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Influence of Variety and Cultivation Technologies on Cucumber Growth, Yield and Insect Pests Management in Sierra Leone

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Authors' contributions

This work was carried out in collaboration among all authors. Authors VA and AES conceptualized the study, performed methodology and did software analysis. Authors VA, AES and DDQ did data validation. Author VA did formal analysis. Authors VA, AES and WF investigated the study. Author WF searched for resources and wrote the original draft. Authors VA and WF did data curation. Authors VA, AES and WF wrote, reviewed and edited the manuscript. Authors VA, AES and DDQ did data visualization and supervision. All authors read and approved the final manuscript.

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ABSTRACT

The present study aimed to evaluate the influence of different cultivation technologies on the insect population, damage, weeds population and damage growth and yield of cucumber in two cropping years. Cucumber is an important and versatile fruit and vegetable because of its various uses, ranging from salads, pickles, and beauty in Sierra Leone. However, the cultivation of this crop is hindered by pests diseases and poor soil fertility. A two-year field experiment was conducted at the School of Agriculture and Food Science to evaluate the effect of cultivation technologies on the management of pests and weeds cucumbers. The experiment was laid in two two-factor completely randomized design (FCRD) with three replications. The results revealed that cultivation technology one (CT1) had a positive impact and recorded the highest growth and yield during the evaluations (6.5 and 7.8 t/ha). The results on pest and weed management revealed that cultivation technology three (CT3) proved to be the most potent in insect pest management, while cultivation technology two (CT2) was effective in weed management. The economic analysis showed that cultivation technology one (CT1) generated the highest revenue for both 2023 (Le 1,950.00) and 2024 (Le 2,340.00) evaluation years. The study concluded that there are potential benefits of using cultivation technology one and two and recommended that cultivation technology one and two (CT1 and CT2) should be adopted by farmers in the cultivation of cucumbers.

Keywords: Cucumber cultivation; pest management; economic analysis; chemical compounds.

1. INTRODUCTION

The practical use of plant growth regulators can be exploited in monoecious crop like cucumber grown under protected conditions for increasing femaleness and effective pollination there by improving yield and quality. Whereas, the knowledge about application of plant growth regulators and their proper dosage is less among farmers to get the expected results (Dinesh et al., 2024; Choubey et al., 2023; He et al., 2025). Cucumber fruit (*Cucumis sativus* L.) belongs to the Cucurbitaceae plant family and can be cultivated in subtropical and tropical environments; therefore, they are native to many countries of the world (Gross et al., 2016). It is an important fruit vegetable that is cultivated in most parts of Sierra Leone. This plant is a versatile vegetable because of various uses ranging from salads, pickles, beauty products and digestive aids. Cucumber serves as a major source of vitamins and it is widely used by Sierra Leonean in preparing attieke, beans salad and other food. The fresh consumption of this crop provides a variety of health benefits including valuable antioxidants, anti-inflammatory and anti-cancer benefits (Mukherjee et al., 2013). However, despite the importance of this crop, production and productivity are hindered by several factors, such as poor soil fertility, water for irrigation, insect pests infestation, weeds and disease attack factors. Fertilizer is one of the important factors of successful cucumber cultivation. Fertilizers are substances which when added to the soil supply one or more plant nutrients. Inorganic fertilizers are chemical compounds made in factory or obtained from mining while organic fertilizer is composed mainly of waste and residues from plants and animal life (Cooke, 1982). Organic fertilizers are derived from animal matter, animal excreta (manure), human excreta and vegetable matter (Heinrich et al., 2012). Organic fertilizers are used to augment the concentrations of plant nutrients and organic substances (Quee et al., 2020). They can restore soil fertility and enhance the crop yield in quantity and quality. The use of inorganic fertilizer has not been helpful under intensive agriculture because of its high cost and its association with reduced crop yield, soil degradation, nutrient imbalance and acidity (Kang and Juo, 1980; Obi and Ebo, 1995). Complementary use of organic and inorganic fertilizers has been recommended for sustenance of long-term cropping in the tropics. Aliyu (2000) also reported that vegetables grown on plots treated with organic manure are always larger than those grown on plots treated with inorganic fertilizers, because organic manure improves the soil structure, increases aeration, water retention as well as nutrient ions retentions and adsorptions for effective crop growth. Continuous use of synthetic pesticides has resulted in negative effects such as pollution, health hazards and loss of biodiversity, while adoption of botanical pesticides results in a healthy environment and sustainable agriculture. Traditionally, farmers have used crop protection products of plant origin in post-harvest pest management, especially in the preservation of grains during storage. Botanical pesticides are derivatives of plants that repel, inhibit growth or kill pests (Hikal, et al.,2017) and most of the botanical pesticides are used to manage insect pests and many studies have focused majorly on insect pest management. Therefore, the aim of this study is to evaluate the influence of different cultivation technologies on the insect population, damage, weeds population and damage growth and yield of cucumber in two cropping years.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The field experiments were conducted in 2023 and 2024 cropping seasons in the upland of the experimental site of Crop Protection Department, School of Agriculture and Food Science, Njala University, Njala, Sierra Leone to evaluate the effect of cultivation technologies (organic and inorganic pests mamagement) on insect pests, weeds and the production and productivity of cucumber. Njala University, Njala Campus is located at about one hundred and fourteen miles (114) from the Capital city, Freetown or Southern Sierra Leone at approximately 7 miles off the Bo-Freetown highway.

