AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING

AND ENTREPRENEURIAL DEVELOPMENT

FACULTY OF AGRICULTURE EDUCATION

ASANTE MAMPONG

EFFECT OF PRUNING AND STAKING ON GROWTH AND YIELD OF CUCUMBER (*Cucumis sativus* L.)

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A THESIS IN THE DEPARTMENT OF CROP AND SOIL SCIENCES EDUCATION, FACULTY OF AGRICULTURE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF PHILOSOPHY CROP SCIENCE (AGRONOMY)

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis, with the exception of quotations and references contained in published works which have been duly acknowledged; is the result of my own original work and that no part of it has been presented for another degree at this university or elsewhere.

Candidate Name: Alice Oduro Nkansah

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Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development.

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DEDICATION

This thesis is dedicated to my parents, Mr. Ernest Oduro Kingsley and Mrs. Comfort Sekyere, my husband Rev. Father Joseph Adarkwah Yiadom for his prayers and to my son Abdul Rashid.

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LIST OF ABBREVIATIONS/ACRONYMS

DAP	Days After Planting
FAO/UNESCO	Food and Agriculture Organization of the United Nations (FAO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO)
FAOSTAT	Food and Agriculture Organization Statistics
MSP	Multiple sucker pruning
NSP	No sucker pruning
SPS	Single plant staking
SSA	Sub-Saharan Africa
SSP	Single sucker pruning
TTS	T-trailers staking
VSS	V-shape staking

ABSTRACT

This study was conducted to determine the phenology, growth and fruit yield of cucumber as affected by different pruning and staking methods. The experiment was conducted at the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED), Mampong Campus, Multipurpose Crop Nursery in two cropping seasons (major and minor) in the year 2023. The experimental design was a 3 × 3 factorial experiment arranged in a Randomized Complete Block Design (RCBD) with four (4) replications. The first factor was pruning which included (i) single sucker pruning, (ii) multiple sucker pruning, and (iii) no sucker pruning (control) and the second factor was staking which also included (i) V-shape staking (ii) single plant staking (control) and (iii) T-trailer staking). The results showed that V-shape staking produced plant with shorter days to 50% flowering than the other staking methods and also produced more number of fruit set and percentage plant establishment. Multiple sucker pruning improved the vine length and leaf area of cucumber and No sucker pruning also produced more number of leaves than the pruning methods. V-shape staking produced wider or thicker stems than the other staking methods and also longer vines. Single plant staking also improved the leaf area of cucumber. Multiple sucker pruning + T-trailers staking improved the vine length of cucumber, Multiple sucker pruning + V-shape staking rather improved the stem diameter and Single sucker pruning + V-shape staking produced longer fruits and wider fruits than the other interactions. Multiple sucker pruning + T-tailers staking produced higher fruit yield of cucumber than the other interactions. It is therefore recommended that, Single sucker pruning and V-shape staking are to be considered for adoption for longer and wider fruits. Also, Multiple sucker pruning and T-tailers staking for higher fruit yield of cucumber.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Cucumber (Cucumis sativus L.) is a commonly cultivated climbing vine belonging to the gourd family, Cucurbitaceae (Dahal et al., 2020). It is a monoecious plant, similar to other vine fruits, with discrete male and female flowers occurring on the same plant (Makawana & Pastagia, 2022). The origin of the cucumber is in southern Asia; however, numerous cultivars have been introduced and are cultivated worldwide. FAOSTAT (2017) reports that China is the predominant producer of cucumbers, with an average annual product yield of 54.3 million tonnes, followed by Turkey, which produces 1.7 million tonnes per year. In Africa, Egypt is the primary producer of cucumbers, with an annual fruit yield of 613 thousand tonnes, ranking ninth globally, while Cameroon is ranked twenty-first with a fruit yield of 224 thousand tonnes per year (FAOSTAT, 2017). Cucumbers are primarily cultivated for their small, delicate fruits. It is primarily favored for salads and relishes. Cucumbers are also utilized as vegetables, similar to other members of the gourd family. The stems of the cucumber generate tendrils that are infrequently branched. The fruit consists predominantly of water, with over 96% of the edible unpeeled portion being water (Ajibola & Amujoyegbe, 2019). Cucumbers are classified into three distinct varieties: seedless, seeded, and mini (Tahir et al., 2019).

There are approximately 100 varieties, with prevalent types including English, Persian, mini, and lemon (Ugwu & Suru, 2021). The English cucumber is the longest, slender, seedless variety, frequently sold wrapped in plastic. The epidermis of English cucumbers is thin and typically does not necessitate scraping, characterized by its dark green coloration. Consumers typically eliminate the epidermis due to its bitter flavor. Persian cucumbers are referred to as burp-less due to their smaller, shorter, and more compact size, as well as their milder taste and lack of seeds. The epidermis is more refined, thinner, and, akin to the

English variant, does not necessitate peeling. These cucumbers are distinguished by their succulent and firm texture, along with a milder flavor, rendering them more agreeable to the digestive system. Mini cucumbers are gaining popularity in the marketplace due to shifting consumer preferences. They possess a broad spectrum of skin colors, spanning from yellow to dark green. Lemon cucumbers are spherical and yellow, reminiscent of lemons, but they are fragrant, possess thin coverings, and contain seeds. There are three distinct applications for cucumbers in the marketplace: fresh whole, fresh sliced, and preserved (Jakob & Geyer, 2021). Whether it is the English, Persian, mini, or lemon variety, fresh whole cucumbers are cultivated for retail sale to consumers. Freshly sliced cucumbers are generally cultivated garden varieties, specifically produced for the food service industry, which necessitates uniformly sized segments for packaged salads and restaurant chain salad bars.

Cucumber has been recognized as one of the most significant fruit vegetables for its medicinal properties; it contains essential vitamins and minerals such as A, B6, C, K, potassium, as well as dietary fibers, pantothenic acid, magnesium, phosphorus, copper, and manganese (Ikenganyia et al., 2015). It contains ascorbic acid and caffeic acid, both of which contribute to alleviating skin irritation and minimizing edema (Ravetti et al., 2019). It was noted that the skin of cucumber fruit contains chlorophyll and silica; two advantageous components that are lost when the vegetables are skinned. Cucumber juice is frequently advised as a source of silica to enhance skin complexion and overall skin health. Cucumbers' fiber-rich epidermis, elevated levels of potassium and magnesium, and their capacity to facilitate the body's excretion of uric acid all contribute to lowering blood pressure and promoting nutritional functions. This information is particularly beneficial for individuals suffering from arthritis (Maurya et al., 2019). The magnesium content of cucumbers also contributes to enhancing blood circulation while simultaneously calming the nerves and muscles (Festus, 2023). The pickling procedure diminishes or deteriorates a significant portion of the nutrient content, particularly vitamin C (Swamy, 2017). Currently, cucumber is gaining popularity in many developing countries, likely due to its high nutritional and medicinal benefits, as well as its versatility as an ingredient in pharmaceuticals, salads, homemade beverages, and industrial fruit drinks. Cucumber fruits are advantageous for individuals with diabetes owing to their minimal sugar content, which facilitates the reduction of excess body fat (Kumar et al., 2012). It is one of the most significant and versatile vegetables cultivated year-round in Ghana due to its extensive range of applications. Recently, the demand for cucumbers in Ghana has been rising due to increasing awareness of their numerous health benefits, including hygiene and other advantages (Singh et al., 2021).

Cucumber fruits are advantageous for individuals with diabetes owing to their minimal sugar content, which facilitates the reduction of excess body fat (Kumar et al., 2012). Pruning involves the selective removal of particular components of a tree or shrub, including seedlings, branches, or roots (Ndukwa et al., 2021). According to Mathiyazhagan et al. (2021), pruning is a horticultural, arboricultural, and silvicultural technique that involves the selective elimination of specific sections of a plant, including branches, buds, or roots. Proper pruning guarantees the health and aesthetic appeal of your shrubs and trees. Pruning promotes the health of plants, guides their proper growth, enhances quality, and, in certain instances, limits their development. Pruning has been shown to diminish competition and improve the efficiency of plant photosynthesis and overall performance by optimizing the utilization of growth factors (Garba et al., 2020). It has also been shown to enhance airflow around the plant, thereby contributing to a reduction in the occurrence of parasites and diseases. In a different study, Goke et al. (2020) indicated that pruning improves the marketable produce concerning the size and weight of the crops.

Studies conducted by Asseng et al. (2020) demonstrate that vertical cultivation of crops necessitates specific trail arrangements, resulting in a threefold increase in yield compared to traditional ground-based cultivation. Damages may result when crops are permitted to fall to the ground (Hussein et al., 2020), thereby increasing their susceptibility to insect infestations. Every gardener's aspiration is to ensure that their plants remain free from maladies. This can be accomplished through staking crops instead of permitting them to sprawl on the ground. When plants are supported by supports, they benefit from improved air circulation, which diminishes the occurrence and dissemination of diseases. Staking cucumbers and other ascending vegetables offers numerous benefits. The inherent tendency of cucumber vines is to climb; therefore, positioning a stake near the plant as it begins to grow enables the vines to hold the stake and ascend around it (Logsdon, 2022). When staking is implemented, cucumber fruits are readily accessible during harvest, and productivity is significantly increased as it reduces the likelihood of insect harm to the plants.

Studies by Asseng *et al*. (2020) show that growing crops vertically implies to specifically trail crops so as increases yield three times than when they are allowed to run on the ground. Damages can occur when fruits are allowed to run on the ground (Hussein *et al*., 2020) which can be exposed to insect attacks. Every gardener's wish is to make sure their plants are free from diseases. This can be achieved by staking crops rather than allowing them to run on the ground. When plants are raised up with stakes, they experience better air circulation which reduces the incidence and spread of diseases. Staking cucumbers, and other climbing vegetables, has many advantages. The natural tendency of cucumber vines is to climb, so placing a stake near the plant as it begins to grow allows the vines to grasp the stake and grow around it (Logsdon, 2022). When staking is done, cucumber fruits are easily accessed during harvesting, there is also high productivity because it does not give room to pest to damage the plants.

1.2 Problem Statement and Justification

Despite the significance of cucumber as one of the principal vegetables, achievable yields and overall productivity are significantly limited by suboptimal agronomic practices, pests, diseases, high produce perishability, and the exacerbating effects of climate change (Garba et al., 2020). In developing nations like Ghana, cucumber cultivation remains limited to a small group of farmers who lack awareness of the agronomic practices essential for producing high-yielding and marketable fruits. Furthermore, cucumber fruit production in Ghana is markedly diminished (Ajibola, 2017) due to several constraints, including insufficient vine management, poor soil fertility, limited access to mulching materials technology, and a deficiency in production knowledge. Cucumber (Cucumis sativus) cultivation is of paramount importance in global agriculture, making substantial contributions to the food supply and the economic prosperity of many regions. Nevertheless, despite its extensive cultivation, a noticeable void remains in our comprehension of how particular pruning and staking techniques influence essential growth and yield parameters in cucumber plants.

Current cucumber cultivation practices frequently lack optimization in terms of pruning and staking techniques. Farmers depend on conventional methods without a thorough comprehension of how these practices affect the development, flowering, and productivity of cucumber plants (Motzke et al., 2015). Inefficient utilization of resources constitutes a notable concern in cucumber cultivation. According to Sarvade et al. (2019), a comprehensive investigation is required into the effects of various pruning techniques on water and nutrient absorption, as well as the contribution of staking in offering structural support, to promote the optimal utilization of resources including soil water, nutrients, and sunlight. The impact of pruning and staking techniques on cucumber yield remains insufficiently documented, resulting in a lack of precise guidance for producers regarding the most effective practices to achieve optimal production (Gatahi, 2020). Effective staking techniques offer structural stability, diminishing the likelihood of maladies and promoting improved sunlight exposure. Enhancing these practices is crucial for sustainable and resource-efficient cultivation. According to Dalai et al. (2016), the overall health, development, and maturation of cucumber plants are directly correlated with yield and produce quality. Examining the impact of pruning and staking techniques enables the identification of strategies that foster healthier plants, resulting in higher yields and enhanced produce quality. Farmers encounter economic difficulties, and their selection of cultivation practices directly impacts their financial outcomes.

Identifying the most economical pruning and staking techniques can assist producers in optimizing their return on investment. A study conducted by Pradhan et al. (2021) on the effects of various staking methods and their cost-effectiveness on the growth, yield, and yield components of cucumber demonstrated a positive impact of staking on the yield and its components. Plant growth, yield, and yield components were superior under staking compared to no staking, with the highest performance observed using the 5-meter raised platform staking method, as the increased exposure to sunlight effectively enhanced the number of leaves, blossoming, and fruiting. Research conducted by Kumar and Rajkumar (2022) on staking and plant spacing in cucumber cultivation demonstrated improvements in the number of fruits, the quantity of marketable fruits, and the fruit weight. The staked treatment consistently outperformed the non-staked treatment with higher values. Oga and Umekwe (2015) reported that the application of NPK fertilizer and staking techniques significantly influenced the growth and productivity of watermelon, affecting vine length, the number of flowers, fruits, and marketable fruits. According to Pradhan et al. (2021), staking and pruning enhanced the growth and yield of cucumber. The non-staked treatment exhibited greater vine length, number of flowers, total fruit count, and unmarketable fruits, whereas the staked treatment yielded a higher number of marketable fruits, along with increased fruit weight, length, and diameter. The unpruned plants yielded the greatest total number of fruits, including both marketable and non-marketable ones, while the weight, length, and diameter of the fruits were maximized on plants subjected to single-stem pruning. Despite the recognized importance of pruning and staking in cucumber cultivation, there remains a limited body of literature on the optimal pruning and staking methods that effectively enhance cucumber growth, yield, and yield components. Therefore, this study seeks to assess the impact of various pruning and staking techniques on the growth and yield of cucumber.

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1.3 Objectives of the Study

1.3.1 Main Objective

The main objective of the study was to determine the growth and yield of cucumber as affected by different pruning and staking methods.

1.3.2 Specific Objectives

The specific objectives of the study were to:

i. Evaluate the effect of pruning and staking as well as their interactions on the phenology of cucumber.
ii. Determine the effect of pruning and staking as well as their interactions on growth of cucumber.
iii. Assess the interactive effect of pruning and staking on yield and yield components of cucumber.

CHAPTER TWO: LITERATURE REVIEW

2.1 Origin and Distribution

Cucumber originated in India, possibly Burma, where the plant exhibits considerable variability in both vegetative and fruit characteristics. It has been cultivated for a minimum of 3000 years. Originating in India, the plant rapidly disseminated to China and was reportedly highly valued by the ancient Greeks and Romans (Mayor, 2019). The Romans employed highly artificial cultivation techniques to produce cucumbers out of season for Emperor Tiberius when required. Columbus introduced the cucumber to the New World, along with numerous other vegetables. Currently, cucumber is extensively cultivated across temperate and tropical regions worldwide (Jia & Wang, 2021). According to Jia and Wang (2021), the global cucumber production totaled 87,805,086 tons, with Asia serving as the leading producer, accounting for 84.9% of the world's total output in 2019. With its ample water content, nutrients, and phytochemical composition, cucumber possesses diverse applications in culinary, therapeutic, and cosmetic fields (Jia & Wang, 2021). Cucumber offers several advantages, including its diploid nature, compact genome size, brief life cycle, and self-compatible reproductive system, making it suitable for genetic research. Furthermore, cucumber has been recognized as a model organism for research in sex determination and plant vascular biology (Jia & Wang, 2021).

