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Comparison of Organic vs Inorganic Fertilizers on Germination and Growth of Bijinbira and Jirani Bazawara Rice Varieties

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ABSTRACT

Background and Objective: Rice is a staple crop critical to global food security, yet sustainable fertilizer management remains challenging. While organic and inorganic fertilizers are widely used, their specific impacts on germination and early growth of different rice varieties are poorly understood. This study evaluates the effects of these fertilizers on the germination and growth of Bijinbira and Jirani Bazawara rice varieties, addressing a key gap in knowledge and contributing to sustainable agricultural practices. **Materials and Methods:** Samples of Bijinbira and Jirani Bazawara rice seeds were obtained from Dankure Market. Poultry droppings from Dankure market. Cow dung and NPK fertilizer were collected from the Kara market. The rice seeds were assessed using a water flotation test. The experiment used a Completely Randomized Design (CRD) with four treatments: Cow dung, poultry droppings, NPK fertilizer, and a control (no fertilizer) over five weeks. Germination was assessed by counting seeds with the first count on the fifth day to measure seed vigor and the final count on the tenth day for the germination percentage. The length and width of seeds from each treatment group were measured using a digital caliper. Descriptive statistics (mean and SD) were calculated for germination percentages, seed lengths, and widths, followed by independent t-tests to compare means between two rice varieties, with significance set at $p<0.05$. The ANOVA and *post hoc* Tukey's HSD tests were used to analyze and identify significant differences ($p<0.05$) in germination rates across treatments. **Results:** The germination percentages of Bijinbira and Jirani Bazawara showed significant variation, with Bijinbira achieving the highest germination rate of (90.00%) under combined poultry and cow dung, while the control treatment exhibited the lowest germination at (30.00%). Seed length and width were also measured, with Jirani Bazawara seeds recording the highest seed length (10.15 mm) and Bijinbira seeds achieving the widest seed width (2.21 mm). The results indicate that organic fertilizers, particularly poultry droppings and cow dung, enhance germination and seed development more effectively than inorganic fertilizers. The findings align with previous research supporting the use of organic fertilizers to improve plant growth in nutrient-deficient soils. **Conclusion:** This study concludes that organic inputs are more beneficial for the early growth stages of these rice varieties and recommends further research into optimizing fertilizer application rates. Farmers are encouraged to adopt organic fertilizers to improve crop productivity sustainably.

KEYWORDS

Bijinbira, Jirani Bazawara, germination, cow dung, poultry droppings, rice varieties

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INTRODUCTION

Rice (*Oryza sativa*), believed to have originated around 11,500 years ago in regions like Shandong, China, is an essential staple crop in Nigeria. It plays a key role in addressing food security by providing a minimum of 2,400 calories per person daily[1]. Historically, rice has held a unique place in human culture, being cultivated by emperors and kings, offered as a sacred gift to deities, and consumed by both the wealthy and the poor[2,3]. In Nigeria, rice consumption transcends socio-economic and cultural divides, making it a vital component of both everyday meals and festive occasions[4,5]. Rice is crucial across Nigeria, consumed by people of diverse cultural, religious, and ethnic backgrounds. Available in both urban hotels and rural eateries, its significance extends beyond basic nutrition, playing a prominent role during festivities and special occasions. Despite its widespread demand, Nigeria struggles to meet consumption needs through domestic production alone, necessitating imports from countries like Thailand and India[3,4].

Recent government efforts, such as the Value Chain Development Program (VCDP) in partnership with organizations like the International Fund for Agricultural Development (IFAD) and Olam International, aim to increase local production and reduce reliance on imports[6]. These initiatives target challenges such as post-harvest losses, low mechanization, and access to finance, empowering smallholder farmers and improving food security[4,5]. However, despite improvements, only about 57% of Nigeria's rice consumption is produced locally, underscoring the need for continuous investment in agricultural development[3,4].

