Inpari-1 variety.

Keywords: Compost, Fe content, Fe uptake, Organic Fe

How to cite this:
Mowidu I, Jayanti KD, Ridwan Y and Tinggogoy D, 2019. Effect of compost application on organic Fe composition in the soil, Fe uptake, and rice yield at Inceptisols in Meko, Indonesia. Asian J. Agric. Biol. Special Issue: 155-159.

Introduction

Iron is one of the major components (fourth biggest) of lithosphere. Iron content on lithosphere was around 5.1% (Lindsay, 1979) or varied from 200 ppm to 100,000 ppm (Tisdale & Nelson, 1975) or 0.7% to55% (Havlin et al., 2005: Havlin et al., 2014), and according to Goldschmidt (1958), most soil had Fe around 50,000 ppm. Iron can exist in the soil in crystalline form, amorphous form, or in complex form with soil organic materials. Turhadi et al. (2018) stated that iron toxicity is one of a limiting factor for rice production.

Paddy fields in Poso district generally had low fertility and high iron content. Mowidu et al. (2015) reported that the total Fe content of paddy fields around Lake Poso was 1.16% - 2.26% with very high levels. Soils with high Fe content in logged conditions would dissolve iron as Fe^{2+}. The solubility could reach 6,000-8,000 ppm (Patrick & Reddy, 1978), whereas the concentration of Fe^{2+} (1.000-2.000 ppm) could affect rice production (Asch et al., 2005).

Special management is needed for soils with high Fe content to control the solubility of Fe and to prevent it to reach the poisonous level. Iron stress in plants could be reduced by regulating the rhizosphere, so as not to be too reductive (Ma'as, 2011) through intermittent water system (logged and dried, one week each) with the planting time was 14 days after being water logged (Khairullah, 2012), and providing organic fertilizer with ratio of C / N <25 so that the redox potential did not decrease to <100 mV (Ma'as, 2011).

Syafruddin (2012) found that with the application of 5.0 t ha^{-1} of *in situ* rice straw compost to Inceptisol in Morowali could significantly reduce available Fe and plant uptake of Fe. The results of Khairullah's research (2012) on acid sulphate tidal swamp land showed that the application of ameliorant (5 t ha^{-1} straw + 2.5 t ha^{-1}chinese water chestnut or *Eleocharis dulcis*) significantly decreased the concentration of soil Fe, Fe content in roots, stems, leaves and grain. Fahmi (2008) with an experiment using 5 t ha^{-1} straw compost on acid sulphate soil obtained a significant increase in Fe^{2+} concentration in the soil. Yusuf's research (2010) using rice straw and Chinese water chestnut at various levels of decomposition in acid sulphate soils showed that application of organic matter with various decomposition levels significantly increased Fe^{2+} concentrations at 2-4 weeks after planting (WAP), and decreased Fe in leaves, and slightly increased Fe uptake at the root. The objective of this research was to study the effect of compost application to organic Fe composition in the soil, Fe uptake and level in the plant as well as rice yield at Inceptisol in Meko.

Material and Methods

The experiment was conducted in glasshouse using Inceptisol Meko soil that had been air-dried and sifted using 2 mm sieve. The treatments used were application of 5 t ha^{-1} compost mixture with various composition between rice straw and cacao peel. The treatments were K0: without compost, K1: 100% straw compost, K2: 75% straw compost + 25% cocoa peel (CP), K3: 50% straw compost + 50% CP, K4: 25% straw compost +75% CP, and K5: 100% CP compost. The experimental units were arranged using in Completely Randomized Design pattern with three replications. Soil was mixed homogenously with 5 t ha^{-1}compost in accordance with treatments at 2 weeks before planting. Basic fertilizers were given that consisted of 90 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1}, dan 60 kg K_2O ha^{-1}. The plant material used was Inpari-1 rice seedling having 15 days of age after planting, 3 seedlings per clump.

The observation was conducted on organic Fe (Fe-p) of air-dried soil samples, rice Fe content and uptake at 14, 40, 70, and 75 days after planting (DAP) and at harvest time, and rice yield. Soil organic Fe was extracted using selective solubility method with 0.1 M Na-pyrophosphate as extractor and measured using AAS. Soil and plant tissue analysis were conducted in Soil Research Laboratory, Bogor.