2.2 Botany

Cucumis sativus originated in India, and potentially Burma, where the species exhibits considerable variation in both vegetative and fruiting characteristics. Cultivation of this species has been documented for a minimum of three millennia. Originating in India, the plant subsequently disseminated rapidly to China, and it purportedly garnered significant esteem from the ancient Greeks and Romans (Mayor, 2019). The Romans employed sophisticated techniques to cultivate cucumbers, ensuring their availability for Emperor

Tiberius even when they were not in season. Christopher Columbus introduced the cucumber to the New World, in addition to several other vegetables. Presently, cucumber cultivation is prevalent in temperate and tropical regions globally (Jia & Wang, 2021). Jia and Wang (2021) reported a global cucumber production of 87,805,086 tons. Asia was the leading producer, contributing 84.9% of the worldwide total in 2019. Due to its high water content, nutrient profile, and phytochemical composition, the cucumber possesses diverse applications in culinary, therapeutic, and cosmetic contexts (Jia & Wang, 2021). Cucumber possesses several advantageous characteristics, including its diploid nature, small genome size, brief life cycle, and self-compatible reproductive system, rendering it appropriate for genetic investigations. Furthermore, cucumber has been established as a model organism for investigating sex determination and plant vascular biology (Jia & Wang, 2021).

2.3 Varieties

The cucumber plant (Weng, 2021), which originated in India and has been characterized by numerous cultivars, is the subject. There are two primary categories of cucumbers: those intended for raw consumption following peeling and slicing, commonly referred to as slicing market types (Hongu et al., 2017), and those used for processing, also known as pickling varieties. The most widely accepted and favored type of cucumber is the dark-green, smooth-skinned, elongated variety commonly utilized in salad preparation (Suma et al., 2021).

Concerning the sexual characteristics of cucumbers, there are monoecious cultivars that bear both male and female flowers on a single plant, gynoecious cultivars that produce exclusively female flowers, and parthenocarpic cultivars whose female flowers develop into fruit without the need for pollination or fertilization. Generally, the most productive varieties of cucumber are gynoecious, producing exclusively female flowers, and their crops feature smoother surfaces compared to monoecious varieties, which produce both male and female flowers. Most greenhouse-cultivated cucumbers are parthenocarpic, or seedless, as the fruits develop without pollination (Grumet, 2022; Sharma et al., 2020; Pawełkowicz et al., 2019).

2.4 Uses and Nutritional Benefits

Sharma et al. (2020) indicated that cucumber is among the commodities cultivated for commercial purposes in tropical regions. Cucumbers constitute a vital vegetable within the culinary and pharmaceutical sectors. Nearly all palatable parts of the majority of Cucurbitaceae vegetables are utilized (Rolnik & Olas, 2020). Cucumbers may be consumed fresh as a condiment or incorporated into vegetable salads, stews, or sandwiches in Ghana. Harmayani et al. (2019) suggest that, owing to their distinctive texture and flavor, cucumbers are frequently consumed as an appetizer or in combination with other vegetables. In terms of their commercial importance in Asia, cucumbers are positioned after tomatoes, cabbage, and scallions, whereas in Western Europe, they are ranked second only to tomatoes. The commodity is among the foreign vegetables cultivated in Ghana and possesses export potential. A 100-gram portion of palatable fruit comprises 96 percent water, 0.5 grams of protein, 2.9 grams of carbohydrates, 0.1 grams of lipids, and 0.6 grams of fiber. This 100g portion also provides 13 kcal of energy, along with 14 mg of calcium, 17 mg of potassium, and 2 mg of sodium, as well as 0.03 mg of thiamine, 0.02 mg of riboflavin, 0.30 mg of niacin, and 4.7 mg of ascorbic acid (Khawar, 2018). Cucumbers serve as an excellent source of vitamins A, C, K, and B6. Cucumber fruit is a valuable source of minerals and also contains phytonutrients such as xanthin-B, lutein, and carotene-B. Cucumber juice promotes healthy skin and complexion development and exhibits anti-inflammatory properties. The fruit is consumed in its natural state and contains pantothenic acid along with a reduced calorie content. Phytochemical investigations have demonstrated that cucurbits exhibit a wide range of therapeutic properties. Several compounds with therapeutic properties, including momorcharins, momordenol, charantine, cucurbitins, cucurbitacins, cucurbitanes, urease, and polypeptide-P insulin, are extracted from cucurbits and employed for both rodents and humans (Singh et al., 2017). Cucumber extracts, including cucurbitacin, suppress the activity of cyclooxygenase enzymes, which would otherwise promote inflammation. Cucumber leaves are occasionally desiccated and milled into powder for preservation purposes. The seed is frequently utilized as a consumable oil in Asia. Cucumber seeds are frequently utilized as substitutes for desiccated peas and legumes in rice dishes and soups (Chinatu et al., 2017). In Nigeria, the seeds are consumed as a dietary staple; embryonic stewed fruits are utilized in the treatment of dysentery in children. Yellow curry cucumber (dosakayi) is extensively utilized in a variety of curry and stew preparations in South India, often incorporating buttermilk and yogurt. The ascorbic acid present in cucumber aids in alleviating irritation and inflammation of the epidermis (Garg et al., 2016). Cucumber peel is a valuable source of dietary fiber that aids in alleviating constipation and provides some protection against colon cancer by removing noxious substances from the gastrointestinal tract. Cucumber leaves and seed-cake are occasionally utilized as cattle fodder, and the leafy crowns are browsed by livestock and game (Chinatu et al., 2017).

2.4.1 Medicinal Benefits

Since antiquity, the medicinal advantages of cucumber have been well documented. Various plant components, such as leaves, fruits, and seeds, have been examined for their medicinal properties. C. sativus fruits and seeds possess notable therapeutic importance within Indian medicinal practices, especially in Ayurveda, where more than 200 botanicals, minerals, and various formulations are utilized for the management of aging. They are frequently employed in the treatment of various dermatological conditions, such as periorbital edema and dermatitis. It is asserted that they offer inflamed skin a soothing, calming, healing, relaxing, emollient, and anti-itching effect (Mukherjee et al., 2022; Uthpala et al., 2020; Ergun & Susluoglu, 2019). In traditional Chinese medicine, the leaves, stems, and roots are conventionally utilized as remedies for antidiarrheal, detoxification, and antigonorrheal purposes. This plant has been associated with multiple pharmacological properties, including antioxidant, antiwrinkle, antibacterial, anti-diabetic, and hypolipidemic effects. Antihyaluronidase and anti-elastase activities have been demonstrated for cosmetic uses, including facial masks, body balms, moisturizers, and shampoos.

Limited bioactive compounds from various chemical classes have been isolated from this plant (Mukherjee et al., 2013). The nutritional composition of cucumber per 100 g of edible portion (ends trimmed, unpeeled, with 97 percent edible content) is as follows: Water: 96.4 g; Energy: 42 kJ (10 kcal); Protein: 0.7 g; Fat: 0.1 g; Carbohydrates: 1.5 g; Dietary fiber: 0.6 g; Calcium: 18 mg; Magnesium: 8 mg; Phosphorus: 49 mg; Iron: 0.3 mg; Zinc: 0.1 mg; Beta-carotene: 60 µg; Thiamin: 0. Crepsin, a proteolytic enzyme; ascorbic acid, oxidase; and succinic and malic dehydrogenase have also been identified in fruits. Likewise, Watson (2000) reported that lycopene, found in cucumbers, is a potent antioxidant believed to prevent illness, assist in the prevention of certain cancers such as cervical and prostate malignancies, and combat cardiovascular disease by inhibiting arteriosclerosis. One cup of cucumber contains 9.09 mg of lycopene, whereas one cup of raw tomatoes provides only 4 mg (NWPB, 2003). According to Aqilah et al. (2023), cucumber fruits possess a notable concentration of ascorbic acid, while extracts from the pith and rind contain lactic acid (7-8 percent w/w), which exhibits antioxidant properties. Fermented cucumbers subjected to 2 percent NaCl treatment were discovered to contain volatile compounds (Mukherjee et al., 2013). As a fruit and vegetable, cucumber represents an essential commodity for the culinary, medicinal, and cosmetic sectors.

2.5 Production Estimate

Despite the significance of the cucumber crop in Asia and Western Europe, it has not been graded in Africa owing to limited demand (Babatunde, 2022). China is the world's foremost producer of cucumbers. Egypt was the leading producer of cucumbers in Africa and ranked ninth globally among cucumber-producing countries. Côte d'Ivoire was the leading producer of cucumbers in West Africa, with a total of 23,000 tons, and was ranked 67th globally, whereas Ghana produced the fewest, amounting to 132 tons, and was ranked 125th worldwide (Marina et al., 2018).

Between 2012 and 2022, Africa's total output value experienced an average annual growth of 1.4%; the trend pattern indicated significant fluctuations throughout the period under review (Babatunde, 2022). The growth rate was observed to be the highest in 2020, with an increase of 35 percent. From 2014 to 2022, however, the level of output was unable to regain its momentum. In 2022, Egypt, Sudan, and Cameroon led Africa in production volumes, representing 67 percent of the continent's total output.

From 2012 to 2022, Sudan experienced the most significant increase in production, whereas the production levels of the other leaders grew at more moderate rates. In 2022, the average production of cucumbers and gherkins in Africa experienced a minor decline and stabilized at the levels observed in 2021. Generally, the pattern of yield remained relatively stable. In 2019, the most significant rate of growth was observed when the produce increased by 12 percent. In 2014, the yield attained its peak; however, from 2015 to 2022, it was considerably lower. Future yield figures may continue to be influenced by extreme weather conditions despite the increased adoption of modern agricultural techniques and practices. Compared to 2021, the average production of cucumbers and gherkins in Africa remained relatively stable in 2022. From 2012 to 2022, the harvested area increased at an average annual rate of 2.4%; the trend remained relatively stable with only minor variations throughout the period under review. In 2014, the most significant growth rate reported was a 13 percent increase. The quantity of harvested area attained its peak in 2016; however, from 2017 to 2022, it did not resume its previous growth rate.The production rate, production per person, production size and yield of the first 10 ranked producer of cucumber worldwide is shown in Table 2.1.

Table 2.1: Top 10 Leading Producers of Cucumber

S/N	Country	Production (Tons)	Production Per Person (Kg)	Acreage (Hectare)	Yield (Kg/Hectare)
	China	56,293,530	40.387	1,046,237	53,805.7
	Iran	2,283,750	27.933	79,649	28,672.8
	Turkey	1,848,273	22.872	37,605	49,149.8
	Russian Federation	1,604,346	10.923	42,830	37,458.5
	Mexico	1,072,048	8.594	19,597	54,704.8
	Ukraine	985,120	23.309	49,500	19,901.4
	Uzbekistan	857,076	26.247	23,077	37,139.8
	United States of America	700,819	2.138	44,880	15,615.4
	Spain	643,661	13.795	7,507	85,741.4

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In terms of productivity per hectare, cucumber production in Ghana was 12 tons, compared to 37.4 tons in Morocco and an average of 666.7 tons in the Netherlands. Rising human populations compete for arable land to support activities such as the development of settlements, recreational facilities, and waste disposal, leading to land scarcity and limitations that diminish the available area for agriculture and decrease crop yields (Johnson & Lewis, 2007). Most of Ghana's soils are lacking in organic matter, leading to reduced agricultural productivity. The irregularity of rainfall in Ghana induces water stress, which subsequently affects hydration, biochemical and metabolic activities, nutrient uptake and translocation, photosynthesis, respiration, as well as crop yield and quality (Hasan & Rahman, 2019). At present, most cucumbers are cultivated in open fields subject to abiotic factors such as elevated temperatures, low temperatures, and weather variability. Biotic factors, including fruit fly infestations and the presence of downy and powdery mildew, also adversely affect cucumber growth in open fields. Therefore, it is not feasible to produce cucumbers that match the size, shape, and color of those cultivated in a protected environment while remaining free from diseases and parasites (Kumar & Reddy, 2021; Kumari et al., 2018).

2.6 Climatic and Soil Requirements

Cucumber cultivation is optimal under conditions of elevated temperature, low humidity, moderate light intensity, well-structured soil, and a consistent supply of water and nutrients (Singh et al., 2017). The optimal temperature for cucumber cultivation ranges from 20 to 25°C, with growth diminishing below 16°C and above 30°C. The growth and development of cucumbers were negatively impacted at temperatures below 50°C; however, as temperatures increased up to 40°C and above, a significant decline was observed (Amin et al., 2021; Qu et al., 2022). Humidity is influenced by precipitation; therefore, it tends to be greater during the rainy season compared to the arid season. The drawbacks of cultivating in conditions of high relative humidity encompass an elevated risk of water condensation on the plants, which can lead to the development of severe diseases such as Downy mildew and Powdery mildew. The observed poor transpiration rates are attributed to insufficient absorption and transportation of specific nutrients, particularly calcium, to the leaf margins and fruits. At low humidity levels, irrigation assumes a vital role, as substantial amounts of water must be supplied to the growth medium without continuously inundating the roots or depriving them of oxygen (Bhattacharya, 2021). Additionally, low relative humidity promotes the proliferation of powdery mildew and spider mites. According to Nnadi and Carter (2021), the occurrence of fungal disease is directly correlated with atmospheric humidity. Heat-induced sterility in cucumber occurs prior to or during anthesis (Yan et al., 2020). Cucumbers thrive in light-textured soils that are well-drained, rich in organic matter, and maintain a pH range of 6 to 6.8. Suitable for a broad spectrum of soil types, yet will yield early in infertile soils. Cucumbers demonstrate a reasonable tolerance to acidic soils, with an acceptable pH level as low as 5.5 (Kader et al., 2016). When the pH is excessively low, incorporate ground calcitic limestone, or an equivalent amount of dolomitic limestone if the soil's magnesium content is deficient, in order to elevate it to a suitable level.

2.7 Crop Propagation

Cucumbers are warm-season crops and thrive optimally within temperatures ranging from 18.30°C to 23.90°C. The plants are unable to withstand extended exposure to temperatures below 23.80°C or above 32.2°C. Cucumbers are cultivated either in open fields or within greenhouses (Miller & Wehner, 2021). Field-grown cucumber plants are generally propagated from seeds and are planted either manually or through mechanical means. Numerous commercial enterprises cultivate their plants to grow on pillars or trellises in order to suspend the produce. Multiple training systems are employed for trellis cultivation, with the umbrella system being the most prevalent. Within the umbrella system, all lateral branches are pruned as they emerge until the main stem attains a specified height. The plant is subsequently permitted to develop more readily, enabling it to prioritize fruit production over vertical growth. Certain cultivators cultivate bush-type varieties and permit the fruit to disperse across the ground (Saha et al., 2015). To facilitate various harvesting methods, field cucumbers cultivated for the raw or sliced market are spaced approximately 91.4 to 187.9 inches apart, compared to eight to 25.4 inches for cucumbers intended for pickling. Unlike field-grown cucumbers, cucumbers cultivated in greenhouses are typically propagated as transplants. Greenhouse cucumber plants possess notably large foliage and exhibit vigorous growth. Each plant is allocated five to seven square feet of space and is consistently cultivated on a trellis.

