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Research Article

Influence of Indigenous Microorganisms Fertilizer on the Growth Performance of Huckleberry (*Solanum Scabrum*) in Mile 3, Nkwen Bamenda

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Abstract

Solanum scabrum (huckleberry) is widely used as a leafy vegetable, mostly cultivated using chemical fertilizers and pesticides which temporarily boost up productivity, but has a long term negative effect on the environment and human health. The main objective of this study was to find out whether farmers can boost productivity of *S. scabrum* with the use of indigenous microorganisms (IMO) fertilizer. This research was carried out in Mile 3 Nkwen Bamenda. A randomized block design was used with three treatments (IMO, urea and control) and four replications. The different parameters measured were the number leaves, plant height, number of branches, stem girth and fresh weight of plants. One of the four blocks was shaded to study the influence of IMO on the soil moisture content. Results showed that plants treated with IMO had the highest number of leaves (24.85 ± 2.25) while control plants had the lowest (19.15 ±2.681) which was not significantly different ($p<0.05$) from that of urea (19.75 ± 4.363). The maximum plant height was recorded in plants treated with IMO (75.35 ± 15.816 cm) which was significantly different ($p>0.05$) from that of plants treated with urea (19.75 ± 5.809 cm) and control (24.68±6.742 cm). The highest plant weight was recorded in plants treated with IMO (1.2425 ±0.59528 kg) and the lowest was plants of the control (0.1125 ±0.12659 kg) which was not significantly different ($p>0.05$) from that of plants treated with urea (0.1175 ±0.12093 kg). Significant and positive correlations were observed among growth parameters but insignificant between growth and yield parameters. IMO had the highest soil moisture content (Nor (10 to 20%)) while urea and control had the lowest (dry+ (< 5% moisture level)). This study showed that IMO is a good fertilizer to increase the productivity of *S. scabrum*.

Keywords

IMO, Fertilizers, Urea, *Solanum Scabrum*

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1. Introduction

Solanum scabrum (huckleberry) also known as African night shade, is widely used as a vegetable especially in West, Central and East Africa where it is cultivated as leafy vegetable. In Cameroon, it is one of the popular cash crops grown in the northwest and west region and locally called "njama njama" [16]. The leaves are mostly consumed and are rich in nutrients, especially proteins, iron, ascorbic acid and riboflavin. This makes it a very important nutritional source for poor people [17]. Though inorganic fertilizers increase crop production, their overuse has hardened the soil, reduces fertility, strengthened pesticides, polluted air and water, and released greenhouse gases, thereby bringing hazards to human health and environment. Researchers debate in favor of organic fertilizers being the best option to avoid soil pollution and many other threats to environment and life caused by the excessive use of chemical fertilizers [4]. Local microorganisms serve as biological activators and components of utilizing local organic materials to decompose agricultural, household, and industrial waste into nutrient-rich substances. This process adds value to waste materials and supports sustainable agriculture by providing plants with nutrients, promoting growth, and reducing reliance on costly inorganic fertilizers. One of these applications is the use of indigenous microorganisms (IMO) fertilizer. Indigenous microorganism (IMO) fertilizer supplies beneficial microbes that enhance soil fertility and stimulates plant growth through improved nutrient availability and plant defense mechanisms [15]. These biofertilizers can increase nutrient uptake (like nitrogen, phosphorus, and potassium), enrich soil microbial communities, and promote plant health and yields. Soil particles are lumped in aggregates and fostered to provide air and water retention, which in turn creates a good habitat for other symbiotic microbes [2].

Farmers cultivate this cherished vegetable mostly with chemical fertilizers which boost up productivity, but have a long term negative effect on the environment. In addition to that, chemical fertilizer prices show an upward trend globally from 2015 with the most significant surge in 2018 when average import prices increased by 22% [9]. These prices have remained elevated and very expensive for farmers. Plants require nutrients to grow and develop. However, some soils naturally contain sufficient nutrients to support this, but most will require fertilizer application to optimize growth and yield [3], hence a need for an alternative. The aim of this study was to use indigenous microorganism (IMO) fertilizer to boost *Solanum scabrum* productivity and its effect on the soil moisture content.