Njala University, Njala Campus experiences a distinct dry and wet season because of the denial nature of the area. The rainy season starts from April to November and the dry season starts from October to May. The mean monthly air temperature ranges from 21^0C to 23^0C for a greater part of the day and night especially during the rainy season. Predominantly, the landscape of Njala University, Njala Campus is covered with secondary bush and consists of well-balanced mixture of sand, clay, and humus. The site to be specific was densely covered with elephant grass, spear grass and sedges. The land is relatively close to the swamp and the bio-factory of the Crop Protection department. The soil of the experimental site belongs to the Njala University, Njala Campus soil series (orthxic-palehumult). Prior to conducting the experiments, soil samples were collected at a 20 cm depth using a soil auger at different points within the site to assess physical and chemical parameters (Table 1). From the soil analysis, it was revealed that the nitrogen levels were considerably low compared to phosphorus and potassium. The soil of the experimental sites was generally low in moisture, low nutrient status and highly acidic in both 2023 and 2024 which are below the optimum pH of 6.5.

2.2 Experimental Design, Layout, Materials, Treatments and Management

The two-year experiments were laid in two factorial completely randomized design (FCRD) 2 x 4 levels with three replications and the experimental area for both experiments were 28 x 11cm (308 cm^2) with 1.0 x 0.5 m space apart. The material used were botanic seeds of two varieties of cucumber which the straight eight (improved) and gboto (local). These seeds were acquired from the Central Agricultural Research Institute (CARI), Monrovia, Liberia and they were shown directly after the land have prepared. The treatments involved two varieties of cucumber, local (gboto) and improved (straight eight) in combination with four cultivation technologies including CT1 (cultivation technology 1), CT2 (cultivation technology 2), CT3 (cultivation technology 3) and CT4/control (cultivation technology 4). The cultivation technology 1 (CT1) involved the use of chicken manure (CM) at 5 t ha^{-1}, *gracida sepium* as mulching material at 5 kg $plot^{-1}$, and the locally processed neem kernel extracted at 180 g L $H_2 0^{-1}$. After the chicken manure was incorporated into the soil it was left to decompose before planting. Mulching was done immediately after planting to prevent the emergence of insect pests and weeds. When there was a sign of pest' infestation on the crop, the neem extract was prepared from dried neem seed and the seed was pounded in a mortar to form powder, the powder was weighed at 180g and dissolved into 1L water in combination with 5 g of Saba soap. The solution was left to ferment 24 hours before application. The CT2 included locally prepared mango biofertilizer at 12 L ha^{-1}, and the manufactured neem extract in aqueous form (AZAGRO 3000) applied at 30 ml 6 L $H_2 0^{-1}$ ha^{-1}. The CT3 comprised of the application of N.P.K 15:15:15 fertilizer application at 88.9 kg ha^{-1} applied one after germination and chlorpyrifos application at 6 ml 6 L ha^{-1} when pests attack the plants. C4 is the control treatment which represents conventional. The experimental field was manually cleared of vegetation, debris removed, thoroughly ploughed to the depth of about 10-15 cm and later level using hoes and shovels and seeds were directly sowed in two per hill at a spacing of 30×60 cm (25,000 plants ha^{-1}).

Table 1. Physico-chemical properties of soil sample of the experimental site for 2023 and 2024 cropping season

Properties	Sampling in 2023 before planting	Sampling 2023 after planting	Sampling in 2024 before planting	Sampling in 2024 before planting
Soil pH	5.4	6.0	5.0	5.7
Nitrogen (% N)	0.04	1.8	0.05	2.0
Phosphorus(P)(mg/soil)	7.46	8.0	7.50	9.0
Potassium(K)(mg/soil)	94.4	9.7	8.1	8.8
Electrical Conductivity(µS/cm)	27	27	25	26
Soil organic Carbon (%)	1.74	1.66	1.87	1.88

2.3 Data Collection

Growth parameters recorded included vine length, number of branches, leaf number and leaf area were measured randomly from ten selected tagged plants in each plot from the middle row using a measuring tape from the soil surface to the tip of the plants at 2,4 and 6 weeks after planting.

Plant height was measured from ten randomly selected and tagged plants in each plot from the middle rows using a measuring tape from the soil surface to the tip of the plant at 2,4 and 6 weeks after transplanting. At harvest parameters like number of flowers, number of fruits, fruits weight, fruits size and fruits length were collected from ten tagged and the total number of fruits obtained from the selected plants was divided to get the average number of fruits per plant.

$$\text{Number of fruits per plant} = \frac{Total\ number\ of\ fruits\ from\ ten\ hills}{10}$$

At harvest the weight of the total number of fruits from ten tagged plants for each plot was recorded using a digital balance. The fresh fruit per plant was determined by dividing the total weight of the fruits by 10.

$$\text{Fresh fruit weight up per plant} = \frac{Total\ weight\ of\ fruits\ from\ ten\ hills}{10}$$

The insect pest's population was determined by randomly selected and tagged 10 plants from the middle rows per plot at 3 and 6 WAP. The number of insects per plant was estimated by dividing the total number of insects by 10.

$$\text{Number of insects per plant} = \frac{Total\ number\ of\ insects\ from\ ten\ hills}{10}$$

The percentage leaf damage per plot by insects was determined by dividing the total percentage of leaf damage from the 10 selected plants by 10 and multiplying it by 100.

$$\text{Percentage leaf damage} = \frac{leaf\ damage\ \ from\ ten\ hills}{10} \times 100$$

2.4 Data Analysis

Data collected were subjected to analysis of variance and Ducan multiple tests was used to compare means at 0.05 level of probability using RStudio software.

