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EFFICACY OF INDOLE-3-ACETIC ACID, MORINGA LEAF EXTRACT AND ALOE VERA EXTRACT ON THE GROWTH AND YIELD OF CUCUMBER (CUCUMIS SATIVUS) ON A TROPICAL INCEPTISOL, SOUTHWEST, NIGERIA

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Abstract: The use of synthetic chemical fertilizer has an adverse effect on the growth of crops, soil and the environment itself. However, moringa leaf extract and aloe vera extract can serve as an alternative which are eco - friendly. The study was carried out in the Teaching and Research farm of the University, Okitipupa during March 2024- July 2024. The aim was to evaluate the effects of Indole-3-acetic acid, moringa leaf extract and aloe vera extract on the growth and yield of cucumber. The Pot experiment was a Completely Randomized Design (CRD) replicated three times involving four treatments namely: control (no extract), moringa leaf extract at 25ml, aloe vera extract at 100% concentration and Indole-3-acetic acid at 25ml. Growth and yield parameters such as plant height, number of leaves, stem diameter, days to flowering, fruit weight, fruit length and fruit diameter were evaluated and data collection was subjected to analysis. The results of the study showed that there were significant differences (P=0.05) among the treatments as pots that received 25ml of moringa leaf extract (MLE)performed best on Plant height 145.20 ± 0.02 cm, number of leaves 24.86, stem diameter with value 0.70 was higher in Indole-3-acetic acid and low in control (0.30). In terms of yield contributing parameters with control, showed the lowest days (36 days) to flowering 3.06 and the highest days (29) to flowering was Indole-3-acetic acid. Moringa leaf had the highest values of fruit weight 4.06, fruit diameter 13.50 and fruit length 14.96. This was followed by pots that received 100% aloe vera extract and 25ml of Indole-3-acetic acid with values of 3.06 and 2.56: 12.50 and 12.00, 13.96 and 13.46 in the corresponding treatments respectively. Soil analysis results showed that treatments, moringa leaf extract and aloe vera extract improved soil properties and fertility. Here, maximum plant height, number of leaves, fruit weight, fruit diameter, fruit length was produced by plants sprayed with 25ml of moringa leaf extract. Therefore, it is concluded that moringa leaf extract of 25ml had a significant effect on the growth and yield of cucumber and can be recommended for other crops.
Keywords: Cucumber; Aloe vera; Soil properties; IAA; Moringa; Yield

1 INTRODUCTION

Cucumber *(Cucumis sativus)*, an annual trailing vine vegetable belonging to *Cucurbitaceae* family, is the most widely grown vegetable of the family after watermelon. The demand and supply for cucumber has been expeditiously increased in the last few years and now it is grown throughout the world using fields or greenhouse culture. It has a diploid chromosome number of 14, 2n= 14 (Kadi *et al.*,2018). Although it is very watery, with little flavor and not very nutritious, it is a common ingredient of salads and pickles, being valued primarily for its crisp texture and juiciness.

The seeds are extremely enriched with nutritive compounds; protein (33.8%), fat (45.2%), carbohydrates (10.3%), and crude fibers (2.0%) and the seed oil consist of four chief fatty acids; linoleic acid (61.6%), oleic acid (15.7%), stearic acid (11.1%), and palmitic acid (10.7%) as described by [1]. The fruits are extremely nutritive and consist of 95% water, extremely small calories (about 15 calories per cup) reported by [2]. The fruit also consists of calcium (20mg/100g), iron (0.7mg/100g), thiamin (0.3mg/100g), niacin (0.01mg/100gm) and some natural antioxidants that reduce chronic diseases [3].

The major problem is maleness in cucumber which greatly decrease the fruit yield [4]. Other problems include shape distortion, untimed maturity, fruit drop, late flowering, early senescence, and so on which can be solved by the recommended dose of plant growth regulators. People are nowadays better concerned about what they eat and how they are produced or processed [5]. For this reason, healthy concentrations of plant growth regulators should be applied.

Plant growth regulators, commonly known as phytohormones, are those chemical compounds that control all aspects of growth and development within the plants. There are five majors classical phytohormones which consist of more than 20 types of PGRs; they are auxin, cytokinin, gibberellins, abscisic acid, and ethylene. In addition, cucumber also contains a diverse variety of biologically active, non-nutritive compounds regarded as phytochemicals like alkaloids, flavonoids, tannins, phlobatannins, steroids, saponins and many others. The physiological processes like growth and development of the plant, enhancement of the fruit color, flower differentiation, fruit ripening, tissue growth, etc. are controlled by the

appropriate application of plant growth regulators [6].. It also controls vegetative growth of plant and helps to increase the plant population per area [7]..

Indole-3-acetic acid (IAA) is the most abundant naturally occurring auxin with a well-documented ability to regulate many aspects of plant development some of them include the differentiation of vascular tissues, elongation growth, apical dominance, lateral root initiation, fruit setting and ripening [8]. Plants produce active IAA both by de novo synthesis and by releasing IAA from conjugates [9] .

A natural plant growth regulator, Zeatin is a natural form of cytokine which can be found in a high level (5 µg and 200 µg/g) in fresh moringa leaves. It was mentioned by several researchers includes [10] that due to having zeatin in the moringa leaves, which is an effective plant growth hormone, many crop yields as soybean, maize and coffee can be improved by 25-30% using moringa juice extract.

