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COMPARATIVE STUDY OF TWO NIGERIAN BEANS VARIETIES PRODUCTIVITY THROUGH DIFFERENT APPLICATION OF NODUMAX BIOFERTILIZATIO

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ABSTRACT
This study investigated the effects of varying concentrations of Nodumax (0.5g, 1g and 5g) on the growth and reproductive performance of two cowpea (*Vigna unguiculata*) varieties—*Ife brown* and *Ife omo* at the Greenhouse of the Department of Plant and Environmental Biology, Kwara State University, Malete, Nigeria. A number of three seeds were planted per pot, and each treatment was replicated three times. Prior to planting, three concentrations [low (0.5g), high (5g) and IITA Standard inoculum of concentrations of Nodumax], were applied to the soil. Uninoculated pots served as controls. Growth parameters were assessed monthly from April to June, while reproductive traits were measured after three months. Results revealed that high Nodumax concentration (5g) significantly enhanced nodulation and biomass. For instance, *Ife omo* recorded the highest nodule count (34.77 ± 0.03), pod with seeds (10.38 ± 0.07), and wet weight (28.04 ± 0.17g) in June under high concentration. Similarly, *Ife brown* showed improved stem length (30.80 ± 0.06 cm) and number of leaves (19.60 ± 0.06). High Nodumax treatments outperformed both the IITA Standard and control, indicating a positive correlation between rhizobial concentration and plant performance. This study fills a critical gap in cowpea agronomy by demonstrating that optimized rhizobial inoculation enhances varietal productivity and supports sustainable legume-based farming systems.

Keywords: Nodumax, *Vigna unguiculata,* Agronomy, Cowpea

INTRODUCTION
The cultivation of leguminous crops such as cowpea (*Vigna unguiculata* L. Walp) plays a vital role in enhancing food security, promoting sustainable agriculture, and improving soil fertility through biological nitrogen fixation (BNF) (Rahiel *et al*., 2023). Among cowpea varieties, *Ife brown* and *Ife omo* are widely cultivated in Nigeria due to their adaptability, nutritional content, and economic relevance (Saka *et al*., 2018; Ikhajiagbe *et al* 2023). However, their productivity is often constrained by nitrogen-deficient soils and limited access to chemical fertilizers, which are not only costly but also environmentally unsustainable (Rodriguez-Espinosa *et al*., 2023).
Rhizobial inoculation using commercial biofertilizers such as Nodumax has emerged as a promising alternative to chemical nitrogen sources (Marco *et al*., 2023). Nodumax, a formulation of *Bradyrhizobium spp.*, enhances nodule formation, promotes vegetative growth, and increases seed yield in cowpea under tropical conditions (Akley *et al*., 2023). While numerous studies have highlighted the general efficacy of rhizobial inoculants, findings remain inconsistent across locations, varieties, and environmental conditions, highlighting the need for variety-specific and site-specific assessments (Rahman *et al*., 2023).
Despite the growing body of literature on rhizobial inoculation, limited research has directly compared the differential responses of *Ife brown* and *Ife omo* cowpea varieties to varying concentrations of Nodumax across growth and reproductive stages. This presents a critical knowledge gap in optimizing inoculation strategies for enhanced productivity and environmental sustainability, particularly under field conditions representative of West African agroecosystems.
Therefore, this study investigates the growth and reproductive responses of *Ife brown* and *Ife omo* to low and high concentrations of Nodumax, alongside standard and uninoculated controls. By analyzing vegetative parameters (leaf area, stem length, number of leaves, nodulation, biomass) and reproductive performance (pods per plant, seed quality), the research aims to identify the optimal inoculation regime for each variety and to establish a basis for their integration into eco-efficient farming systems.

MATERIALS AND METHODS
The research was carried out in the Greenhouse of the Department of Plant and Environmental Biology, Kwara State University, Malete, Nigeria, with Latitude 8.438236° and Longitude 4.2911466°. The soil sample used was collected from an undisturbed land at a depth of 0-30cm, air dried and filtered with a 2mm sieve to remove large particles. Soil analysis was carried out to determine its physico-chemical properties and mineral content (AOAC, 2019). 20kg of soil was measured in perforated polythene nylon.