Greenhouse cucumbers necessitate careful nutrient management to ensure optimal health and yield. Like most commodities, cucumbers thrive optimally under specific soil and temperature conditions. Cucumbers can be cultivated in a broad range of soil types; nevertheless, deep, nutrient-rich soils that percolate effectively and have a pH ranging from six to six and a half are optimal. Inadequate plant development and diminished yield may occur as a consequence of soil that is overly acidic, with a pH level below six. To safeguard the fruit from frost and regulate temperatures during the early and late seasons, cucumbers may be cultivated beneath plastic row coverings. The coverings can subsequently be removed and repurposed as windbreaks to shield the plants from foot traffic and wind-related damage. (Madison, 2018)

2.8 Agronomic Practices

2.8.1 Weed and Pest Control

Weed and vermin management are also essential practices to ensure optimal production. plant management in cucumber cultivation is achieved through a range of techniques, including the utilization of cover crops and mulches, mechanical cultivation and manual weeding, as well as the administration of herbicides tailored to target the prevalent plant species in a specific field. Cucumber plants are vulnerable to a range of insect, bacterial, fungal, and nematode infestations. Prompt detection of such infections or infestations is essential for implementing effective and prompt control measures (Daramola, 2021; Osundare et al., 2019; Sharma et al., 2016). During the development process, cucumbers may be impacted by various insect parasites, leading to a reduction in both yield and quality. The primary insect parasites affecting cucumbers include Bactrocera cucurbitae, Raphidopalpa foveicollis, Epilachna implicata, Myzus persicae, Aphis gossypii, Anasa tristis, Trialeurodes vaporariorum, Bemisia tabaci, and B. argentifolii (Jia & Wang, 2021). Currently, pest management primarily depends on chemical pesticides, which contribute to environmental pollution, develop pest resistance, and disrupt the ecological equilibrium between pests and natural adversaries. Furthermore, this control strategy poses a risk to human health. Therefore, an integrated pest management approach encompassing pest monitoring, cultural practices, host resistance, botanical agents, biological control, and the prudent application of pesticides is recommended for effective pest control (Kaur & Kaur, 2020).

2.8.2 Disease Control

Disease prevention strategies encompass crop rotation, meticulous field selection, sanitation measures, soil remedies, and the selection of suitable seed varieties. It is a widely adopted practice to employ soil mulches for vegetation suppression, insect prevention, soil temperature regulation, water conservation, and erosion control (Rawat et al., 2021). Numerous diseases induced by viral, bacterial, fungal, and nematode pathogens significantly impact the cultivation and yield of cucumbers. Downy mildew, powdery mildew, and anthracnose also result in significant reductions in cucumber yield (Bondarenko et al., 2021). Some pathogenic fungi, including Alternaria tenuis, Fusarium equisett, Phytophthora capsici, Botrytis cinerea, and Cladosporium tenuissimum, are responsible for causing decay and significant post-harvest losses in cucumbers (Arogundade et al., 2021).

2.8.3 Mulching

Mulches may consist of peat moss or other organic substances. Numerous commercial agricultural activities utilize plastic sheeting as a mulch to safeguard crops. Depending on the intended effect, producers may utilize colors such as clear, black, white, or aluminum. These colors all exert a warming influence on the soil in the evening but may warm, chill, or have no effect during the daytime (Drobnik & Stebel, 2017).

2.8.4 Watering

Irrigation is achieved either by flooding furrows or by employing direct trickle lines positioned along the planted sections (Sivanappan & Padmakumari, 2016). Cucumbers necessitate regular watering throughout the cultivation period. Insufficient moisture can impact fruit morphology, while waterlogged fields may promote the development of mildew and other disease issues (Cakir et al., 2017).

2.8.5 Fertilization

Assessing the necessity of fertilization for cucumber cultivation areas is typically conducted through soil nutrient analysis—generally performed at least four months prior to planting and plant tissue nutrient analysis. For plant tissue analysis, actively growing leaves are collected and examined for their macro- and micronutrient composition. Based on the outcomes of these analyses, the requirements for fertilization to supply macronutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur are established (Liu et al., 2018).

2.9 Harvesting

Growers typically cultivate between 40,000 and 90,000 plants per acre. Some cultivators cultivate as many as 150,000 per acre. Although the majority of cucumbers are harvested manually, larger-scale operations employ mechanical harvesting methods (Tripathy et al., 2019). The duration from planting to harvest may be comparatively brief, ranging from approximately 36 to 40 days, depending on the variety and prevailing weather conditions. As a general estimate, the initial harvest date can be projected by counting forward approximately eight to ten days from the initial apparition of fully opened female flowers. Cucumbers are harvested at various phases, ranging from immature to fully mature before the seeds attain complete maturation and harden. Those harvested before seed maturation are classified as seedless (Costa et al., 2018). Fruit is harvested once uniformity in length, shape, and diameter is achieved, and prior to the onset of discoloration at the blossom end. Generally, the duration of harvest is dictated by the intended market. Typical fruit length for English-type cucumbers intended for the fresh whole market ranges from 30.5 cm to 35.6 cm. Garden cucumbers harvested for the fresh sliced market are typically between 19.1 cm and 21.6 cm in length. Although no USDA standards are established for mini-cucumbers, these fruits are generally harvested when they measure between five and eight inches. Regular harvesting is essential due to the rapid ripening of crops. Ongoing and punctual harvesting maintains the plants in an optimal productive state, as cucumber plants have a finite capacity for supporting a specific number of crops simultaneously (Hochmuth, 2018). Cucumbers intended for the fresh sliced market are hand-harvested once to three times weekly, depending on weather conditions and the growth stage. Pickling cucumbers are typically harvested manually more often, or they may be collected mechanically in larger quantities to facilitate land replanting or crop rotation. Cucumbers are examined in the field before harvest for mechanical damage, disease, and cosmetic imperfections. Unmarketable produce are removed from the plants and incorporated into the soil through disking after the harvest has been completed.

2.10 Effects of Staking on Vegetables

Pradhan et al. (2021) indicated that anchoring plants is an effective method to enhance vegetable yields. Vegetables greatly benefit from staking and also exhibit healthy growth. The process may be somewhat laborious, but the final outcome is promising. The most essential requirement is that the stakes are robust and firmly embedded into the ground to adequately support the weight of the fruiting plants. Ensure that the support is sufficiently robust to bear the weight of the fruit and is capable of withstanding severe winds or rainfall (Kakade et al., 2022). There are numerous advantages to staking climbers. A basic comprehension of these advantages will motivate every cultivator to contemplate adopting the system rather than permitting crops to grow directly on the ground. Falodun and Bakare (2023) stated that the primary motivation for staking crops is to enhance yield. Research conducted in various regions indicates that vertical cultivation of cereals results in a threefold increase in productivity compared to traditional ground cultivation (Asseng et al., 2020). A high-quality, blemish-free fruit commands a more favorable price. That is why gardeners will go to great lengths to prevent injury to their crops. Damages may arise when crops are permitted to fall to the ground, rendering them susceptible to insect infestation and other invasive pests (Singh et al., 2022).

Crops such as tomatoes require maximum sunlight exposure during the day, and staking for these crops increases the surface area of the foliage available to sunlight, which is essential for their energy production and healthy growth (Gatahi, 2020). Staking enables efficient utilization of limited space. It facilitates the processes of harvesting, sprinkling, fertilizer application, and irrigation.

Staking is a technique employed to offer structural support to cucumber plants, inhibit sprawling, and enhance access to sunlight (Abdullah et al., 2021). According to Stock et al. (2022), various staking techniques, including vertical staking, trellising, and cage systems, have been utilized in cucumber cultivation. Research on staking techniques has demonstrated prospective advantages in terms of enhanced yield and decreased vulnerability to soil-borne diseases (Norman et al., 2015). Nevertheless, identifying the most effective staking method to optimize survival rates, promote growth and blossoming, and ensure a substantial produce remains an area that warrants further investigation. Staking cucumbers and other ascending vegetables offers numerous benefits. The inherent inclination of cucumber vines is to climb; therefore, positioning a stake adjacent to the plant as it starts to develop facilitates the vines in wrapping around the stake and ascending it. It was observed that the conventional agricultural practice of installing stakes for climbing vegetables and flowering plants, including cucumbers, conferred a measurable benefit.

The containers are highly efficient, and staking offers a relatively straightforward means of access to all the cucumbers. Furthermore, it safeguards the plants from insect damage (Kale, 2020). Staking also ensures that all cucumbers receive uniform exposure to sunlight and airflow, while allowing them to surmount the supports and grow outward. The nearest plant spacing (50 cm x 30 cm) yielded the greatest number of fruits, as well as the highest counts of marketable and unmarketable fruits, whereas fruit length and weight were maximized at 50 cm x 40 cm (Singh et al., 2015). Kapuriya et al. (2017) reported the greatest fruit yield at a 20 cm spacing, which was the closest plant spacing employed. While Masa et al. (2017) noted that the most proximate plant spacing resulted in the greatest early yield. Additionally, Ding et al. (2020) reported that the produce yield declined as plant density increased from four to ten plants per square meter. However, the observations acquired in the trial are inconsistent with the findings of Hamayoun et al. (2018) and Sanni & Adenubi (2020), who reported the maximum yields at greater plant spacing. The yield parameters of cucumber evaluated were observed to be higher in the staked plants compared to those on the ground (Nweke et al., 2013). Hardy and Rowell (2002) observed that the yield of super select cucumbers was greater in the trellised treatment compared to the non-trellised treatment. Davis et al. (2023) reported that staked cucumbers yielded an average of 25 tons per acre in marketable produce, compared to 16.4 tons per acre for non-staked cucumbers. Pradhan et al. (2021) determined that staked cucumbers yielded crops that were twice as numerous as those grown on the ground. Additionally, the quantity of unmarketable fruit was greater in the non-staked treatment compared to the staked treatment. This may be attributed to the substandard coloration of the fruit, shortened fruit length, and the development of yellow stomachs on the fruits, which increases their susceptibility to decomposition. Asante (2022) reported that staking results in enhanced color quality, increased fruit length, and higher sugar content in tomato fruits. Adesida et al. (2020) confirmed that staking enhances the coloration and reduces the occurrence of yellow stomachs in cucumber. The non-staked treatment consistently yielded the lowest values across all evaluated yield parameters, except for the number of unmarketable crops.

A study conducted by Okonmah (2011) on the effects of various staking methods and their cost-effectiveness on cucumber yield and its components demonstrated a positive impact of staking on both yield and its components. Yield and yield components were higher with staking compared to no staking, with the greatest results observed using the 5-meter raised platform staking method, as the increased exposure to sunlight notably improved the number of leaves, flowering, and harvesting. Research conducted by Nweke et al. (2013) on the effects of staking and plant spacing on cucumber growth and yield demonstrated improvements in the number of fruits, the quantity of marketable fruits, and the weight of the fruits. The staked treatment consistently outperformed the non-staked treatment with higher values. Oga and Umekwe (2015) reported that the application of NPK fertilizer and staking techniques significantly influenced the growth and productivity of watermelon, affecting vine length, the number of flowers, fruits, and marketable fruits. The staked treatment consistently yielded superior results with higher values compared to unstaked plants. Staking is implemented to provide plants with support during periods of high winds, thereby preventing root displacement and damage to root hairs. It also facilitates upright growth as intended and prevents crops from coming into contact with the earth, reducing the risk of rot. Staking aids in the application of treatments for disease and pest control; it also simplifies activities such as weeding, harvesting, and other farm operations compared to those involving vines that trail along the ground (Sarkka et al., 2017). Mutual shading is minimized, thereby enhancing the plant's photosynthetic capacity and leading to increased dry matter accumulation within the crop's leaf canopy. Research has also demonstrated that staking enhances dry matter yield and leaf area index (LAI). Sroyraya et al. (2017) reported that anchoring cucumbers enhanced produce yield due to improved light interception. The duration to reach 50% anthesis was longer in the staked treatment compared to the no-stake treatment. This aligns with the findings of Asamoah (2022), who noted that staking extends vegetative growth and postpones fruit development. The unstaked treatment consistently yielded lower values across all evaluated vegetative parameters, with the exception of the number of flowers. Nweke (2013) reported that the staked cucumber plants yielded a higher number of leaves compared to the no-stake treatment, and the difference was not statistically significant, indicating that staking treatments do not have a substantial effect on leaf number. They also determined that the leaf area in staked cucumber plants was greater than in unstaked plants.

2.11 Effects of Pruning on Vegetables

Pruning involves the selective removal of particular components of a tree or shrub, including seedlings, branches, or roots (Ndukwa et al., 2021). According to Mathiyazhagan et al. (2021), pruning is a horticultural, arboricultural, and silvicultural technique that involves the selective elimination of specific sections of a plant, including branches, buds, or roots. Proper pruning guarantees the health and aesthetic appeal of your shrubs and trees. Pruning promotes the health of plants, guides their proper growth, enhances quality, and, in certain instances, limits their development. Pruning has been shown to decrease competition and improve the efficiency of plant photosynthesis and overall performance by optimizing the utilization of growth resources. Garba et al., 2020. It has also been shown to enhance airflow around the plant, thereby contributing to a reduction in the occurrence of parasites and diseases. In a different study, Goke et al. (2020) indicated that pruning improves the marketable yield concerning the size and weight of the fruit. Cucumber plants are aesthetically pleasing and adaptable, and generally exhibit robust productivity. A cucumber plant that is not pruned will become significantly overburdened over time. Pruning cucumbers is also essential for optimizing the overall yield.