In everyday life, synthetic growth regulators are still difficult to find, and the price is relatively expensive, so need to look for other alternatives. One of the natural plant growth regulators (bio regulator) are easy and cheap to obtain is the leaf of aloe vera gel. The use of Aloe vera leaf gel as a bioregulator were tested on several types of plants. This is presumably because the aloe vera gel contains plant growth regulators, especially auxin, amino acids, vitamins and minerals that could encourage the growth of cuttings [8].

2 MATERIALS AND METHODS

2.1 Site Description

The study site is the Teaching and Research Farm Olusegun Agagu University of Science and Technology, Okitipupa, Ondo state, Nigeria which lies in the latitudes 6.50’ N and 7.5 20’ N and longitudes 4.37’E and 5.55’ E, 33.22 m above sea level within the tropical rain forest zone of Nigeria. The study site falls within a tropical region and includes a diversity of land uses: forested regions, farmland and developed areas.

This experiment was conducted in March – July 2024.

2.2 Climate

The climate of the study area is characteristic of southern Nigeria, where tropical humid conditions prevail. This region experiences two distinct seasons: a rainy season and a dry season. The rainy season and a dry season. The rainy season typically spans from March to November, with peaks in July and September, while the dry season occurs from December to February, characterized by reduced rainfall and higher temperatures. Average annual rainfall can range from 1,500 mm to 2,000 mm, which supports both the dense forest cover and the extensive farming activities observed in the area. Temperature in these regions is generally warm throughout the year, with average daily temperature ranging from 25 C TO 30 C. Humidity levels are also high, particularly during the rainy season, which contributes to the lush vegetation observed in the forested areas of the study site. The climate plays a crucial role in shaping the land use patterns in the study area. The abundant rainfall and warm temperatures support a diverse range of vegetation, making the region ideal for both forestry and agriculture

2.3 Vegetation and Land-Use

The vegetation of the study site is diverse and reflects the region’s tropical climate. The forested areas shown on the map are likely dominated by tropical rainforest species, which are known for their dense canopies and high biodiversity. These forests serve as critical ecosystems, providing habitat for wildlife, maintaining soil fertility. The farmland areas represent a significant portion of the study site, indicating the importance of agriculture in the local economy. The farmland is likely used for growing crops such as cassava, maize, yams and vegetables, which are staples in the diets of local communities. Additionally, some areas may be used for animal husbandry, including cattle, goats and poultry.