2. Methodology

2.1. Description of the Experimental Site

The research was carried out in Mile3 Nkwen Bamenda in Mezam division of the North West Region of Cameroon (Figure 1). The city has a population of about 150,000 inhabitants. It is known for its cool climate and scenic hilly location, with a tropical monsoon climate. Nkwen is located on latitude 05^0 58'42.6" N and longitude 10^0 8'52" E and has an elevation of 1229m above sea level. The people highly depend on agriculture for survival [12].

2.2. Preparation of the Nursery

Dry huckleberry seeds were bought from a local farmer in mile 3 Nkwen and non-viable seeds were separated from viable seeds by completely submerging the seeds in a bowl of water the floating seeds (non-viable seeds) were removed by decanting. Viable seeds were then sun-dried and nursed with compost on a cultivated ridge. Nursed seeds were covered immediately with dry grass which was removed after one week, when the seeds germinated. The seedlings were being watered twice a week for four weeks before transplanting.

2.3. Preparation of Indigenous Microorganism Fertilizer

IMO was prepared using local materials [10]. Five wooden boxes of 40 by 60 cm were made and half cooked rice placed in them. The boxes were covered completely with a new paper towel, transparent plastic paper, fixed in place with a rubber band, to prevent water or small insects from getting in. The boxes were half buried under mango and plum trees around the farm and covered with of leaves. Five days later, white molded rice was weighed mixed with brown sugar in equal ratios, and transferred to a clay pot. The pot was well covered with clean paper towel, fixed with a rubber band and kept in a dark, cupboard for seven days. It was mixed with 20 L of fish pond water, and 25 kg of wheat bran. The mixture was kept to ferment for eight days and stored in a plastic container. The IMO fertilizer was ready for use.

2.4. Experimental Design and Treatments

The experimental design was a randomized block design with three treatments (IMO, Urea and Control (No fertilizer)) and four replications (blocks) was used. Each block had three ridges of 1.5 m wide by 4 m length, each of which represents a treatment. One of the four replications (block 4) was shaded with white transparent plastic papers in order to study the soil moisture content.

2.5. Farm Preparation, Application of Manure and Transplanting

Three weeks after establishing the nursery, the experimental field was cleared using a cutlass and raked. Ridges were constructed and 5 kg of IMO fertilizer was applied on each of the IMO ridges in block1, block2, block3 and block4 respectively. Then the seedlings (3 to 9cm tall) were transplanted. The interval between plants was 10cm. A week after transplanting, 0.5 kg of urea was applied on the four different ridges, in each block. Two weeks after transplanting a shade was constructed over one block (block 4) using white transparent plastic papers, pegs and bamboos. This block was being watered throughout whenever the soil moisture level was less than 5%.

