Nano-Enhanced Fertilizers for Energy-Efficient Rice Farming: A Comparative Study

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Abstract. The objective of this study is to determine the differences in Oryza sativa (rice) growth, as cultivated on conventional pig manure relative to that on nano-enhanced poultry manure mixed with sesbania. Improving nutrient delivery and achieving better chemical reactions in the soil resulted in increased plant growth and sustainability when nanomaterials were added to poultry manure. The experimental field area covered 1000 square feet, divided into two groups: Group 1 is working with nano-enhanced poultry manure together with Sesbania, while Group 2 is using only pig dung. A total of 40 samples consisted of 20 samples from each group. Using G-power, the sample size of 80% power and 95% confidence interval was established, with statistical analysis performed in SPSS software. With 105–150 days, the average plant height of nano-enhanced poultry manures along with Sesbania reached 87 cm, whereas the pig manure had just 70 cm, stated the results. The variation showed an p-value of 0.001 ($p < 0.05$), indicating it was statistically significant.

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The improved performance of the manure is attributed to its greater chemical interactions and efficient nutrient absorption thanks to nanotechnology. This work provides important information on energy-efficient, high-yield farming techniques by bringing attention to the potential benefits of merging nanotechnology with organic fertilizers for sustainable rice cultivation. Results indicate that combining organic inputs with innovative technologies may greatly improve the quality of soil and nutrient supply, benefiting energy-efficient agriculture and sustainable manufacturing.

1. Introduction

The grass species that produce rice are Oryza sativa, commonly called Asian rice, or less commonly, Oryza glaberrima, occasionally referred to as African rice. More than 50% of the world's people consume rice, a cultivated cereal grain principally grown in Asia and Africa, as their primary food [1] . Being third after sugarcane and maize, it is the largest agricultural product in the world. Rice is the key food crop for nutritional value and calorie consumption, making up more than one-fifth of all calories that people around the world eat [3]. As a monocotyledonous plant typically grown as an annual, rice can, in tropical locations, grow perpetually and yield fresh harvests for as much as 30 years. Annual rice plants that produce food can grow as tall as 1.2 meters [2].

The tall, flat leaves are what the hollow stems are there to support. The root system is usually widely spread. Shrestha et al.[4] define inflorescences, commonly called flower clusters, as structures composed of spike lets that yield either grain or fruit. There are considerable variations in types with respect to the length, form, weight, and total productivity of a plant. Due to its labor and water intensive nature, rice farming does best in regions blessed with ample rainfall and low labor costs. The mineralization of Novel Poultry manure when paired with Sesbania has led to its recognition as a useful source of plant nutrients for the summer growing season [5].By contrast, the sustained application of poultry manure blended with sesbania to crops grown in a specified rotation is not solidly supported by scientific research. In northwest India, the usual crop rotation involves growing lowland rice in sequences with wheat, but there is a deficit of information about how Novel Poultry manure and Sesbania contribute to fertilizer value. In addition, there is insufficient understanding of the importance of adding organic matter to subtropical soils by Novel Poultry manure with Sesbania to both sustain and increase yields [6]. Investigations into the height of Oryza sativa (rice) yield 1500 articles on Google Scholar and 300 on Science Direct. Novel Poultry dung with Sesbania, and similar organic manures, liberate nutrients essential for plant growth, enhancing soil organic matter (OM) and thus making those nutrients available to plants [7]. Because it has essential nutrients linked to high photosynthetic activity, it encourages vegetable and root growth.

Previous research has shown that intensive agricultural production benefits more from using both inorganic fertilizer and organic manure in tandem than from using either fertilizer option separately. Research finds that to increase agricultural stability and improve the fertility status of the soil, it may be beneficial to fuse chemical and organic manure fertilizers. Being a rich nutrient source, poultry dung is compatible with a wide range of fertilizer applications. For the mitigation of nutrient imbalances and the inherent risks to animal health coupled with the pollution of surface and groundwater, effective soil fertility management requires that manure application be performed correctly [8]. By using fewer chemical fertilizers and more cow dung, rice straw, novel poultry manure with sesbania, and other such materials, it is also possible to drastically reduce the quantity of pollution released into the environment. Phosphorus is the second most critical nutrient for plant growth, and rice crops

require more of it than other crops. The right amount of phosphorus fertilizer must be applied in order to enhance output. The purpose of this study was to determine how wetland rice development and output are impacted by phosphorus levels and green manure. The entire height of the crop grown using an organic fertilizer called Novel Poultry dung has not yet been compared by the researchers to that of Sesbania and pig manure. Comparing studies of crop yields of Oryza sativa (rice) using a novel poultry manure with Sesbania and pig manure, which promotes high crop development, is the aim of this study.

