Enhancing Nitrogen Uptake and Rice Productivity in Inceptisols Through *Moringa oleifera* and Golden Snail-Based Liquid Organic Fertilizers

Widyatmani Sih Dewi[1*], *Rani* Rahmawati[2], *Okta* Loveana[2], *Sudadi* Sudadi[1], *Ongko* Cahyono[1], *Srie Juli* Rachmawatie[3], *Eko Rini* Indrayatie[4], and *A.A Sagung Putri Risa* Andriani[5]

[1]Department of Soil Science, Faculty of Agriculture, Sebelas Maret University, Jebres 57126, Surakarta, Indonesia
[2]Undergraduate of Soil Science, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami 36A Kentingan, Jebres, Surakarta, 57026, Indonesia
[3]Agrotechnology Study Program, Faculty of Agriculture, Islam Batik University, Surakarta 57147, Indonesia
[4]Department of Forestry, Faculty of Forestry, Lambung Mangkurat University, Jl. A. Yani Km. 35, Banjabaru, Indonesia
[5]Agrotechnology Study Program of Warmadewa University. Jl. Terompong No.24 Tanjung Bungkak Denpasar, Indonesia

Abstract. Nitrogen deficiency remains a major constraint to organic rice productivity in Inceptisols. This study introduces a novel liquid organic fertiliser (LOF) derived from fermented Moringa oleifera leaves and golden snails (Pomacea canaliculata) to enhance nitrogen uptake and improve crop performance. A greenhouse experiment was conducted using a completely randomised design with two factors: LOF formulation (100% moringa, 100% snail, and a 50:50 mix) and LOF concentration (0, 20, 40, 60, and 80 mL/L), applied weekly over a 16-week period. Results revealed a significant interaction between formulation and concentration on nitrogen uptake. The highest uptake, 161.2% above control, was achieved with 100% moringa LOF at 60 mL/L, which also enhanced grain yield and quality. Meanwhile, the combined formula (50% moringa + 50% snail) promoted soil health, indicated by the highest population of non-symbiotic nitrogen-fixing bacteria. These findings highlight the potential of moringa- and snail-based LOFs as sustainable, locally sourced alternatives to chemical fertilizers, particularly for nutrient-poor soils. Future research should evaluate their field-scale performance and long-term effects on soil microbial dynamics.

---

* Corresponding author: widyatmanisih@staff.uns.ac.id

1 Introduction

In tropical regions, Inceptisols dominate agricultural landscapes, covering approximately 23.6% of the land area. Despite their prevalence, these soils are inherently low in fertility, characterised by an acidic pH and limited macronutrients, including organic carbon, nitrogen (N), phosphorus (P), and potassium (K). Nitrogen, a vital macronutrient for plant growth and metabolism. is often deficient in Inceptisols, necessitating external inputs to sustain rice (Oryza sativa L.) productivity.

Rice requires approximately 20–50 kg of nitrogen per tonne of grain, yet Inceptisols rarely meet this demand. Nitrogen sources include fertilization, biological fixation by nitrogen-fixing bacteria (NFB), and natural cycling. . Uptake is influenced by soil and plant factors.

Organic farming provides a sustainable alternative to chemical fertilisation, promoting soil health and nutrient cycling while minimising ecological harm [6,7]. Liquid organic fertilisers (LOF) are particularly promising due to their rapid nutrient availability, biostimulant effects, and compatibility with irrigation systems [8, 9]. Among potential LOF sources, Moringa oleifera leaves and Pomacea canaliculata (golden snails) are locally abundant and rich in nitrogenous compounds, making them promising candidates for biofertilizer production. Their use is also permitted under Indonesian agricultural regulations.