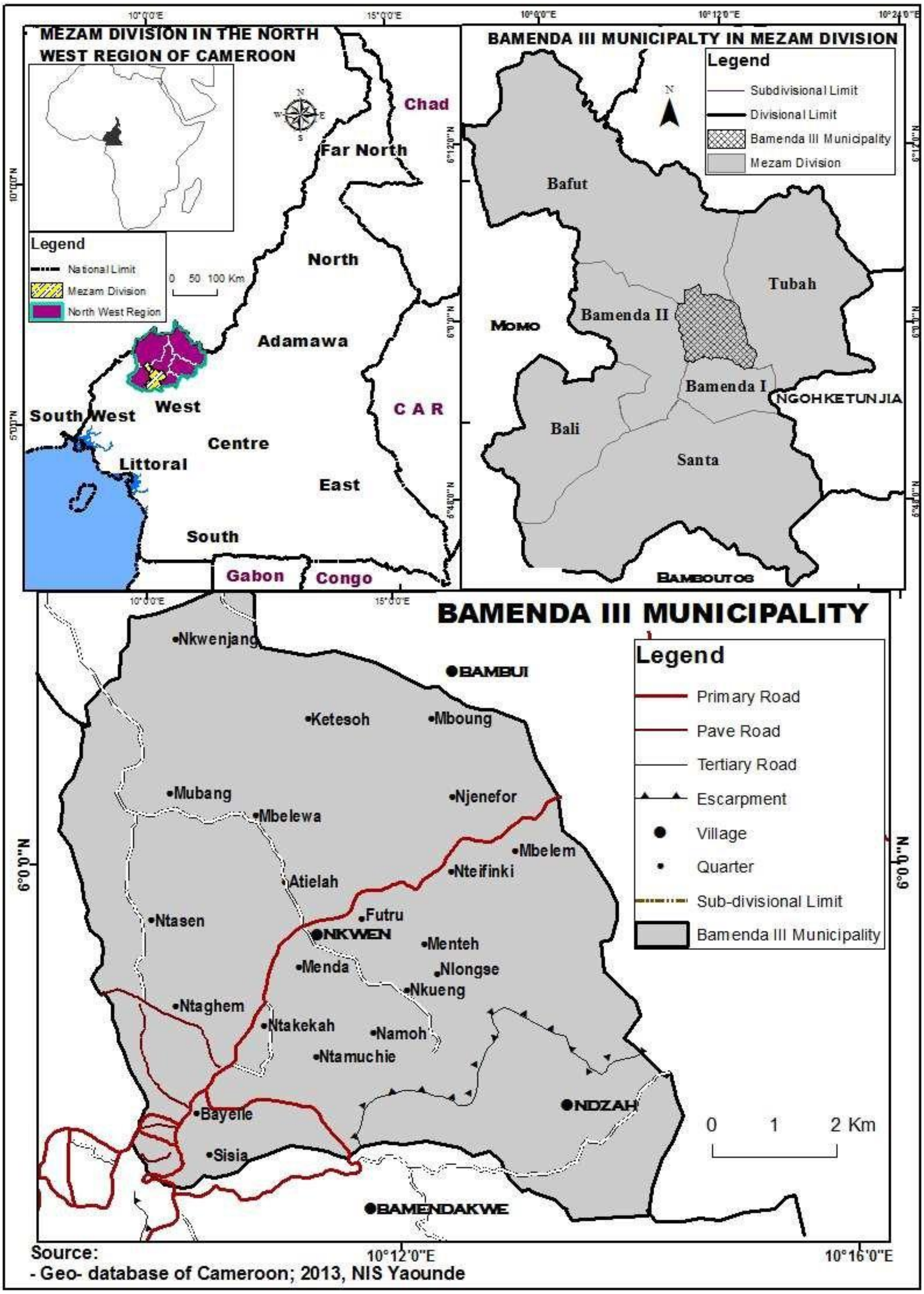

Figure 1. *Map of Nkwen (Geo- database of Cameroon; 2013, NIS Yaounde; [12].*

2.6. Measurement of Growth and Soil Parameters

Field growth parameters were being collected from twenty tagged plants selected randomly from each treatment in every block. The number of leaves and branches were counted, plant height, measured using a measuring tape weekly from the 6th to the 15th week after transplanting. Stem girth was measured using a Micrometer Scroll Gauge from the 11th to the 15th week. The fresh weight was taken by harvesting all plants per treatment (from the 7th to 17th week after transplanting) and weighed using a scale except the tagged plants. Soil moisture content, temperature and pH were also measured weekly using a Zd-O7 4-in-1 Soil Survey Instrument. The instrument was reading moisture levels in ranges: dry+ (<5%), dry (5 to 10%), Normal (10 to 20%), wet (20 to 30%) and wet+ (>30%).

2.7. Crop Maintenance

Weeding was done once every two weeks with a hoe and hands. 5 kg of IMO and 500g of urea were being applied after every four weeks. The application of urea was done at the ground level, avoiding it from getting in direct contact with foliage and stem. Harvesting was done with a blade in order to avoid tissues destruction.

2.8. Data Analysis

Collected data was keyed in Microsoft excel spreadsheet 2016. The data was then analyzed using a one-way analysis of variance (ANOVA) of the statistical analysis system SPSS, 2006. Means were separated using Duncan's Multiple Range Tests (DMRT) at 0.05 level of probability.

3. Results

3.1. Variation in the Number of Leaves

Generally, it was observed that the number of leaves increased from the 6th right up to the 15th week for all the treatments. Plants treated with IMO had the highest number of leaves (24.85 ± 2.25) while control plants had the lowest (19.15 ± 2.681) which was not significantly different from that of urea (19.75 ±4.363) (Table 1).