Procedure for determining organic Fe: weighed 1000 g of fine soil sample (less than 0.5 mm in diameter), 100 ml of 0.1 M Na-pyrophosphate extractor was added and stirred for 16 hours. Mixture than centrifuged to get supernatant. The supernatant then diluted five times with ion-free water. Fe in diluted solution was measured using SSA using standard series as comparison (Eviati and Sulaeman, 2009).

Results and Discussion

Organic Fe

Compost application significantly affected soil organic Fe at 40 and 70 DAP. The dynamics of Fe-p changes as result of compost application was shown in Figure 1.

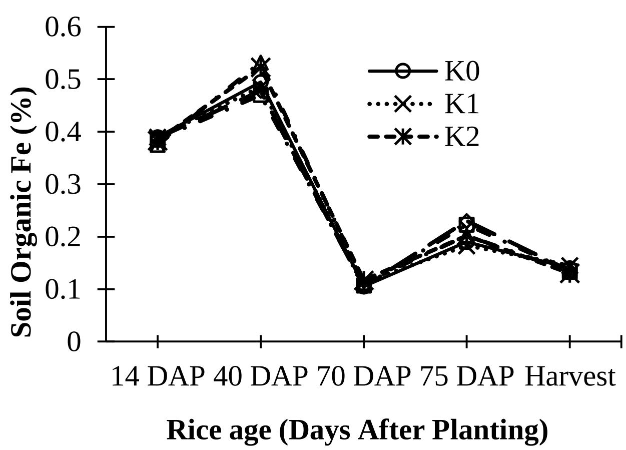
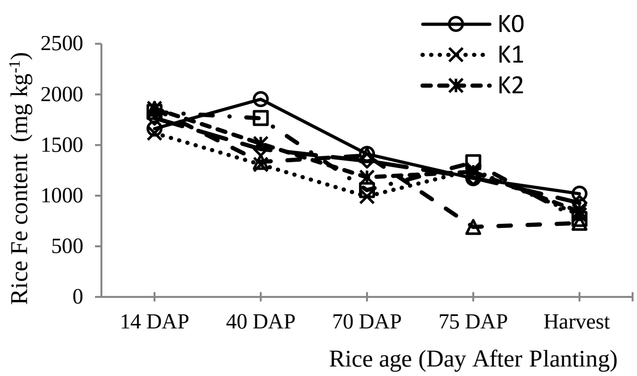


Figure-1: Soil Fe-organic dynamics as effect of compost application in Inceptisol Meko

(K0: without compost, K1: 100% straw compost, K2: 75% straw compost + 25% cocoa peel (CP), K3: 50% straw compost + 50% CP, K4: 25% straw compost +75% CP, and K5: 100% CP compost)

The peak of Fe-p formation was at 40 DAP (Figure 1). This peak was related to high C-organic content and high reduction rate in which Fe^{3+} was reduced into Fe^{2+} being more soluble. The released Fe^{2+} formed a complex with organic anions in the soil. According to Ponnamperuma et al. (1967), the amount of extracted Fe increased with increasing amounts of decomposed organic matter, magnified by low initial soil pH and continuous addition of organic matter (Becker and Ash, 2005). The initial soil pH in this study was 5.3. Low soil pH increased the solubility of Fe. Furthermore Dada and Aminu (2013) stated that the application of compost to toxic Fe soil was a good agronomic practice that could be used to reduce the damaging effects of dissolved Fe^{2+} in paddy field environment. Fe oxide has high reactivity to organic matter so that Fe oxide is partially or completely covered by organic material in nature (Kaiser and Zech, 2000 *cit.* Eusterhues, 2014). Olumo et al. (1973) found that all dissolved Fe in several water-logged soils was in complex with organic matter.

Fe content and uptake



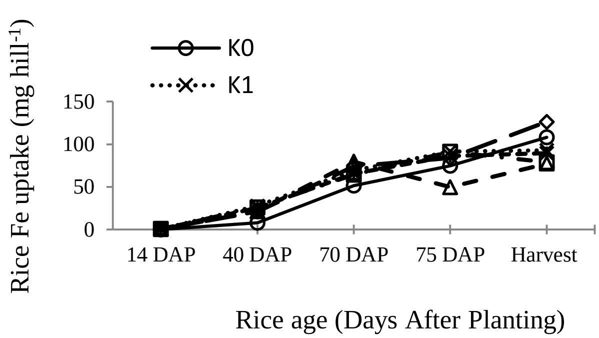


Figure-2: Dynamics of rice Fe content and uptake as effect of compost application in Inceptisol Meko (K0: without compost, K1: 100% straw compost, K2: 75% straw compost + 25% cocoa peel (CP), K3: 50% straw compost + 50% CP, K4: 25% straw compost +75% CP, and K5: 100% CP compost)

Compost application significantly affected rice Fe content at 14, 40 and 75 DAP and at harvest time, as well as Fe uptake at 40, 75 DAP, and harvest time. The dynamics of rice Fe content and uptake was shown in Figure 2.