Anaerobic fermentation enhances the LOF nutrient profiles by converting organic matter into plant-available forms, thereby increasing total nitrogen while minimising contamination and emissions. While previous studies have examined LOF from moringa or golden snails separately, no research has systematically evaluated their combined formulation and application rates in Inceptisols. This gap hampers the development of site-specific, locally sourced organic fertilization strategies for tropical rice systems. This study investigates the effects of LOF formulations and concentrations derived from moringa and golden snails on nitrogen uptake and rice yield in Inceptisols, aiming to inform sustainable nutrient management for organic rice cultivation.

2 Materials and Methods

2.1 Study site and experimental duration

This study was conducted in a greenhouse at the Pest and Plant Disease Observation Laboratory in Sukoharjo, Central Java, Indonesia (7° 34′ 47″ S; 110° 52′ 18″ E; altitude 99 m above sea level). The area has an average monthly rainfall of 137 mm and an air temperature range of 23 °C to 34°C. The planting medium was Inceptisols collected from Mojogedang, Karanganyar. These soils are typical of tropical regions and are generally characterised by low fertility, acidic pH levels, and low organic matter content. Cow manure was applied at a rate equivalent to 2.5 tons/ha seven days before planting. Organic amendments like this are commonly used in Inceptisol-based organic systems to improve baseline fertility.

2.2 Experimental design and treatment

A completely randomized design (CRD) was used, consisting of two treatment factors: LOF formula and LOF concentration. The formula factor included three levels: 100% *Moringa oleifera* (P1), 100% golden snail (*Pomacea canaliculata*) (P2), and a 50% moringa + 50% golden snail combination (P3). The concentration factor consisted of 0, 20, 40, 60, and 80 mL/L (K0-K4). Each treatment was replicated three times, resulting in a total of 45 experimental units (pots).

Rice (*Oryza sativa* L., var. Mentik Wangi) was directly seeded with three seeds per pot, then thinned to one seedling two weeks after emergence. LOF was applied weekly at a dose of 100 mL/pot for 16 weeks by spraying it onto the soil and leaves. The soil water content was maintained at a saturation level throughout the experiment.

The LOF was prepared by anaerobic fermentation for three weeks. Moringa LOF was made from 1 kg of crushed *Moringa* leaves, 2 L of water, 2 L of rice bran solution, and 50 mL of molasses. Golden snail LOF was prepared from 1 kg of crushed golden snail meat, 4 L of rice bran solution, 500 mL of molasses, and 160 mL of EM-4. Anaerobic conditions were maintained using sealed fermentation containers with gas release outlets. The fermentation process enhances microbial activity and nutrient availability in LOF, particularly in terms of total nitrogen and soluble organic matter. Figure 1 presents a flowchart summarizing the experimental design to clarify the methodology.

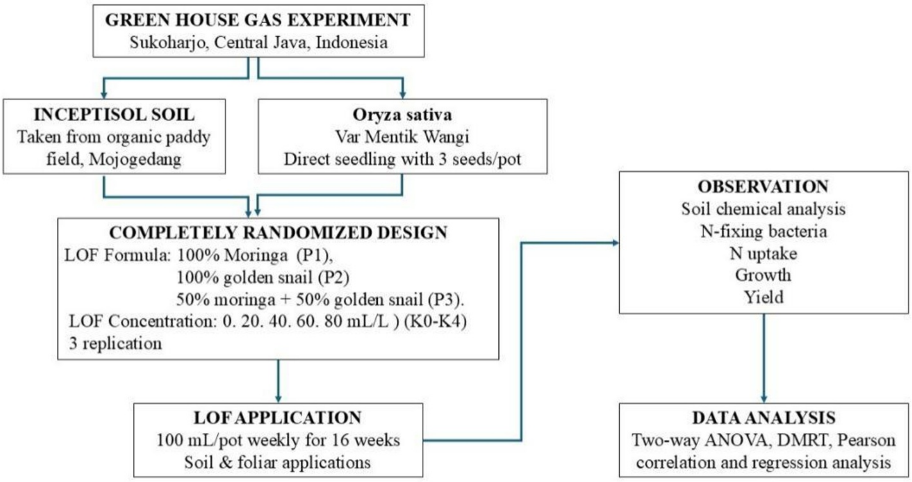

Fig. 1. Flowchart summarizing the experimental design, treatment structure, and observation for LOF application in rice grown on Inceptisols.