***Table 1**. Variation of number of leaves under different treatments overtime.*

Duration (weeks)	IMO	UREA	CONTROL
6	10.00 ±0.918b	9.45 ±2.438ab	8.75 ±1.446a
7	12.05 ±0.945b	10.40 ±1.536a	10.10 ±1.683a
8	13.75 ±1.293b	11.75 ±1.803a	11.40 ±1.984a
9	15.50 ±1.504b	13.35 ±2.390a	12.70 ±2.080a
10	17.45 ±1.395b	14.25 ±2.291a	13.45 ±2.038a
11	19.10 ±1.586b	15.10 ±2.469a	15.10 ±2.469a
12	20.55 ±1.877b	17.00 ±2.884a	16.45 ±2.837a
13	22.30 ±1.867b	18.75 ±2.918a	17.95 ±2.605a
14	24.70 ±2.130b	19.35 ±3.990a	19.35 ±3.014a
15	24.85 ±2.254b	19.75 ±4.363a	19.15 ±2.681a

Means with the same letter in the same line are not significantly different at $p<0.05$ (DMRT)

3.2. Variation in Plant Height at Different Treatments

There was an increase in the plant height from the 6th to the 15th week for all the treatments. The maximum plant height was recorded in plants treated with IMO (75.35 ±15.816 cm) while plants treated with urea had the lowest (19.75 ±5.809 cm) which was not significantly different from that of control (Table 2).

Table 2. Variation in plant height (cm) under different treatments over time.

Duration (weeks)	IMO	UREA	CONTROL
6	10.73 ±2.635b	7.40 ±3.397a	6.15 ±2.455a
7	15.93 ±3.109b	8.85 ±3.309a	7.95 ±2.559a
8	20.03 ±3.447b	10.38 ±3.410a	9.45 ±3.090a
9	30.20 ±5.095b	11.80 ±3.420a	12.70 ±3.632a
10	37.05 ±6.329b	13.15 ±3.731a	14.65 ±3.397a
11	46.25 ±8.218b	14.38 ±3.943a	16.83 ±4.708a
12	56.45 ±10.731b	16.05 ±4.307a	18.75 ±5.381a
13	64.85 ±12.819b	17.53 ±4.753a	20.83 ±5.856a
14	71.13 ±14.543b	18.78 ±5.275a	22.98 ±6.427a
15	75.35 ±15.816b	19.75 ±5.809a	24.68 ±6.742a

Means with the same letter in the same line are not significantly different at $p<0.05$ (DMRT).

3.3. Variation of Number of Branches Per Plant

There was an increase in the number of branches in all the treatments from the 6th to the 15th week. The highest number of branches per plant was recorded in plants treated with IMO (22.35 ±2.300) which was significantly different from that of plants treated with urea (15.90 ±5.590) and control (16.05 ± 3.790) (Table 3).

Table 3. Number of branches per plant under different treatments over time.

Duration (weeks)	IMO	UREA	CONTROL
6	3.80 ±0.894b	2.40 ±1.392a	1.85 ±0.988a
7	5.85 ±1.268b	4.10 ±1.410a	3.35 ±1.461a
8	7.95 ±1.276b	5.65 ±1.814a	4.70 ±2.080a
9	11.45 ±1.468b	7.85 ±2.519a	7.10 ±2.511a
10	13.55 ±1.731b	9.50 ±3.380a	8.50 ±2.503a
11	16.70 ±2.179b	10.95 ±3.993a	10.35 ±3.117a
12	19.05 ±1.638b	12.80 ±4.479a	11.95 ±3.154a
13	20.00 ±1.522b	14.50 ±4.548a	13.60 ±3.500a
14	21.75 ±1.943b	15.05 ±5.472a	15.40 ±3.500a
15	22.35 ±2.300b	15.90 ±5.590a	16.05 ±3.790a

Means with the same letter in the same line are not significantly different at $p< 0.05$. (DMRT)

3.4. Stem Girth of Plants

Generally, it was observed that there was an increase in plant stem girth from week 11th to week 15th in all the treatments with the highest observed with IMO plants (9.7440 ± 1.79249 mm) and the lowest was with control (5.0735 ± 1.67672 mm) which was not significantly different from that of plants with urea (5.2470 ±2.26152 mm) (Table 4).