There are few occurrences more disheartening than a cucumber plant with abundant tendrils and minimal fruit; without proper pruning, the plants allocate all their energy to the vines rather than the cucumbers themselves. Cucumber harvests from unpruned plants generally tend to be drier, smaller, and less flavorful, with extended maturation periods, resulting in a harvest that is ultimately shorter, smaller, and less satisfying (Nabhan, 2022). The true indicator of healthy growth in a cucumber plant is not the quantity of its vines but the condition of its produce. According to Prasad et al. (2018), the development of healthy produce at the appropriate time and optimal size signifies a healthy cucumber plant. Sucker formation, also referred to as side branches in cucumbers, generally begins during the vining stage of development when the plants have developed 5-6 nodes, typically within the vegetative growth phase. At this stage of plant development, runners develop from the leaf axils along the primary vine. These specimens develop into new branches when left undisturbed. Pruning to eliminate these runners improves the redirection of the cucumber plant's energy toward fruit development. Research examining the impact of pruning on cucumber plants has yielded varied results (Shivaraj et al., 2018). Certain studies indicate that moderate pruning may improve light penetration and air circulation, thereby fostering overall plant health and productivity (Nath et al., 2019). Conversely, some studies contend that excessive pruning could result in heightened tension and an increased vulnerability to maladies. This dichotomy in findings underscores the importance of conducting an exhaustive analysis of various pruning methods and their distinct effects on the growth, blossoming, and yield of cucumber plants. According to Pradhan et al. (2021), the combined application of staking and pruning enhanced the growth and yield of cucumbers. They reported that vine length, number of flowers, total fruit count, and the number of unmarketable fruits were greater in the non-staked treatment, whereas staking led to an increased number of marketable fruits, as well as improvements in fruit weight, length, and diameter. The unpruned plants yielded the greatest total number of fruits, including both marketable and non-marketable ones, while the weight, length, and diameter of the fruits were maximized on plants subjected to single-stem pruning.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Experimental Location and Description

Two field investigations were conducted from March to June 2023 during the main rainfall season and from August to November 2023 during the secondary rainy season. Both field investigations were carried out at the Research Field of the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED), Asante Mampong Campus. Asante Mampong is situated within the Forest-Savannah transitional zone of Ghana. The average annual precipitation in Asante Mampong is approximately 1270 mm, characterized by a bimodal rainfall distribution. The principal rainy season commences in early April and concludes in July, whereas the secondary rainy period begins in September and terminates in November. There is a brief period of drought in August, but the primary dry harmattan season commences in December and concludes in March. The soil at the experimental site originates from Voltaian sandstone and is classified within the Bediese Series of the Savannah Ochrosol category. It is designated as Chromic Luvisol according to the classification system established by the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) (FAO/UNESCO, 2008). It is a deep red, powdery loam that is devoid of stones. It is well-drained, exhibits favorable water retention, texture, and structure, with an approximate pH of 6.5.

3.2 Experimental Design and Treatments

3.2.1 Experimental Design

The experimental design used was a 3 x 3 factorial experiment arranged in a Randomized Complete Block Design (RCBD) with nine treatments and each replicated four (4) times.

3.2.2 Treatments

In all there were nine (9) treatments. There were two factors, (A) Pruning methods [(i) single sucker pruning, (ii) multiple sucker pruning, and (iii) no sucker pruning (control)] and (B) Staking methods [(i) V-shape staking (ii) single plant staking (control) and (iii) T-trailer staking)]

The total number of treatment combinations is provided in Table 3.1

Table 3.1: Treatment combinations

Treatment Codes	Pruning	Staking	Combinations
T1	Single sucker pruning	V – shape staking	SSP x VSS
T2	Single sucker pruning	Single plant staking	SSP x SPS
T3	Single sucker pruning	T – trailer staking	SSP x TTS
T4	Multiple sucker pruning	V – shape staking	MSP x VSS
T5	Multiple sucker pruning	Single plant staking	MSP x SPS
T6	Multiple sucker pruning	T – trailer staking	MSP x TTS
T7	No sucker pruning	V – shape staking	NSP x VSS
T8	No sucker pruning	Single plant staking	NSP x SPS (Control)
T9	No sucker pruning	T – trailer staking	NSP x TTS

3.3 Planting Materials

The Poinsett cucumber variety was selected as the planting material for this investigation. Seeds were acquired from a licensed agrochemical retailer in Asante Mampong and were pre-treated with Seed Care (SEEDCARE GOLD, containing Imidacloprid 10% and Thiram 10% WS as active ingredients) prior to sowing to safeguard against insect and pest infestations. It exhibits resistance to prevalent cucumber diseases, demonstrates vigorous plant development, and is capable of continuous production over an extended period, thereby offering high yield potential.

3.4 Land Preparation and Planting

The land was prepared in March 2023 for the primary cropping season and in August for the secondary cropping season through ploughing and harrowing, subsequently levelled and divided into four blocks for both trials. The field measured 45 meters by 15 meters, with each plot having dimensions of 4.8 meters by 3.0 meters. The cucumber seeds were sown directly into raised beds, with three seeds per cavity at a depth of 3-5 centimeters, maintaining a planting distance of 80 cm by 30 cm. The seedlings were pruned to one per hill fourteen days after planting (DAP). Each plot contained six (6) rows, with ten (10) plants in each row, resulting in a total of sixty (60) plants per plot.

3.5 Cultural Practices

3.5.1 Weed Control

Weed management was carried out using a plow and a cutlass. The initial weeding was performed two weeks following seedling emergence. The second and third weedings were performed 30 and 60 days after planting, respectively. The weeding was conducted to prevent plants from competing with the crops for nutrients and soil moisture, thereby ensuring optimal yield.

3.5.2 Irrigation

Owing to irregular rainfall, additional irrigation was performed on days without precipitation. Subsequent irrigation was carried out every other day in the morning and evening using watering cans to assist in maintaining leaf turgidity, thereby supporting the process of photosynthesis. This was implemented particularly during the initial stage of plant development to facilitate successful establishment.

3.5.3 Fertilizer Application

NPK 15:15:15 was administered two weeks after planting (WAP) at a rate of 60 kg/ha across the entire field and 5 g per plant, following the recommendation of Umekwe et al. (2015), with the fertilizer being side-placed.

3.5.4 Pest and Disease Control

Frequent excursions to the experimental field were conducted to monitor the occurrence of pests and diseases, such as damping-off, which manifested two weeks after planting and was managed with Provax (active ingredients: thiram and carboxin), applied at a rate of 25 ml per kilogram of seed. Pests and diseases were managed using a CP 15 knapsack sprayer, applied at the prescribed rate of 30 grams per 15 liters of water. Any pests and diseases that emerged were managed through the implementation of appropriate measures. The cucumber beetle present on the plants was managed using Permethrin containing dimethylcyclopropanecarboxylic acid as the active constituent at 3 WAP. During the flowering period, mealybugs also appeared in the field and were managed using Permethrin. All of these phenomena emerged during the primary cropping season. During the minor cropping season, leaf spot observed in the field was managed effectively using Bendazim, whose active constituent is Methylbenzimidazol-2-ylcarbamate. However, no cucumber plant insect was detected during the minor season.

3.6 Pruning

Pruning was carried out in accordance with the procedures at three weeks post-planting. For single sucker pruning, two (2) suckers were removed three (3) weeks after planting (during the vegetative growth stage) from the main vine. In the case of multiple sucker pruning, two (2) suckers were pruned at three weeks after planting, with subsequent pruning occurring at one-week intervals for three additional times. For the purpose of sucker pruning, suckers were neither pruned nor removed.

3.7 Staking

Staking was carried out in accordance with the procedures and was performed three weeks after planting. The V-shape staking (VSS) was executed by constructing a V-shaped support framework, either through the use of individual stakes and string to form a V-shaped structure. Single plant staking (SPS) was performed by inserting a solitary stake adjacent to the plant's base and firmly securing the plant to the stake to facilitate its growth. T-Trailer staking (TTS) was also implemented utilizing a T-shaped trellis framework to support the expanding vines.

3.8 Data Collected

3.8.1 Phenology

- **Percentage Plant Establishment**

The percentage of plant establishment was assessed four weeks (30 days) after seed sowing. This was accomplished by enumerating the number of plants established within the four central divisions, estimating the percentage of plant establishment, and calculating the mean estimate.

- **Days to 50% Flowering**

Days to 50% flowering was assessed by counting from the four central rows, the days after flowering when 50% or half of the plants had flowered.

- **Number of Flower Onset**

The number of open flowers were determined by counting the number of open flowers that had appeared within the four central rows and the mean was estimated.

- **Number of Fruit Set**

The total number of fruits developed after pollination and fertilization was counted and the mean values were estimated.

3.8.2 Vegetative Growth

- **Vine length**

The vine length was determined from the base of the plant to the tip of the apical bud using the meter rule. This was done from the five randomly selected and tagged plants in the four central rows, four weeks after planting and every one-week interval, and their mean values were estimated.

- **Stem Diameter**

The stem diameter was measured with a Venier caliper from the five randomly selected tagged plants in the central rows on each plot at four weeks after planting and the average stem diameter was estimated.

- **Number of Leaves per Plant**

The number of foliage per plant from the five randomly selected and tagged plants in the four central harvestable rows was assessed by tallying the total number of open leaves on each tagged plant. This was conducted four (4) weeks after planting and at weekly intervals, with their mean values subsequently estimated.

- **Leaf Area**

The length of each completely extended leaf lamina was measured from the leaf base to the tip, and the breadth was recorded at the broadest point of the lamina. The leaf area was calculated by multiplying the product of leaf length and breadth by a factor of 0.75 (Saxena and Singh, 1965). This was performed at four weeks post-planting and subsequently at one-week intervals, with their mean values duly recorded.

- **Shoot Dry Matter Accumulation**

The dry matter content of the shoot was measured at 35 and 42 days post-planting. Two plants were extracted from each allotment. Each of the plants was subsequently cut into smaller sections for weighing. The fresh shoot, after being weighed with the Westinghouse electronic scale, was enclosed in an enclosure and placed in the oven for drying at 70°C until reaching a constant weight, and the mean value was recorded.

3.8.3 Yield and Yield Components

- **Number of Fruits Per Plot**

The total number of fruits harvested from the four central rows was counted and the mean were estimated.

- **Number of Marketable Fruits Per Plot**

Following the harvest from the four central rows of each plot, fruits exhibiting desirable characteristics—including appropriate size, length, weight, shape, green coloration, firmness, and the absence of defects, cuts, or bruises—were selected and tallied as marketable. The mean values for these were subsequently recorded for each treatment.

- **Number of Non-Marketable Fruits Per Plot**

Following the harvest from the four central rows of each plot, fruits that did not meet criteria for size, length, weight, shape, green coloration, firmness, or exhibited defects, cuts, or injuries were identified and counted as non-marketable fruits for each treatment, and the mean values were documented.

- **Marketable Fruits Weight Per Plot**

The weight of marketable fruits per plot was determined by weighing all fruits measuring 15-20 cm in length and weighing 80-180 g from each plot using an electronic scale, with the average values recorded.

- **Fruit Length**

A ruler was employed to measure the length of the fruit from the basal to the apical curvature. Five fruits were randomly chosen from each plot post-harvest, and the mean values were calculated.

- **Fruit Diameter**

A Vernier caliper was employed to measure the fruit diameter at the broadest point of five randomly selected fruits from each plot following harvest, and the average was subsequently calculated.

- **Fruit Yield (t/ha)**

The fruit yield was estimated using the formula below:

Fruit Yield (t/ha) = (Total fruit weight (kg)/ Area (m^2)) * (10,000 m^2/1,000 kg) (Ngbolua *et al.*, 2019).

- **Harvest Index**

The Harvest Index was determined as the ratio of economic yield to biological yield, where economic yield represents the fruit yield and biological yield encompasses the entire vine, including leaves and fruits. HI = (Economic Yield) / Total Plant Biomass) × 100 (Van-Eerd & O’Reilly, 2009)

3.9 Statistical Analysis

The collected data were analyzed through Analysis of Variance (ANOVA) utilizing GenStat 11th edition. Tukey's Honestly Significant Difference (HSD) test was employed to distinguish treatment means at a 5% significance level. A correlation analysis was conducted between vegetative traits and yield, as well as yield components of cucumber.

CHAPTER FOUR: RESULTS

4.1 Climatic Conditions at the Experimental Site

The cumulative precipitation during the primary rainy season amounted to 585.9 mm. The peak relative humidity (92%) was observed in June, whereas the lowest (88%) was recorded in March 2023 during the primary rainy season. The average maximum and minimum temperatures during the 2023 main rainy season were 33.8°C and 23.2°C, respectively (Table 4.1). The cumulative precipitation during the minor rainy season of the experiment was 580.0 mm. The highest relative humidity, at 74%, was observed in November and October, whereas the lowest, at 66%, was recorded in August. The average maximum and minimum temperatures during the minor rainy season were 33.1°C and 22.4°C, respectively (Table 4.1).

Table 4. 1: Climatic Conditions for Experimental sites during Major and Minor Cropping Seasons in 2023

Month	**Total Rainfall (mm)**	**Relative Humidity (%)**	**Mean Temperature (^{0}C)**	
			Maximum	**Minimum**
Major Cropping Season, 2023				
March	57.8	88	33.8	23.1
April	258.8	91	33.3	22.7
May	71.3	90	32.8	23.2
June	198	92	30.3	23.0
Total	**585.9**			
Minor Cropping Season, 2023				
August	79.6	66	29.0	22.5
September	147.8	71	30.6	22.4
October	149.0	74	32.0	23.0
November	203.6	74	33.1	23.5
Total	**580.0**			

(Ghana Meteorological Agency-Mampong Ashanti, 2023)

4.2 Phenology of Cucumber as affected by Pruning and Staking

4.2.1 Percentage Plant Establishment

The results in Table 4.2 show the percentage plant establishment of cucumber for major and minor cropping seasons. There were no significant (P≥0.05) differences among the pruning and staking methods in percentage plant establishment in both the major and minor cropping seasons. Percentage plant establishment ranged from 50.3-57.3% and 69.4-77.1% for the major and minor seasons, respectively.

Table 4. 2: Effect of Pruning and Staking on Percentage Plant Establishment of Cucumber in 2023 Major and Minor Seasons

Treatment	Percentage Plant Establishment (%)	
	Major Season	Minor Season
Pruning (P)		
Single sucker pruning	53.3	70.6
Multiple sucker pruning	52.9	77.1
No sucker pruning	56.7	71.0
HSD (p<0.05)	**NS**	**NS**
Staking (S)		
V-shape staking	57.3	75.4
Single plant staking	50.3	69.4
T-trailer staking	55.2	73.8
HSD (p<0.05)	**NS**	**NS**
CV (%)	**14.9**	**16.8**
Pruning (HSD) (p>0.05)=	NS	
Staking (HSD) (p>0.05)=	NS	
Season (HSD) (p<0.05)=	5.63**	
Pruning × Staking (HSD) (p>0.05)=	NS	

CV (%)= coefficient of variation, HSD= honestly significant difference, NS= not significant

4.2.2 Days to 50% Flowering

Table 4.3 shows results of days to 50% flowering of cucumber for the major and minor seasons. There were no significant (P≥0.05) differences between individual effect of staking on days to 50% flowering in both major and minor cropping seasons. However, pruning significantly influenced days to 50% flowering in both major and minor cropping seasons, as well as the interaction of pruning and staking.

For pruning, No sucker pruning recorded the highest days to 50% flowering as 30 days, followed by Single sucker pruning as 29 days and then Multiple sucker pruning recorded the shortest number of days as 27. For the interaction, the highest number of days was recorded by No sucker pruning + T-trailer staking and No sucker pruning + V-shape staking as 30 days and the least was recorded on Multiple sucker pruning + V-shape staking (26 days) for the major season. In the minor season, the highest was again recorded on No sucker pruning + T-trailer staking as 39 days and the shortest day was counted on Multiple sucker pruning + V-shape staking as 33 days.