2.3 Soil and plant parameters, and data analysis

Observed variables included soil chemical properties (pH, organic carbon, and total nitrogen), population of non-symbiotic nitrogen-fixing bacteria (NFB), plant tissue nitrogen content, nitrogen uptake, and plant growth and yield components (total number of tillers, shoot and root dry weight, grain yield per pot, and 1000-grain weight).

Soil pH was measured using a pH meter. Organic carbon was analysed using the Walkley-Black method, while total nitrogen was determined by the Kjeldahl method. The population of NFB was assessed using serial dilution and plate count techniques on Jensen's medium [1]. Tissue nitrogen content and total nitrogen uptake were measured at the vegetative stage using standard laboratory procedures. The LOF quality parameters were interpreted in accordance with the minimum standards for organic liquid fertilisers established by the Indonesian Ministry of Agriculture [2].

All data were analyzed using a two-way ANOVA to assess the effects of treatment combinations. Significant differences among treatments were identified using Duncan's

Multiple Range Test (DMRT) at a 5% significance level. Pearson correlation and linear regression analyses were performed to examine the relationships between key variables.

3 Results and Discussion

3.1 Soil properties before and after LOF application

The Inceptisols utilized in this study were classified as slightly acidic, with low organic matter content and deficiencies in key macronutrients, including N, P, and K (Table 1). The acidic soil pH impairs nutrient availability due to the predominance of H^+, Al^{3+}, and Fe^{3+} ions within the exchange complex. These ions compete with nutrient cations, thereby restricting their absorption by plants [3]. Such soil characteristics align with previous findings that document similar fertility constraints in paddy field Inceptisols from the Karanganyar region [4].

The soil exhibited a relatively high cation exchange capacity (CEC) of 25.34 cmol(+)/kg, primarily attributed to its clay loam texture, with a clay fraction of 33.4%. CEC is largely influenced by the proportion of clay particles and the presence of soil organic matter [5]. According to the USDA Soil Taxonomy, Inceptisols typically feature a cambic horizon, possess a CEC exceeding 16 cmol(+)/kg within the upper 50 cm of the soil profile, and lack lithic contact or petrocalcic horizons at shallow depths [6].

Table 1. The characteristics of Inceptisols before LOF application.

No	Characteristics	Value	Category [31]
1.	pH	5.87	Slightly acid
2.	Organic C (%)	1.41	Low
3.	Total N (%)	0.15	Low
4..	Available P (ppm)	2.65	Very Low
5.	Exchangeable K (cmol(+)/ kg)	0.12	Low
6.	CEC (cmol(+)/kg)	25.34	High
7.	BS (%)	23	Low
8.	Texture		Clay loam
	Clay (%)	33.43	
	Silt (%)	45.28	
	Sand (%)	21.29	
9.	Non-symbiotic NFB (cfu/g soil)	9.94×10^4	-

3.2 Quality of liquid organic fertilizer

The quality of LOF is influenced by its nutrient content, pH, organic carbon concentration, and C/N ratio, all of which affect nutrient availability and microbial activity in the soil. Among the formulations tested, the golden snail-based LOF demonstrated the highest total nutrient content (6.44%) and organic carbon level (2.27%), outperforming both the moringa-based and combined formulations (Table 2). This superior performance is attributed to the high protein and fat content of the golden snail substrate, which enhances microbial fermentation and nutrient solubilization..

All LOF formulations exhibited acidic pH values, ranging from 4.00 to 5.58 (Table 2), primarily due to the accumulation of organic acids generated during anaerobic fermentation. These pH levels remain within the acceptable range established by Indonesian national standards for the quality of liquid organic fertilisers [4]. Among the variants, the combined

LOF (moringa + snail) recorded a pH of 4.78, indicating heightened microbial metabolism and increased acid production during the co-fermentation process [11].