2. Materials and Methods

The experimental area featured 1000 square feet of farmland. A plow was equipped along with the change in depth to suit the soil. Before initiating the tractor and going to the field's initiation point, a review for hindrances took place in the landscape (Shrestha et al., 2020). With the implement fixed, the tractor rolled in uniform lines, filling the entire area with a small slight overlap between its passes. To fully prepare the ground, use tractors loaded with plows to break down soil clods and provide a fine seedbed for plant growth and seed germination (Anhar et al., 2020). Until the entire area was prepared, the procedure took place repeatedly. The seeds from EXNORA International. The seed germination process was successfully finished for the rice plant. In 25 to 30 days, the seeds received a transplant. A total of two groups took part in the research. Every collection contains 20 samples and the full sample is 40. The team first applies manure from poultry combined with sesbania and next uses pig manure in Group 2. The objective of the pretest analysis was to estimate the sample size based on a 95% confidence interval, an 80% G power and a 0.04 threshold. Two different types of organic amendments were developed - a mixture of poultry manure and Sesbania, and pig manure left to decompose over a period of 8 months. With the implement engaged, the tractor moved in straight lines, covering the entire area with a tiny overlap between passes. Till the ground fully with tractors equipped with plows to break up clods and create a fine seedbed that will support plant growth and seed germination (Anhar et al., 2020). Until the entire field was ready, the procedure was repeated. The seeds from EXNORA International. For the rice plant, the initial seed germination process was completed. After 25 to 30 days seeds were transplanted. The total number of groups involved in the study was two.

Each group carries 20 samples and the total sample is 40. Group 1 is the sample using poultry manure mixed sesbania and Group 2 uses pig manure. The pretest analysis was carried out to calculate the sample size with 95% confidence interval, 80% G power and with 0.04 threshold. Organic amendments of two sorts were prepared. poultry manure was blended in a Sesbania. Pig manure was collected and allowed to decompose for 8 months. The study entitled "Oryza Saitva (Rice)" in the field examined the progress and growth of the plant. Agricultural fertilizer contained a new poultry manure combined with sesbania. 25–30 days after, seeds were transplanted. All participants in the study included two different groups. Totalling 40 samples, each group carries 20 samples. In Group 2, they use pig manure; as an illustration, Group 1 uses poultry dung in combination with sesbania. The sample size estimate was computed based on pretest analysis, having 95% confidence interval, 80% G power, and an 0.04 threshold. For the study, two different organic amendments were prepared. Mixed with the material is manure from poultry. Pig waste was collected and given eight months to disintegrate. Using Oryza Saitva (rice) as a crop in the field provided researchers the opportunity to follow the development and growth of the plant. To serve as agricultural fertilizer, sessions of new poultry manure combined with sesbania were employed. The first move in the process is to obtain thoroughly aged chicken manure from

chicken farms. Be sure the manure is clean and has sufficiently decomposed to address problems such as nitrogen burn. Sesbania plants are simultaneously gathered, and their ability to fix nitrogen increases soil fertility in a natural way. When shredded, biomass from Sesbania is more easily incorporated into the mixture during the breakdown process.