Table 4. 3: Effect of Pruning and Staking on Days to 50% Flowering of Cucumber in 2023 Major and Minor Seasons

Treatment	Days to 50% Flowering	
	Major Season	Minor Season
Pruning (P)		
Single sucker pruning (SSP)	29	36
Multiple sucker pruning (MSP)	27	35
No sucker pruning (NSP)	30	37
HSD (P<0.05)	**1.26**	**NS**
Staking (S)		
V-shape staking (VSS)	28	35
Single plant staking (SPS)	29	37
T-trailer staking (TTS)	29	37
HSD (P=0.05)	**NS**	**NS**
Pruning (P) × Staking (S)		
SSP + VSS	29	36
SSP + SPS	29	38
SSP + TTS	29	35
MSP + VSS	26	33
MSP + SPS	29	36
MSP + TTS	28	35
NSP + VSS	30	37
NSP + SPS	28	36
NSP + TTS	30	39
Mean	**28.5**	**36.2**
HSD (P=0.05)	**3.01**	**5.01**
CV (%)	**3.70**	**4.84**
Pruning (HSD) (p<0.05)=	1.09***	
Staking (HSD) (p<0.05)=	1.06*	
Season (HSD) (p<0.05)=	0.73***	
Pruning × Staking (HSD) (p<0.05)=	2.71**	

*CV (%) = coefficient of variation, HSD = Tukey’s honestly significant difference at 5% probability, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.2.3 Number of Fruit Set

The results of number of fruits set of cucumber for the major and minor seasons are shown in Table 4.4. There was no significant ($P \geq 0.05$) difference on individual effect of staking in the major season. However, there were significant ($P \leq 0.05$) differences among individual effect of pruning on number of fruit set of cucumber, and also the interactive effect of pruning and staking of cucumber.

For the individual effect of pruning, Multiple sucker pruning recorded the highest number of fruit set (3.0), while Single sucker pruning had the least (2.0) in the minor season. For the interaction, Multiple sucker pruning + V-shape staking and No sucker pruning + Single plant staking both recorded the same fruit number (3.0) as the highest during the major season, while Single sucker pruning + Single plant staking recorded the least (1.0). During the minor season, Multiple sucker pruning + V-shape staking recorded the highest number of fruit set (5.0) and the least was recorded on Single sucker pruning + Single plant staking (Table 4.4).

Table 4. 4**:** Effect of Pruning and Staking on Number of Fruit Set Per Plant of Cucumber in 2023 Major and Minor Seasons

Treatment	Number of Fruit set per plant	
	Major Season	Minor Season
Pruning (P)		
Single sucker pruning (SSP)	1	2
Multiple sucker pruning (MSP)	3	4
No sucker pruning (NSP)	2	3
HSD (P=0.05)	**0.89**	**0.93**
Staking (S)		
V-shape staking (VSS)	2	4
Single plant staking (SPS)	2	3
T-trailer staking (TTS)	2	3
HSD (P=0.05)	**NS**	**0.95**
Pruning (P) × Staking (S)		
SSP × VSS	1	4
SSP × SPS	1	1
SSP × TTS	1	2
MSP × VSS	3	5
MSP × SPS	2	4
MSP × TTS	2	4
NSP × VSS	3	3
NSP × SPS	3	4
NSP × TTS	2	2
Mean	**1.9**	**3.3**
HSD (p<0.05)	**2.13**	**2.26**
CV (%)	**31.76**	**24.07**
Pruning (HSD) (p<0.05)=	*0.62****	
Staking (HSD) (p<0.05)=	*0.60****	
Season (HSD) (p<0.05)=	*0.42****	
Pruning × Staking (HSD) (p<0.05)=	*1.47****	

*CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.2.4 Number of Flower onset per plant

The results of number of flower onset per plant of cucumber for the major and minor seasons are shown in Table 4.5. There were no significant (P≥0.05) differences among individual and interactive effect in the number of flower onset per plant as affected by the different pruning and staking in the study in both cropping seasons. Season was also not significantly (P≥0.05) different in number of flower onset per plant of cucumber.

Table 4. 5: Effect of Pruning and Staking on Number of Flower Onset per plant of Cucumber in 2023 Major and Minor Seasons

Treatment	Number of Flower Onset per plant	
	Major Season	Minor Season
Pruning (P)		
Single sucker pruning (SSP)	4	4
Multiple sucker pruning (MSP)	4	4
No sucker pruning (NSP)	4	4
HSD (p<0.05)	**NS**	**NS**
Staking (S)		
V-shape staking (VSS)	4	5
Single plant staking (SPS)	4	4
T-trailer staking (TTS)	4	4
HSD (P=0.05)	**NS**	**NS**
CV (%)	**3.6**	**3.8**
Pruning (HSD) (p>0.05)=	*NS*	
Staking (HSD) (p>0.05)=	*NS*	
Season (HSD) (p>0.05)=	*NS*	

DAP = Days after planting, S = Staking, P = Pruning, CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability.

4.3 Vegetative Growth of cucumber

4.3.1 Vine Length

Table 4.6 show results of vine length of cucumber from 28 DAP to 42 DAP for the major season. The vine length increased throughout the entire period from 28 DAP to 42 DAP. There were significant ($P \leq 0.05$) differences observed in individual effect of pruning in the vine length from 28 DAP to 42 DAP. There were significant ($P \leq 0.05$) differences observed in individual effect of staking in the vine length from 35 DAP to 42 DAP, but there were no significant ($P \geq 0.05$) differences among treatments at 28 DAP. There were significant ($P \leq 0.05$) differences among treatments in the interactive effect of staking and pruning in the vine length from 28 DAP to 42 DAP.

For the individual effect of pruning, from 28 DAP to 42 DAP, during the major cropping season, plants that had undergone multiple sucker pruning recorded the longest vines. In the major cropping season, plants that had undergone multiple sucker pruning had 55.5 cm, 89.8 cm and 142.6 cm at 28 DAP, 35 DAP and 42 DAP respectively, which was highly

significantly different from Single sucker pruned plants which also recorded the shortest vine length at most periods of the study. Single sucker pruning rather had the shortest vine length at 28 DAP, 35 DAP and 42 DAP (31.5 cm, 59.7 cm and 109.8 cm respectively).
For the individual effect of staking, from 35 DAP to 42 DAP, T-trailer staking recorded the shortest vine length throughout and V-shape staking also recorded the longest vines. At 35 DAP, V-shape staking had 86.0 cm for major season, T-trailer staking recorded 68.5 cm. See suggestion at p 42. At 42 DAP, V-shape staking recorded 138.6 cm, Single plant staking had 112.3 cm and T-trailer staking also recorded 120.9 cm.

For the interactive effect, Multiple sucker pruning + T-trailer staking recorded the longest vines at 28 DAP (68.2 cm), while Multiple sucker pruning × V-shape staking rather had the longest vine length from 35 DAP to 42 DAP (94.3 cm and 154.0 cm respectively), and Single sucker pruning × Single plant staking recorded shorter vine length throughout the study period at both seasons (25.3 cm, 43.5 cm and 88.0 cm for 28 DAP, 35 DAP and 42 DAP respectively) (Table 4.6).

Table 4.7 show results of vine length of cucumber from 28 DAP to 42 DAP for the minor season. The vine length increased throughout the entire period from 28 DAP to 42 DAP. There were significant ($P \leq 0.05$) differences observed in individual effect of pruning in the vine length from 28 DAP to 42 DAP. There were significant ($P \leq 0.05$) differences observed in individual effect of staking in the vine length from 35 DAP to 42 DAP but there were no significant ($P \geq 0.05$) differences observed at 28 DAP. There were significant ($P \leq 0.05$) differences observed in the interactive effect of staking and pruning in the vine length from 35 DAP to 42 DAP.

For the individual effect of pruning, from 28 DAP to 42 DAP, at the minor cropping season, Multiple sucker pruned plants had 53.6 cm, 87.3 cm and 140.3 cm at 28 DAP, 35

DAP and 42 DAP respectively, which was highly significant from Single sucker pruned plants which also recorded the shortest vine length at most periods of the study. Single sucker pruning rather had the shortest vine length (26.4 cm, 56.9 cm and 106.3 cm) at 28 DAP, 35 DAP and 42 DAP respectively.

For the individual effect of staking, from 35 DAP to 42 DAP, T-trailer staking recorded the shortest vine length throughout and V-shape staking also recorded the longest vines. At 35 DAP, V-shape staking had 83.6 cm, T-trailer staking recorded 65.7 cm. At 42 DAP, V-shape staking recorded 136.2 cm in the minor season where Single plant staking had 109.3 cm.

For the interactive effect, Multiple sucker pruning + T-trailer staking recorded the longest vines at 28 DAP (64.6 cm), while Multiple sucker pruning × V-shape staking rather had the longest length from 35 DAP to 42 DAP (94.0 cm and 154.0 cm respectively) and Single sucker pruning × Single plant staking recorded shorter vine length through the study period at both seasons (20.3 cm, 38.5 cm and 83.6 cm for 28 DAP, 35 DAP and 42 DAP respectively). Multiple sucker pruning + T-trailer staking recorded 64.6 cm at 28 DAP for the minor season (Table 4.7).

Table 4. 6: Effect of Pruning and Staking on Vine Length of Cucumber in the 2023 Major Cropping Season

Treatment	Vine Length (cm)		
	28 DAP	35 DAP	42 DAP
Pruning (P)			
Single sucker pruning (SSP)	31.5	59.7	109.8
Multiple sucker pruning (MSP)	55.5	89.8	142.6
No sucker pruning (NSP)	38.2	76.7	119.4
HSD (P<0.05)	**9.38**	**15.34**	**22.95**
Staking (S)			
V-shape staking (VSS)	42.7	86.0	138.6
Single plant staking (SPS)	39.3	71.7	112.3
T-trailer staking (TTS)	43.3	68.5	120.9
HSD (P<0.05)	**NS**	**15.34**	**22.95**
Pruning (P) × Staking (S)			
SSP × VSS	37.1	75.3	127.9
SSP × SPS	25.3	43.5	88.0
SSP × TTS	32.2	60.1	113.4
MSP × VSS	47.3	94.3	154.0
MSP × SPS	50.9	88.5	123.7
MSP × TTS	68.2	86.6	150.0
NSP × VSS	43.7	88.3	133.9
NSP × SPS	41.5	83.1	125.1
NSP × TTS	29.3	58.8	99.2
HSD (P<0.05)	**22.30**	**36.46**	**54.56**
CV (%)	**18.69**	**16.91**	**15.39**

DAP = Days after planting, S = Staking, P = Pruning, CV = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability.

Table 4. 7: Effect of Pruning and Staking on Vine Length of Cucumber in the 2023 Minor Cropping Season

Treatment	Vine Length (cm)		
	28 DAP	35 DAP	42 DAP
Pruning (P)			
Single sucker pruning (SSP)	26.4	56.9	106.3
Multiple sucker pruning (MSP)	53.6	87.3	140.3
No sucker pruning (NSP)	34.7	72.7	116.4
HSD (p<0.05)	**10.12**	**15.67**	**23.64**
Staking (S)			
V-shape staking (VSS)	39.2	83.6	136.2
Single plant staking (SPS)	36.8	67.6	109.3
T-trailer staking (TTS)	38.7	65.7	117.6
HSD (p<0.05)	**NS**	**15.67**	**23.64**
Pruning (P) × Staking (S)			
SSP × VSS	32.1	73.7	122.2
SSP × SPS	20.3	38.5	83.6
SSP × TTS	26.9	58.5	113.1
MSP × VSS	45.9	91.0	154.0
MSP × SPS	50.3	85.8	123.0
MSP × TTS	64.6	85.2	144.0
NSP × VSS	39.7	86.3	132.3
NSP × SPS	39.8	78.4	121.1
NSP × TTS	24.6	53.5	95.9
HSD (P<0.05)	**24.05**	**37.25**	**56.19**
CV (%)	**21.99**	**18.01**	**16.23**

DAP = Days after planting, S = Staking, P = Pruning, CV = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability.

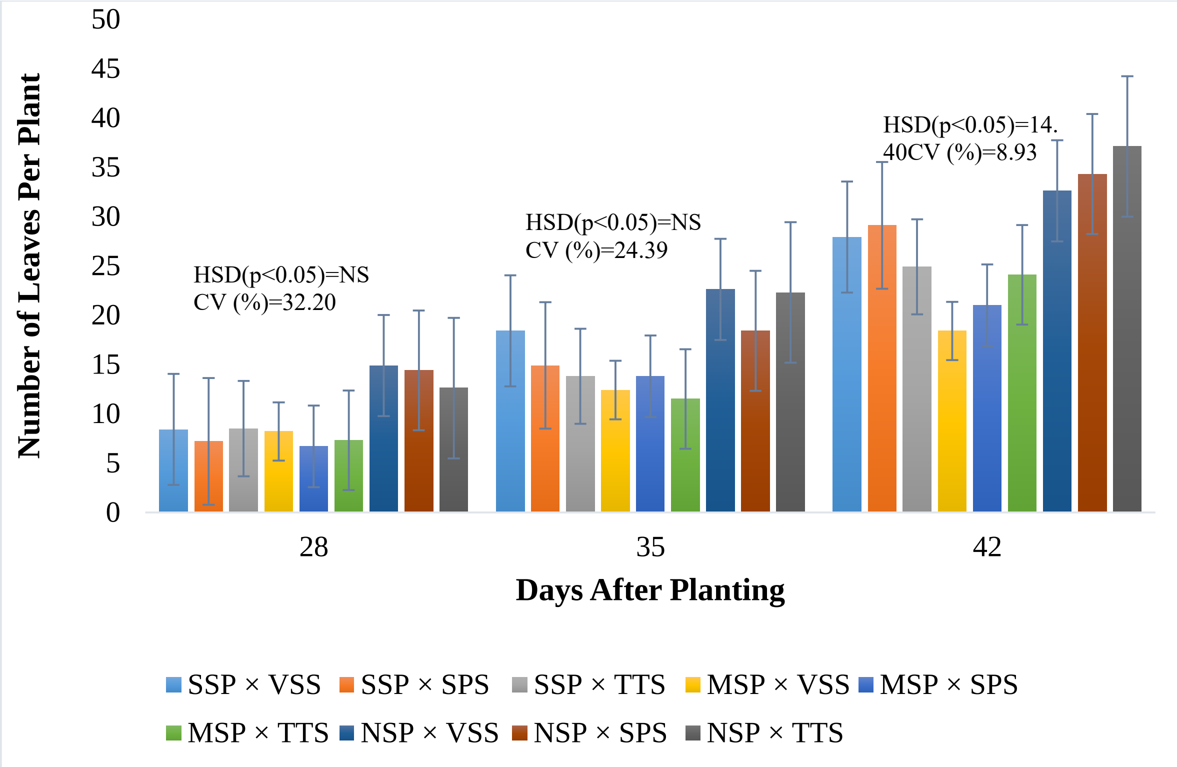
4.3.2 Number of Leaves Per Plant

Figure 4.1A shows the results of number of leaves of cucumber as affected by interaction of the different pruning and staking treatments. The number of leaves increased throughout the entire period from 28 DAP to 42 DAP. There were no significant (P≥0.05) differences observed in individual effect of pruning in the number of leaves during the major cropping season from 28 DAP to 35 DAP, except at 42 DAP. There were no significant (P≥0.05) differences observed in individual effect of staking in number of leaves from 28 DAP to 42 DAP.