Although the organic carbon content of all LOFs was below the minimum standard of 10%, each formulation met the required thresholds for total nutrient content (greater than 4%) and pH (4.0–9.0) [28]. The moringa-based LOF exhibited the lowest C/N ratio (5.7), which is favorable for rapid mineralization and accelerated nitrogen release to crops. This finding aligns with previous studies, which indicate that organic inputs with low C/N ratios promote faster microbial decomposition and enhance nitrogen availability [12].

Table 2. Chemical characteristics of liquid organic fertilizer (LOF).

Parameter	**Moringa LOF**	**Golden snails LOF**	**Combination of moringa and golden snails LOF**	**Quality standard [28]**
pH	5.58	4.00	4.78	4-9
Organic C (%)	0.68	2.27	1.47	Minimum 10 %
Total N (%)	0.12	0.18	0.15	-
Total P (%)	0.60	0.74	0.67	-
Total K (%)	5.59	5.52	5.55	-
N + P + K	6.31	6.44	6.37	2-6 %
C/N ratio	5.7	12.44	9.8	-

3.3 Effect of LOF on soil chemical and biological properties

The interaction between LOF formulation and application concentration significantly influenced soil pH, organic carbon content, and total nitrogen levels, as well as plant tissue nitrogen concentration and nitrogen uptake ($p < 0.05$; Table 3). Increasing LOF concentrations generally led to elevated soil pH across all formulations. The highest pH value was observed in the P3 formulation applied at 60 mL/L (K3), which was not significantly different from the 80 mL/L concentration. This trend is likely attributable to the buffering capacity of organic matter and microbial metabolites present in the LOF [9].

Table 3. Effects of LOF formula, application concentrations, and their interaction on soil chemical properties, plant tissue nitrogen content, and nitrogen uptake in Inceptisols.

Factor of LOF treatment	**Soil chemical**			**Tissue N (%)**	**N uptake (mg/plant)**
	pH	**Organic C (%)**	**Total N (%)**		
Formula (P)	0.00*	0.00*	0.53ns	0.00*	0.00*
P1	6.47 c	0.95 b	0.18 a	1.29 a	44.09 a
P2	6.67 ab	1.05 a	0.18 a	1.33 a	30.31 b
P3	6.70 a	0.97 b	0.19 a	1.17 b	24.01 b
Concentration (K)	0.00*	0.00*	0.00*	0.02*	0.02*
K0	6.35 d	0.94 b	0.16 c	1.12 b	25.76 c
K1	6.59 c	0.99 a	0.18 b	1.28 a	28.66 bc
K2	6.69 b	1.01 a	0.20 a	1.32 a	32.29 abc
K3	6.71 ab	0.99 a	0.21 a	1.30 a	41.28 a
K4	6.71 a	1.01 a	0.17 b	1.31 a	36.08 ab
Interactions (P x K)	0.00*	0.00*	0.00*	0.00*	0.00*
P1K0	6.35 f	0.94 c	0.16 cde	1.03 e	25.1 de
P1K1	6.38 f	1.02 b	0.16 de	1.18 de	23.8 de
P1K2	6.57 d	1.02 b	0.18 bcd	1.33 bcd	48.5 bc
P1K3	6.55 d	0.82 e	0.20 bc	1.32 bcd	67.4 a

Factor of LOF treatment	Soil chemical			Tissue N (%)	N uptake (mg/plant)
	pH	Organic C (%)	Total N (%)		
P1K4	6.48 e	0.96 c	0.21 b	1.60 a	55.7 ab
P2K0	6.31 g	0.95 c	0.15 ef	1.23 cds	28.8 de
P2K1	6.65 c	1.06 ab	0.20 b	1.51 ab	26.5 de
P2K2	6.77 b	1.10 a	0.24 a	1.46 bc	26.3 de
P2K3	6.77 b	1.11 a	0.19 bcd	1.27 bcde	38.5 cds
P2K4	6.84 a	1.03 b	0.13 f	1.20 de	31.5 cdes
P3K0	6.38 f	0.95 c	0.15 ef	1.10 de	23.4 de
P3K1	6.75 b	0.88 d	0.17 bcd	1.14 dec	35.6 cdes
P3K2	6.74 b	0.92 cd	0.18 bcd	1.18 de	22.1 dec
P3K3	6.82 a	1.06 ab	0.25 a	1.31 bcde	17.9 e
P3K4	6.82 a	1.04 b	0.19 bcd	1.14 dec	21.1 dec