The crop is commonly consumed as a food crop for household food security. The average Nigerian consumes 24.8 kg of rice per year, representing 9% of annual caloric intake[7]. Successive Nigerian governments have responded to the persistent rice supply deficit by implementing tariff increases aimed at boosting domestic rice production. These policies were designed to protect local farmers and encourage self-sufficiency by making imported rice more expensive, thereby expanding the market for locally grown rice. However, despite these efforts, Nigeria has become one of the largest rice importers globally, second only to Indonesia during the period between 2000 and 2005[8,9].

The import value of rice surged significantly, rising from $259 million in 1999 to $655 million in 2001 and $756 million in 2002[7]. However, these figures do not account for the substantial quantities of rice smuggled into the country, which further complicates the accurate assessment of Nigeria's rice importation landscape[8]. Nigeria is among the world's largest importers of rice, despite the vast land area suitable for rice cultivation and the fact that farmers constitute about 70% of Nigeria's population. The reliance on imports has led to revenue loss and unemployment, discouraging local rice cultivation.

Recently, the Nigerian government's dependence on rice importation has discouraged local farmers and contributed to rising domestic rice prices[8]. Despite tariff interventions intended to boost local production, the easy availability of imported rice has slowed domestic farming efforts[3]. To overcome these challenges, promoting research on improved rice varieties and modern farming techniques is essential. Limiting rice imports could strengthen local agricultural markets and enhance food security across the country[5,8].

In Sokoto State, Bijinbira and Jirani Bazawara varieties offer promising solutions to the challenges facing rice farmers, including high production costs and limited mechanization. Promoting these varieties could provide job opportunities and ensure year-round farming, which is vital for economic sustainability[9]. The purpose of the study comparison of organic vs inorganic fertilizers on germination and growth of Bijinbira and Jirani Bazawara rice varieties is to evaluate and compare the effects of organic and inorganic fertilizers on the germination and growth of two specific rice varieties. The study aims to provide a clear understanding of how different fertilization methods influence key growth parameters such as seed germination rate, plant height, and overall yield potential. By conducting this comparison, the study is expected to contribute valuable insights into the sustainability of using organic fertilizers versus inorganic alternatives in rice farming. Furthermore, the research will examine the environmental implications of both fertilizer types, highlighting the potential benefits of organic fertilizers in promoting soil health and reducing dependence on synthetic inputs. Ultimately, the study seeks to enhance the knowledge base surrounding rice cultivation and support more sustainable agricultural practices, contributing to the optimization of rice farming and environmental sustainability.

MATERIALS AND METHODS

Study area: The research was conducted over a total duration of six months, beginning with a one-month literature review and planning phase. This was followed by a month's date from February to May, 2023 dedicated to the planting, monitoring, and cultivation of Bijinbira and Jirani Bazawara rice varieties under different fertilizer treatments. Data collection and analysis were completed in the subsequent two months, culminating in the final preparation of results and reporting.

The study was conducted within Sokoto Metropolis, situated in Sokoto State, Nigeria, in the extreme northwest region of the country. Sokoto lies at the confluence of the Sokoto and Rima Rivers and spans an area of 25,973 km^2[10]. According to the National Bureau of Statistics, Sokoto has an approximate population of 563,861[10,11]. Geographically, the city is positioned at 13.0609°N Latitude and 5.2431°E Longitude, with an average elevation of 272 m above sea level[11].

Sokoto's climate and geography are crucial to its agricultural practices, making it an important area for crop production in Nigeria[12]. The climate is semi-arid, typical of the Sahel region, with a wet season from June to September. Annual rainfall ranges from 300 to 800 mm, while the mean annual temperature is approximately 34°C, often exceeding 40°C in the dry season[12]. The region's vegetation is shaped by temperature, rainfall, and soil type, contributing to the essential role agriculture plays in local livelihoods. Key crops grown during the dry season, primarily under irrigation, include onions, tomatoes, and peppers, alongside other staple crops like carrots, rice, wheat, and garden eggs[13].