3. RESULTS AND DISCUSSION

3.1 Effects of Variety and Cultivation Technologies on the Growth of Cucumber

Varietal and cultivation technologies significantly ($P \leq 0.05$) influenced vine length at 3, and 5 weeks after planting in both 2023 and 2024 cropping seasons. Variety x Treatment interactions were also significant ($P \leq 0.05$) in both cropping years (2023 and 2024). Improved variety (Straight eight) gave the highest vine length at 3WAP (37.5 and 47.5 cm) and at 5WAP (90.3 and 92.1 *cm*) in both 2023 and 2024 cropping seasons respectively compared to and local variety (Gboto). CT1 treated plot recorded the tallest vine length of cucumber at 3 WAP (45.0 cm and 58.3 cm) and at 5 WAP (120.4 *cm* and 130.3 *cm*) consistently for both 2023 and 2024 cropping seasons, respectively followed by CT2, While the shortest vine length was produced in control/CT4 plots at 3(29.6 and 34.9 *cm*), at 5 WAP (56.8 and 56.9 *cm*) in 2023 and 2024 cropping seasons, respectively. (Table 2).

Similarly, treatment effects and treatment by varietal interaction were significant ($P \leq 0.05$) for number of leaves at 3, and 5 weeks after planting in 2023 and 2024 cropping seasons. The improved variety (straight eight) has a higher number of leaves at 3WAP (5.5 and 6.1 plant^{-1}) and at 5 WAP (10.3 and 11.6 plant^{-1}) for both 2023 and 2024 cropping seasons respectively than local. However, CT1 treated

Table 2. Growth response (Vine Length and Number of leaf plant) of cucumber under organic and inorganic control conditions for 2024 cropping seasons

Treatments	**2023**				**2024**			
	Vine length(cm)		**Number of leaf plant^{-1}**		**Vine length(cm)**		**Number of leaf plant-1**	
Variety	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP
Straight eight	37.5±2.6	90.3±6.9	5.5±3.3	10.3±1.6	47.5±2.8	92.1±8.0	6.1±0.6	11.6±0.8
Gboto	35.5±1.6	85.0±7.6	5.3±2.1	9.5±0.4	45.6±3.6	87.7±7.8	5.6±0.3	10.9±1.0
CT1	43.2±4.0	116.2±5.6	6.7±0.6	12.3±1.1	55.9±1.6	125.4±2.3	7.0±0.9	14.0±1.4
CT2	39.2±3.0	84.0±4.0	5.1±0.1	10.5±0.3	48.0±2.8	93.5±2.0	6.0±0.3	11.3±0.3
CT3	35.5±2.5	96.0±1.0	6.0±0.3	11.5±1.3	50.6±1.5	100.0±0.0	6.1±1.3	12.3±1.3
CT4	29.6±1.6	56.8	4.0±1.5	6.0±1.6	34.9±3.4	56.9±4.9	4.6±1.5	7.8±0.7
F-statis tic								
CTs (Pr > F)	<0.001	<0.001	0.05	0.05	<0.001	<0.001	0.05	0.03
Variety (Pr > F)	0.05	0.05	ns	ns	0.05	0.05	ns	ns
CTs*Variety (Pr > F)	<0.001	<0.001	0.05	0.05	<0.001	<0.001	0.05	0.05
CV%	10.0	14.2	11.0	13.5	17.8	21.0	10.0	13.4

Note: NS= not significant, CT= Cultivation technology plot recorded the highest number of leaves at 3 WAP (6.8 and 7.4 plant^{-1}), at 5(13.0 and 15.0 plant^{-1}) for both 2023 and 2024 cropping seasons respectively. This was followed by CT2 treated plots (Table 2).