Plant Materials
Two varieties of Beans [Ife brown (NGVU 91-2) and Omo) and Nodumax were purchased from The International Institute of Tropical Agriculture (IITA), Idi Ose, Oyo Road, Ibadan, Oyo State, Nigeria. Ife brown is a semi erect, 75days maturity, Day length neutral, brown seeded and fast cooking beans. Omo variety is known for its early maturity, good seed quality, and tolerance to major insect pests.

Treatments and Experimental Design
Treatments on the test crops consist of 3 levels of NoduMax strain laid out in a randomized complete block design (RCBD). The 3 levels of treatments of NoduMax strain were High concentration, IITA Standard and Low concentration replicated in five with control. The treatments were prepared following the NoduMax user's instruction for Standard with

a slight adjustment for High and Low concentrations. The procedure for determining the low and high concentrations are shown below:
Low concentration: - 0.5g NoduMax, 0.2g Arabic gum, 100gseed, 2ml warm water.
Standard concentration: - 1g NoduMax, 0.2g Arabic gum, 100gseed, 2ml of warm water.
High concentration: - 5g NoduMax, 0.2g Arabic gum, 100gseed, 2ml of warm water.
Control – No NoduMax strain

Planting and Harvesting
The seeds were planted 10minutes after application of the NoduMax, three (3) seeds per pot in five replicates for each treatment. The plant were wet on a daily basics and the plant parameter was taken ones a month for 3 months.

Data collection and Analysis
Growth Parameter: Data were collected for plant height, pods per plant, and seed per pod, leave area stem length, and number of leaves analyses. Leave Area was calculated using the Bhatt and Chanda, (2003) developed model formula for *Phaselus vulgaris.*
Yield Parameter: Record data on number of pods per plant, seed per pod, Wet weight, Dry weight and overall yield per pod.
Plant parameters and detailed observation were taken five randomly selected plant per plot.
Statistical Analysis Approach
Inferential Statistics: ANOVA (Analysis of variance), compare the means of more than two groups (e.g different treatment on a single variety). Assess the effect of two independent variable and their interaction on dependent variable e.g the interaction of Nodumax on varieties yield.

RESULTS AND DISCUSSION
Growth Performance of *Ife Brown* and *Ife Omo* Bean Varieties
The application of different concentrations of Nodumax significantly influenced the growth parameters of both *Vigna unguiculata* varieties across the three-month period (April–June).

April Observations
In Table 1, higher Nodumax concentration (5g) promoted better growth in Ife brown, with noticeable increases in leaf area (9.30 ± 0.60 cm²), stem length (15.10 ± 0.05 cm), number of leaves (8.10 ± 0.06), and number of nodules (10.53 ± 0.67), compared to the control and lower concentration (0.5g) treatments. Similarly, Ife omo responded positively to higher Nodumax, especially in nodule formation (20.30 ± 0.10) and leaf development (8.32 ± 0.39), aligning with findings by Ogbuehi *et al*. (2022), who highlighted the role of effective rhizobial inoculants in boosting leguminous crop productivity. In addition, this result differs from that of Binang *et al*. (2017) where no significant difference was observed in the reproductive as well as growth parameters examined.

May Observations
Table 2 shows that there was a consistent increase in all parameters. For Ife brown, stem length peaked under IITA standards (29.00 ± 0.00 cm), while leaf production (16.45 ± 0.03) and dry weight (10.17 ± 0.17 g) were highest under high Nodumax application. Ife omo recorded the highest leaf area (15.50 ± 0.06 cm²) and number of nodules (26.50 ± 0.06) with 5g Nodumax, indicating enhanced rhizobial activity. These results suggest that proper inoculant dosage improves nitrogen fixation and biomass accumulation (De Oliveira *et al*., 2025).