There were no significant (P≥0.05) differences among the interactive effect of staking and pruning in number of leaves from 28 DAP and 35 DAP. There were significant (P≤0.05) differences among the interactive effect of staking and pruning in number of leaves at 42 DAP. At 42 DAP, No sucker pruning + T-trailer staking recorded the highest number of leaves, followed by No sucker pruning and Single plant staking, and Multiple sucker pruning + V-shape staking had the fewest number of leaves (Figure 4.1A).

In the minor season, there were significant ($P \leq 0.05$) differences observed in the interactive effect of pruning and staking in number of leaves per plant from 28 DAP to 42 DAP. At 28 DAP, Single sucker pruning + T-trailer staking recorded the highest number of leaves per plant, followed by Single sucker pruning + Single plant staking recorded the fewest number of leaves (Figure 4.1B). At 35 DAP, Single sucker pruning + T-trailer staking again recorded the highest number of leaves per plant which was significant from Single sucker pruning + Single plant staking, but Single sucker pruning + V-shape staking recorded the fewest number of leaves. At 42 DAP, Single sucker pruning again had the highest number of leaves per plant and Multiple sucker pruning + Single plant staking recorded the fewest (Figure 4.1B).

(A) Major Season



(B) Minor Season

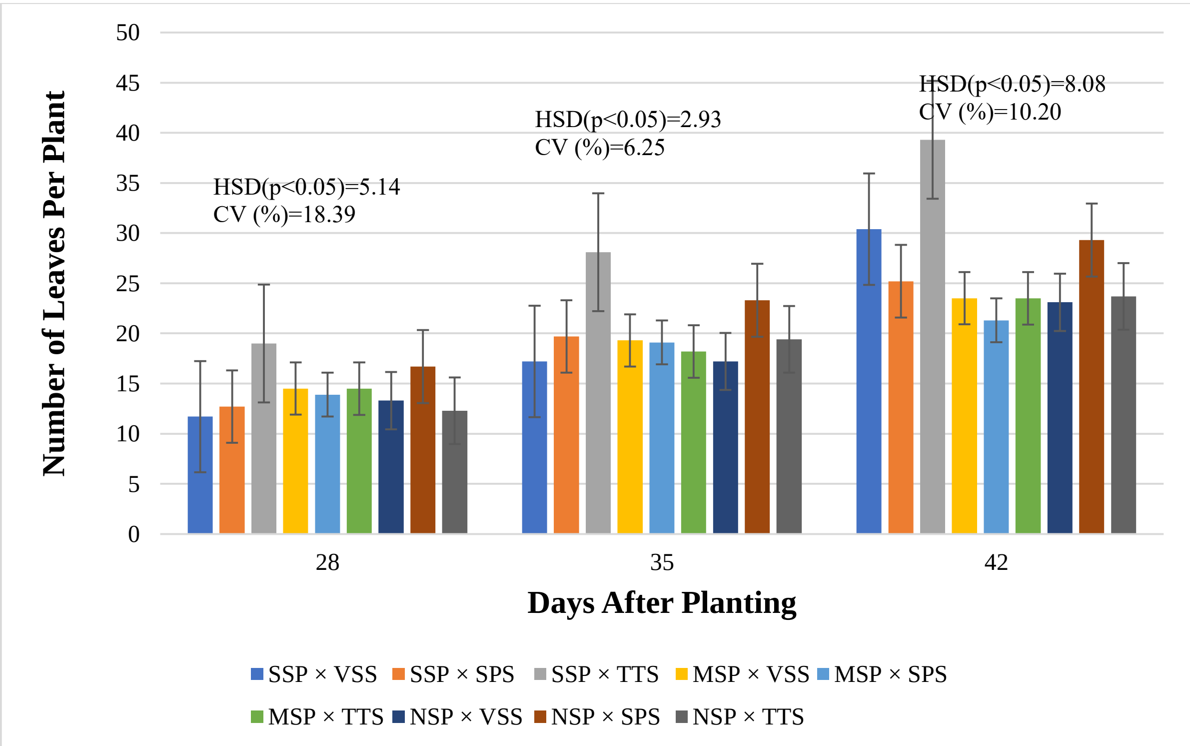


Figure 4. 1: Number of Leaves per Plant as Affected by Pruning and Staking During 2023 Major and Minor Cropping Seasons

4.3.3 Stem Diameter

Table 4.8 shows results of stem diameter of cucumber from 28 DAP to 42 DAP during the major season. The stem diameter increased throughout the entire period from 28 DAP to 42 DAP. There were significant (P≤0.05) differences among treatments from 28 DAP to 42 DAP. At 28 DAP, No sucker pruning recorded 0.3 cm as the widest stem and both Multiple sucker pruning and Single sucker pruning had 0.1 cm as the thinnest. At 35 DAP, Single sucker pruning rather recorded the widest stem as 0.6 cm and both Multiple sucker pruning and No sucker pruning had 0.5 cm as the thinnest and at 42 DAP, Multiple sucker pruning had 1.0 cm as the widest while No sucker pruning had the thinnest as 0.6 cm.

There were significant (P≤0.05) differences among treatments in individual effect of staking on stem diameter from 28 DAP to 42 DAP. At 28 DAP, T-trailer staking recorded 0.3 cm as the widest stem and Single plant staking had 0.1 cm as the thinnest. At 35 DAP, V-shape staking rather recorded the widest stem as 0.6 cm and Single plant staking had 0.3 cm as the thinnest and at 42 DAP, V-shape staking had 0.9 cm as the widest while Single plant staking had the thinnest as 0.6 cm (Table 4.8).

There were significant (P≤0.05) differences among interactive effect of pruning and staking in the stem diameter at 28 DAP to 42 DAP. At 28 DAP, No sucker pruning + T-trailer staking recorded the widest stem grith as 0.5 cm, followed by both Single sucker pruning + V-shape staking, Single sucker pruning + T-trailer staking, No sucker pruning + V-shape staking and No sucker pruning + Single plant staking which all recorded (0.2 cm) and then all the rest had (0.1 cm) as the thinnest girth. At 35 DAP, the widest was recorded on No sucker pruning + T-trailer staking as (0.7 cm) and the thinnest was also recorded by Single sucker pruning + Single plant staking as (0.2 cm) and at 42 DAP, the widest was recorded on Multiple sucker pruning + V-shape staking as (1.4 cm) and the thinnest was recorded on No sucker pruning + Single plant staking as (0.4 cm) (Table 4.8).

Table 4.9 shows results of stem diameter of cucumber from 28 DAP to 42 DAP during the minor season. The stem diameter increased throughout the entire period from 28 DAP to 42 DAP. There were no significant (P≥0.05) differences among treatment effect of pruning on the stem diameter during 28 DAP, but there were significant (P≤0.05) differences in treatment of staking from 28 DAP to 42 DAP. At 35 DAP, No sucker pruning recorded (0.6 cm) as the widest stem and both Multiple sucker pruning and Single sucker pruning had (0.5 cm) as the thinnest. At 35 DAP, Single sucker pruning rather recorded the thinnest stem as (0.6 cm) and both Multiple sucker pruning and No sucker pruning had (0.8 cm) as the widest and at 42 DAP, Multiple sucker pruning had (1.3 cm) as the widest while No sucker pruning had the thinnest as (0.8 cm).

There were significant (P≤0.05) differences among treatments effect of staking in stem diameter from 28 DAP and 35 DAP, but no significant (P≥0.05) difference was observed at 42 DAP. At 28 DAP, T-trailer staking recorded (0.7 cm) as the widest stem and Single sucker pruning had (0.5 cm) as the thinnest and at 35 DAP, T-trailer staking rather recorded the widest stem as (0.9 cm) and both V-shape staking and Single plant staking had (0.7 cm) as the thinnest. (Table 4.9).

There were significant (P≤0.05) differences among interaction of pruning and staking in stem diameter at 35 DAP to 42 DAP, but there was no significant (P≥0.05) difference among treatments at 28 DAP. At 35 DAP, both No sucker pruning + T-trailer staking and Single sucker pruning + T-trailer staking recorded the widest stem girth (0.9 cm), followed by both Multiple sucker pruning + V-shape staking and Multiple sucker pruning + Single plant staking and Multiple sucker pruning + V-shape staking which all recorded (0.8 cm) and then Single sucker pruning + V-shape staking and Single sucker pruning + Single plant staking recorded (0.5 cm) as the thinnest stem diameter. At 42 DAP, the widest was recorded on Multiple sucker pruning + V-shape staking (1.4 cm), followed by Multiple sucker pruning + T-trailers staking (1.3 cm) and No sucker pruning + T-trailer staking as (0.9 cm) and the thinnest was also recorded on both Single sucker pruning + V-shape staking and Single sucker pruning + Single plant staking as (0.7 cm) (Table 4.9).

Table 4. 8: Effect of Pruning and Staking on Stem Diameter in the 2023 Major Cropping Season

Treatment	Stem diameter (cm)		
	28 DAP	35 DAP	42 DAP
Pruning (P)			
Single sucker pruning (SSP)	0.1	0.6	0.7
Multiple sucker pruning (MSP)	0.1	0.5	1.0
No sucker pruning (NSP)	0.3	0.5	0.6
HSD (p<0.05)	**0.03**	**0.13**	**0.16**
Staking (S)			
V-shape staking (VSS)	0.2	0.6	0.9
Single plant staking (SPS)	0.1	0.3	0.6
T-trailer staking (TTS)	0.3	0.5	0.8
HSD (p<0.05)	**0.03**	**0.13**	**0.16**
Pruning (P) × Staking (S)			
SSP × VSS	0.2	0.6	0.9
SSP × SPS	0.1	0.2	0.6
SSP × TTS	0.2	0.4	0.7
MSP × VSS	0.1	0.9	1.4
MSP × SPS	0.1	0.4	0.8
MSP × TTS	0.1	0.6	1.0
NSP × VSS	0.2	0.3	0.5
NSP × SPS	0.2	0.3	0.4
NSP × TTS	0.5	0.7	0.8
HSD (p<0.05)	**0.08**	**0.5**	**0.40**
CV (%)	**16.76**	**0.32**	**18.05**

DAP = Days after planting, S = Staking, P = Pruning, CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability.

Table 4. 9: Effect of Pruning and Staking on Stem diameter in the 2023 Minor Cropping Season

Treatment	Stem diameter (cm)		
	28 DAP	35 DAP	42 DAP
Pruning (P)			
Single sucker pruning (SSP)	0.5	0.6	1.0
Multiple sucker pruning (MSP)	0.5	0.8	1.3
No sucker pruning (NSP)	0.6	0.8	0.8
HSD (p<0.05)	**NS**	**0.16**	**0.21**
Staking (S)			
V-shape staking (VSS)	0.6	0.7	1.1
Single plant staking (SPS)	0.5	0.7	1.0
T-trailer staking (TTS)	0.7	0.9	1.0
HSD (p<0.05)	**0.18**	**0.16**	**NS**
Pruning (P) × Staking (S)			
SSP × VSS	0.5	0.5	1.1
SSP × SPS	0.4	0.5	1.0
SSP × TTS	0.7	0.9	1.0
MSP × VSS	0.6	0.8	1.4
MSP × SPS	0.5	0.8	1.1
MSP × TTS	0.5	0.8	1.3
NSP × VSS	0.6	0.6	0.7
NSP × SPS	0.6	0.7	0.9
NSP × TTS	0.7	0.9	0.9
HSD (p<0.05)	**NS**	**0.39**	**0.52**
CV (%)	**26.92**	**18.88**	**17.71**

DAP = Days after planting, S = Staking, P = Pruning, CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability.

4.3.4 Dry Shoot weight

The results of dry shoot weight of cucumber for the major and minor seasons are recorded in Table 4.10. There were no significant (P≥0.05) difference among the dry shoot weight recorded in individual effect of pruning on dry shoot weight in the minor cropping season at 35 DAP and 42 DAP. Conversely significant (P≤0.05) difference was observed among the dry shoot weight recorded in the major cropping season at 35 DAP and 42 DAP. At 35 DAP, in the major cropping season, Single sucker pruning recorded the heaviest dry shoot weight (62.8 g) and No sucker pruning had the lightest dry shoot weight (26.9 g).

For individual effect of staking, there were no significant (P≥0.05) differences among the dry shoot weight recorded in both major and minor cropping seasons at 35 DAP, but at 42 DAP, significant (P≤0.05) difference was observed in the minor cropping season. At 42 DAP, in the minor cropping season, Single plant staking recorded the heaviest shoots (51.5 g) and V-shape staking recorded the lightest shoot (38.0 g) (Table 4.10).

For Interactive effects of pruning and staking, there were no significant (P≥0.05) differences among the dry shoot weight recorded in both major cropping seasons at both 35 DAP and 42 DAP except during the minor cropping season. During the minor cropping season at 35 DAP, the heaviest dry shoot was recorded on Single plant staking + Single sucker pruning as (71.5 g) and the lightest was also recorded on No sucker pruning + T-trailer staking as (15.3 g). During the minor cropping season at 42 DAP, Single sucker pruning + Single plant staking again recorded the heaviest shoot as (79.9 g) and the lightest was recorded on No sucker pruning + Single plant staking as (20.6 g). Season did not significantly affect the dry shoot weight (Table 4.10).

Table 4. 10: Effect of Pruning and Staking on Dry Shoot Weight of Cucumber in 2023 Major and Minor Seasons

Treatment	Dry Shoot Weight (g)			
	Major Season		Minor Season	
	35 DAP	42 DAP	35 DAP	42 DAP
Pruning (P)				
Single sucker pruning (SSP)	62.8	69.2	56.3	62.7
Multiple sucker pruning (MSP)	51.5	56.9	44.2	49.8
No sucker pruning (NSP)	26.9	32.2	19.7	24.8
HSD (p<0.05)	**4.08**	**NS**	**NS**	**12.66**
Staking (S)				
V-shape staking (VSS)	39.9	44.5	32.7	38.0
Single plant staking (SPS)	53.1	59.5	46.1	51.5
T-trailer staking (TTS)	48.3	54.4	41.4	47.7
HSD (p<0.05)	NS	NS	NS	**12.04**
Pruning (P) × Staking (S)				
SSP × VSS	40.4	41.6	32.4	36.7
SSP × SPS	76.5	87.6	71.5	79.9
SSP × TTS	71.7	78.5	64.8	71.5
MSP × VSS	53.6	59.1	46.2	52.2
MSP × SPS	50.5	54.9	42.4	46.0
MSP × TTS	50.5	56.7	44	51.0
NSP × VSS	25.6	32.7	19.5	25.2
NSP × SPS	32.2	35.8	24.4	28.7
NSP × TTS	22.9	28	15.3	20.6
HSD (p<0.05)	**NS**	**NS**	**30.2**	**30.25**
CV (%)	9.3	6.9	6.5	25.3
Pruning = HSD (p<0.05)=	*5.23**		*8.45**	
Staking = HSD (p<0.05)=	*NS*		*8.46*	
Season = HSD (p>0.05)=	*NS*		*NS*	

*DAP = Days after planting, S = Staking, P = Pruning, CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.3.5 Leaf Area

Table 4.11 shows results of leaf area of cucumber from 28 DAP to 42 DAP for the major cropping season. There were Significant (P≤0.05) differences among treatments in leaf area recorded during the period for both individual and interactive effect of pruning and staking. For the interaction, No sucker pruning + V-shape staking recorded the largest leaf area from 28 DAP to 42 DAP (173.1 cm, 205.1 cm and 231.3 cm for 28 DAP, 35 DAP and 42 DAP respectively). No sucker pruning + Single plant staking recorded the smallest leaf area at 28 DAP and 42 DAP (46.4 cm^2 for 28 DAP and 143.0 cm^2 for 42 DAP), but No sucker pruning + Single plant staking rather recorded the smallest leaf area at 35 DAP (81.2 cm^2) (Table 4.12).