Figure 2 showed that rice Fe content was high throughout observation period and tended to decrease as plant aged, while Fe uptake continuously increased as plant aged. Fe content in plant tissue was > 500 mg kg^{-1}. While according to Jones (2003), Fe content of > 300 mg kg^{-1} in rice tissue at seedling stage was the critical excess point and toxic to plant. Doberman and Fairhurst (2000) stated that Fe content that could be still tolerated by rice was > 300 – 500 mg kg^{-1}. Fe uptake still increased up to harvest time. Fe uptake increased as plant dry weight increased. Jahan et al. (2013) stated that plant accumulates higher Fe at reproductive stage compared to vegetative stage.

Rice yield

Compost application did not significantly affect grain weight per clump. However, compost application increased 7.84 – 27.36% grain weight per clump compared to control. Converted to hectare unit, compost application gave increase of 0.55 – 1.9 t ha^{-1} to rice yield (7.90 – 27.30%). Grain weight and rice yield per hectare was shown in following Table 1.

Kumar et al. (2014) found that application of 125% from recommended dosage of fertilizer +5 t ha^{-1}vermicompost significantly increased number of panicles m^{-2}, panicle length, panicle weight, weight of 1000 grains and rice yield. Murthy et al. (2010) found that the highest rice yield was with application of recommended dosage of fertilizer +7.5 t ha^{-1}*chromolaena* compost. In this research, fertilizer which was given as basic fertilizer was less than recommended dosage. It was suspected that this was the reason why compost application did not significantly affect yield. According to Suprihatno et al. (2009), average yield of Inpari-2 variety was 7.23 t ha^{-1}. If the results obtained from this research were compared to average yield according variety description, compost application improved yield around 2.60 – 21.04%.

Table-1: Grain weight per clump and rice yield per hectare

Treatment	Grain weight per clump (g)	Improvement from control (%)	Yield (t ha^{-1})	Improvement from control (%)
K0	43.50	-	6.96	-
K1	52.55	20.80	8.41	20.83
K2	50.10	15.17	8.02	15.23
K3	47.56	9.33	7.61	9.34
K4	46.91	7.84	7.51	7.90
K5	55.40	27.36	8.86	27.30

Conclusion

Compost application significantly affected Fe-p at 40 and 70 Day After Planting (DAP), Fe content at 14, 40, and 75 DAP and harvest time, as well as Fe uptake at 40, 75 DAP and harvest time. Compost application did not significantly affect grain weight per clump. The peak of Fe-p formation was 40 DAP where Fe reduction was the highest. Rice Fe content was > 500 mg kg^{-1} throughout the observation, followed by increasing Fe uptake as plant aged. The rice yield increased by 7.90-27.30% compared to control and 2.60-21.04% compared to the average yield according to the description of varieties of Inpari-1.

Contribution of Authors

Mowidu I: Conceived idea, designed research methodology, data collection and manuscript write up
Jayanti KD: Data collection and manuscript write up
Ridwan Y: Data analysis and literature search
Tinggogoy D: Data analysis and literature search

Disclaimer: None.
Conflict of Interest: None.
Source of Funding: None.

References

Asch F, Becker M and Kpongor DS, 2005. A quick and efficient screen for tolerance to iron toxicity in in lowland rice. J. Plant. Nutr. Soil. Sci. 168:764-773.

Becker M and Asch F, 2005. Iron toxicity in rice: Conditions and management concepts. J. Plant. Nutr. Soil. Sci. 168: 558 – 573.

Dada OA and Aminu JA, 2013. The performance of lowland rice (*Oryza sativa* L.) cultivar on iron toxic soil augmented with compost. J. Stress. Physiol. Biochem. 9(4):207-218.

Eusterhues K, Hädrich A, Neldhardt J, Küsel K, Keller TF, Jandt KD and Totsche KU, 2014. Reduction of ferrihydrite with adsorbed and coprecipitated organic matter: Microbial reduction by *Geobacter bremensis* vs abiotic reduction by Na-dithionite. Biogeosci. 11:4953-4966.