June Observations
In Table 3, the highest values across almost all parameters were observed. For instance, Ife brown treated with 5g Nodumax had the highest number of nodules (30.40 ± 0.06) and wet weight (21.83 ± 0.03 g), while Ife omo responded with an even greater number of nodules (34.77 ± 0.03) and dry weight (6.23 ± 0.01 g). This conforms with recent studies by De Lara-Del Rey and Pérez-Fernández, (2023) which assert that enhanced rhizobial inoculation stimulates both vegetative and belowground growth, especially under optimal field conditions.

Reproductive Parameters
After three months, reproductive traits such as pod number, seed content, and pod quality reflected the cumulative effects of Nodumax application. *Ife omo* under high Nodumax concentration (5g) exhibited superior performance, producing 10.38 ± 0.07 pods with seeds and 13.50 ± 0.06 seeds per pod, significantly surpassing the control (2.70 ± 0.05 and 8.30 ± 0.06, respectively). Ife brown also showed improvement under IITA standards and high Nodumax, with up to 9.41 ± 0.05 pods with seeds. These results corroborate findings by Razafintsalama *et al*. (2022), who reported that rhizobial inoculation not only enhances vegetative growth but also boosts reproductive success in legumes.

Table 1: Growth parameters of the two varieties of beans (*Ife brown and Ife omo*) in the month of April

Parameters	Ife brown variety				Ife omo variety			
	Low concentration (05g Nodumax)	High Concentration (5g Nodumax)	IITA Standard (1g Nodumax)	Control	Low concentration (05g Nodumax)	High Concentration (5g Nodumax)	IITA Standard (1g Nodumax)	Control
Leaf area (cm^3)	brown	9.30 ± 0.60^b	7.40 ± 0.60^a	7.20 ± 0.12^b	7.92 ± 0.01^b	8.32 ± 0.39^a	7.80 ± 0.01^b	6.24 ± 0.04^c
Stem length (cm)	16.30 ± 0.15^b	15.10 ± 0.05^c	16.60 ± 0.11^a	5.10 ± 0.05^c	12.40 ± 0.01^b	18.50 ± 0.29^a	12.00 ± 0.00^b	12.40 ± 0.00^b
Number of leaves	5.13 ± 0.07^b	8.10 ± 0.06^a	4.50 ± 0.05^c	8.17 ± 0.03^a	3.86 ± 0.03^d	6.17 ± 0.70^b	4.57 ± 0.006^c	8.20 ± 0.00^a
Number of nodules	5.50 ± 0.06^c	10.53 ± 0.67^a	5.83 ± 0.03^b	5.40 ± 0.01^c	7.00 ± 0.00^b	20.3 ± 0.10^a	4.53 ± 0.03^c	7.23 ± 0.15^b
Wet weight (g)	3.23 ± 0.15^c	7.25 ± 0.08^a	4.53 ± 0.3^c	5.00 ± 0.00^b	3.27 ± 0.11^c	6.65 ± 0.00^a	4.57 ± 0.03^b	4.34 ± 0.01^d
Dry weight (g)	0.76 ± 0.01^d	1.54 ± 0.02^a	1.05 ± 0.01^b	0.86 ± 0.15^c	0.72 ± 0.28^b	1.43 ± 0.07^a	1.00 ± 0.00^a	0.74 ± 0.01^b

n= 54, values with the same superscript along treatments for each variety are not significant at $p \leq 0.05$. Low concentration =12, High concentration = 12, IITA standard = 12, Control= 12.