The study revealed significant effects ($P \leq 0.05$) of varietal and cultivation practices on cucumber vine length at 3 and 5 weeks after planting (WAP) during the 2023 and 2024 cropping seasons. Significant variety × cultivation technology interactions ($P \leq 0.05$) were also observed in both years. The improved variety (Straight Eight) recorded the highest vine lengths at 3 WAP (37.5 *cm* and 47.5 cm) and 5 WAP (90.3 *cm* and 92.1 *cm*) in 2023 and 2024, respectively. Conversely, the local variety *Gboto* showed vine lengths lower than improved variety. Among treatments, the CT1-treated plots produced the tallest vines, with lengths of 45.0 *cm* and 58.3 *cm* at 3 WAP, and 120.4 cm and 130.3 cm at 5 WAP in 2023 and 2024, respectively closely followed CT2-treated plots. However, the shortest vines were observed in control (CT4) plots, with lengths of 29.6 *cm* and 34.9 cm at 3 WAP, and 56.8 cm and 56.9 cm at 5 WAP in 2023 and 2024, respectively (Table 2). For leaf production, significant effects ($P \leq 0.05$) of treatments and Cultivation technology × variety interactions were recorded at 3 and 5 WAP in both cropping seasons. The improved variety (Straight Eight*)* consistently produced a higher number of leaves, with 5.5 and 6.1 leaves plant^{-1} at 3 WAP, and 10.3 and 11.6 leaves plant^{-1} at 5 WAP in 2023 and 2024 compared to local variety (*Gboto)* and CT1-treated plots recorded the highest number of leaves, with 6.8 and 7.4 leaves plant^{-1} at 3 WAP, and 13.0 and 15.0 leaves plant^{-1} at 5 WAP in 2023 and 2024, respectively. CT2-treated plots followed with 6.0 and 6.1 leaves plant^{-1} at 3 WAP, and 11.5 and 12.3 leaves plant^{-1} at 5 WAP (Table 2).

Varietal and treatments effects were significant ($P \leq 0.05$) for number of branches at 3and 5 weeks after planting in the 2023 and 2024 cropping seasons. Treatment and by varietal interactions were also significant ($P \leq 0.05$). Though varietal interaction was not significant at all evaluation period for both cropping years, but the Gboto variety (Local) has higher number of branches at 3WAP (1.1 and 2.4 plant^{-1}) and at 5WAP (4.7 and 4.9 plant^{-1}) in both 2023 and 2024 compared to the straight eight variety(improved). However, CT1 treated plot recorded the highest number of branches for at 3 WAP (1.0 and 2.4 plant^{-1}) and at 5WAP (5.8 and 6.0 plant^{-1}) for both 2023 and 2024 seasons respectively. This was followed by CT2 treated plots. The statistical analysis of variance revealed that varietal and treatments effects and treatment by varietal interaction were significant ($P \leq 0.05$) for leaf area of cucumber. Straight eight variety gave the highest leaf area at 3(70.4 and 87.3 cm^2) and 5(162.1 and 176.5 cm^2) weeks after planting in both 2023 and 2024 cropping seasons respectively, Gboto variety(local) gave leaf area of (66.1 and 79.6 cm^2) and (156 and 166 cm^2) at 3 and 5 weeks after planting for both 2023 and 2024 cropping seasons respectively. CT1 recorded the highest leaf area at 3WAP (80.6 and 110.4 cm^2) and at 5WAP (189.0 and 204.7 cm^2) for both 2023 and 2024 seasons respectively. However, CT4 recorded the lowest leaf area at 3WAP (54.9 and cm^2), at 5(110.6 cm^2) for 2023 and 2024 cropping seasons respectively (Table 3).

3.2 Effects of Cultivation Technologies on the Number and Damage of Major Insect Pests' Pests of Cucumber

Treatments applied and treatment x varietal interaction have significant ($P \leq 0.05$) effects on the number of leaf miner during the two cropping seasons. Straight eight variety(improved) has lower number of leaf miner count at 3WAP (7.5 and 7.1 plant^{-1}) and at 5 WAP (6.2±0.3 and 5.9 plant^{-1}) irrespective of treatment compared to the Gboto variety(local)for both evaluation years. The number of leaf miner was lower with CT3 at 3(4.6 and 4.4 plant^{-1}), at 5(3.1 and 2.0 plant^{-1}) weeks after planting in both 2023 and 2024 seasons respectively. This was closely followed by CT1. However, throughout the evaluation seasons CT4 consistently recorded the highest number leaf miner at 3(10.0 and 9.8 plant^{-1}), at 5(11.1 and 11.2 plant^{-1}) weeks after planting in 2023 and 2024 cropping seasons (Table 4). Similarly, Treatments applied, varietal and treatment x interaction have significant ($P \leq 0.05$) effects in percentage leaf damage of leaf miner during the two-cropping years. Straight eight (improved variety) has lower percentage damage of leaf miner at 3WAP (47.1 and 33.5 %) and at 5WAP (34.6 and 27.2%) irrespective of cultivation technology compared to Gobto (Local variety) for both evaluations' year. CT3 recorded the lowest percentage leaf damage at 3(35.0 and 23.7%) and at 5(20.1 and 12.0%) weeks after planting in 2023 and 2024 cropping seasons. The percentage leaf damage of leaf miner was significantly higher with CT4 at 3(58.0 and 40.8%) and at 5(58.1 and 41.2%) weeks after planting in both cropping seasons (Table 5).