After shredding the Sesbania biomass and poultry manure, the next step is to assemble them in a composting bin, making sure to manage moisture levels and occasionally mixing them to speed up the decomposition. The combination changes into a rich nutrient compost that can be applied for weeks to several months. Forty samples were equally split into two groups—20 samples in each group—for the purpose of measuring plant height. investigated crop height 120 days after fertilizer application. Group 1 categorized the fertilizer based on its better nutritional value for growth promotion. While sesbania manure gives the soil extra nitrogen through its nitrogen-fixing qualities, which strongly affect height growth, poultry manure contains nitrogen, phosphorus, and potassium, all essential nutrients for plant development. Researchers were able to track plant development and growth by employing Oryza Saitva (rice) as the crop in the field. The crop fertilizer consisted of pig waste. For measuring the height of the plants, it is divided the total of forty samples equally into two groups of twenty samples each. The crop was examined with height 120 days after applying the fertilizer. It is considered the fertilizer as Group 1 because it had better nutritional value for promoting growth. Containing calcium, nitrogen, phosphorus, and potassium is the pig dung. The assessment of mean, standard deviation, and significant difference was performed for the Oryza sativa Crop using SPSS V.26. Following several applications using innovative poultry manure combined with sesbania, the plant height is recorded. The population with the maximal measured height records greater performance than the population with the least measured crop production. For the analysis, it is necessary to use the intermediate collected at the final phases of plant development, which should occur once every 25 days, according to Mala et al. (2017).

3. Results & Discussion

In case of Novel Azolla, the maximum stem diameter observed was 4. 3 mm, 3 mm per plant with stem thickness of maximum 3 mm also provided by Goat Manure. 4 mm per plant, and as highlighted in the table 1 below. The summary of the group data of total crop output is provided in Table 2 below. A new Azolla fertilizer helps make Oryza Saitva crops have thicker stems. From the Table 3 there is an indication that $p = 0$. The statistically significant value that was achieved was 0026 ($p < 0.05$). On this it was said that a considerate difference existed between the two groups. Fig. 1 shows the growth of Oryza Saitva using fertilizers: The growth of Oryza Saitva crop in (a); (b); (c) by using novel Azolla fertilizer for 120 days; and (d) by applying goat fertilizer. A comparison of crop development between Novel Poultry Manure with Sesbania (achieving a height of 87.5 cm per plant) and pig manure (obtaining a height of 70 cm per plant) is available in Table 1. Table. 2 presents standard deviation (SD), standard error (SE), and mean of crop yield for the two fertilizers. Statistics show a significant divergence between the two groups; using the novel poultry manure along with Sesbania is more profitable for raising crop yield than just using pig manure. Table. 3 shows that the fertilizer comparison reaches significance at a level of $p = 0.001$, which falls below the usual cutoff of $p < 0.05$. Results from a separate test of plant crop development backed the statistical findings.

The results, which indicated that while some of the nitrogen in the manure was instantly available to plants, the remaining nitrogen gradually metabolized to sustain the N supply for rice and other crops, are in line with the performance of poultry manure. The apparent N

recoveries from applying urea and poultry manure in a 1: Results showed that 1 ratio was indistinguishable from those obtained by using urea or manure separately (Ismael et al., 2021). The innovative poultry manure containing Sesbania produced the greatest height (118.9 cm) throughout the trial; the control treatment yielded the least height (104.8 and 109.8 cm). Amanullah et al. (2016) report that nitrogen boosts cytokinin levels in nodes and leads to primordial germinations that, in turn, increase tiller production. Yield increased by 5% when using unique poultry manure containing Sesbania, compared to the control. Running a trial comparing innovative poultry manure containing Sesbania and Pig manure with the control indicated a 6-12% increase in crop growth (G. S. Kumar et al., 2023). In addition, this application caused an increase in rice straw yields. It is obvious that the application of organic manure together with synthetic fertilizers promoted enriched plant vegetative growth, thereby increasing the quantity of straw generated by rice bushes (Sutardi et al., 2022). The nutrients present in pig manure are quickly available to plants, helping them to absorb them quickly and to dissolve in solutions of soil. Microorganism activity alongside increased soil physical characteristics produces nutrients from organic sources (Moe et al., 2019).