Table 2: Growth parameters of the two varieties of beans (Ife brown and Ife omo) in the month of May

Parameters	Ife brown variety				Ife omo variety			
	Low concentration (05g Nodumax)	High Concentration (5g Nodumax)	IITA Standard (1g Nodumax)	Control	Low concentration (05g Nodumax)	High Concentration (5g Nodumax)	IITA Standard (1g Nodumax)	Control
Leaf area (cm^3)	9.68 ± 0.42^c	11.87 ± 0.04^a	11.40 ± 0.10^b	9.60 ± 0.00^c	9.67 ± 0.03^c	12.58 ± 0.73^b	15.50 ± 0.06^a	8.89 ± 0.05^d
Stem length (cm)	24.53 ± 0.33^c	26.00 ± 0.00^b	29.00 ± 0.00^a	17.47 ± 0.00^d	20.30 ± 0.15^b	16.34 ± 0.08^c	22.22 ± 0.12^a	15.8 ± 0.00^d
Number of leaves	12.30 ± 0.15^a	16.45 ± 0.03^a	12.00 ± 0.00^d	13.53 ± 0.53^b	14.17 ± 0.17^c	17.37 ± 0.19^a	15.20 ± 0.12^b	5.50 ± 0.006^d
Number of nodules	12.17 ± 0.17^a	8.80 ± 3.30^c	9.80 ± 0.06^b	7.40 ± 0.00^d	11.3 ± 0.06^c	26.50 ± 0.06^a	17.17 ± 0.15^b	7.50 ± 0.06^d
Wet weight (g)	6.80 ± 0.06^c	10.17 ± 0.17^a	9.88 ± 0.01^a	7.21 ± 0.05^b	9.62 ± 0.01^c	18.32 ± 0.01^a	14.31 ± 0.09^b	6.54 ± 0.06^d
Dry weight (g)	6.80 ± 0.06^c	10.17 ± 0.17^a	9.88 ± 0.01^a	7.21 ± 0.05^b	1.55 ± 0.03^c	2.15 ± 0.00^a	1.34 ± 0.00^c	1.97 ± 0.00^b

n= 54, values with the same superscript along treatments for each variety are not significant at $p \leq 0.05$. Low concentration =12, High concentration = 12, IITA standard = 12, Control= 12.

Table 3: Growth parameters of the two varieties of beans (*Ife brown and Ife omo*) in the month of June

Parameters	Ife brown variety				Ife omo variety			
	Low concentration (05g Nodumax)	High Concentration (5g Nodumax)	IITA Standard (1g Nodumax)	Control	Low concentration (05g Nodumax)	High Concentration (5g Nodumax)	IITA Standard (1g Nodumax)	Control
Leaf area (cm^3)	11.57± 0.29[a]	13.95 ± 0.29[a]	5.37 ± 0.02[d]	10.93 ± 0.00[c]	13.15 ± 0.10[b]	13.85 ± 0.03[a]	9.19 ± 0.06[d]	10.43 ± 0.03[c]
Stem length (cm)	28.79 ± 0.06[b]	30.80 ± 0.06[b]	28.17 ± 0.09[c]	28.10 ± 0.06[c]	21.40 ± 0.00[c]	28.83 ± 0.64[a]	19.13 ± 0.03[d]	26.11 ± 0.05[b]
Number of leaves	19.60 ± 0.06[a]	18.80 ± 0.06[b]	14.40 ± 0.02[d]	16.79 ± 0.09[c]	21.30 ± 0.06[b]	23.17 ± 0.17[a]	19.20 ± 0.12[c]	18.57 ± 0.03[d]
Number of nodules	12.23 ± 0.12[c]	30.40 ± 0.06[a]	13.40 ± 0.06[b]	10.63 ± 0.03[d]	17.23 ± 0.12[b]	34.77 ± 0.03[a]	16.30 ± 0.15[c]	14.67 ± 0.09[d]
Wet weight (g)	12.53 ± 0.02[c]	21.83 ± 0.03[a]	15.17± 0.12[b]	6.85 ± 0.08[d]	13.52 ± 0.79[b]	28.04 ± 0.17[a]	11.33 ± 0.12[d]	12.74 ± 0.01[c]
Dry weight (g)	4.13 ± 0.09[b]	5.76 ± 0.07[a]	5.70 ± 0.05[a]	2.81 ± 0.01[c]	3.84 ± 0.03[c]	6.23 ± 0.01[a]	5.78 ± 0.01[b]	2.79 ± 0.06[d]

n= 54, values with the same superscript along treatments for each variety are not significant at $p \leq 0.05$. Low concentration =12, High concentration = 12, IITA standard = 12, Control= 12.