Sample collection: Samples of seeds of Bijinbira and Jirani Bazawara rice varieties and poultry droppings were obtained from Dankure Market and samples of cow dung and NPK manure were obtained from the Kara market, Sokoto and stored in clean labeled polyethylene bags and transported to the Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto.

Sample preparation: The seeds of the rice varieties were thoroughly cleaned to remove any debris, and their viability was assessed using the water flotation test. The seeds were placed in a container filled with water and left for approximately 10-15 min; viable seeds sank to the bottom, while non-viable seeds floated on the surface[14,15]. The organic manures were prepared following established guidelines, mixing them with soil to create a suitable growing medium for the seeds[16,17].

Experimental design: The experiment employed a Completely Randomized Design (CRD) with four treatments: cow dung, poultry droppings, NPK fertilizer, and a control (no fertilizer), conducted in a controlled environment at the Biological Garden of Usmanu Danfodiyo University, Sokoto, over 5 weeks. Five treatments were established for each type of manure (poultry droppings, cow dung, and NPK fertilizer), along with a control group containing no manure. Each treatment was replicated in three pots, totaling fifteen pots for the experiment. Before planting, the specified amounts of poultry droppings, cow dung, and NPK were thoroughly mixed into the soil of each pot to ensure uniform nutrient distribution, following standard agronomic practices[10]. The pots were filled with a well-draining growing medium, and ten seeds from each rice variety were sown per pot. The pots were watered daily to maintain moisture at field capacity, adhering to recommended irrigation practices for optimal seed germination[18]. Germination counts were conducted on the fifth- and tenth days post-sowing to assess seed vigor and overall germination percentage, respectively[19].

Germination count: To determine the germination count, seeds were planted and monitored by standard germination protocols[20]. Ten seeds of each rice variety were sown per treatment in clay or plastic pots filled with soil mixed with the specified manure concentrations. The pots were watered daily to maintain optimal moisture levels for germination[20]. Germination was assessed by counting the seeds that successfully sprouted with visible radicle emergence. The first germination count, taken on the fifth day after sowing, evaluated seed vigor, while the final count on the tenth day represented the germination percentage[20]. Germination percentage was calculated by dividing the number of germinated seeds by the total seeds sown, multiplied by 100. Regular monitoring and observations were recorded at consistent intervals to ensure accurate germination data collection[21].

The formula for calculating germination percentage (seed count) is as follows[21]:

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds sown}} \times 100$$

Seed length: To measure seed length, a sample of ten seeds per treatment group was selected and measured using a digital caliper[22,23]. Each seed was positioned flat, with length measured from the tip (apex) to the base along the longest axis. This measurement process was repeated three times for each seed, and the average value was recorded to minimize measurement errors.

Seed width: To measure seed width, a sample of ten seeds per treatment group was selected and measured using a digital caliper[23]. Each seed was positioned flat, and the width was measured three times for each seed, with the mean value recorded to ensure accuracy[22].

Data analysis: The statistical analysis of the rice germination and seed characteristics data involved several key methods to assess differences between the Bijinbira and Jirani Bazawara rice varieties. First, descriptive statistics, including the mean and Standard Deviation (SD), were calculated to assess the variability of germination percentages, seed lengths, and seed widths. To compare the means between the two rice varieties, an independent t-test was performed. This test evaluates whether the difference in means between the two varieties is statistically significant, with a p-value less than 0.05 indicating a significant difference. For the germination data across different treatments, an Analysis of Variance (ANOVA) was used. The ANOVA tests whether there are any significant differences in germination rates between the different treatments by comparing the variance between groups to the variance within groups. If ANOVA revealed significant differences, a *post hoc* Tukey's Honest Significant Difference (HSD) test was applied. This test identifies which specific groups differ from each other, assigning significance letters (a, b, c, etc.) to the treatments. Treatments sharing the same letter are not significantly different, while those with different letters are. Finally, a significance level of $p<0.05$ was used throughout the analysis, meaning that any $p<0.05$ indicates statistically significant results, suggesting that the observed differences are unlikely due to random chance.