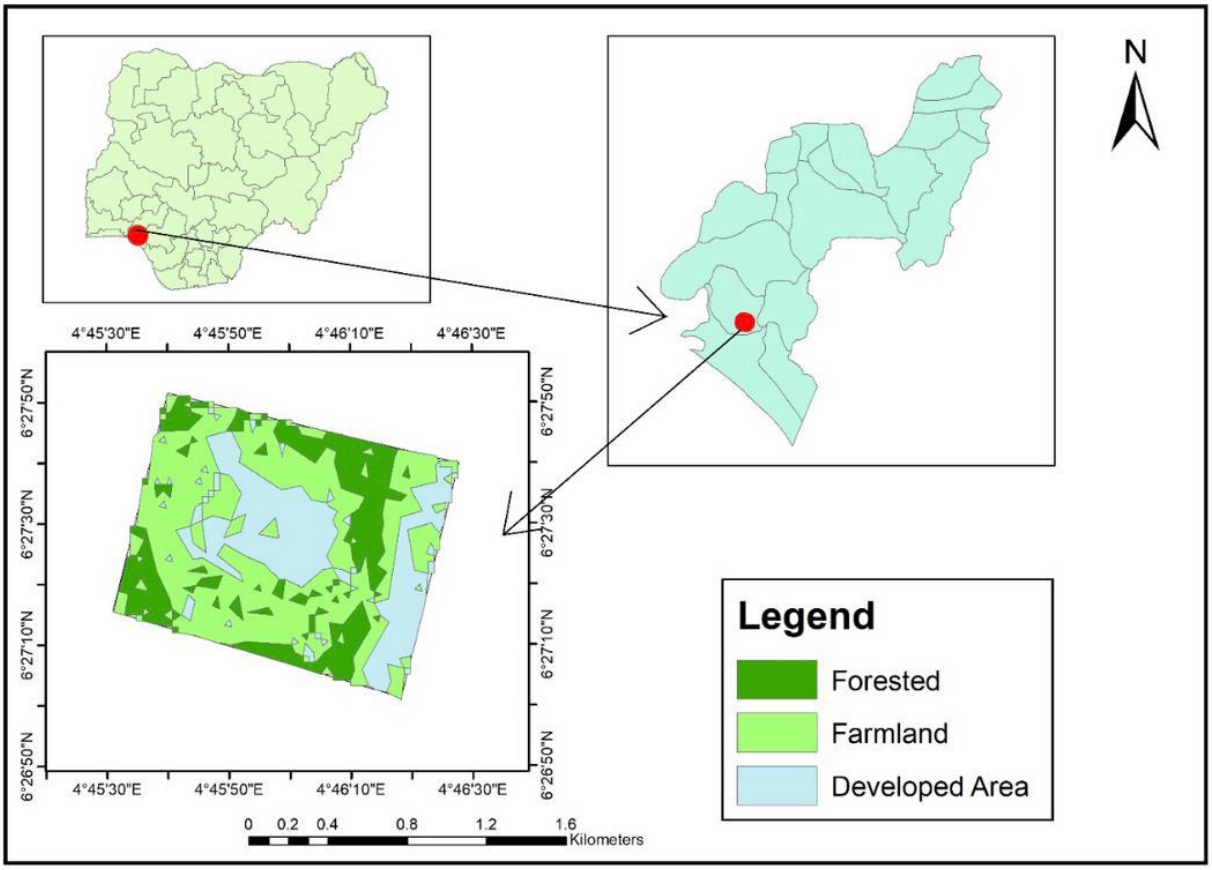

Figure 1 Map of the Study Area, Okitipupa Local Government Area, Ondo State Nigeria [11]

2.4 Experimental Materials

The following materials were used for the experiment:
The test crop - Cucumber *(Cucumis sativus)* obtained from First Let's Farm integrated limited, Akure. The Cucumber species HYB. CUCUMBER SLICING, variety: DARINA F1. Young leaves and branches of moringa and aloe vera were harvested from young fully grown trees located at the University farm. Hoes, vernier caliper, measuring ruler from departmental farm warehouse

2.5 Treatments Preparation

- IAA solution

1g of IAA was weighed and put in a beaker. The IAA will be dissolved with 1000ml of distilled water. 10ml of the IAA solution will be measured and then dissolved in 100ml of water, 25ml will be extracted and sprayed per plant [12]..

- Moringa leaf extract

Fifty grams of Moringa leaves were collected, washed and grinded, 500 ml of distilled water was added and filtered with sieve. Moringa leaf extract was sprayed at the rate of 25ml per plant [13].

- Aloe vera extract

The preparation was kept simple to ensure that rural farmers can prepare it easily. One kilogram of freshly harvested Aloe vera leaves was weighed and washed under a running tap. The weighed leaves were chopped into bits with a clean knife and soaked in 1 litre of water for 72 hours in a plastic basin. At the end of the 72 hours, the extract was obtained by filtering using a piece of regular 2 mm sieve. The quantity of this extract was used directly as 100 percent concentration. [13]. The extract was then sprayed to the plants

2.6 Experimental Design

The experiment was designed using Completely Randomized Design (CRD). There were four treatments replicated three (3) times. The experiment was conducted using pots in screenhouse under controlled environment. The treatments applied includes:

- Treatment 1: Control
- Treatment 2: Moringa leaf extract at 25ml
- Treatment 3: Aloe vera extract at 100% concentration
- Treatment 4: Indole-3-acetic acid at 25ml

Moringa leaf extract, Aloe vera extract and Indole-3acetic acid were sprayed to the plants three weeks after planting, every week to each allocated treatment pots.

2.7 Pot preparation

Topsoil was collected from the experimental field and then pulverized. The inert materials, visible insects, pests, debris and weeds were removed. Then the soil was dried thoroughly. Clean and dried pots of 7-liter size were perforated and used for the experiment. Each pot was filled with 4 kg of previously prepared soil.

2.8 Sowing of Seed

Seeds were sown on 25 of March 2024, with two seeds sown per pot.
Thinning and weeding
The young plants were thinned to one stand per pots after planting. Manual weeding was done as frequently as the situation demanded.

2.9 Agronomic Data Collection

Collection of data commenced three weeks after planting and was done at one week interval. A plant was randomly selected from each treatment pots as specimen plants.

2.10 Plant Sample Collection

The growth parameters and yield parameters taken include.

2.11 Plant Height

This was done using a measuring tape, measured from the soil level to the apex of the terminal leaf.

2.12 Number of Leaves

This was done through physical counting of leaves on the plants.

2.13 Stem Diameter

This was done with the use of vernier caliper to measure the stem girth.

2.14 Days to Flowering

This was done by visual assessment on the cucumber plants.

2.15 Fruit Weight

Fruits were harvested and recorded from the pot of each treatment and then weighed with the aid of a weighing balance.

2.16 Fruit Length

The fruits were measured using meter rule.

2.17 Fruit Diameter

This was done at the middle of the fruits where it is thickest using caliper

2.18 Soil Sample Collection

A composite topsoil within depth 0-15 cm was collected from experimental pots with the aid of soil auger for initial soil analysis. At harvest (end of the study) soil samples were collected from the replicated pots of each treatment then air dried for analysis to determine the changes that occurred due to treatments application.

2.19 Soil Particle Size Analysis

The particle size is one of the most stable soil properties, consequently its analyses is used as a basis of soil textural classification. Soil particle size analyses to determine the sand, silt, and clay content of each soil sample obtained from the different soil depths across the different management practices of cultivated land, regenerated land and forest land was carried out using the hydrometer method described below:
A 30-g (oven-dry weight basis) of ≥ 2 mm sieved soil sample was weighed into a 250 ml beaker and 100ml of Calgon solution added to it, after which the mixture was transferred to a dispersing cup and stirred for about 3 minutes with the help of a mechanical stirrer and subsequently transferred to a sedimentation cylinder which was filled to the mark with distilled water while the hydrometer is in the suspension.
A plunger was then inserted which was moved up and down in a vertical rectilinear manner to mix the contents thoroughly, the stirring was completed with three slow smooth strokes, and the time of stirring completion recorded. The hydrometer was lowered carefully into the suspension and readings taken after 40 seconds (R40secs) and the temperature of the suspension recorded with a thermometer. The suspension was remixed using the plunger and the 40 seconds reading recorded until a reliable and constant reading was obtained. Two (2) hours after the final remixing of the suspension, another hydrometer and temperature reading were obtained (R2hrs). The percentage fractions of the suspension were calculated as follows:

$$\% \text{ (Silt + Clay)} = \times 100 \quad (1)$$

$$\% \text{ Clay} = \times 100 \quad (2)$$

$$\% \text{ Silt} = \% \text{ (Silt + Clay)} - \% \text{ Clay} \quad (3)$$

$$\% \text{ Sand} = 100 - [\% \text{ (Silt + Clay)}] \quad (4)$$

2.20 Soil Chemical Properties Determination

The soil pH was determined by a pH meter in 1:2.5 soil: water (w/v) suspension [14]. Total Organic Carbon (TOC) was determined using the Colorimetric method [15]. The Kjeldahl method was used to determine total Nitrogen [16] (Sáez-Plaza *et al*., 2013). Available phosphorus (Av. P) content in the soil was analyzed following the Bray-1 acid method [17] (Sahrawat *et al*., 1997). Potassium content was determined using a flame photometer (Rhoades, 1983). Effective Cation exchange capacity (ECEC) was estimated by summation of total exchangeable bases and exchangeable acidity (Al + H) determined by 1 M KCl extract and titrated with dilute sodium hydroxide solution [14]..

2.21Data Analysis

The data collected were subjected to analysis of variance (ANOVA) with one-way ANOVA. The experimental design used was Completely Randomized Design, since the plat were potted. and the means were compared using the Duncan multiple range test (DMRT) at a 5% significance level. SPSS. A proximate analysis was carried out to compare the treatments (moringa leaf extract and aloe vera extract) using T-test [18].

RESULTS AND DISCUSSION

3.1 Results

The result for the pre soil analysis is presented in Table 1. This shows the percentage composition of sand to be 60.66±0.57. The texture of soil was sandy loam, a pH of 4.98±0.15 which is slightly acidic with a total nitrogen of 0.25±0.01, total organic matter of 4.86±0.58, total carbon of 2.96±0.60. The exchangeable cations Ca^{2+} Mg^{2+}, Na^{+} and K^{+} had values 4.42±0.02, 3.62±0.35, 0.72±0.02 and 1.64±0.02 respectively. Also, micronutrients like Fe and Mn with values 411±3.60 and 1.31±0.01.

Table 1 Pre-Physical and Chemical Composition of the Soil

Parameters	Composition
Sand (%)	60.66±0.57
Clay (%)	16.20±0.10
Silt (%)	23.50±0.20
pH	4.98±0.15

Total N (%)	0.25±0.01
TOM (%)	4.86±0.58
TOC (%)	2.96±0.60
Total P (%)	8.95±0.02
Na^{+}(cmol/kg)	0.72±0.02
K^{+} (cmol/kg)	1.64±0.02
Ca^{2+} (cmol/kg)	4.42±0.02
Mg^{2+} (cmol/kg)	3.62±0.35
Ex. Acidity (cmol/kg)	1.95±0.01
CEC (cmol/kg)	12.30±0.20
Base saturation (%)	84.14±0.25
Fe (mg/kg)	411±3.60
Mn (mg/kg)	1.31±0.01

3.2 T-Test Comparison of Aloe Vera and Moringa Proximate Composition Analysis

The result for the T - test comparison of Aloe vera extract and Moringa leaf extract proximate composition analysis is present in Table 2. This shows the result of the laboratory analysis with aloe vera extract having high moisture content of 87.7±0.67 than moringa leaf extract of 83.1±0.59. In the Fat content, moringa leaf extract showed higher value of 0.79±0.39 than in aloe vera extract 0.41±0.01. The crude protein content with the value 3.24±0.01 was observed high in aloe vera extract and the lowest value 2.37±0.09 was observed in moringa leaf extract. pH of 6.39±0.00 was high in moringa leaf extract and 6.33±0.00 was low in aloe vera extract. The Magnesium content had a high value 44.5±0.49 in moringa leaf extract and lower value 36.4±0.14 in aloe vera extract. Total organic carbon showed higher value 0.81±0.00 in moringa leaf extract than that of aloe vera extract.

Table 2 T-test Comparison of Aloe vera and Moringa Proximate Composition Analysis

Parameters	Aloe -vera	Moringa	T-Value	p-Value	Significance
Moisture content (%)	87.7±0.67	83.1±0.59	7.222	0.019	Yes
Fat content (%)	0.41±0.01	0.79±0.39	-13.15	0.006	Yes
Ash content (%)	0.59±0.03	0.73±0.01	-6.781	0.021	Yes
Crude fibre (%)	3.19±0.02	2.63±0.53	1.493	0.274	No
Crude protein (%)	3.24±0.01	2.37±0.09	13.64	0.005	Yes
Carbohydrate (%)	4.87±0.66	10.3±1.01	-6.387	0.024	Yes
pH	6.33±0.00	6.39±0.00	-13	0.006	Yes
K (mg/L)	75.6±0.14	68.8±0.49	18.54	0.003	Yes
Ca (mg/L)	40.3±0.28	37.9±0.56	5.367	0.033	Yes
Mg (mg/L)	36.4±0.14	44.5±0.49	-22.39	0.002	Yes
Cu (mg/L)	0.16±0.00	0.21±0.00	-93	0.000	Yes
Fe (mg/L)	0.88±0.00	1.02±0.00	-56.79	0.000	Yes
P (mg/L)	4.74±0.00	6.35±0.01	-143.55	0.000	Yes
TOC (mg/L)	0.69±0.00	0.81±0.00	-116	0.000	Yes

*Significant difference between means when $p < 0.05$.