Note: *(significant, p value <0.05), ns(not significant, p value >0.05). Values in the same column followed by the same letter showed no significant difference based on the DMRT test at 5%.

Organic carbon levels increased across all LOF-treated soils, with the highest value observed in the golden snail-based LOF (P2), particularly under the P2K3 treatment. However, this value was not significantly different from those recorded in P2K2 and P3K3 (Table 3). The elevated carbon content in P2 treatments is attributed to the abundant carbon substrates provided by the snail material, which stimulated microbial activity and enhanced carbon accumulation [10]. The total nitrogen content in the soil also increased significantly with higher LOF concentrations. The highest nitrogen level (0.25%) was recorded in the P3K3 treatment (50% moringa + 50% snail at 60 mL/L), although it was not significantly different from P2K2 (100% snail at 40 mL/L). This pattern aligns with previous studies, which indicate that moringa-based inputs accelerate the mineralisation of snail-derived organic matter due to their low C/N ratio, thereby enhancing nitrogen availability.

Tissue nitrogen content was positively affected by both LOF formula and concentration (Table 3). The maximum tissue N (1.60%) was recorded in the P1K4 treatment, suggesting efficient nitrogen assimilation by rice plants receiving moringa-based LOF. The higher mineralisation rate from moringa LOF improves nitrogen uptake into plant tissue [11].

Nitrogen uptake was significantly enhanced by LOF treatments, with the highest increase observed in P1K3 (100% moringa at 60 mL/L), which showed a 161.2% improvement over the control (from 25.76 to 67.4 mg/plant) (Table 3). This treatment also corresponded with elevated total nitrogen levels and increased tissue nitrogen content, indicating improved nitrogen assimilation.

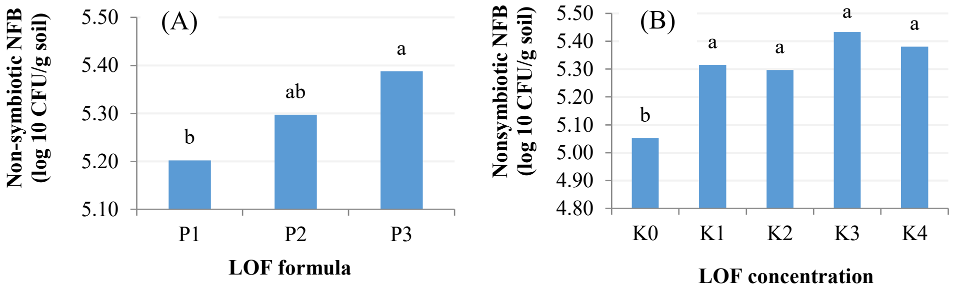

Fig. 2. Effect of LOF formula and application concentration on the population of non-symbiotic nitrogen-fixing bacteria (NFB). Histogram bars labeled with the same letter indicate no statistically significant difference, based on Duncan's Multiple Range Test (DMRT) at the 5% significance level.

The population of non-symbiotic nitrogen-fixing bacteria (NFB) increased significantly following the application of the combined LOF treatment containing 50% moringa and 50% golden snail (Fig. 2A, P3). The highest bacterial count was observed at the 60 mL/L concentration (Fig. 2B, K3), indicating that this dosage effectively promotes microbial proliferation and nitrogen fixation.