Table 4.12 shows results of leaf area of cucumber from 28 DAP to 42 DAP for the minor cropping season. There were significant ($P \leq 0.05$) differences among individual and interactive effect of pruning and staking in leaf area from 28 DAP to 42 DAP. No sucker pruning + V-shape staking recorded the largest leaf area from 28 DAP to 42 DAP (178.1 cm^2, 209.4 cm^2 and 235.3 cm^2 for 28 Dap, 35 DAP and 42 DAP respectively), followed by Multiple sucker pruning + T-trailers staking which recorded 158.5 cm^2, 197.1 cm^2 and 227.1 cm^2 for 28 DAP, 35 DAP and 42 DAP respectively. The smallest leaf area was recorded by Single sucker pruning + Single plant staking at 28 DAP (50.0 cm^2), No sucker pruning + Single plant staking at 35 DAP and Single sucker pruning + Single plant staking at 42 DAP (Table 4.12).

Table 4. 11: Effect of Pruning and Staking on Leaf Area in the 2023 Major Cropping Season

Treatment	Leaf Area (cm^2)		
	28 DAP	35 DAP	42 DAP
Pruning (P) × Staking (S)			
SSP × VSS	73.6	116.3	177.9
SSP × SPS	46.4	85.0	143.0
SSP × TTS	47.8	84.8	156.0
MSP × VSS	132.7	176.3	228.1
MSP × SPS	73.7	102.0	172.6
MSP × TTS	154.8	192.8	223.7
NSP × VSS	173.1	205.1	231.3
NSP × SPS	51.2	81.2	212.8
NSP × TTS	71.7	99.7	159.0
Mean	**91.7**	**127.0**	**189.4**
HSD (p<0.05)	**76.36**	**74.89**	**56.99**
CV (%)	**29.11**	**20.61**	**10.52**

DAP = Days after planting, S = Staking, P = Pruning, CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability.

Table 4. 12: Effect of Pruning and Staking on Leaf Area in the 2023 Minor Cropping Season

Treatment	Leaf Area (cm^2)		
	28 DAP	35 DAP	42 DAP
SSP × VSS	77.3	120.6	182.9
SSP × SPS	50.0	90.0	147.3
SSP × TTS	51.8	88.2	159.7
MSP × VSS	136.3	180.0	233.1
MSP × SPS	78.3	106.3	176.3
MSP × TTS	158.5	197.1	227.1
NSP × VSS	178.1	209.4	235.3
NSP × SPS	54.6	85.9	216.8
NSP × TTS	76.4	104.0	163.0
Mean	**95.7**	**131.3**	**193.5**
HSD (p<0.05)	**75.14**	**75.38**	**57.43**
CV (%)	**27.45**	**20.07**	**10.38**

DAP = Days after planting, S = Staking, P = Pruning, CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability

4.4 Yield and Yield Components of cucumber

4.4.1 Number of Marketable Fruits per plot

The results on number of marketable fruits per plot is shown in Table 4.13. There were no significant (P≥0.05) differences among treatments in number of marketable fruits per plot. The number of marketable fruits recorded ranged from 23 to 32 in the major season and 15 to 25 in the minor season.

Table 4. 13: Effect of Pruning and Staking on Number of Marketable Fruits

Pruning	Number of Marketable Fruits Per Plot							
	Major season				Minor season			
	VSS	SPS	TTS	**Mean**	VSS	SPS	TTS	**Mean**
SSP	18.3	15.0	21.3	**18.2**	27.7	23	24.7	**25.1**
MSP	22.3	15.0	22.0	**19.8**	23.3	26.7	27.3	**25.8**
NSP	17.0	31.0	24.7	**24.2**	31.3	27.3	32.3	**30.3**
Mean	**19.2**	**20.3**	**22.7**		**27.4**	**25.7**	**28.1**	
CV (%)=	29.1				26.3			
Pruning = HSD (p>0.05)=				NS				NS
Staking= HSD (p>0.05)=				NS				NS
Pruning x Staking= HSD (p>0.05)=				NS				NS
Season= HSD (p>0.05)=				NS				

DAP= Days after planting, HSD=Tukey's honestly significant difference (5%), CV (%)=coefficient of variation

4.4.2 Number of Non-marketable Fruits Per Plot

The results for non-marketable fruits per plot for both major and minor seasons are shown in Table 4.14. There were no significant (P≥0.05) differences between pruning and staking for the number of non-marketable fruits in both seasons. There were no significant (P≥0.05) differences between the interaction of pruning and staking in number of non-marketable fruits. The number of non-marketable fruits ranged from 9 to 19 fruits in the major season and 13 to 18 fruits in the minor season (Table 4.14).

Table 4. 14: Effect of Pruning and Staking on Number of Non-marketable fruits

Treatment	Number of Non-marketable fruits Per Plot	
	Major Season	Minor Season
Pruning (P)		
Single sucker pruning (SSP)	11.3	12.6
Multiple sucker pruning (MSP)	12.4	18.3
No sucker pruning (NSP)	17.6	18.2
HSD (p>0.05)	**NS**	**NS**
Staking (S)		
V-shape staking (VSS)	19.0	16.1
Single plant staking (SPS)	13.3	15.0
T-trailer staking (TTS)	9.0	18.0
HSD (p>0.05)	**9.6**	**NS**
CV (%)	**31.2**	**34.2**
Season HSD (p>0.05)=	NS	
Pruning × Staking HSD (p>0.05)	NS	

*DAP = Days after planting, S = Staking, P = Pruning, CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.4.3 Marketable Fruits Weight Per Plot

The results of marketable fruits weight per plot is shown in Table 4.15. There were no significant (P≥0.05) differences among marketable fruits weight per plot in major season as influenced by pruning and staking. There were significant (P≤0.05) differences among treatments in marketable fruits weight per plot in the minor season. Single sucker pruned plants recorded (5.1 kg) as the least, No sucker pruned plants recorded (9.7 kg) and Multiple sucker pruned plants recorded the highest marketable fruits weight per plot (10.1 kg). V-shape staking recorded the highest (10.7 kg) and Single plant staking recorded least (3.9 kg). Multiple sucker pruning + T-trailer staking recorded (12.7 kg) as the highest, and the least was recorded by No sucker pruning + Single plant staking recorded the least marketable fruit weight per plot (1.1 kg) (Table 4.15).

Table 4. 15: Effect of Pruning and Staking on Weight of Marketable Fruits Per Plot

Pruning	Marketable Fruits Weight Per Plot (kg)							
	Major season				Minor season			
	VSS	SPS	TTS	**Mean**	VSS	SPS	TTS	**Mean**
SSP	4.3	3.8	7.5	**5.2**	8.4	1.1	5.8	**5.1**
MSP	5.3	2.9	4.6	**4.3**	12.2	5.3	12.7	**10.1**
NSP	4.8	8.7	5.6	**6.4**	11.4	5.3	12.3	**9.7**
Mean	**4.8**	**5.1**	**5.9**		**10.7**	**3.9**	**10.3**	
CV (%)=	29.1				26.3			
Pruning = HSD (p<0.05)=	NS				1.7			
Staking= HSD (p<0.05)=	NS				1.6			
Pruning x Staking= HSD (p<0.05)=	NS				4.1			
Season= HSD (p<0.05)=	1.64***							

*DAP = Days after planting, S = Staking, P = Pruning, CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.4.4 Number of Fruits Per Plot

The results on the number of fruits per plot for the major and minor seasons are shown in Table 4.16. There were no significant (P>0.05) differences among pruning and staking in number of fruits per plot in both seasons.

Table 4. 16: Effect of Pruning and Staking on Number of Fruits Per Plot in the 2023 Major and Minor Seasons

Treatment	Number of Fruits Per Plot	
	Major Season	Minor Season
Pruning (P)		
Single sucker pruning (SSP)	39.8	30.4
Multiple sucker pruning (MSP)	42.7	37.7
No sucker pruning (NSP)	50.1	41.8
HSD (p>0.05)	NS	NS
Staking (S)		
V-shape staking (VSS)	50.3	34.4
Single plant staking (SPS)	42.3	35.0
T-trailer staking (TTS)	39.9	40.4
HSD (p≥0.05)	NS	NS
CV (%)	**32.3**	**21.2**
Pruning =	*NS*	
Staking =	*NS*	
Season =	*NS*	

*CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability, SSP = Single sucker pruning, MSP = Multiple sucker pruning, NSP = No sucker pruning, VSS = V – shape staking, SPS = Single plant staking and TTS = T – trailer staking, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.4.5 Fruit Length

The results on fruit length are shown in Table 4.17. There were significant (P≤0.05) differences among treatments in fruit length in the minor season, but during the minor season only pruning shown significant (P≤0.05) differences. In the Major season, both Single sucker pruning and Multiple sucker pruning recorded (15.0 cm as longest fruits and No sucker pruning recorded least a mean of 10.2 cm (Table 4.17). In the minor season, Single sucker pruning recorded the longest fruits a mean 16.3 cm, followed by Multiple sucker pruning (16.1 cm) and then No sucker pruning recorded the least (11.4 cm). T-trailers staking also recorded the highest among the different staking methods, followed by V-shape staking and Single plant staking recorded the least. For the interaction, Single sucker pruning + V-shape staking recorded the longest fruits (19.3 cm) in the minor season and the shortest was recorded by No sucker pruning + V-shape staking (10.5) (Table 4.18).

In the major season for the interaction the highest fruit length was from Multilple stem pruning + v-shape staking (17.8)

Table 4. 17: Effect of Pruning and Staking on Fruit Length of Cucumber in the 2023 Major and Minor Seasons

Pruning	Fruit Length (cm)							
	Major season				Minor season			
	VSS	SPS	TTS	**Mean**	VSS	SPS	TTS	**Mean**
SSP	17.7	9.7	17.5	**15**	19.3	10.8	18.8	**16.3**
MSP	17.8	10.7	16.6	**15**	18.9	11.7	17.7	**16.1**
NSP	9.1	9.7	11.8	**10.2**	10.5	11.1	12.7	**11.4**
Mean	**14.9**	**10**	**15.3**		**16.2**	**11.2**	**16.4**	
CV (%)=	9.80				11.31			
Pruning = HSD (p<0.05)=	1.7				1.8			
Staking= HSD (p<0.05)=	NS				1.6			
Pruning x Staking= HSD (p<0.05)=	NS				4.1			
Season= HSD (p<0.05)=	1.64***							

*CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.4.6 Fruit Diameter

The results on fruit diameter are shown in Table 4.18. There were significant (P≤0.05) differences among treatments in fruit diameter during both seasons. Both Single sucker pruning and Multiple sucker pruning recorded the highest fruit diameter (3.9 cm) for each, while No sucker pruning recorded the least (2.6) during the major season. For minor season, Both Single sucker and Multiple sucker pruned plants again recorded the widest fruit diameter (4.2 cm) for each and No sucker pruning had the thinnest diameter (3.0 cm) (Table 4.18).

T-trailer staking recorded the widest fruits (3.9 cm), followed by V-shaped staking also and Single plant staking had the thinnest fruit diameter (2.6 cm) during the major season.

However, in the minor season, both T-trailer staking and V-shaped staking both recorded 4.2 cm as the widest fruit diameter while Single plant staking had the thinnest (2.9 cm) (Table 4.18).

Both Single sucker pruning + V-shape staking and Multiple sucker pruning + V-shape staking produced fruits with the widest diameter (4.6 cm) during the major season while No sucker pruning + V-shape staking produced fruits with the thinnest diameter (2.3 cm). During the minor season, only Single sucker pruning + V-shape staking produced fruits with the widest diameter (5.0 cm) and No sucker pruning + V-shape staking again produced fruits with the thinnest diameter (2.9 cm) (Table 4.18).

Table 4. 18: Effect of Pruning and Staking on Fruit Diameter in the 2023 Major and Minor Seasons

Pruning	Fruit Diameter (cm)							
	Major season				Minor season			
	VSS	SPS	TTS	**Mean**	VSS	SPS	TTS	**Mean**
SSP	4.6	2.5	4.5	**3.9**	5.0	2.8	4.8	**4.2**
MSP	4.6	2.8	4.3	**3.9**	4.9	3.0	4.6	**4.2**
NSP	2.3	2.5	3.0	**2.6**	2.7	2.9	3.3	**3.0**
Mean	**3.8**	**2.6**	**3.9**		**4.2**	**2.9**	**4.2**	
CV (%)=	11.3				9.8			
Pruning = HSD (p<0.05)=	0.52				0.40			
Staking= HSD (p<0.05)=	0.49				0.32			
Pruning x Staking= HSD (p<0.05)=	1.02				1.10			
Season= HSD (p<0.05)=	0.20**							

*CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.4.7 Fruit Yield

The results for fruit yield (t/ha) for both the major and minor seasons are shown in Table 4.19. There were no significant ($P \geq 0.05$) differences among individual treatments in fruit yield (t/ha) in major season, except for interactions. Conversely, there were significant ($P \leq 0.05$) differences among both individual and interaction treatments in fruit yield (t/ha) during minor season. Single sucker pruning + T-trailer staking recorded the highest fruit yield (7.5 t/ha), followed by No sucker pruning + Single plant staking (7.3 t/ha) and Multiple sucker pruning + Single plant staking recorded the least mean fruit yield of 2.9 t/ha.

During the minor season, Multiple sucker pruning recorded mean fruit yield of 8.6 t/ha fruit yield as the highest and the least was recorded by Single sucker pruning as 4.7 t/ha. V-shape staking also recorded the highest mean fruit yield of 9.1 t/ha and the least was recorded by Single plant staking (4.1 t/ha). For the interactive effect, Multiple sucker pruning + T-trailer staking recorded the highest fruit yield (10.8 t/ha) in the major season followed by Multiple sucker pruning + V-shape staking (10.1 t/ha) and the lowest was recorded on Single sucker pruning + Single plant staking (1.6 t/ha) (Table 4.19).