3.3 Effect of Growth IAA, Moringa and Aloe Vera on Growth Parameters

The result presents the vegetative growth parameters of cucumber plant with treatments: moringa leaf extract, aloe vera extract, Indole-3acetic acid and a control group. The measured growth parameters are plant height, the number of leaves and stem diameter. The statistical analysis

Table 3 Effect of Growth IAA, Moringa and Aloe Vera on Growth Parameters

Parameter	Treatment	Week1	Week2	Week3	Week4
Plant Height	Control	$16.00±0.30^{a}$	$25.06±0.00^{a}$	$35.66±0.01^{a}$	$43.66±0.03^{a}$
	Moringa	$118.20±0.10^{c}$	$127.13±0.30^{c}$	$137.20±0.01^{d}$	$145.20±0.02^{d}$
	Aloe vera	$117.13±0.15^{bc}$	$126.13±0.15^{c}$	$136.06±0.25^{c}$	$144.20±0.02^{c}$
	IAA	$116.33±1.52^{b}$	$125.00±1.00^{b}$	$135.00±0.20^{b}$	$143.23±0.03^{b}$
No of Leaves	Control	$3.66±0.03^{a}$	$5.60±0.11^{a}$	$8.66±0.20^{a}$	$13.66±0.01^{a}$
	Moringa	$10.88±0.06^{d}$	$14.89±0.03^{d}$	$19.89±0.00^{d}$	$24.86±0.01^{d}$
	Aloe vera	$9.89±0.01^{c}$	$13.89±0.01^{c}$	$18.89±0.02^{c}$	$23.89±0.02^{c}$
	IAA	$9.39±0.02^{b}$	$125.00±1.00^{b}$	$18.39±0.01^{b}$	$23.39±0.01^{b}$

Stem Diameter	Control	0.04±0.03[a]	0.13±0.01[a]	0.21±0.02[a]	0.30±0.01[a]
	Moringa	0.35±0.03[c]	0.42±0.01[c]	0.51±0.03[c]	0.60±0.01[c]
	Aloe vera	0.24±0.03[b]	0.32±0.01[b]	0.41±0.02[b]	0.50±0.02[b]
	IAA	0.44±0.25[d]	0.54±0.01[d]	0.61±0.01[d]	0.70±0.01[d]

*Mean with same superscript along the columns are not significantly different at p>0.05

The result for the yield parameters of the cucumber plant is presented in Table 4. The days of flowering shows that the treatments aloe vera, moringa and indole-3-acetic acid shared the superscript 'a' which indicates that there is no significant difference in flowering time among these three treatments although all significantly reduced flowering time compared to the control.

Table 4 Effect of IAA, Moringa and Aloe vera on the yield of Cucumber

Parameters	Control	Moringa	Aloe Vera	Indole-3- acetic acid
Days to Flowering	36.00±1.00 [b]	30.66±2.08 [a]	29.66±2.08 [a]	29.00±1.80 [a]
Fruit Weight	3.36±0.15 [d]	4.06±0.15 [d]	3.06±0.15 [d]	2.56±0.15 [d]
Fruit Diameter	7.63±0.32 [c]	13.50±0.88 [d]	12.50±0.88 [b]	12.00±0.88 [a]
Fruit Length	10.06±0.15 [a]	14.96±0.15 [b]	13.96±0.15 [b]	13.46±0.15 [b]

*Mean with same superscript along the rows are not significantly different at p>0.05

Table 5 presents some of the physiochemical properties of the soil of the experimental site after harvesting of cucumber plants. This shows the results for the analysis with control having the highest sand content (62.80%), The soil pH with the highest value 5.16 in indole-3-acetic acid and lowest value 5.04 in moringa. Total organic matter showed significant differences among all treatments, in terms of value, moringa had the highest 4.10 and the lowest value 3.19 in control. Total phosphorous was observed higher 10.04 in moringa and the lowest value 7.94 in control. The calcium and magnesium content had no significant variation across all treatments, indole-3-acetic acid had the highest values 4.10 and 3.47 respectively and the lowest value 3.13 and 3.25 in the control.