Table 3. Growth response (Number of branches plant and Leaf area) of cucumber under organic and inorganic control conditions for 2024 cropping seasons

Treatments	**2023**				**2024**			
	Number of branches plant^{-1}		**Leaf area(cm^2)**		**Number of branches plant^{-1}**		**Leaf area(cm^2)**	
Variety	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP
Straight eight	1.0±0.0	3.8±0.3	70.4±6.0	162.1±11.7	1.9±0.0	3.9±0.3	87.3±6.5	176.5±12.4
Gboto	1.1±0.0	4.7±0.4	66.1±5.3	156.0±10.9	2.4±0.0	4.9±0.3	79.6±7.2	166.8±16.0
CT1	1.0±0.0	5.8±0.6	80.6±7.5	189.0±7.6	2.4±0.3	6.0±0.3	110.4±9.2	204.7±15.2
CT2	1.0±0.0	3.5±0.3	76.7±4.6	167.0±10.9	1.9±0.5	4.6±0.4	86.9±6.2	188.3±16.0
CT3	1.0±0.0	3.8±0.1	78.7±4.5	180.3±6.8	2.5.0±0.5	4.7±0.0	95.1±6.2	192.5±16.0
CT4	1.0±0.0	2.0±0.0	45.7±2.6	112.0±10.5	1.0±0.0	2.1±0.0	56.8±5.0	120.6±10.0
F-statis tic								
CTs (Pr > F)	NS	0.002	<0.001	<0.001	0.05	<0.001	<0.001	<0.001
Variety (Pr > F)	NS	NS	0.05	<0.001	NS	NS	0.04	<0.001
CTs*Variety (Pr > F)	NS	0.05	0.03	<0.001	0.05	0.05	<0.001	<0.001
CV%	12.7	15.6	11.0	13.0	13.5	17.8	15.0	14.4

Note: NS= not significant, CT= Cultivation technology

Treatments applied and Treatment by varietal interaction has significant (*P ≤ 0.05*) effects on the number of whiteflies during the two evaluation seasons. Straight eight (improved variety) has lower number of whiteflies count at 3WAP (7.4 and 6.6 plant^{-1}) and at 5 WAP (6.1 and 5.6 plant^{-1}) irrespective of production technology compared to Gboto (local variety) for both 2023 and 2024 evaluation seasons. CT3 consistently recorded the lowest number of whiteflies at 3WAP (4.5 and 3.2 plant^{-1}), at 5 WAP (3.1 and 2.3 plant^{-}) in the 2023 and 2024 cropping season closely followed CT1. CT4 recorded the highest number of whiteflies at 3(10.0 and 10.1 plant^{-1}), at 5(10.8 and 11.2 plant^{-1}) both 2023 and 2024. In 2023 cropping season, the number of whiteflies was higher at all evaluation periods than what was observed in the 2024 cropping season (Table 4).

Similarly, treatments applied and treatment x varietal interaction have significant (*P ≤ 0.05*) effects on the percentage damage of whiteflies during the two evaluation years. Straight eight (improved variety) has low percentage damage of whitefly at 3WAP (42.8 and 29.4 %) and at 5WAP (32.5 and 25.2%) irrespective of treatment compared to Gboto (local variety). CT3 recorded the lowest percentage leaf damage of whiteflies at 3WAP (35.5 and 22.2 %) and at 5 WAP (25.0 %) in 2023 cropping season. Similar result was observed in the 2023 cropping season at 2WAP (22.2 %) and at WAP 5(15.3 %). This was followed by CT1 at 3(40.5 %), at 5(25.0%) weeks after planting in 2023 season and in 2024 season, at 3(18.3%) and at 5(13.3%) weeks after planting respectively. However, CT4 recorded the highest percentage leaf damage for both varieties in the 2023 cropping season at 3(50.0%) and at 5(50.4%) weeks after planting and in the dry season at 3(45.0%) and at 5(31.2%) weeks after planting. It was revealed that the percentage leaf damage of whiteflies in 2023 season was higher than the percentage leaf damage that was recorded in the 2024 seasons.

Treatments applied, varietal and treatment x varietal interaction have significant (P ≤ 0.05) effects on the number of Aphid during the two-evaluation years. Straight eight (Improved variety) has lower number of Aphid count at 3WAP(7.1plant^{-1}) and at 5WAP (5.6 plant^{-1}) irrespective of treatment compared to Gboto (Local variety) at 3WAP (7.7 plant^{-1}) at 5WAP (6.0 plant^{-1}) for 2023 and 2024 cropping seasons. The number of Aphid for was lower in CT3 at 3(6.2 plant^{-1}), at 5(2.0 plant^{-1}) weeks after planting in 2023 cropping season and in 2024 cropping season, at 3(4.5 plant^{-1}), at 5(2.0 plant^{-1}) weeks after planting respectively. This was followed by CT1 at 3(7.0 plant^{-1}) and at 5(4.0 plant^{-1}) weeks after planting in 2023 cropping season and in 2024 cropping season at 3(6.7plant^{-1}), at 5(4.0 plant^{-1}) weeks after planting respectively. However, throughout the two years evaluations, CT4 recorded the highest number Aphids at 3(11.3 plant^{-1}), at 5(and 11.5 plant^{-1}) weeks after planting in 2023 season and in 2024 season at 3(11.3 plant^{-1}) and at 5(11.5 plant^{-1}) weeks after planting respectively (Table 4). The number of Aphids was lower in the 2024 cropping season than what was recorded in the 2023 cropping season.