RESULTS

The result for germination percentage showed that Bijinbira rice varieties had the highest germination percent with 90.0±23.56 under combined poultry and cow dung treatment, and the lowest germination with 30.0±23.56 was recorded under control conditions. For Jirani Bazawara, the highest germination with 70.0±16.05 was observed under poultry dropping, and the lowest germination percent with 70.0±16.05 was recorded in the control group. Both rice varieties showed similar germination rates of 65.0±23.56 and 65.0±16.05 under NPK fertilizer, respectively shown in Table 1.

In Table 2, the result showed that the Bijinbira rice variety had the highest seed length of (7.31 mm) in seed 3 and the lowest was (5.99 mm) in seed 8. Jirani Bazawara had the highest seed lengths of (10.15 mm) in seed 6, while the lowest was (8.88 mm) in seed 7.

Table 1: Germination percent of Bijinbira and JiraniBazawara rice variety

Treatment	Bijinbira (Mean±SD)	Jirani Bazawara (Mean±SD)
Cow dung	80.0±23.56[a]	55.0±16.05[b]
Poultry droppings	80.0±23.56[a]	70.0±16.05[a]
NPK	65.0±23.56[b]	65.0±16.05[a]
Poultry+cow dung	90.0±23.56[a]	65.0±16.05[a]
Control	30.0±23.56[c]	30.0±16.05[c]

Mean with the same letters are not significantly different ($p<0.05$)

Table 2: Seed length measurements of Bijinbira and JiraniBazawara rice variety

Seed number	Bijinbira seed length (mm)	Jirani Bazawara seed length (mm)
1	7.12	09.59
2	6.95	09.25
3	7.31	10.02
4	7.02	09.69
5	6.89	08.95
6	6.52	10.15
7	7.05	08.88
8	5.99	10.01
9	7.12	09.69
10	6.85	09.03
Mean±SD	6.882±0.357[a]	09.526±0.447[b]

Mean with same letters are not significantly different ($p<0.05$)

Table 3: Seed width measurements of Bijinbira and Jirani Bazawara rice variety

Seed number	Bijinbira width (mm)	Jirani Bazawara width (mm)
1	1.83	1.62
2	1.56	1.40
3	1.92	1.88
4	2.01	2.00
5	1.21	1.01
6	2.21	1.20
7	1.75	1.05
8	2.12	2.31
9	1.73	1.65
10	2.01	1.03
Mean±SD	1.835±0.293[a]	1.515±0.53[a]

Mean with same letters are not significantly different ($p<0.05$)

The widths of the Bijinbira seeds ranged from 1.21-2.21 mm, with the highest width observed in seed 6 with (2.21 mm) and the lowest in seed 5 with (1.21 mm). Jirani Bazawara rice seeds ranged from 1.01-2.31 mm with the highest width recorded in seed 8 at 2.31 mm and lowest in seed 5 at 1.01 mm in Table 3.

DISCUSSION

The study highlights the significant impact of various fertilizers on the germination percentage, seed length, and seed width of two rice cultivars, Bijinbira (B.B) and Jirani Bazawara (J.B). Germination percentages for Bijinbira and Jirani Bazawara under different treatments align with previous studies indicating that organic and inorganic fertilizers enhance seed performance. Bijinbira exhibited a germination rate of 80.0 ± 23.56%, significantly higher than Jirani Bazawara's 55.0 ± 16.05%. This suggests that Bijinbira may be more responsive to organic fertilization with cow dung. Sharada and Sujathamma[24] reported that organic fertilizers, such as cow dung, can enhance germination and early seedling vigor in rice varieties. Cow dung's ability to improve soil structure and increase microbial activity in the soil is believed to contribute to enhanced nutrient availability, which promotes better seedling development Sharada and Sujathamma[24]. However, the varietal difference observed in this study (Bijinbira outperforming Jirani Bazawara) suggests that Bijinbira may be more responsive to organic amendments, which is in line with other studies that have noted varietal-specific responses to organic fertilizers. This variability further highlights the importance of selecting the right fertilizer for specific rice varieties.