Correlation analysis revealed a strong positive relationship between total soil nitrogen and NFB population (r = 0.52; Fig. 3A), as well as between total soil nitrogen and tissue nitrogen content (r = 0.38; Fig. 3B). These findings suggest that enhanced microbial activity contributes to improved nitrogen availability and assimilation in plants.

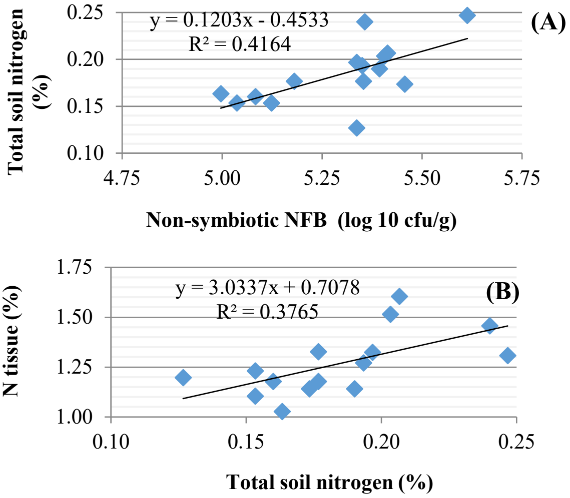

Fig. 3. Regression analysis between (A) non-symbiotic nitrogen-fixing bacteria (NFB) population and total soil nitrogen, and (B) total soil nitrogen and plant tissue nitrogen content.

3.4 Effect of LOF on growth and yield of rice

The interaction between LOF formula and concentration significantly influenced rice growth and yield parameters, particularly the 1000-grains weight (Table 4). The most notable improvement occurred at 60 mL/L (K3), which produced the highest number of tillers (7.44/clump) and grain yield (4.28 g/pot) (Fig. 4), corresponding to increases of 91.3% and 115% over the control, respectively. This finding supports previous reports that moderate concentrations of organic inputs optimize microbial activity and nutrient availability in the rhizosphere [11].

Table 4. ANOVA results showing the effects of LOF formula, application concentration, and their interaction on paddy growth and yield parameters.

Treatments	Total number of tillers per clump	Shoot dry weight (g/pot)	Root dry weight (g/pot)	Rice yields (g/pot)	1000 grains weight (g)
Formulas (P)	0.82ns	0.98ns	0.27ns	0.73ns	0.00*
Concentration (K)	0.01*	0.21ns	0.09ns	0.04*	0.00*
Interactions (P x K)	0.13ns	0.31ns	0.66ns	0.13ns	0.00*

Remarks: *(significant at p value $p<0.05$), ns(not significant, p value >0.05).

Although shoot and root dry weights did not differ significantly among treatments (Table 4), this may indicate a physiological shift in resource allocation from vegetative to reproductive growth, particularly under conditions of improved nitrogen uptake. The application of LOF likely enhanced nitrogen use efficiency at the physiological level, rather than directly promoting biomass accumulation [12].

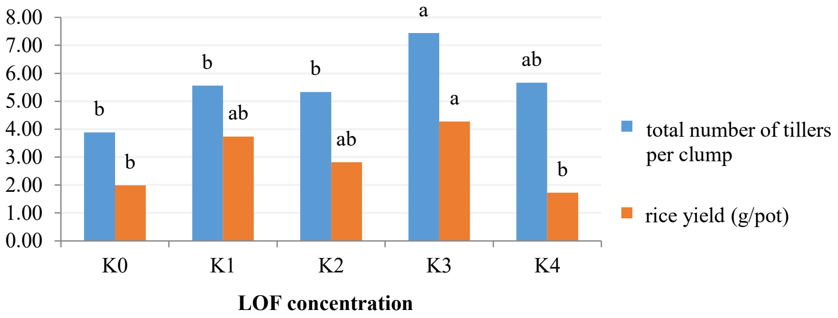

Fig. 4. Effect of LOF concentration application on the total number of tillers per clump and rice yield. Histogram bars sharing the same letter and color indicate no significant difference, based on DMRT at the 5% significance level.