Table 4: Reproductive parameters of the two varieties of beans (Ife brown and Ife omo) after three months of planting

Parameters	Ife brown variety				Ife omo variety			
	Low concentration (05g Nodumax)	High Concentration (5g Nodumax)	IITA Standard (1g Nodumax)	Control	Low concentration (05g Nodumax)	High Concentration (5g Nodumax)	IITA Standard (1g Nodumax)	Control
No of Pod per plant	2.30 ± 0.06[b]	2.6± 0.03[b]	3.50 ± 0.06[a]	1.83 ± 0.03[c]	3.17 ± 0.17[a]	3.27 ± 0.15[a]	2.80 ± 0.00[b]	1.80 ± 0.00[c]
No of Seed per pod	8.33 ± 0.35[b]	2.50 ± 0.06[c]	10.20 ± 0.12[b]	7.87 ± 0.03[b]	2.50 ± 0.06[d]	13.50 ± 0.06[a]	11.34 ± 0.19[b]	8.3 ± 0.06[c]
Pod without seeds (g)	5.54 ± 0.08[c]	9.13 ± 0.13[a]	7.19 ± 0.12[b]	0.84 ± 0.03[d]	4.84 ± 0.03[a]	1.62 ± 0.04[a]	1.31 ± 0.05[a]	3.60 ± 2.70[a]
Pod with seeds (g)	1.32 ± 0.04[d]	9.41± 0.05[a]	7.01 ± 0.06[b]	3.73 ± 0.04[c]	8.2 ± 0.12[b]	10.38 ± 0.07[a]	6.21 ± 0.05[c]	2.70 ± 0.05[d]

CONCLUSION

Nodumax inoculation significantly improved the growth performance of both Ife Brown and Ife Omo across all assessed morphological and physiological parameters, including leaf area, leaf number, stem length, nodulation, and biomass accumulation. These improvements were consistently superior to those observed in the uninoculated control and the IITA standard treatment. The application of Nodumax at a high concentration (5 g) yielded the most pronounced benefits, particularly in terms of enhanced nodulation, dry biomass, and fresh biomass, underscoring the critical importance of inoculum dosage in maximizing biological nitrogen fixation. Among the two cultivars, Ife Omo demonstrated a higher degree of responsiveness and adaptability to rhizobial inoculation, indicating its greater suitability for integration into biofertilizer-supported legume production systems. The vegetative growth enhancements recorded during April and May were positively associated with improved reproductive outcomes in June, especially in Ife Omo, which produced a greater number of pods with viable seeds and exhibited a higher seed count per pod. A positive correlation was observed between effective nodulation, vegetative vigor, and reproductive efficiency, emphasizing the significance of balanced nutrient allocation in optimizing legume yield. The consistent agronomic performance of the high Nodumax concentration across the experimental period highlights its potential for sustained enhancement of soil fertility and plant productivity in the absence of chemical nitrogen inputs. Conclusively, these results confirm that rhizobial inoculation—when optimized for concentration and host cultivar compatibility—constitutes a viable and sustainable strategy for improving legume productivity, minimizing reliance on synthetic nitrogen fertilizers, and promoting environmentally sustainable agricultural practices.

REFERENCES

Akley, E. K., Rice, C. W., Ahiabor, B. D. K., & Prasad, P. V. V. (2023). Bradyrhizobium inoculants impact on promiscuous nodulating soybeans cultivars in Ghana's farming systems. *Agronomy Journal*, 115(3). https://doi.org/10.1002/agj2.21273

AOAC International. (2019). *Official methods of analysis of AOAC INTERNATIONAL* (21st ed.). AOAC International.