Both varieties showed improved germination rates with poultry droppings: 80.0±23.56% for Bijinbira and 70.0±16.05% for Jirani Bazawara. The higher nutrient content in poultry manure, particularly nitrogen, may contribute to enhanced seed germination. Anisuzzaman *et al.*[19] found that poultry manure application positively affected rice growth and yield components.

Both Bijinbira and Jirani Bazawara showed improved germination under poultry droppings treatment (Bijinbira: 80.0±23.56%, Jirani Bazawara: 70.0±16.05%). This result aligns strongly with the work of Anisuzzaman *et al.*[19], who reported that poultry manure significantly boosted rice growth and seedling vigor due to its high nitrogen content, which accelerates seedling establishment. Poultry droppings also provide essential micro-nutrients like phosphorus and potassium, which support root and shoot development Anisuzzaman *et al.*[19]. The positive response in both rice varieties is consistent with the broader literature, where poultry manure is considered an excellent organic fertilizer for rice, improving not only germination but also post-germination growth. Furthermore, the higher germination rate in Bijinbira compared to Jirani Bazawara in this treatment suggests a possible varietal specificity, similar to results reported by Akata *et al.*[25], who found that organic fertilizers could have varied effects on different rice cultivars.

Germination rates were 65.0±23.56% for Bijinbira and 65.0±16.05% for Jirani Bazawara, indicating that inorganic NPK fertilizer supports moderate germination in both varieties. However, excessive reliance on chemical fertilizers can lead to soil degradation over time. Sharada and Sujathamma[24] emphasized the benefits of integrating organic and inorganic fertilizers to improve rice growth and yield sustainably.

Lasmini *et al.*[26], found that inorganic fertilizers like NPK provide essential nutrients that support moderate germination but may not promote the same level of early growth observed with organic fertilizers. Inorganic fertilizers such as NPK typically provide quick-release nutrients that may not be as effective in promoting long-term seedling vigor compared to organic amendments, which release nutrients more gradually Lasmini *et al.*[26]. This result corroborates the finding that although NPK fertilizers can enhance seedling growth, their effects on germination may be less pronounced compared to organic options, particularly in nutrient-deficient soils.

Control treatment, with no fertilization, resulted in the lowest germination rates for both varieties (30.0±23.56% for Bijinbira and 30.0±16.05% for Jirani Bazawara). This finding is in full agreement with the work of Moe *et al.*[27], who noted that the absence of fertilization limits essential nutrients needed for seed germination, leading to poor seedling establishment Moe *et al.*[27]. The significantly low germination in both rice varieties under control conditions further emphasizes the importance of fertilization for optimal rice seedling growth. The absence of added nutrients likely resulted in insufficient energy for seedling emergence, as the seeds could not access the necessary macro- and micronutrients needed for early development (Moe *et al.*[27]). This result reinforces the essential role of fertilization in rice production, highlighting the detrimental effects of nutrient deficiency on seedling growth.

Larger seed size is generally associated with better seedling establishment and early growth due to the increased energy reserves available for the developing plant. This relationship is supported by Shi *et al.*[28], who examined early vigor in rice cultivars and highlighted that larger seeds contribute to stronger initial growth and better seedling establishment. They found that increased early vigor is a key factor in determining overall rice productivity. Similarly, the current study suggests that Jirani Bazawara, with its larger seed size, could exhibit better early growth compared to Bijinbira, which had smaller seeds. This aligns with the notion that larger seeds are more robust and have better survival and growth rates in the early stages of rice development.

The impact of seed size on germination is well-documented in other crops, and rice is no exception. Yisau *et al.*[29] explored the effect of seed size on germination potentials in *Anacardium occidentale* seeds and found that larger seeds generally exhibit higher germination rates. This finding is consistent with the results of the present study, where larger seeds from Jirani Bazawara may contribute to higher germination success, similar to other findings on seed size and its role in early crop establishment.