In contrast, the weight of 1,000 paddy grains was significantly influenced by the interaction between LOF formulation and application concentration (Fig. 5). The highest grain weight (26 g) was recorded in the P1K3 treatment (100% moringa LOF at 60 mL/L), representing a 16.7% increase over the control. This result suggests that moringa-derived inputs, rich in soluble nitrogen compounds and natural biostimulants, support more efficient grain filling during the generative phase [13].

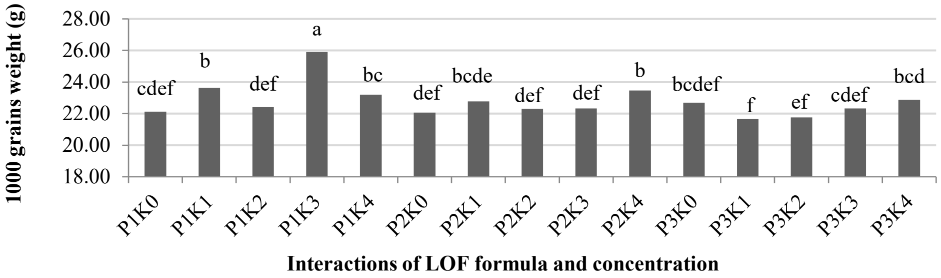

Fig. 5. Effect of LOF concentrations on the weight of 1,000 paddy grains. Bars labeled with the same letter indicate no statistically significant difference, based on DMRT at the 5% level.

Nitrogen uptake exhibited a strong positive correlation with both grain yield and 1,000-grain weight. Regression analysis indicated that nitrogen uptake accounted for 37.32% of the variation in 1,000-grain weight ($R^2 = 0.3732$) (Fig. 6). This reflects a moderate yet meaningful contribution of nitrogen assimilation to reproductive output. Although nitrogen remains a critical determinant, other physiological factors, such as hormonal regulation, assimilate partitioning, and source–sink dynamics, may also play significant roles in determining final grain weight [14].

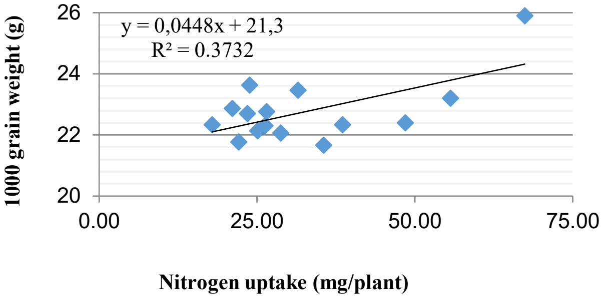

Fig. 6. Regression between nitrogen uptake and weight of 1,000 paddy grains.

4 Conclusion

LOFs made from *Moringa oleifera* and golden snail improved soil nutrients, nitrogen uptake, and rice yield in Inceptisols. The most effective treatment was 100% moringa LOF at 60 mL/L, which enhanced grain quality through high nitrogen content and rapid mineralization. The combined formula (50% moringa + 50% snail) also supported soil health, shown by the highest population of nitrogen-fixing bacteria.

These findings suggest that moringa- and snail-based LOFs are promising, eco-friendly alternatives to chemical fertilizers for low-fertility soils. Further research is needed to test their performance at field scale and assess long-term impacts on soil health.

Acknowledgments

Universitas Sebelas Maret’s flagship grant funded this research. The authors thank the Indonesian Agency for Agricultural Research and Development for access to facilities and technical support, the Head of the Plant Disease Observation Laboratory, Sukoharjo, for providing greenhouse use, and Bagus Hanafi for assistance with manuscript layout.