Table 5 Comparison of Soil Physiochemical Properties after Harvesting of Cucumber Plants

Parameters	Control	MSA	ISA	ASA
Sand (%)	62.80±0.10 [d]	54.40±0.30 [b]	50.90±0.10 [a]	56.30±0.10 [c]
Clay (%)	17.70±0.10 [b]	18.90±0.10 [c]	20.00±0.11 [d]	16.50±0.12 [a]
Silt (%)	19.50±0.10 [a]	26.70±0.20 [b]	29.10±0.10 [d]	27.20±0.20 [c]
pH	5.07±0.01 [a]	5.04±0.02 [a]	5.12±0.01 [b]	5.16±0.02 [c]
Total N (%)	0.16±0.02 [a]	0.23±0.02 [a]	0.20±0.10 [a]	0.19±0.02 [a]
TOM (%)	3.19±0.02 [a]	4.10±0.02 [c]	3.65±0.01 [b]	3.60±0.30 [b]
TOC (%)	1.85±0.02 [a]	2.37±0.03 [d]	2.12±0.01 [c]	2.01±0.01 [b]
Total P (mg/kg)	7.94±0.03 [a]	10.04±0.13 [d]	8.58±0.01 [b]	9.05±0.02 [c]
Na^+ (cmol/kg)	0.57±0.02 [a]	0.66±0.03 [c]	0.62±0.01 [b]	0.65±0.02 [bc]
K^+ (cmol/kg)	1.50±0.20 [a]	1.52±0.03 [a]	1.69±0.01 [a]	1.70±0.10 [a]
Ca^{2+} (cmol/kg)	3.13±0.25 [a]	3.95±0.03 [b]	3.36±0.01 [a]	4.10±0.10 [b]
Mg^{2+} (cmol/kg)	3.25±0.02 [c]	2.85±0.03 [b]	2.59±0.01 [a]	3.47±0.02 [d]1.69±0.03 [a]
Ex.Acidity (cmol/kg)	1.77±0.02 [a]	1.98±0.02 [b]	2.10±0.01 [c]	11.51±0.03 [c]
CEC (cmol/kg)	10.20±0.20 [a]	10.93±0.45 [b]	10.47±0.19 [ab]	
Base Saturation (%)	82.54±0.04 [c]	81.95±0.03 [b]	79.73±0.02 [a]	85.32±0.02 [d]
Fe (mg/kg)	373±3.00 [c]	385±1.00 [d]	365±1.00 [b]	360±1.52 [a]
Mn (mg/kg)	1.02±0.01 [d]	0.76±0.01 [b]	0.91±0.01 [c]	0.73±0.01 [a]

*Mean with same superscript along the rows are not significantly different at p>0.05. MSA- moringa soil analysis, ISA- indole-3acetic soil analysis, ASA- aloe vera soil analysis.

3 DISCUSSION

The soil texture of the study site was sandy loam. The site was moderately acidic (pH 4.98). The initial chemical compositions of the soil used in this study are presented in Table 1. The nitrogen was high (0.25), though the phosphorous levels (8.95) seemed moderate. Exchangeable cations, sodium (0.72), potassium (1.64) are present in high concentrations. Calcium with value 4.42 seemed moderate and magnesium (3.62) was high. The high base saturation of 84.14% shows that the soil has good potential to support healthy plant development despite its acidity. The high cation exchange capacity 12.30 cmol/kg also indicates that the soil can retain and supply essential nutrients effectively. effectively. Micronutrients such as iron are present in high concentrations (411), while manganese content (1.31) is moderate, both of which are important for plant function. [19] .

4.1 T-Test of the Moringa and Aloe Vera Leaf Extract Used in the Experiment

The data shown in Table 2 above represents the results of the proximate analysis carried out to compare aloe vera extract and moringa leaf extract using Ttest. The moisture content of aloe vera extract (ALE) was significantly higher than moringa leaf extract. A moisture content of 87.7% in aloe vera extract compared to 83.1% in moringa leaf extract, suggests that aloe vera extract is more hydrated, which could make it more prone to microbial growth but may also impart a fresher texture. This difference is statistically significant (p=0.019), the higher moisture content in aloe vera extract could influence its storage and shelf life. The moringa leaf extract fat content (0.79%) is nearly double that of aloe vera extract (0.41%), with a significant p-value (0.006). Fat content is crucial because it affects the energy value, taste, and texture of the food product. Ash content represents the total mineral content. Aloe vera extract has a slightly lower ash content (0.59%) compared to moringa leaf extract (0.73%), which is significant (p=0.021). In the results**,** while aloe vera has a higher crude fiber content (3.19%) than moringa (2.63%), the difference is not statistically significant (p=0.274). The Protein content is significantly higher in aloe vera (3.24%) compared to moringa leaf extract (2.37%) with a p-value of 0.005. Carbohydrate content of moringa leaf extract shows a significantly higher carbohydrate content (10.3%) compared to aloe vera extract (4.87%), with a p-value of 0.024. Carbohydrates are the body's primary energy source, and the higher content in AMP suggests that it could be more energy dense. The pH values of aloe vera extract and moringa leaf extract are very close (6.33 vs. 6.39), with a significant difference (p=0.006). Both values indicate a slightly acidic environment, which can influence the preservation and microbial growth. potassium, calcium, magnesium, copper, iron, phosphorous, and total organic carbon) showed significant differences in mineral content between aloe vera and moringa leaf extract suggest that each may offer different nutritional benefits. Aloe vera extract has higher levels of potassium and calcium 75.6 and 40.3 respectively. The differences in (Mg, Cu, Fe, P and TOC) between the two samples, with moringa leaf extract generally showing higher values, suggest that AMP could be more beneficial in providing essential nutrients that support various physiological functions in plants.