Treatments applied and treatment x varietal interaction have significant (P ≤ 0.05) effects on the percentage damage of Aphid during the two-evaluation years. Straight eight (Improved variety) has low percentage leaf damage of Aphid at 3WAP (27.4%) and at 5WAP (20.4%) irrespective of treatment compared to Gboto (local variety) at 3WAP (30.2%) and at 5WAP (22.3 %) for both 2023 and 2024 evaluation seasons. CT3 recorded the lowest percentage leaf damage at 3(30.2%) and at 5(15.0 %) weeks after planting in 2023 cropping season and in 2024 cropping season at 3(18.5 %), at 4(10.0%) weeks after planting respectively. The percentage leaf damage of Aphid was significantly higher with CT4 throughout the evaluation at 3(55. %) and at 5(55.0 %) weeks after planting in 2023 season and at 3(36.9%) and at 5(41.0 %) weeks after planting in 2024 cropping season (Table 5). The percentage leaf damage of Aphids was higher in 2023 cropping season than it was recorded in the 2024 season.

3.3 Yield and Yield Parameters of Cucumber Response Cultivation Technologies of Pests' Management

Cultivation technologies applied and cultivation technologies x varietal interaction have significant (P ≤ 0.05) effects on the number of flowers and fruits and fruits of cucumber during the two evaluation seasons. Straight eight (Improved variety) has higher number of flowers per plant (27.1 and 30.6 plant^{-1}) and number of fruits (13.7 and 15.3 plant^{-1}) irrespective of treatment compared to Gboto (Local variety) for number of flower (22.8 and 26.3 plant^{-1}) and number of fruits (11.6 and 13.0 plant^{-1}) for both 2023 and 2024 evaluation years. CT1 recorded the highest number of flowers per plant (38.5

Table 4. Effects of cultivation technologies on the number of major insect pests of cucumber (Leaf miner, whitefly and Aphids) in 2023 and 2024 cropping years

Treatments	2023						2024					
	Number of Leaf Miner plant^{-1}		Number whitefly plant^{-1}		Number of Aphids plant^{-1}		Number Leaf Miner plant^{-1}		Number Whitefly of plant^{-1}		Number of Aphids plant^{-1}	
	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP
Variety												
Straight eight	7.5±0.5	6.2±0.3	7.4±0.4	6.1±0.3	7.8±0.4	5.9±0.3	7.1±0.4	5.9±0.3	6.6±0.4	5.6±0.2	7.1±0.5	5.9±0.5
Gboto	8.2±0.7	6.6±0.3	7.6±0.3	6.6±0.5	8.4±0.6	6.2±0.5	7.7±0.3	6.1±0.6	7.2±0.3	5.8±0.2	7.7±0.6	6.0±0.3
CT1	7.4±0.3	4.1±0.5	7.5±0.3	4.6±0.0	7.0±0.0	4.0±0.3	6.2±0.0	3.9±0.0	6.3±0.3	3.3±0.2	6.7±0.2	4.0±0.0
CT2	8.2±0.5	6.7±0.0	7.9±0.2	5.5±0.4	8.3±0.2	6.8±0.4	8.0±0.5	6.5±0.5	7.0±0.4	5.0±0.4	7.6±0.3	6.6±0.3
CT3	4.6±0.2	3.1±0.0	4.5±0.4	3.1±0.2	6.2±0.4	2.0±0.4	4.4±0.3	2.0±0.4	3.2±0.5	2.3±0.4	4.5±0.3	2.0±0.3
CT4	10.0±0.5	11.1±0.5	9.9±0.4	10.3±0.2	10.0±0.3	10.8±0.3	9.8±0.2	11.2±0.3	10.1±0.2	11.2±0.4	9.9±0.3	11.0±0.2
F-statis tic												
Treatments (Pr > F)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Variety (Pr > F)	0.05	NS	NS	NS	0.05	0.05	NS	NS	0.05	NS	NS	NS
Treatment*Variety (Pr > F)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cv%	14.4	15.2	16.5	13.0	17.1	16.6	11.1	13.0	15.0	18.0	17.0	16.7

Note: NS = Not significant, CT = Cultivation technology

Table 5. Effects of organic and inorganic control options of pests and diseases of cucumber on the percentage damage of major insect pests of cucumber (Leaf miner, whitefly and Aphids) in 2024 cropping seasons

Treatments	**2023**						**2024**					
	percentage of Leaf Miner plant (%)		**Percentage damage whitefly plant (%)**		**Percentage damage of Aphids plant (%)**		**Percentage damage Leaf Miner plant (%)**		**Percentage damage Whitefly of plant (%)**		**Percentage of Aphids plant (%)**	
	3WAP	**5WAP**	**3WAP**	**5WAP**	**3WAP**	**5WAP**	**3WAP**	**5WAP**	**3WAP**	**5WAP**	**3WAP**	**5WAP**
Variety												
Straight eight	47.1±3.5	34.6±0.3	42.8±3.9	32.5±2.8	42.3±4.2	31.5±2.8	33.5±3.5	27.2±2.8	29.4±2.7	25.2±2.4	27.4±2.3	20.4±2.2
Gboto	49.2±4.0	36.9±0.3	44.1±4.0	34.2±2.1	45.1±4.3	33.2±3.3	36.7±3.4	29.9±2.6	31.5±3.0	26.6±2.3	30.2±2.9	22.3±2.0
CT1	45.6±3.3	25.1±1.5	40.5±2.3	25.0±2.0	40.0±3.0	24.0±1.3	35.2±2.0	32.9±2.0	18.3±0.8	13.3±2.2	24.7±1.2	15.0±0.0
CT2	50.0±4.5	35.0±2.0	45.2±2.3	30.0±2.4	46.0±2.2	28.8±1.4	40.0±2.5	30.5±1.5	37.0±2.4	21.0±1.4	32.6±3.3	23.6±0.8
CT3	35.0±2.2	20.1±1.0	35.5±3.0	25.1±1.2	30.2±1.4	15.0±1.0	23.7±1.3	12.0±0.8	22.2±1.5	15.3±0.6	18.5±0.7	10.0±0.3
CT4	58.0±3.5	58.1±2.5	50.0±4.4	50.3±1.2	53.0±3.3	55.0±4.3	40.8±3.2	41.2±2.3	45.1±2.2	31.2±2.4	36.9±2.3	41.0±3.2
F-statistic												
Treatments (Pr > F)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Variety (Pr > F)	0.05	ns	0.05	0.002	0.05	0.05	0.05	0.05	0.05	ns	0.05	0.05
Treatment*Variety (Pr > F)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cv%	17.0	13.3	15.1	16.4	18.0	14.1	18.5	20.0	11.0	16.0	20.0	14.9

