Aerobic decomposition and organic amendment effects on grain yield of triple-cropped rice in the Mekong Delta, Vietnam

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Abstract
The objective of this study was to determine whether soil aeration during decomposition of incorporated crop residues and application of organic amendments contributes to the improvement of soil quality and rice yield for sustainable intensive rice production in the Mekong Delta. A field experiment was conducted on triple-cropped rice during three consecutive crops with five treatments: (1) Conventional anaerobic decomposition of crop residues as a control (2) Air-drying of soil for three weeks before planting to foster aerobic decomposition of crop residues; (3) Air-drying of soil for three weeks combined with application of 10 Mg ha^{-1} compost of sugarcane filter cake (4) Air-drying of soil for four weeks before planting; and (5) Double-cropping of a rice-maize rotation.

The results showed that the intensity of soil reduction was highest in continuous submergence of triple-cropped rice with anaerobic decomposition of rice crop residues. All treatments with aerobic decomposition during three weeks with and without organic amendments, and double rice crops rotated with maize led to increased levels of soil labile organic carbon, available phosphorus and nitrogen mineralization compared to continuous triple rice with anaerobic decomposition. The mobile humic acid content in the soil was not different among treatments, due to high replicate variability. Consequently, through three consecutive crops, rice yield was improved compared to triple-cropped rice. The practice of drying soil for aerobic decomposition resulted in a higher amount of available soil nitrogen and increased rice grain yield, and it might benefit long-term sustainability of continuous rice cropping in the Mekong Delta.

Key Words
Triple rice, aerobic decomposition, rice rotation, organic amendments, rice grain yield

Introduction
In the Mekong delta, intensive triple rice cultivation inside dike built for flood control has led to soil degradation and a decline in rice yield. Continuous rice cultivation with the conventional practice of anaerobic decomposition of crop residues can enhance N binding to lignin-derived phenols which can result in limited soil N mineralization (Schmidt *et al*., 2004; Olk *et al*., 2009). Organic amendments promote longer-term N mineralization as a source of plant available N (Tamara *et al.,* 2006). This study aims at finding practical means to enhance soil nutrient supply for higher rice yield through crop residue management and crop rotation.

Methods
A field experiment was carried out during three consecutive rice crops in the first wet season 2007, the second wet season 2007 and the dry season 2007-2008 on an alluvial soil in Cho Moi district. Five treatments were arranged in a randomized complete block design with four replications, and four of them were triple-cropped continuous rice: (1) Conventional anaerobic decomposition of crop residues as a control (2) Air-drying of soil for three weeks before planting to foster aerobic decomposition of crop residues; (3) Air-drying of soil for three weeks combined with application of 10 Mg ha^{-1} compost of sugarcane filter cake (4) Air-drying of soil for four weeks before planting; Treatment (5) was Double-cropping of a rice-maize rotation. Analysis of variance was used to determine significant differences in soil variables and grain yield. Means were compared using LSD multiple range tests using MSTATC software. Results were considered statistically significant at $P<0.05$ level. Five soil samples were taken at random from each replicated plot (0-20cm). The soil samples were pooled to get one composite sample for each field plot. With four replications for each treatment, twenty soil samples were obtained at each soil sampling. Soil samples were collected at 10 days after planting before fertilizer application to determine labile C and carry out an aenarobic

incubation to mineralizable N (Silveira *et al*. 2008). At two months after planting , the soil redox potential was measured in the field. Additional, soil samples were collected ten days before grain harvesting for determining the contents of the mobile humic acid (MHA) fraction.

Results

During the dry season, soil reduction was less than during the wet season due to a high solar radiation and low water levels in the rice fields. A high intensity of soil reduction was found in continuous triple rice compared to the rice-maize rotation and the soil aeration few weeks before planting triple rice (Table 1). Soil labile organic carbon as well as N mineralisation increased significantly as a result of the aerobic decompostion of soil organic residues by rotation with upland crop or drying soil before rice planting. The MHA fraction tended to be high in triple rice, but there was no difference significantly among treatments (Figure 1, 2, 3). These results confirmed the finding by Olk et al.(2007) that continuous intensive irrigated rice led to reduce soil organic matter quality by accumulation of phenolic compounds which resulted in less available N in soil. By applying a period of aeration and organic amendment, soil nutrient supplying capacity increased and rice yield was improved in the triple rice system (Figure 4).

Table 1. Effect of soil management on the soil redox potential in a triple-cropped rice system.