Fahmi A, 2008. Pengaruh aplikasi bahan organik jerami padi terhadap kehilangan fosfat dan ferro di tanah sulfat masam [The effect of organic rice straw application on phosphate and ferro loss in acid sulphate soil]. Thesis. Post Graduated Program Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, Indonesia.

Goldschmidt VM, 1958. Geochemistry, Oxford University Press, London.

Havlin JL, Beaton JD, Nelson SL and Nelson WL, 2005. Soil fertility and fertilizers: An introduction to nutrient management. Pearson Prentice Hall, New Jersey, USA.

Jahan MS, Khanif YM, Syed Omar SR and Sinniah OR, 2013. Effect of low water input in rice yield: Fe and Mn bioavailability in soil. Pertanika. J. Trop. Agric. Sci. 36(1):27-34.

Jones Jr JB, 2003. Agronomic handbook: management of crops, soils, and their fertility, CRC Press, Boca Raton.

Khairullah I, 2012. Gatra fisiologis dan agronomis pengaruh pengendalian keracunan Besi padi sawah di lahan rawa pasang surut sulfat masam [Physiological and agronomic aspect of iron poisoning management in sulphuric acid tidal swamp paddy field]. Dissertation. Post Graduated Program, Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, Indonesia.

Lindsay WL, 1979. Chemical equilibria in soil. John wiley & Sons, Inc. Toronto.

Maas A, 2011. Teknologi antisipasi cekaman abiotik budidaya padi [Technology to anticipate abiotic stress in rice cultivation]. Makalah Seminar

Nasional BB Padi, Balitbang Pertanian, Sukamandi, Indonesia.
Mowidu I, Bambang H, Sunarminto, Purwanto BH and Nuryani SHU, 2015. Kadar Fe total pada tanah sawah rawa lebak di Kabupaten Poso [Total Fe Level in Lebak Swamp Rice Field in Poso District]. J. Agropet. 12 (1): 1-5.
Murthy RK, Raveendra HR and Reddy TBM, 2010. Effect of Chromolaena and Parthenium as green manure and their compost on yield, uptake and nutrient use efficiency on typic Paleustalf. Env. J. Biol. Sci. 4(1):41-45.
Olumo MO, Raczand GJ and Cho CM, 1973. Effect of flooding on the Eh, pH and concentrations of Fe and Mn in several Manitoba soils. Soil. Sci. Soc. Am. Proc. 37:220-224.
Patrick WH and Reddy CN, 1978. Chemical change in rice soils in International Rice Research Institute. Soils and Rice. Los Banos, Philippines.
Ponnamperuma FN, Tianco EM and Loy T, 1967. Redox equilibria in flooded soils: The iron hydroxides systems. Soil. Sci. 103:374-382.
Suprihatno B, Daradjat AA, Satoto, Baehaki SE, Widiata IN, Setyono A, Indrasari SD, Lesmana OS and Sembiring H, 2009. Deskripsi varietas padi [Description of rice varieties]. BB Penelitian Tanaman Padi, Sukamandi, Indonesia.
Syafruddin, 2012. Kesinergian kompos jerami dan pupuk NPK dengan sistem aplikasi air untuk penanggulangan keracunan Besi, ketersediaan dan serapan hara N, P, K, dan Fe serta hasil padi pada lahan sawah inceptisol Morowali [The synchronization of straw compost and NPK fertilizer with water application system for preventing iron poisoning, availability and nutrient uptake of N, P, K, and Fe and rice yield on inceptisol rice field in Morowali]. Dissertation. Post Graduated Program, Universitas Padjadjaran, Indonesia.
Tisdale SL and Nelson WL, 1975. Soil fertility and fertilizers. 3rd ed. Macmillan Publishing Co, New York, USA.
Turhadi, Hamim, Ghulamahdi M and Miftahudin, 2018. Morpho-physiological responses of rice genotypes and its clustering under hydroponic iron toxicity conditions. Asian J. Agric. Biol. 6(4):495-505.
Yusuf WA, 2010. Aplikasi jerami padi dan purun tikus pada berbagai tingkat dekomposisi terhadap konsentrasi Besi dalam tanah dan serapan Besi oleh padi di tanah Sulfat masam [Application of straw and purun rat at various levels of decomposition on iron concentrations in soil and iron uptake by rice in acid sulphate soil]. Thesis. Post Graduated Program, Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, Indonesia.