Note: Ns = Not significant, CT = Cultivation technology

Table 6. Effects of organic and inorganic management options of major pests and diseases of cucumber on the yield and its component cucumber in 2024 cropping seasons

	2023					2024				
Treatment	**Number of flower plant^{-1}**	**Number of fruit plant^{-1}**	**Fruit weight(*t/ha*)**	**Fruit size(*cm*)**	**Fruit length (*cm*)**	**Number of flower plant^{-1}**	**Number of fruits plant^{-1}**	**Fruit weight(t/ha)**	**Fruit size(*cm*)**	**Fruit length(*cm*)**
Variety										
Straight eight	27.1±0.0	21.5±2.0	4.3±3.0	3.7±0.0	11.9±0.0	30.6±0.0	15.3±0.0	5.0±0.0	4.0±0.0	15.4±0.0
Gboto	22.3±0.0	16.3±1.0	4.1±2.0	4.2±0.0	11.2±0.0	26.3±0.0	13.0±0.0	4.7±0.0	4.2±0.0	14.6±0.0
CT1	38.5±0.0	30.5±15.0	6.5±0.3	4.5±0.0	15.6±1.0	42.5±0.0	40.5±5.0	7.8±0.3	5.0±0.0	17.6±1.0
CT2	26.5±0.0	20.5±10.0	4.2±0.2	4.3±0.3	11.0±0.0	33.0±0.0	25.5±0.0	4.6±0.0	4.4±1.6	17.0±0.0
CT3	32.6±0.4	23.6±8.0	4.5±0.2	4.0±0.0	13.0±1.1	33.0±0.4	27.6±3.0	5.2±0.2	4.3±0.0	16.0±1.1
CT4	10.6±6.0	10.0±10.0	2.0±0.0	2.5±0.0	8.2±0.6	16.6±0.0	15.5±0.0	2.3±0.0	2.3±0.1	11.0±1.0
F-Statistic										
Treatment	<0.001	<0.001	0.02	0.05	0.02	<0.001	0.02	0.05	0.05	0.02
Variety	0.05	ns	ns	ns	ns	0.05	0.05	ns	ns	0.05
Treat*Variety	<0.001	<0.001	0.04	0.05	0.02	<0.001	0.05	0.05	0.05	0.05
CV%	13.4	15.7	10.6	12.0	17.1	15.0	18.3	11.0	15.7	13.6

Note: Ns = Not significant, CT = Cultivation technolog plant^{-1}) in the 2023 cropping season and in the 2024 cropping season (40.0 plant^{-1}). Similarly, the number of fruits was also higher (30.5 plant^{-1}) in the 2023 cropping season and in the 2024 cropping season (40.5 plant^{-1}). This was closely followed by CT3 (32.6 plant^{-1}) and number of fruits per plant (23.6 plant^{-1}) in the 2023 cropping and the 2024 cropping season for the number of flowers (33.0 plant^{-1}) and the number of fruits (27.6 plant^{-1}). However, CT4 recorded the low number of flowers (10.6 plant^{-1}) and fruits (10.0 plant^{-1}) respectively in the 2023 cropping season and in the 2024 cropping season for the number flowers (16.6 plant^{-1}) and in the number of fruits (15.5 plant^{-1}) respectively. Overall, the number of flowers and fruits per plant obtained was higher in 2024 cropping season than in the 2023 cropping season (Table 6). There was a significant difference between treated plots and CT4 plots in fruit weight and size, in the 2023 and 2024 cropping seasons. Straight eight (improved variety) recorded the higher fruits weight (4.3 t/ha) than Gboto (local variety) in 2023 cropping year (4.1 t/ha) and this was consistent in the 2024 cropping season for straight eight (improved variety) fruits weight (5.0 t/ha) than Gobto (improved variety(4.7 t/ha). CT1 recorded the highest fruits weights (6.5 t/ha) and fruits size (4.5) in the 2023 cropping year, and in the 2024 cropping year fruits weight (7.8 t/ha) and fruits size (5.0 cm) (Table 6). This was followed by CT3 for fruits weight (4.5 t/ha) and fruits size (4.0 cm) in the 2023 season and in the 2024 season for fruits weight (5.2 t/ha) and fruit size (4.1 cm). In general, CT4 recorded the low fruit weight (2.3 t/ha) and size (2.5 cm) in the 2023 cropping year and in the 2024 cropping year for fruit weight (2.3 t/ha) and fruit size (2.3 cm).