Table 4. *Stem girth (mm) of plants under different treatments over time.*

Duration (weeks)	IMO	UREA	CONTROL
11	5.7665 ±0.94619b	3.5995 ±1.47232a	3.2075 ±1.05856a
12	6.6540 ±1.05283b	3.8225 ±1.53497a	3.7310 ±1.08276a
13	7.5075 ±1.41490b	4.5240 ±1.74010a	4.0635 ±1.36539a
14	8.4645 ±1.56506b	4.8215 ±2.06353a	4.5035 ±1.44697a
15	9.7440 ±1.79249b	5.2470 ±2.26152a	5.0735 ±1.67672a

Means with the same letter in the same line are not significantly different at p<0.05 (DMRT)

3.5. Fresh Weight of Plants

The fresh weight of plants increased from the 7th to the 9th week for all the treatments after which it started decreasing till the 17th week. The highest plant weight was recorded in plants treated with IMO (1.2425 ±0.59528 kg) and the lowest was with plants of control (0.1125 ±0.12659 kg) which was not significantly different from that of plants treated with urea (0.1175 ±0.12093 kg) (Table 5).

Table 5. *Fresh weight (kg) of plants for different treatments over time.*

Duration (weeks)	IMO	UREA	CONTROL
7	0.8725 ±0.10340b	0.5600 ±0.39674a	0.5250 ±0.43301a
8	0.9225 ±0.15500b	0.2500 ±0.11547a	0.5450 ±0.40992a
9	1.2425 ±0.59528b	0.4175 ±0.32510a	0.3725 ±0.35406a
10	1.1300 ±0.50306b	0.3975 ±0.37161a	0.3875 ±0.37241a
11	1.1925 ±0.60939b	0.3725 ±0.38439a	0.3875 ±0.37241a
12	0.8200 ±0.42880b	0.1175 ±0.12093a	0.4025 ±0.37730a
13	0.8925 ±0.52347b	0.1250 ±0.13892a	0.2000 ±0.21939a
14	0.6575 ±0.25131b	0.2875 ±0.42500a	0.1125 ±0.12659a
15	0.7150 ±0.38622b	0.4500 ±0.51962a	0.0875 ±0.09674a
16	0.6650 ±0.35000b	0.4250 ±0.49244a	0.2625 ±0.43084a
17	0.6650 ±0.35000b	0.02275 ±0.03862a	0.2275 ±0.44836a

Means with the same letter in the same line are not significantly different at p<0.05. (DMRT)

3.6. Correlation Between Growth and Yield Parameters

A positive significant correlation was generally observed among the growth parameters but insignificant between growth and yield parameters in all the treatments. In IMO plants there was a positive significant correlation between the number of leaves and number of branches (0.965**) and stem girth (0.639**); also between stem girth and height of plants (0.791**), stem girth and number of branches (0.745**). A negative but non-significant correlation was noticed between weight of plant and growth parameters. The same tendency was observed in plants treated with urea. For the control plants the weight was positively non-significant between growth parameters except the height which was negative (-0.200) (Table 6).

Table 6. Correlation between growth parameters of different treatments and fresh weight.

IMO	No leaves	height	No branches	Stem girth	Weight
No leaves	1				
Height	0.219	1			
No branches	0.965**	0.378	1		
Stem girth	0.639**	0.791**	0.745**	1	
Weight	-0.871	-0.153	-0.056	-0.404	1
UREA					
No leaves	1				
Height	0.813**	1			
No branches	0.906**	0.758**	1		
Stem girth	0.734**	0.603**	0.859**	1	
weight	-0.261	-0.615	-0.409	-0.786	1
CONTROL					
No leaves	1				
Height	0.639**	1			
No branches	0.883**	0.737**	1		
Stem Girth	0.747**	0.656**	0.805**	1	
Weight	0.400	-0.200	0.800	0.000	1

** correlation is significant at the 0.01 (2-tailed)

3.7. Soil Parameters Under Different Treatments at the Shaded and the Non-shaded Area

Generally, IMO had the highest soil moisture content both in the shaded and the non-shaded area (normal (10 to 20% moisture level)) while urea and control had the lowest (dry+ (< 5% moisture level)). Urea and control always had the same readings at both shaded and the non-shaded area.