Bhatt, M., & Chanda, S. V. (2003). Prediction of leaf area in *Phaseolus vulgaris* by non-destructive method. *Bulgarian Journal of Plant Physiology*, 29(2), 96-100.

Binang, W. B., Ojikpong, T. O., & Takim, F. O. (2017). Nodulation, biomass production and yield of some indigenous legumes as influenced by Rhizobium inoculation in the rainforest agro-ecological zone of Nigeria. *Journal of Applied Life Sciences International*, 11(4), 1-9. https://doi.org/10.9734/JALSI/2017/32624

De Lara-Del Rey, I. R., & Pérez-Fernández, M. A. (2023). Regulatory effect of light and rhizobial inoculation on the root architecture and plant performance of pasture legumes. *Agronomy*, 13(8), 2058. https://doi.org/10.3390/agronomy13082058

De Oliveira, C. A. G., Monteiro, E. D. C., Souza, W. D. S., Pio, P. V. A., Machado, J. C., Alves, B. J. R., Boddey, R. M. & Urquiaga, S. (2025). Contribution of biological nitrogen fixation to the biomass productivity of elephant grass grown in low-fertility soil for energy purposes. *Agronomy*, 15(3), 605. https://doi.org/10.3390/agronomy15030605

Ikhajiagbe, B., & Ogwu, M. C. (2023). Seed phenotypic variations in cowpea, *Vigna unguiculata*, from selected open markets in Edo State, Nigeria. *Developmental Cell*, 7(2), 89-101. https://doi.org/10.13057/cellbioldev/v070206

Marco, E. O., Ojija, F., & Aloo, B. N. (2023). The role of Rhizobia toward food production, food and soil security through microbial agro-input utilization in developing countries. *Case Studies in Chemical and Environmental Engineering*, 8, 100404. https://doi.org/10.1016/j.cscee.2023.100404

Ogbuehi, H. C. (2020). Effect of nodumax inoculant on morpho-physiological parameters, nutrient content and yield of soybean (*Glycine max* L.). *Journal of Agriculture and Food Sciences*, 18(2), 54-72. https://doi.org/10.4314/jafs.v18i2.4

Rahiel, H. A., Badji, A., Ozimati, A., Dramadri, I. O., Edema, R., Mukankusi, C., & Adipala, E. (2023). Advancing resilient legume crops for sustainable agriculture and feeding Africa: Genetics and genomics studies on cowpea and common bean. *African Journal of Rural Development*, 9(1), 16-36. https://afjrdev.org/index.php/jos/index

Rahman, A., Manci, M., Nadon, C., Perez, I. A., Farsamin, W. F., Lampe, M. T., Le, T. H., Martinez, L. T., Welberg, A. J., Chang, J. H. & Sachs, J. L. (2023). Competitive interference among rhizobia reduces benefits to hosts. *Current Biology*, 33(14), 2988-3001.e4. https://doi.org/10.1016/j.cub.2023.06.081

Razafintsalama, H., Trap, J., Rabary, B., Razakatiana, A. T. S., Ramanankierana, H., Rabeharisoa, L., & Becquer, T. (2022). Effect of Rhizobium inoculation on growth of common bean in low-fertility tropical soil amended with phosphorus and lime. *Sustainability*, 14(9), 4907. https://doi.org/10.3390/su14094907

Rodriguez-Espinosa, T., Papamicheal, I., Vaulkkali, I., Gimeno, A. P., Candal, M. B. A., Navarro-Pedreño, J., Zorpas, A. A., & Lucas, I. G. (2023). Nitrogen management in farming systems under the use of agricultural wastes and circular economy. *Science of the Total Environment*, 876, 162666. https://doi.org/10.1016/j.scitotenv.2023.162666

Saka, T. O., Agbeleye, A., Ayoola, T. O., & Lawal, B. O. (2018). Assessment of varietal diversity and production systems of cowpea (*Vigna unguiculata* (L.) Walp.) in Southwest Nigeria. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 119(2), 43–52. https://doi.org/10.17170/kobra-2018121864