4. DISCUSSION

Cucumber is one of the most important vegetables in Sierra Leone that are produce local or poor resource farmers and are consumed by many Sierra Leonean. However, the production of this vegetable is constrained by insect pests, weed infestation and poor soil fertility. A study conducted to evaluate various cultivation technologies on the management of major insect pests and weeds of cucumber indicated that the cultivation technologies have a positive impact on the growth, yields, insect pests and weed population, damage and infestation of cucumber. CT1 which comprises of chicken manure, mulching and a locally prepared Neen extract proved to be the most effective treatment in terms of increasing vegetative growth, this might be simply because the application of chicken manure and *Gliricidia sepium* as a mulching material increases the nitrogen content of soil and suppress weeds that complete with for nutrient as it was indicated by the soil analysis, the nitrogen level of the soil was low before application of the chicken manure but after the application of the chicken manure the nitrogen level increase which might have triggered the increase in vegetative growth. Cropping year variation had a notable effect, with the 2024 cropping year generally producing higher growth metrics across all treatments compared to the 2023 cropping year. This trend is particularly evident in vine length, where CT1 in the 2024 cropping resulted in the tallest plants. The increase in vegetative growth in the year 2024 cropping can be attributed to the fact that treatments applied were very potent leading to low weed competition against the desired crop, a low number of insect pests and their damage on the crop and thus the crop was maintained, and low leaching of inorganic fertilizer and the biofertilizers. This finding agrees with the work of Usman, (2015) who found superior effects of chicken manure on the growth parameters of tomato. Samura et al.,2024 also observed variation in the growth of tomatoes by cropping years. Usman, (2015) revealed that plant heights at harvest differ significantly among treatments with the highest recorded in plots fertilized with poultry manure. CT3 which comprises of NPK 15:15:15 and chlorpyrifos was promising though does not perform as compared to CT1. The findings suggest the potential benefits of using CT1 and CT3(organic and inorganic) pest management practices in cucumber cultivation to improve plant growth and yield. The yield of cucumber was significantly influenced by all cultivation technologies applied with CT1 being the most superior as it gives higher fruits weight, length, number of fruit and fruit size compared to other treatments. This might be because of the high performance of the crop due to the application chicken manure and *Gliricidia sepium* mulching which are both rich in nitrogen which lead to an increase in fruit weight, number and size. A similar observation was made by Ilodibia et al. (2015), they reported that the application of 10 t ha-1 rates of poultry manure resulted in the highest fruit and seed yield values of 8570.66 and 18.13 kg hg-1 of tomato respectively. The cultivation technologies in insect pests management showed positive effectiveness in the management of major insect pests of cucumber during the evaluations. CT4, which comprises of N.P.K 15:15:15 and urea, promethrin herbicides and chlorpyrifos pesticides prove to be the most potent and effective technology as it reduces the number and percentage damage of whitefly, leaf miner and Aphids which suggest that chemical control is most effective control measure of major insect pests of cucumber. The findings confirm the work of Abbas et al. (2022) who revealed superior effects of chemical pesticides on the major insect pests. Abbas et al. (2022) reported that the superiority of the pesticide (Aster) against pests (especially Aphid and leaf miner) which can be attributed to the effect of the pesticide on the protein transporter Glutathione s-transferase. This transports enzymes which digest the protein in the insect's food, thus acting as a nutritional inhibitor. CT1 and CT2 were very promising in controlling the population and damage of major insect pests in the field. Verma et al. (2021) found out from their review study that the application of neem extract could be a potent source to enhance protection from insect pests and diseases and ultimately improve the productivity and quality of crops. The effectiveness of CT3 in controlling major insect pests is not significantly different from that of CT1 which suggests that CT1 should be recommended to farmers as it is environmentally friendly compared to inorganic treatment that pose serious health problems to the environment.

5. CONCLUSION

The study concluded that all cultivation technologies were very promising, increasing growth, reducing insect pest populations and damage, and reducing weed infestation. Among the cultivation technologies applied, cultivation technology one (CT1), which comprises chicken manure, mulching, *Gliricidia sepium*, and locally prepared neem extract, proved to be the most effective in terms of increasing vegetative growth, yield and reduced pest population and damage. The study also concluded that cultivation technology two (CT2), which comprised biofertilizer, hand weeding, and processed commercially bottled neem, also showed promising results, although it was not as effective as CT1 and CT3. On the other hand, the growth of cucumber plants in CT3 was not encouraging compared to CT1. It was concluded also that yield was high with CT1 (6.5 and 7.8 t/ha), which was the most superior cultivation technology for both years. This cultivation technology resulted in higher fruit yield, likely due to the high growth performance of the crop and reduced pests' population and damage resulting from the application of chicken manure and *Gliricidia sepium* mulching, both of which are rich in nitrogen

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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