Treatment	Eh (mV)	
	Crop 2 (Wet season)	Crop 3 (Dry season)
Triple-cropped rice	- 148a	-54a
Triple-cropped rice - 3 weeks aeration	- 89 b	21b
Triple-cropped rice - 3 weeks aeration + compost	- 89b	27b
Double-cropped rice-maize	- 86b	18b
Triple-cropped rice - 4 weeks aeration	- 72b	24b

Means followed by the same letters do not different at the 5% level of probability

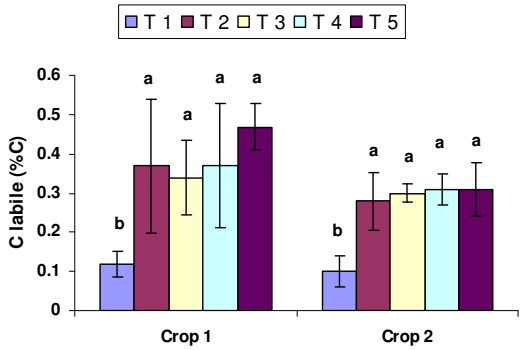

Figure 1. Effect of aerobic decomposition of crop residues and organic amendment on labile soil organic carbon l. T1.Conventional anaerobic decomposition of crop residues as a control; T2. Air-drying of soil for three weeks before planting to foster aerobic decomposition of crop residues; T3. Air-drying of soil for three weeks combined with application of 10 Mg ha^{-1} compost; T4. Air-drying of soil for four weeks before planting; and T5. Double-cropping of a rice-maize rotation. Means followed by the same letters do not different at the 5% level of probability. Bars are stadard deviation of the means.

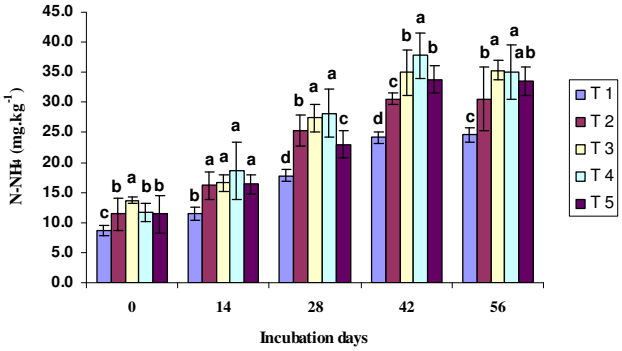

Figure 2. Effect of aerobic decomposition of crop residues and organic amendment on soil N mineralization. See

Figure 1 for legend details.

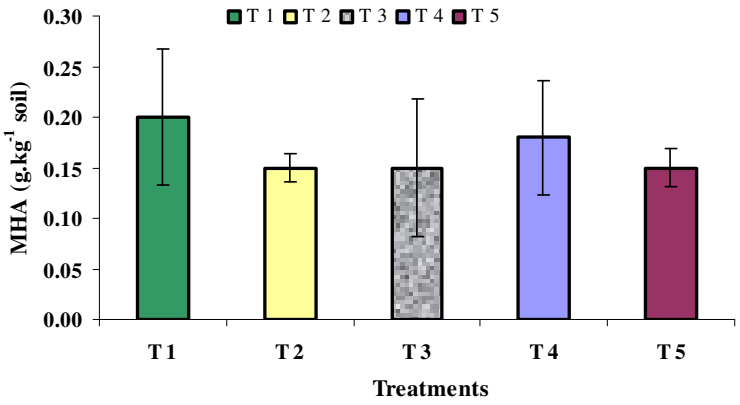

Figure 3. Effect of aerobic decomposition of crop residues and organic amendment on the quantity of the mobile humic acid fraction. See Figure 1 for legend details. Bars are standard deviation of the means.

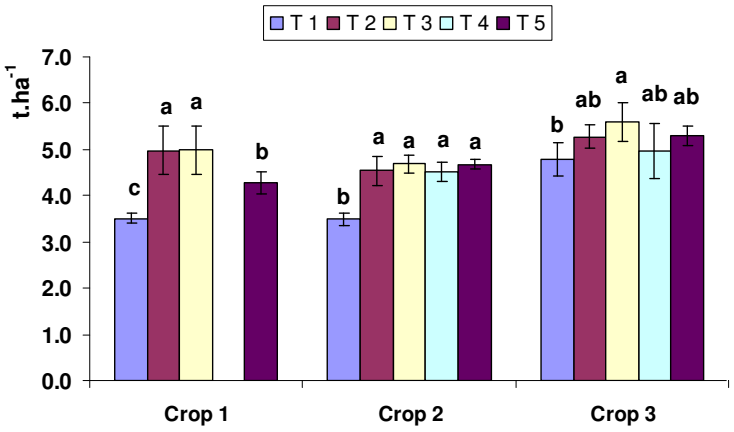

Figure 4. Effect of aerobic decomposition of crop residues and organic amendment on rice yield during three continuous rice crops. See Figure 1 for legend details. Means followed by the same letters do not different at the 5% level of probability. Bars are standard deviation of the means.

Conclusion

Soil aeration options for triple-cropped rice include aeration for three weeks before sowing to promote aerobic decomposition of crop residues, this same aerobic decomposition combined with compost amendment, and rotation of rice with maize, an upland crop. Compared to the conventional practice of anaerobic decomposition of crop residues, soil aeration provided a far less negative soil redox potential, improved soil quality as represented by soil N supply, and increased rice grain yield. An apparent decrease, i.e. enhanced mineralization, of the mobile humic acid fraction with increased soil aeration was obscured by a high variability among field replicates.

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