Table 1. The results of the stem diameter based of the Oryza Sativa plant treated with the novel azolla and goat manure

S. No	Height of the plant in cm when poultry manure Mixed Sesbania	Height of the plant in cm when Pig manure
1	87	86
2	87	87
3	87	75.33
4	87	76
5	85	77.3
6	85	76.38
7	89	78
8	90	75.38
9	81	79.39

S. No	Height of the plant in cm when poultry manure Mixed Sesbania	Height of the plant in cm when Pig manure
1	87	86
2	87	87
3	87	75.33
4	87	76
5	85	77.3
6	85	76.38
10	83	70
11	82	74.93
12	84	75.34
13	87	76.78
14	89	79
15	90	78
16	81	77.84
17	88	80
18	85	79.39
19	87	76
20	82	79.42

Table 2. The The mean and standard deviation for the samples poultry manure with sesbania and pig manure

Group Statistics					
S. No	Sample	N	Mean	Std. deviation	Std Error mean

1.	Poultry manure with Sesbania	20	85.9500	3.01706	.67463
2.	Pig manure	20	77.0479	2.39007	.54832

Table 3. The rice growth independent sample t test with a significance threshold of p = 0.001, below p = 0.05

Independent samples Test										
Plant Height	Levene's Test for equality of variances			T-test for equality of means					95%confidence interval of the difference	
		F	Sig	t	df	Sig (2 tailed)	Mean Diff	Std error Diff	Lower	Upper
	Equal variance assumed	2.36	.13	10.17	37	.001	.001	2.36	.13	10.17
	Equal variance not assumed			10.24	35.87	.001	.001			10.24

The comparative analysis of the crop growth of Oryza sativa (rice) utilizing novel poultry manure containing Sesbania and pig manure is shown in Fig. 1(a–d). (a) Shows the germination of the Oryza sativa crop height after 15 days; (b) After 120 days, displays the new poultry manure with a mixed fertilizer of Sesbania and pig manure; (c) Shows how to use pig manure as a crop fertilizer; and (d) Shows fully grown Oryza sativa using the organic fertilizer. Several authors have found that the addition of organic amendments greatly contributes to both the extended development of soil quality and the prompt supply of nutrients to rice crops irrigated by floods. In addition, using organic manures connected to

better soil architecture and root development, higher soil water availability, and greater soil nutrient availability (La Ode et al., 2022). During the first and second years of the research, the dwarf plants grew to 106.9 and 111.1 cm, respectively. According to Siavoshi et al. (2011), root growth because of phosphorus administration contributed to greater photosynthetic activity, greater water and nutrient absorption, and a noticeable improvement in plant size

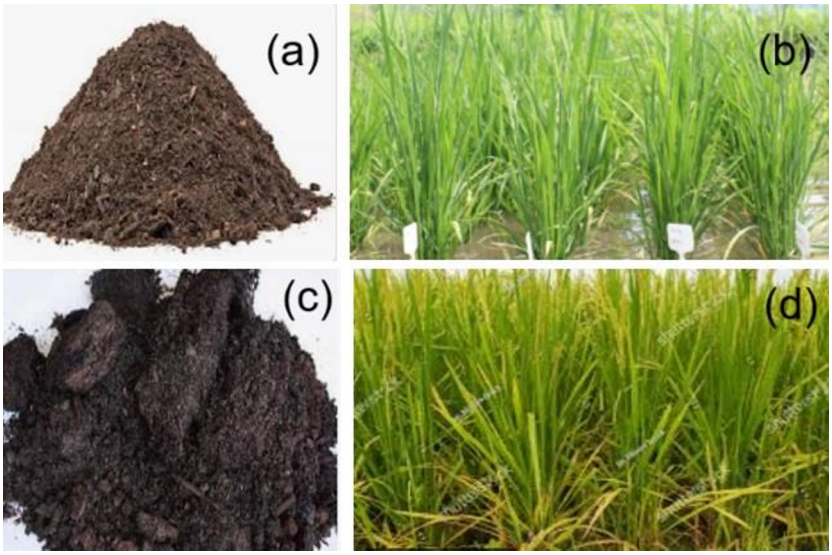

Fig. 1. The growth of Oryza Saitva crop (a) by using novel Azolla fertilizer (b) in 120 days; and (c) by applying pig manure (d) in 120 days.

Unique poultry manure enriched with Sesbania can lead to sustainable harvests of rice, which receive adequate nutrients at important stages of development. Improved root growth and soil water retention because of organic matter from poultry manure together with Sesbania could produce greater rice grain yields (Moreno-García et al., 2017). In the beginning, variations in the quantity and rate of nutrient release from poultry manure can make it difficult to precisely manage nutrients, which can lead to either imbalances or insufficiencies that are bad for rice growth. Sesbania finds it challenging to supply rice with a steady supply of nitrogen because of three factors: the level of temperature, degree of moisture in the soil, and pH. Evaluating planting density, timing, and management techniques with care is important to understand sesbania's ability to fix nitrogen within rice fields without hindering rice growth or causing resource conflict. To alleviate potential harmful effects, more study is necessary to examine the allelopathic influence of Sesbania residues on rice germination and early growth and development.