For soil pH, urea recorded the lowest value (6) in both areas while IMO and control recorded the highest (7). The non-shaded area often had low pH values in IMO (6.5) treatment than the shaded area (7), while urea and control had the same pH values in both areas. Control was having a neutral pH (7) throughout.

For soil temperature, just a slight different was observed between IMO (25 ℃ and 24 ℃), urea and control (26 ℃ and 25 ℃) only on week fifteen and sixteen respectively. Generally, in most cases the soil temperature of the shaded area was always higher (28 ℃) than that of the non-shaded area (26 ℃) (Table 7).

Table 7. Soil parameters under the shaded and the non-shaded treatments over time.

Time (weeks)	Soil property	Shaded block (4)			Non-shaded blocks (1, 2, 3)		
		IMO	Control	Urea	IMO	Control	Urea
	Moisture	5 - 10%	<5%	<5%	5 - 10%	5 - 10%	5 - 10%
9	pH	7	7	6	6.5	7	6
	Temperature	28 ℃	28 ℃	28 ℃	26 ℃	26 ℃	26 ℃
10	Moisture	5 - 10%	5 - 10%	5 - 10%	10 - 20%	5 - 10%	5 - 10%

Time (weeks)	Soil property	Shaded block (4)			Non-shaded blocks (1, 2, 3)		
		IMO	Control	Urea	IMO	Control	Urea
	pH	7	7	6	6.5	7	6
	Temperature	24 ℃	25 ℃	25 ℃	23 ℃	24 ℃	24 ℃
	Moisture	5 - 10%	<5%	<5%	5 - 10%	5 - 10%	5 - 10%
11	pH	7	7	6.5	7	7	6.5
	Temperature	22 ℃	22 ℃	22 ℃	22 ℃	22 ℃	22 ℃
	Moisture	5 - 10%	5 - 10%	5 - 10%	5 - 10%	5 - 10%	5 - 10%
12	pH	7	7	7	7	7	7
	Temperature	24 ℃	24 ℃	24 ℃	23 ℃	23 ℃	23 ℃
	Moisture	5 - 10%	<5%	<5%	10 - 20%	5 - 10%	5 - 10%
13	pH	7	7	6	6.5	7	6
	Temperature	27 ℃	27 ℃	27 ℃	26 ℃	26 ℃	26 ℃
	Moisture	5 - 10%	5 - 10%	5 - 10%	10 - 20%	5 - 10%	5 - 10%
14	pH	7	7	6	6.5	7	6
	Temperature	22 ℃	22 ℃	22 ℃	22 ℃	22 ℃	22 ℃
	Moisture	<5%	<5%	<5%	5 - 10%	5 - 10%	5 - 10%
15	pH	7	7	6.5	7	7	6.5
	Temperature	25 ℃	26 ℃	26 ℃	25 ℃	25 ℃	26 ℃
	Moisture	5 - 10%	5 - 10%	5 - 10%	5 - 10%	5 - 10%	5 - 10%
16	pH	7	7	7	7	7	7
	Temperature	24 ℃	25 ℃	25 ℃	24 ℃	24 ℃	24 ℃

