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Effectiveness of green manure incorporation combined with organic fertilizers for enhancing soil fertility in rice production: a case study in the Mekong River Delta

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Can Tho University - Vietnam

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CONTENT

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Introduction

- Rice (*Oryza sativa L.*) is a staple food for more than half of the world's population, particularly in Asia, where it represents a vital source of livelihood and economic stability (FAO, 2022).
- The Mekong River Delta (MRD) contributes nearly 50% of the country's total rice production and over 90% of rice exports (Nguyen et al., 2021).
- However, continuous triple-cropping systems and the excessive use of inorganic fertilizers have led to **soil degradation, nutrient imbalance, and declining soil organic matter**, ultimately threatening the sustainability of rice production (Tran & Vo, 2020).

Introduction

- Use of **organic fertilizers** (OF) and **green manure incorporation** has gained attention due to their synergistic effects on improving soil fertility and sustaining crop productivity (Rahman et al., 2020; Liu et al., 2019).
- **Organic fertilizers** enhance soil physical and biological properties by increasing organic matter content, cation exchange capacity, and microbial biomass (Chen et al., 2021).
- Green manure crops such as *Sesbania rostrata*, and *Azolla pinnata* play a critical role in biological nitrogen fixation and organic carbon enrichment (Islam et al., 2018)

Introduction

However, **limited research has been examined their combined effects** under tropical lowland rice ecosystems—especially within the unique hydrological conditions of the MRD for developing sustainable nutrient management strategies that enhance soil fertility while maintaining high yield performance.

Study objective

To evaluate **effectiveness of green manure incorporation combined with organic fertilizers** on improving soil fertility and rice productivity in the Mekong River Delta. The results are expected to provide scientific evidence for integrating organic nutrient sources into sustainable rice-based farming systems in the region.

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Materials and methods

Study design and data collection

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MATERIALS AND METHODS

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- ✓ The pot experiment was carried out **in** the **green-house area of the College of Agriculture, Can Tho University, Vietnam**.
- ✓ A greenhouse experiment was conducted in a completely randomized design with **three green manure treatments** (no incorporation (NI), incorporation of Azolla pinnata (AI), and Sesbania rostrata (SI); each was combined with **three fertilizer treatments** (no fertilizer (C), organic fertilizer from chicken manure fertilizer (OF_1), and organic fertilizer from fishery processing by-products (OF_2).
- ✓ Experimental soil was collected from an organic transition paddy field.

Study treatments

1. Green manure incorporation experiment

- Without green manure incorporation **(NI)**
- *Azolla pinnata* incorporation **(AI)**
- *Sesbania rostrata* incorporation **(SI)**

The green manure biomass was incorporated into the soil and left for **two weeks**

2. Rice cultivation experiment

In rice growing season, application of 2 types of organic fertilizers **O1** and **O2** from chicken manure and fishery processing by-products, respectively.

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STUDY MATERIALS AND METHODS

Nutrients from different organic fertilizers and green manure

Organic fertilizer	N (%)	P (%)	K (%)	OM (%)
Azolla pinnata	2.38	0.30	1.79	-
Sesbania rostrata	1.45	0.42	1.48	-
OF from chicken manure (OF_1)	0.82	0.31	0.36	25
OF from by-products of fishery processing factory (OF_2)	5.81	3.44	5.30	30

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STUDY MATERIALS AND METHODS

1. Soil parameters analyzed: commencement, panicle initiation and harvesting stages.

(1) Soil available N & P
(2) Other soil chemical properties: pH, EC, other parameters,…

2. Crop parameters monitored: plant growth, yield components, rice biomass and yield.

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Results and discussion

Effects of the soil management on soil properties – Soil EC (50DAS)

Experimental factor	Treatments	EC (dS m^{-1})
Factor 1 (Green manure)	NI	0.24
	AI	0.21
	SI	0.20
Factor 2 (Organic fertilizer)	Control	0.18b
	OF_1	0.18b
	OF_2	0.29a
P (A)		ns
P (B)		***
P (A x B)		ns

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Effects of the soil management on soil properties – Soil pH (50DAS)

Experimental Factor	Treatments	pH
Factor 1 (Green manure)	NI	5.24c
	AI	5.45b
	SI	6.03a
Factor 2 (Organic fertilizer)	Control	5.51
	OF_1	5.59
	OF_2	5.61
P (A)		***
P (B)		ns
P (A x B)		ns

1. no incorporation (NI),
2. incorporation of Azolla pinnata (AI)
3. incorporation of Sesbania rostrata (SI)

1. no organic fertilizer (Control)
2. organic fertilizer from chicken manure fertilizer (OF_1)
3. organic fertilizer from fishery processing by-products (OF_2)

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Effects of the green manure on soil N and P (2 weeks after incor)

Treatments	Soil NH_4^+ (mg kg^{-1})	Soil P (mg kg^{-1})
NI	97,1a	55.75a
AI	99,2a	41.33b
SI	13,28b	38.14b
P	*	*

1. no incorporation (NI),
2. incorporation of Azolla pinnata (AI)
3. incorporation of Sesbania rostrata (SI)

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Effects of the soil management on soil properties - N & P_50 DAS