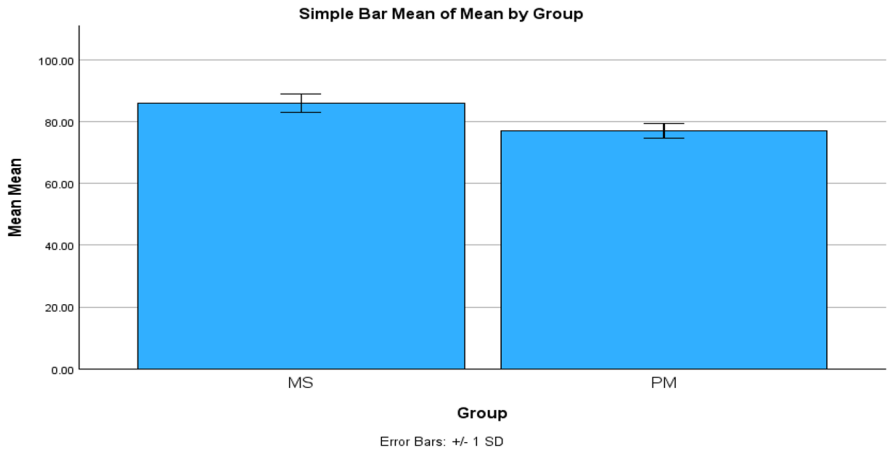

Fig. 2. The rice growth of Oryza Saitva using Novel Azolla and pig manure with +/- 1 standard deviation and at 95% confidence interval. A significance value of 0. 0026 was obtained

4. Conclusion

Newly collected poultry manure with Sesbania and pig dung were used for a comparative analysis of Oryza sativa (rice) growth, showing clear variations. Thanks to the Sesbania in the new poultry manure, not only did rice production increase, but also the output improved due to the release of sufficient nutrients. In addition, the special poultry manure rich in Sesbania advanced the quality of the soil, leading to greater development and yield. Also, it seems that the new, unique poultry manure that contains a combination of Sesbania and pig manure could be a superior addition to pure pig manure, resulting in greater yields both for plant growth and agriculture. The results show that the crop yield from the unique poultry manure blend exceeded that of pure pig manure at 87.5 cm/plant, with the pig manure reaching 70 cm/plant. Establishing the statistical importance of these results with respect to crop output is the resulting significance value, $p = 0.001$ ($p < 0.05$).

References

1. A. Nicolas, J.-L. Barrat, J. Rottler, Effects of inertia on the steady-shear rheology of disordered solids. Phys. Rev. Lett. **116**, 058303 (2016)
2. A. Lohrasebi, T. Koslowski, Modeling water purification by an aquaporin-inspired graphene-based nano-channel. J. Mol. Model. **25**, 280 (2019). https://doi.org/10.1007/s00894-019-4160-y
3. M. Ben Rabha, M.F. Boujmil, M. Saadoun, B. Bessaïs, Eur. Phys. J. Appl. Phys. (to be published)

Books

4. J. Couturier, Y.H. Abou and E. Grolleau, Element of nuclear safety, (EDP Sciences, Les Ulis, 2019)
5. M.N. Ozisik, Radiative transfer and interactions with conduction and convection (John Wiley and Sons, New York, 1973)

Proceedings

6. J. Rhodes, K. Smith, D. Lee, CASMO-5 development and applications, in Proceedings of the PHYSOR-2006 conference, ANS Topical Meeting on Reactor Physics, Vancouver, BC, Canada, September 10-14, September 10-14 (2006), B144

Theses

7. S. Azzaoui, SCALE-6 fuel depletion analyses: Application to the ARIANE program, Master Thesis, SCK-CEN, Belgium, 2010
8. K. Ambrožič, L. Snoj, Characterization of gamma field in the JSI TRIGA reactor, Ph.D. thesis, University of Ljubljana, Faculty of Mathematics and Physics (2020)