References

1. A.C. Zebua, H. Guchi, M. Sembiring, Isolation of non-symbiotic nitrogen fixing bacteria on Andisol land affected by Sinabung eruption, IOP Conf. Ser.: Earth Environ. Sci. 454, 012007 (2020). https://iopscience.iop.org/article/10.1088/1755-1315/454/1/012167
2. Indonesian Minister of Agriculture, Minimum technical requirements for organic fertilizers, biological fertilizers, and soil conditioners, Decree of the Minister of Agriculture No. 261 (2019). https://psp.pertanian.go.id/layanan-publik/keputusan-menteri-pertanian-nomor-261-kpts-sr-310-m-4-2019-tentang-persyaratan-teknis-minimal-pupuk-organik-pupuk-hayati-dan-pembenah-tanah
3. J. Miller, Soil pH affects nutrient availability, University of Maryland Extension (2016). https://doi.org/10.13016/M2PN59
4. J. Syamsiyah, Sumarno, Suryono, W. Sari, M. Anwar, Chemical properties of Inceptisol and rice yields applied with mixed source fertilizer (MSF), J. Trop. Soils **23**(1), 1–9 (2018). https://doi.org/10.5400/jts.2018.v23i1.1-9
5. E.F. Solly, V. Weber, S. Zimmermann, L. Walthert, F. Hagedorn, M.W.I. Schmidt, A critical evaluation of the relationship between the effective cation exchange capacity

and soil organic carbon content in Swiss forest soils. Front. For. Glob. Change **3**, 98 (2020). https://doi.org/10.3389/ffgc.2020.00098

6. Soil Survey Staff, Keys to Soil Taxonomy, 12th ed. (USDA-NRCS, Washington, DC, 2014). https://www.nrcs.usda.gov/resources/guides-and-instructions/keys-to-soil-taxonomy
7. Indonesian Center for Agricultural Soil Research and Development (ICASRD), Technical guidelines for conducting soil fertility research (IAARD Press, Bogor, 2014). https://repository.pertanian.go.id/server/api/core/bitstreams/ad299beb-1c84-4dea-b16b-2abcec2a7358/content
8. P. Marschner, Marschner's Mineral Nutrition of Higher Plants, 3rd ed. (Academic Press, Elsevier, Amsterdam, 2012), 475 p. https://doi.org/10.1016/C2009-0-63043-9
9. P. Sasongko, P. Purnomo, W.S. Dewi, R. Hidayat, Soil microbial communities below decomposing plant litter from different land uses in Tutur Village, AIP Conf. Proc. 2019, 040002 (2018). https://doi.org/10.1063/1.5061872
10. S. Ghosh, C. Jung, V.B.M. Rochow, Snail as mini-livestock: nutritional potential of farmed Pomacea canaliculata (Ampullariidae), Agric. Nat. Resour. **51**(6), 504–511 (2017). https://doi.org/10.1016/j.anres.2017.12.007
11. Y. Retnowati, A.S. Katili, Identification of fermentative bacteria on local microorganisms of golden snail (Pomacea canaliculata Lamarck, 1822). Biodiversitas 22, 778–784 (2021). https://doi.org/10.13057/biodiv/d220231
12. N.S. Aggangan, P.J.S., Tamayao, E.A., Aguilar, J.A., Anarna, T.O., Dizon, Arbuscular mycorrhizal fungi and nitrogen-fixing bacteria as growth promoters and biological control agents against nematodes in tissue-cultured banana var., Philipp. J. Sci. **142**(2), 153–165 (2013). https://www.ukdr.uplb.edu.ph/journal-articles/2298/
13. S. Khan, D. Ibrar, Z. Hasnain, M. Nawaz, A. Rais, S. Ullah, S. Gul, M.H. Siddiqui, S. Irshad, Moringa leaf extract mitigates the adverse impacts of drought and improves the yield and grain quality of rice through enhanced physiological, biochemical, and antioxidant activities, Plants **12**(13), 2511 (2023). https://doi.org/10.3390/plants12132511
14. M.I. Bahua, H. Gubali, Direct seed planting and LOF for yield improvement, AGRIVITA J. Agric. Sci. **42**(1), 68–77 (2020). https://doi.org/10.17503/agrivita.v42i1.2324