4.2 Effects of Moringa Leaf Extract Aloe Vera Extract and Indole-3-Acetic Acid on the Growth Parameters of Cucumber

The increase in plants growth over the four weeks period was markedly influenced by the different treatments. The control group, which did not receive any additional treatments, exhibited the slowest growth throughout the experiment. Starting from an average height of 16.00 cm in the first week, control plants increased gradually reaching 43.66 ± 0.03 cm by the fourth week. This limited growth can be attributed to the fact that control plants rely solely on the inherent nutrient availability within their growing medium. Aloe vera and IAA treatments also stimulated notable growth, reaching 144.00 cm and 143.23 cm, respectively, by week four.

Among the treatments, Moringa treated plants showed the most substantial effect on plant height, with an initial height of 118.20 ± 0.10 cm in the first week, rising to 145.20 ± 0.02 cm by the fourth week. In contrast, foliar application of MLE at 1:32 concentration increased the plant height in maize [20], tomato [21] , beans and maize [2]. This might be due to zeatin, which is the most common cytokinin in the extract, responsible for the improved plant height. These results agree with the findings of [22], [12] and [23], they reported the increased plant height, fresh weight and dry weight of shoot and better crop growth rate in different vegetable crops including tomato, eggplant, common bean, cauliflower, cucumber and cabbage respectively with foliar application of MLE compared to control. [24] reported that exogenous application of MLE at 10% concentration increased the plant height of the jojoba plant. In a related study, [25] reported that MLE used at the rate of 10% concentration at one week interval increased the plant height.

Leaf production is another critical indicator of plant health, reflecting the plant’s ability to photosynthesize and sustain growth. The control plants, which did not receive any supplemental treatments, exhibited a relatively slow increase in leaf number. Starting with an average of 3.66 ± 0.03 leaves in the first week, the control plants produced 13.66 ± 0.01 leaves by the fourth week. The other treatments, however, significantly boosted leaf production. Moringa-treated plants of 25ml exhibited the most notable increase, with the number of leaves rising from 10.88 in the first week to 24.86 in the fourth week. Aloe vera and IAA also resulted in considerable leaf growth, ending the four weeks with approximately 23 leaves each. The results showed that Moringa not only contributed to the overall plant height but also stimulated a greater increase in leaf production compared to the other treatments. This is also consistent with the findings of [26] who observed that MLE application increased the number of leaves, shoot length, leaf area per plant, old dry leaf weight of Phaseolus vulgaris (common bean).

Stem diameter is a crucial parameter for evaluating the structural integrity and strength of plants. A thicker stem provides better support for leaves and branches. In results, the control plants exhibited the smallest stem diameter, with a final measurement of 0.30 ± 0.01 cm by the fourth week. This thinner stem indicates that control plants, which lacked growth stimulants, developed less structural strength compared to the treated groups. Moringa treated plants showed a marked improvement in stem diameter, starting at 0.35 ± 0.03 cm in the first week and increasing to 0.60 ± 0.01 cm by the fourth week. The improvement in stem diameter indicates that Moringa contributes not only to growth but also to the strengthening of the plant's structure. Aloe vera treatment resulted in a significant increase in stem diameter, from 0.24 ± 0.03 cm in the

first week to 0.50 ± 0.02 cm in the fourth week. Indole-3-acetic acid treated plants exhibited the highest stem diameter by the fourth week, measuring 0.70 ± 0.01 cm. Auxins like IAA are known to play a key role in vascular differentiation and the stimulation of cambial activity, which leads to thicker, stronger stems. Studies have shown that exogenously applied IAA affects plant root and stem growth positively [27, 28]. The results indicate that IAA was the most effective treatment for increasing stem diameter, making the plants more structurally stable and potentially more resistant to environmental stresses.

4.3 Effects of Moringa Leaf Extract, Aloe Vera Extract and Indole-3-Acetic on the Yield Parameters of Cucumber

The treated plants flowered significantly earlier than the control, The number of days to flowering is reduced in plants treated with Moringa (30.66 days), Aloe Vera (29.66 days), and IAA (29.00 days) compared to the Control group (36.00 days). The reduction in flowering time implies that these treatments (especially Aloe Vera and IAA) accelerate the plant's transition to the reproductive stage. This is beneficial in a farming context because faster flowering leads to earlier harvests. Aloe Vera, Moringa, and IAA indicates that there is no significant difference in flowering time among these three treatments, although all significantly reduce flowering time compared to the Control.

Moringa-treated plants of application 25ml produced the heaviest fruits significantly higher than other treatments which is a desirable trait for both commercial and subsistence farming. Heavier fruits are often associated with better market value and higher nutritional content. Moringa treatment resulted in the highest fruit weight (4.06), which was significantly greater than the Control (3.36). Aloe Vera (3.06) and IAA (2.56) produced smaller fruits compared to the Control, with IAA showing the least fruit weight among all treatments. This could be due to the high nutrient content or growth-promoting hormones in Moringa, which support fruit development. These results resemble those reported by [29] that application of MLE caused a significant increase in fruit weight of cucumber. The differences in fruit weight suggest that Moringa significantly enhances the growth and size of the fruit, likely due to the bioactive compounds- phenolic, flavonoid and saponin compounds in Moringa that promote better nutrient absorption and growth. Aloe Vera and IAA may have had less impact on fruit weight, potentially due to their mode of action or concentration used. Similarly, [30], [31] and [22] found significant positive effects of MLE application on yield components and better yields of vegetables with various doses of MLE. In the Fruit Diameter**,** Moringa treatment of 25ml resulted in the largest fruit dimensions, indicating that it not only promotes vegetative growth but also enhances reproductive output. Moringa again had the largest effect on fruit diameter (13.50), followed by Aloe Vera (12.50) and IAA (12.00). The Control had a significantly smaller fruit diameter (7.63). This indicates that Moringa, Aloe Vera, and IAA all help to increase fruit size. In terms of value, Moringa was higher than the other treatments. This could be attributed to the growth-promoting properties of the compounds present in Moringa, which could lead to enhanced cell division, expansion in the fruit and supporting fruit development. Therefore, moringa extract is expected to affect the yield attribute of days of flowering, fruit weight, fruit diameter and fruit length. [32, 33].