Zainol *et al.*[30] also examined the importance of quality rice seeds in rice cultivation. Although this study primarily focused on the effects of seed quality on overall cultivation practices, it indirectly highlights how seed characteristics like size and vigor influence crop establishment and productivity. Given that Jirani Bazawara has larger seeds, its seed quality could contribute to better performance in terms of germination and early growth, providing a slight edge over Bijinbira in terms of rice cultivation outcomes.

The findings of this study suggest that Bijinbira has a wider seed compared to Jirani Bazawara, but both varieties fall within a similar range of seed widths. According to Moe *et al.*[27] grain size (including both width and length) is a crucial factor that determines rice quality, as it directly impacts milling yield, cooking properties, and nutritional value. Although seed width did not show significant statistical differences between the varieties, the larger seed width in Bijinbira could imply a higher potential for better grain quality and larger grain size post-harvest, which is often a preference in the market.

Bijinbira exhibited a mean seed width of 1.835±0.293 mm, while Jirani Bazawara had a mean seed width of 1.515±0.53 mm. Although there was no significant difference in seed width between the two varieties ($p<0.05$), the observed difference in seed width between the two varieties.

Luo *et al.*[31] examined the impact of seed size and cotyledon damage on seedling growth in Quercus wutaishanica. They found that larger seeds generally result in better seedling growth, as they provide more stored nutrients and energy for early development. The study emphasized that seed size plays a crucial role in determining early vigor and subsequent growth. While the present study focused on rice seeds, the findings from Luo *et al.*[31] support the idea that wider seeds, like those of Bijinbira, could lead to better early growth, even if the statistical difference in seed width was not significant. The seed size effect observed in this study is consistent with the general concept of seed size influencing early development and seedling vigor.

Hernández-Soto *et al.*[32] explored the effects of seed size on agronomic traits, specifically in rice breeding. They concluded that seed size is an important determinant of agronomic performance, including seedling vigor, germination rates, and overall yield potential. The study also found that larger seeds tend to perform better in terms of early establishment, which is critical for successful rice cultivation. The findings from Hernández-Soto *et al.*[32] align with the current study's observation that Bijinbira, with its wider seed size, might have a potential advantage in seedling establishment, even though the statistical difference between varieties was not significant.

Mogiso[33] focused on the effect of seed rate on the yield response of upland rice varieties in Ethiopia. The study found that seed size, alongside seed rate, significantly influenced rice yield. Larger seeds were associated with better grain size and overall yield potential, which correlates with the current study's findings that Bijinbira, with its wider seeds, may exhibit better potential in terms of growth, even if statistical significance was not observed. The broader consensus in this study is that seed size impacts yield, which aligns with the findings from Mogiso[33].

CONCLUSION

The study found that organic fertilizers, particularly poultry droppings and cow dung, significantly improved germination rates and seed quality in two rice cultivars, Bijinbira and Jirani Bazawara, compared to NPK and control treatments. Jirani Bazawara showed longer seeds, while Bijinbira had slightly wider seeds. These findings suggest that organic fertilizers can enhance crop performance and emphasize the need for selecting suitable cultivars for organic farming. Future research should explore cultivar performance under organic conditions, and farmers should be trained on combining organic fertilizers with NPK to improve germination and soil health.

SIGNIFICANCE STATEMENT

This study investigates the comparative effects of organic and inorganic fertilizers on the germination and growth of two rice varieties, Bijinbira and Jirani Bazawara. Understanding the role of fertilization methods in improving rice growth is critical for sustainable agricultural practices. The results highlight the potential of organic fertilizers to enhance soil health and improve crop yield, while also considering the efficiency of inorganic fertilizers in boosting growth performance. This research offers valuable insights into optimizing rice production for improved food security and sustainable farming practices.

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