4. Discussion

The results of this study showed that all the growth parameters increased up to week 15th in all the treatments except for the number of leaves in control which started decreasing from the 15th week. Plants treated with IMO recorded the highest values in all the growth parameters which were significantly different from those of urea and control. While control had the lowest values which were not significantly different from those of urea. High values of IMO treatments likely indicate a soil enriched with diverse, beneficial microbes that improve soil fertility by breaking down organic matter into humus, enhance nutrient absorption by plant roots, and suppress plant diseases. These microorganisms provide essential nutrients and growth-promoting substances, improve soil structure, and create a healthier soil environment through processes like nitrogen fixation and biocomposting [11]. Lower values of urea treatment may be because urea and other nitrogenous fertilizers can, over time, contribute to soil acidification, which negatively impacts soil organic matter, beneficial organisms, and nutrient availability, potentially leading to stunted growth, increased pests, and heavy metal accumulation [13]. These results are similar to research carried out on rice in Nigeria and showed that a combination of IMO and NPK recorded highest plant height and leaf area index, IMO was the second, NPK followed with the control having the least [8]. From the results, it was generally observed that there was an increase in the fresh weight of harvested plants in all the treatments from week 7th to week 9th after which it started decreasing. This might be due to the fact that *S. scabrum* is a short-lived perennial herb which rapidly grows at the early stage and then prioritises seed production. The highest fresh weight of plants recorded by IMO which was significantly different from that of urea and control, could be as a result of beneficial microorganisms in IMO which enabled further soil mineralization by rapidly breaking down organic matter into humus and increases the absorption of soil nutrients by plant roots, thereby increasing yields [14]. For the plants under treatment with urea, might be there was an imbalance between the three macronutrients, N, P and K over time which could result to lack of micronutrients, damages topsoil, resulting in reduced crop yields [6]. Significant positive correlations were only among growth parameters that is, between number of leaves, plant height, number of branches and stem girth. This implies that the value increase of one of these parameters leads to an increase of the parameter to which it is significantly correlated to. The growth parameters and fresh weight generally had a negative insignificant correlation. This may be because the weight was taken from young, fresh and succulent *S. scabrum* shoots whose weight might have been influenced more by water content rather than growth parameters. This was not in line with the case of soybean in which plant height and number of leaves had a strong correlation with yield parameters such as fresh biomass and number of pods [5]. Also was the investigation on the correlation between various growth parameters of five bamboo species in India and the results obtained indicated that the length and dameter of culm was postively correlated to the fresh weight of bamboo plant [1]. IMO treatment had the highest soil moisture content both in the shaded and the non-shaded area, which was significantly different from that of urea and control. Urea and control always had the same readings at both shaded and the non-shaded area. This may be explained by the fact that upon application of indigenous microorganisms in farms, the soil regains its loaminess thereby increasing the soil nutrients and moisture [7]. For soil pH, urea recorded the lowest values (less than 7) in both areas while IMO and control were neutral (7). The non-shaded area often had low pH values in IMO treatment than the shaded area, while urea and control had the same pH values in both areas. This might be due to over application of chemical fertilizers causing soil acidification by the transformation of ammonium containing materials to nitrates in soils by bacteria, thereby releasing hydrogen ions which increase acidity. This could be related to a study carried out by examining the Mayurakshi-Basloi interfluves and found out that the long-term, continuous application of chemical fertilizers to crops, particularly NPK and urea that led to a decrease in soil pH over time [16].

For soil temperature, just a slight different was observed between the treatments which occurred only on week 15th and 16th. Generally, in most cases the soil temperature of the shaded area was always higher than that of the non-shaded area. This might be due to poor circulation of air in the shaded area.

5. Conclusion

From this study, the plant height, number of leaves, number of branches, stem girth and fresh weight was best obtained by plants grown with IMO fertilizer, which was significantly different from that of urea and control. IMO fertilizer is better in preserving the soil moisture content than urea and There was a strong correlation and significant relationship among the four growth parameters (plant height, girth, no of leaves and branches) which was weak between growth parameters and the fresh weight. This implies that an increase in one of the growth parameters leads to the increase of other growth parameters but does not significantly affect the fresh weight. IMO is also a good alternative for soil amendments which can improve productivity while maintaining the moisture content.

Abbreviations

IMO	Indigenous Microorganisms
ANOVA	Analysis of Variance
SPSS	Statistical Package for
DMRT	Duncan Multiple Range Test
NPK	Nitrogen Phosphorus Potassium

Author Contributions

Muyang Rosaline Fosah: Conceptualization, Investigation, Writing – original draft

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Mbah Harry Agwa: Writing – review & editing

Bailack Yvonne Nghoke: Investigation

Taffouo Victor Desire: Supervision

Fotso: Supervision

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Conflicts of Interest

The authors declare no conflicts of interest.

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