The longest fruits were produced with the Moringa treatment (14.96), followed by Aloe Vera (13.96) and IAA (13.46), which were all significantly longer than the Control (10.06). Like the fruit diameter, this shows that the treatments particularly Moringa stimulate better fruit development, resulting in longer fruits compared to the untreated control group. This is like the findings of [34] they showed that all levels of MLE led to significant increases in fruit yield compared to the control treatment (Tap water) and at the same time enhanced its components, i.e., number of fruits and plant, fruit length, diameter, fresh and dry weight as well as early and total yield. Research studies therefore suggested that the increase could be due to the presence of zeatin, and sufficient micronutrients in the moringa leaf.

The result in this investigation corresponds with the findings of [21], that moringa leaf extract increases growth and yield of tomatoes and the greater the frequency of application, the greater the increase in yield. Many researchers have recently focused that MLE application to plant can provide beneficial nutrient elements, improve antioxidant defense system and enhance vegetative as well as reproductive growth resulting in higher yield and economic benefits under stressed and non-stressed situations [35-36].

4.4 The Soil Physiochemical Properties after Harvesting of Cucumber Plants

The varying percentages of sand, clay and silt across the treatments suggest different soil textures, which can influence water retention, drainage and root penetration. For example, control has the highest sand content (62.80%), which may lead to better drainage but lower nutrient retention. Indole-3-acetic soil (ISA) with higher clay content 20.00% might retain more nutrients but could also impede drainage and root growth. The soil pH ranges from 5.04 to 5.16 across the treatments, indicating slightly acidic conditions. The relatively close pH values suggest that the treatments do not drastically alter soil acidity, which is beneficial for maintaining a stable growing environment. The Total N showed no significant difference among all treatments including the control. The highest value 0.23 was in the moringa soil (MSA). Total Organic Matter (TOM), Total Organic Carbon and Total Phosphorus (P), Moringa soil had the highest total organic matter 4.10% and total organic carbon 2.37% indicating richer organic content which can enhance soil fertility and microbial activity. Also, moringa soil had the highest total phosphorus 9.05 mg/kg. In terms of value, Exchangeable cations including K, Ca and Mg were observed to be higher in aloe vera soil, potassium 1.70 cmol/kg, calcium 4.10 cmol/kg and magnesium 3.47 cmol/kg. Ex acidity had no significant difference across all treatments but in terms of value, 2.10 cmol/kg indole-3-acetic soil is

higher than other treatments. The Cation Exchange Capacity (CEC) and Base saturation, shows that aloe vera soil exhibits the highest CEC (11.51 cmol/kg) and base saturation (85.32%). High base saturation indicates that a greater proportion of the soil's exchange sites are occupied by basic cations (e.g Ca^{2+}, Mg^{2+}), which is generally favourable for plant growth. The concentration of micronutrients like Iron (Fe) and Manganese (Mn) varies across all treatments with moringa soil having the highest iron content (385 mg/kg), while Iron is essential for plant growth, excessive amounts can be toxic. The manganese content showed significant difference across all treatments with was lower value (0.73 mg/kg) in aloe vera soil. high manganese content can lead to toxicity in plants. The results showed that the treatments especially Moringa soil (MSA) and Aloe vera soil (ASA) are effective in enhancing soil properties, including nutrient content, organic matter and soil fertility.

4 CONCLUSION

From findings of the present study, it can be concluded that there was significant variation among the treatments in the growth and yield of cucumber plants. Moringa leaf extract of 25 ml application foliar application exhibited the highest results in respect of growth and yield compared to other treatments; control, Aloe vera extract and Indole-3-acetic acid. The control plants showed lowest performance in terms of growth and yield.
The results of the experiment showed that the use of plant extract as plant growth promoter had positive impact on moringa leaf extract in the growth and yield of cucumber.

5 RECOMMENDATION

The excessive use of synthetic chemical fertilizers is associated with environmental pollution and soil degradation. In addition, the high cost of these fertilizers necessitates the search for alternative eco-friendly and safe natural resources of phytonutrients. Chuene victor *et al*., (2022). In this study, aqueous extraction of plant extracts was used as it is environmentally friendly and can be used by local, subsistence and commercial farmers as well as the local communities. Though, there are various method of extraction. But the aqueous extraction is recommended because it is easy to prepare and apply by farmers. It has been investigated in this study that moringa leaf extract of 25 ml foliar application could result in a great increase on the growth and yield of cucumber.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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