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Experimental Factor	Treatments	Soil NH_4^+ (mg kg^{-1})	Soil P (mg kg^{-1})
Factor 1 (Green manure)	NI	19.58	24.61
	AI	20.32	22.37
	SI	19.18	25.28
Factor 2 (Organic fertilizer)	Control	18.97	17.75b
	OF_1	18.64	18.77b
	OF_2	21.47	**35.74a**
P (A)		ns	ns
P (B)		ns	***
P (A x B)		ns	ns

1. no incorporation (NI),
2. incorporation of Azolla pinnata (AI)
3. incorporation of Sesbania rostrata (SI)

1. no organic fertilizer (Control)
2. organic fertilizer from chicken manure fertilizer (OF_1)
3. organic fertilizer from fishery processing by-products (OF_2)

Effects of the soil management on growth_Height

Experimental Factor	Treatments	30 DAS	50 DAS
Factor 1 (Green manure)	NI	62.88a	74.90b
	AI	**63.61a**	**77.36a**
	SI	59.02b	68.98c
Factor 2 (Organic fertilizer)	Control	60.88b	68.44c
	OF_1	60.92b	71.92b
	OF_2	**63.78a**	**81.78a**
P (A)		***	***
P (B)		***	***
P(A x B)		***	*

1. no incorporation (NI),
2. incorporation of Azolla pinnata (AI)
3. incorporation of Sesbania rostrata (SI)

1. no organic fertilizer (Control)
2. organic fertilizer from chicken manure fertilizer (OF_1)
3. organic fertilizer from fishery processing by-products (OF_2)

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Effects of the soil management on number of tillers

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Experimental Factor	Treatments	30 DAS	50DAS
Factor 1 (Green manure)	NI	33.67b	30.22a
	AI	**35.33a**	**30.74a**
	SI	29.60c	27.59b
Factor 2 (Organic fertilizer)	Control	30.25c	25.58c
	OF_1	31.34b	28.87b
	OF_2	**37.00a**	**34.10a**
P (A)		***	***
P (B)		***	***
P (A x B)		***	ns

1. no incorporation (NI),
2. incorporation of Azolla pinnata (AI)
3. incorporation of Sesbania rostrata (SI)

1. no organic fertilizer (Control)
2. organic fertilizer from chicken manure fertilizer (OF_1)
3. organic fertilizer from fishery processing by-products (OF_2)

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Effects of the soil management on SPAD index

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Experimental Factor	Treatments	30 DAS	50 DAS
Factor 1 (Green manure)	NI	33.67b	30.22a
	AI	35.33a	**30.74a**
	SI	29.60c	27.59b
Factor 2 (Organic fertilizer)	Control	30.25c	25.58c
	OF_1	31.34b	28.87b
	OF_2	37.00a	**34.10a**
P (A)		***	***
P (B)		***	***
P (A x B)		***	ns

1. no incorporation (NI),
2. incorporation of Azolla pinnata (AI)
3. incorporation of Sesbania rostrata (SI)

1. no organic fertilizer (Control)
2. organic fertilizer from chicken manure fertilizer (OF_1)
3. organic fertilizer from fishery processing by-products (OF_2)

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Effects of the soil management on panicles /pot

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Experimental factor	Treatments	Number of panicles per pot
Factor 1 (Green manure)	NI	17.66a
	AI	**17.88a**
	SI	12.55b
Factor 2 (Organic fertilizer)	Control	13.66b
	OF_1	14.88b
	OF_2	**19.55a**
P (A)		***
P (B)		***
P (A x B)		ns

1. no incorporation (NI),
2. incorporation of Azolla pinnata (AI)
3. incorporation of Sesbania rostrata (SI)

1. no organic fertilizer (Control)
2. organic fertilizer from chicken manure fertilizer (OF_1)
3. organic fertilizer from fishery processing by-products (OF_2)

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Effects of the soil management on yield and yield components

Experimental factor	Treatments	Dry plant biomass (g)	Yield (g/plot)
Factor 1 (Green manure)	**NI**	94.77a	35.84b
	AI	**84.66b**	**46.76a**
	SI	69.77c	24.22c
Factor 2 (Organic fertilizer)	**Control**	75.22b	22.42b
	OF_1	73.77b	28.44b
	OF_2	**100.22a**	**55.42a**
P (A)		***	***
P (B)		***	***
P (A x B)		**ns**	**ns**

1. no incorporation (NI),
2. incorporation of Azolla pinnata (AI)
3. incorporation of Sesbania rostrata (SI)

1. no organic fertilizer (Control)
2. organic fertilizer from chicken manure fertilizer (OF_1)
3. organic fertilizer from fishery processing by-products (OF_2)

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Conclusion and recommendation

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- ✓ The incorporation of *Azolla pinnata* showed positive improvements in soil chemical properties, such as decreasing soil electrical conductivity (EC), enhancing soil pH, and maintaining the nutrient content.

- ✓ The incorporation of *Azolla pinnata* improved not only soil nutrient availability, but also plant height, number of panicles, rice yield.

- ✓ Among the tested organic fertilizers, OF from by-products of fishery processing factory (OF_2) showed effectiveness in enhancing soil quality (P availability) and significantly improved in rice growth and yield under greenhouse conditions.

Conclusion and recommendation

- Further studies are required to investigate the effects of green manure incorporation periods in the field and examine the mineralization dynamics of N and P.
- Evaluating the responses of soil microbial activity in the soil management.

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