Table 4. 19: Effect of Pruning and Staking on Fruit Yield of Cucumber in the 2023 Major and Minor Seasons

Pruning	Fruit Yield (t/ha)							
	Major season				Minor season			
	VSS	SPS	TTS	**Mean**	VSS	SPS	TTS	**Mean**
SSP	4.1	3.4	7.5	**5.0**	7.6	1.6	4.9	**4.7**
MSP	5.4	2.9	4.2	**4.2**	10.1	4.9	10.8	**8.6**
NSP	4.0	7.3	5.4	**5.6**	9.6	5.8	9.5	**8.3**
Mean	**4.5**	**4.5**	**5.7**		**9.1**	**4.1**	**8.4**	
CV (%)=	23.3				13.8			
Pruning = HSD (p<0.05)=	NS				1.2			
Staking= HSD (p<0.05)=	NS				1.2			
Pruning x Staking= HSD (p<0.05)=	1.02				1.1			
Season= HSD (p<0.05)=	1.48**							

*CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.4.8 Harvest Index

Table 4.20 shows the results on harvest index of cucumber for the major and minor seasons. There were significant (P≤0.05) differences among treatments in harvest index during the major season except for staking. There were significant (P≤0.05) differences among treatments in harvest index during the minor season. During the major season, No sucker pruning had the highest harvest index (0.7), followed by Multiple sucker pruning (0.3) And then Single sucker pruning had the least (0.2). T-trailers staking also recorded the highest harvest index (0.5), followed by V-shape staking (0.4) and then Single plant staking recorded the least (0.3). No sucker pruning + T-trailer staking recorded the highest harvest index (0.9) and Single sucker pruning + Single plant staking had least harvest index (0.1).

During the minor season, Multiple sucker pruning rather recorded the highest harvest index (0.5), followed by No sucker pruning (0.4) and Single sucker pruning recorded the least harvest index (0.3). T-trailer staking recorded the highest harvest index (0.5) in the minor season, followed by V-shaped staking (0.4) and Single plant staking recorded the least harvest index (0.3). Both multiple sucker pruning + T-trailer staking and No sucker pruning + T-trailer staking recorded (0.6) harvest index as the highest, and the least was recorded by Single sucker pruning + T-trailer staking as (0.3) (Table 4.20).

Table 4. 20: Effect of Pruning and Staking on Harvest Index of Cucumber in the 2023 Major and Minor Seasons

Pruning	Harvest Index							
	Major season				Minor season			
	VSS	SPS	TTS	**Mean**	VSS	SPS	TTS	**Mean**
SSP	0.5	0.1	0.3	**0.3**	0.3	0.1	0.3	**0.2**
MSP	0.4	0.4	0.6	**0.5**	0.3	0.2	0.3	**0.3**
NSP	0.4	0.3	0.6	**0.4**	0.5	0.7	0.9	**0.7**
Mean	**0.4**	**0.3**	**0.5**		**0.4**	**0.3**	**0.5**	
CV (%)=	1.11				18.3			
Pruning = HSD (p<0.05)=	0.1				0.1			
Staking= HSD (p<0.05)=	NS				0.1			
Pruning x Staking= HSD (p<0.05)=	1.02				1.1			
Season= HSD (p>0.05)=	NS							

*CV (%) = coefficient of variation, HSD = Tukey's honestly significant difference at 5% probability, *=significant at probability of 0.05, **=significant at probability of 0.01, ***=significant at probability of 0.001*

4.5 Correlation Analysis

Tables 4.21 and Table 4.22 show correlation matrix analysis among some vegetative growth parameters and yield and yield components during the major and minor cropping seasons respectively. During the major cropping season, vine length and fruit yield were strong and positively correlated (0.588**), there were positive correlation between vine length and fruit diameter (0.394*) and between vine length and marketable fruit weight per plot (0.395*) with significant differences. Similarly, number of leafs per plant significantly and positively correlated with fruit diameter (0.493**). Stem diameter also positively and significantly correlated with fruit diameter (0.439*) and fruit yield (0.570**). Fruit diameter was highly positively correlated with fruit length (0.999***) (Table 4.21).

During the minor cropping season, vine length and stem diameter were moderately positively correlated (0.386*), vine length and fruit yield was weak positively correlated but not significant (0.020ns), there was moderate positive correlation between vine length and fruit diameter (0.391*) and fruit length (0.387*). Similarly, number of leaves per plant was significantly, highly and positively correlated with fruit yield (0.789***) and marketable fruit weight per plot (0.777***). Stem diameter was positively and significantly correlated with fruit yield (0.531***). Fruit diameter was also positively correlated with fruit length (0.999**) (Table 4.21).

Table 4. 21: Correlation Matrix Analysis of Vegetative and Yield and Yield Components of Cucumber during 2023 Major Season

	1	2	3	4	5	6	7
1. Vine Length	1	-0.338ns	0.203ns	0.506**	0.395*	0.394*	0.588**
2. Number of Leaves per plant		1	0.240ns	0.151ns	0.493**	0.493**	0.169ns
3. Stem diameter			1	0.648***	0.442*	0.439*	0.570**
4. Marketable fruits Weight per plot				1	0.358ns	0.357ns	0.976***
5. Fruit diameter					1	0.999***	0.3667ns
6.Fruit Length						1	0.365ns
7. Fruit Yield							1

ns=p>=0.05, *=p<0.05, **=p<0.01 and ***=p<0.001, Numbers in columns corresponds with numbers and parameters/variables in rows

Table 4. 22: Correlation Matrix Analysis of Vegetative and Yield and Yield Components of Cucumber during 2023 Minor Season

	1	2	3	4	5	6	7
1. Vine Length	1	-0.056ns	0.386*	0.006ns	0.391*	0.387*	0.020ns
2. Number of Leaves per plant		1	0.475*	0.777***	0.219ns	0.217ns	0.789***
3. Stem diameter			1	0.503**	0.348ns	0.349ns	0.531**
4. Marketable fruits Weight per plot				1	0.020ns	0.019ns	0.980***
5. Fruit diameter					1	0.999***	0.089ns
6.Fruit Length						1	0.088ns
7. Fruit Yield							1

ns=p>=0.05, *=p<0.05, **=p<0.01 and ***=p<0.001, Numbers in columns corresponds with numbers and parameters/variables in rows

CHAPTER FIVE: DISCUSSION

5.1 Effect of Pruning and Staking on Phenology of cucumber

The maximum percentage of plant establishment resulting from single sucker pruning combined with V-shape staking during the major season, and single sucker pruning combined with T-trailer staking during the minor season, may be attributed to a combination of factors including temperature, seed quality, and rainfall. Temperature is a vital factor influencing the germination and initial development of plants. The primary season likely experienced more favorable temperature conditions, including optimal soil and ambient temperatures conducive to seed germination and seedling development. During the minor season, the temperature conditions may have been conducive to the treatment combination of single sucker pruning and T-trailer staking, resulting in improved plant establishment for this specific cucumber variety. It is possible that the seeds used in the Single sucker pruning × V-shape staking treatment combination during the main season were of higher quality, which may have contributed to an increased plant establishment rate compared to other combinations. This aligns with the findings of Finch-Savage and Bassal (2016), who demonstrated that crop yield and resource efficiency are contingent upon successful plant establishment in the field. They emphasized that seed vigor determines the capacity for rapid, uniform, and robust germination and seedling establishment across a variety of environmental conditions. The non-significant differences observed between the main and minor seasons may be attributed to favorable growing conditions, which mitigate the influence of environmental and other factors on cucumber growth.

Across both cropping seasons, plants subjected to multiple sucker pruning, as well as the interaction of multiple pruning with V-shape staking, exhibited a substantially reduced number of days to 50% flowering compared to plants without sucker pruning. Removing suckers from the base of the plant directs nutrients and assimilates to the main stem and developing blooms, resulting in earlier flowering. Generally, V-shaped staking may enhance ventilation and light penetration, potentially expediting the blossoming process. This contradicts the findings of Alam et al. (2016), who reported that staking and pruning do not significantly influence the number of days to 50% blossoming. Musa et al. (2021) reported that staking cucumbers enhanced phenological parameters due to improved light interception.

The markedly higher fruit set observed with Multiple Sucker Pruning across both seasons may be attributed to the removal of suckers, which facilitated the redistribution of nutrients and assimilates to the main stem, thereby promoting earlier fruit development. The highest fruit set observed with V-shape staking in both seasons may be attributed to the improved projection of the cucumber stem, which enhanced its capacity to capture sunlight and perform photosynthesis, thereby promoting flowering and subsequent fruit development. This aligns with the findings of Nipa et al. (2020), who reported that staking substantially influences the number of crops per plant. Once again, the interaction between No Sucker Pruning and Single Plant Staking resulted in a substantially higher number of fruit sets in both seasons compared to Single Sucker Pruning and Single Plant Staking. Staking supports cucumber plants in maintaining an upright position and prevents them from bending or fracturing under the weight of their crops, particularly after rainfall or breeze. This support facilitates healthier plant growth, enhances airflow around the foliage, and offers structural stability, especially for plants bearing large blossoms or susceptible to wind damage (Asamoah, 2022).

5.2 Effect of Pruning and Staking on Growth of cucumber

Vine length was notably influenced by pruning, staking, and their interaction throughout both cropping seasons. This may be due to the fact that pruning and staking played a pivotal role in shaping the development of the vines. Vine development, which is essential for plant growth and productivity by allowing plants to climb and access sunlight, enhancing air circulation, and simplifying harvesting and pest control, may also significantly influence photosynthesis in plants. This process could be more affected by pruning and staking, supported by other factors such as soil health, microbial activity, and overall environmental conditions. Similarly, in support of this finding, Masrie et al. (2023) asserted that vine length was affected by stem pruning and securing. Wubetie and Wubetu (2025) suggested that staking can promote plant growth by improving resource utilization and establishing conducive conditions for crop development.

The maximum count of leaves with no sucker pruning and V-shape staking recorded during the minor season may be attributed to the competitive effect for solar radiation among the numerous branches in the no sucker pruning and V-shape staking plants. This effect was statistically significant across the treatments. This aligns with the findings of Kakade et al. (2022), who examined the effects of various staking methods on cucumber growth and yield, and reported that staking markedly enhanced both vegetative development and productivity compared to non-staked plants. T-trailer staking was generally observed to influence cucumber growth and yield parameters. This was probably attributable to improved light interception, which decreased the incidence of disease and pests while also promoting better air circulation (Mohammed-Saifuddin et al., 2007). A similar observation was reported by Gomasta et al. (2024), who suggested that pruning directly promotes the development of larger leaves, enhances mesophyll size and moisture content, and extends the duration of stomatal opening.

The notable impact of pruning on the number of leaves during the minor season may be attributed to environmental conditions and the specific Pointsett variety employed. The results in this study is contrary to the findings of Nweke et al (2013) who reported that staking and pruning have significant effect on number of leaves and vine length of cucumber. Furthermore, the notable impact of staking on the number of leaves during the main season may be attributed to the fact that the cucumber varieties examined in this study were determinate types and potentially did not necessitate staking.

This finding confirms the report by Hanson et al., 2000, which stated that determinate varieties do not require stakes, unlike indeterminate varieties. This may also be ascribed to the various cultivars resulting from phenotypic differences in trait expression influenced by environmental interactions. The notable interactive effect of pruning and staking within a few days after planting across the two seasons may be ascribed to variations in the growth characteristics of different crop varieties, including differences in the distribution of the crop canopy, leaf arrangement, chlorophyll content, photosynthetic activity, and suitability to agro-ecological conditions. This aligns with the findings of Enujeke (2013), Ibrahim et al. (2008), and Sajjan et al. (2002), who reported that the genetic constitution of crop varieties influences the growth traits they express.

Stem diameter was substantially influenced by both the individual and combined effects of pruning and staking. This finding corroborates the report by Lamptey and Koomson (2021), which indicated that cucumber vines and their leaves are subjected to increased sunlight exposure, a vital factor for photosynthesis and overall plant development due to more favorable environmental conditions. Additionally, it may be attributable to the climatic conditions prevailing during the two cultivation seasons. The variations in temperature in the two planting seasons could be associated with the substantial difference observed on the stem diameter in both the main and minor cropping seasons. Temperature can impact stem diameter by affecting growth rates, with optimal temperatures typically supporting the development of broader stems. This statement aligns with the findings of a study conducted by Sakamoto and Suzuki (2015). The notable variation observed in cucumber stem diameter may be attributed to the differing pruning and staking techniques, which potentially influence the availability of nutrients to the plants.

There were no notable differences in the individual or combined effects of pruning and staking on the dry stem weight and dry root weight. This may be attributed to the reduced atmospheric temperature during that period. This aligns with the findings of Iseki et al. (2022), who indicated that temperature and competitive growth factors reduce shoot and root dry weights.

The notable variations in leaf area among treatments may be attributed to nutrient redistribution toward the individual plants, as competition was diminished due to pruning and staking. Pruning facilitates the exposure of plants to light conditions that enhance photosynthetic activity. This finding aligns with Abdel-Wahab (2018), who indicated that pruning markedly affects leaf area due to the redistribution of nutrients to the main shoot to enhance photosynthetic capacity. Additionally, it prevents congestion and facilitates proper exposure or positioning of cucumber leaves to sunlight, thereby promoting effective photosynthesis and increasing produce yield. This finding aligns with Hamayoun et al. (2018), who reported that staked plants receive increased light interception, resulting in enhanced photosynthetic activity and greater vegetative growth.

5.3 Effect of Pruning and Staking on Yield and Yield component of cucumber

The insignificant variation observed in the quantities of marketable and non-marketable fruits across both the main and minor seasons may be attributed to a combination of genetic and environmental factors. The interactive effect of no sucker pruning combined with single plant staking yielded the highest number of marketable fruits during the main season, while the interaction between no sucker pruning and T-trailer staking resulted in the greatest number of marketable fruits per plot in the minor season. This may likely be attributed to the genetic composition of the cucumber employed in the study, as reported by Akpan and Okamigbo (2023), who indicated that high-yielding traits in certain cucumber varieties result from their genetic makeup and environmental conditions.

There were notable differences in the weight of marketable fruits during the minor season, while no substantial difference was observed in the weight of marketable fruits during the main seasons. The interactive effect of multiple sucker pruning combined with T-trailer staking resulted in the maximum weight of marketable fruits during the main season, while no sucker pruning combined with single plant staking yielded the highest weight of marketable fruits in the minor season. The variation in the marketable products of cucumber during both the minor and main seasons may be attributed to genotypic and climatic factors. Khan et al. (2023) indicated that genotype is a primary factor affecting fruit weight in cucumber, with different varieties exhibiting considerable variation in their fruit size and weight. The markedly greater fruit weight observed during the main season suggests that these varieties may be genetically inclined to produce larger fruits.

The results indicated that pruning, staking, and their interaction significantly affected the total number of fruits per plot in both the main and minor seasons. This may be attributed to the genotypic and environmental conditions present during the cultivation seasons. Staking prevents congestion and facilitates proper exposure or positioning of cucumber leaves to sunlight, thereby promoting efficient photosynthetic activity and increasing fruit yield. Staking enhances the number of branches, leaves, vine length, and leaf area in cucumber plants compared to unstaked specimens. Research has documented an increase in fruit yield, a decrease in non-marketable fruit, and an improvement in the quality of high-grade fruits resulting from staking. Pruning enhances plant vigor and aesthetic appeal by eliminating vulnerable portions to reduce the risk of insect damage, while also promoting optimal growth patterns and improving air circulation (Adebayo et al., 2021). The findings of this study are contrary to those of Adesida et al. (2020), who reported that staking tomatoes resulted in higher yields and superior quality produce with increased market value, and recommended staking to achieve improved quality and greater yields of tomatoes.

Staking and pruning techniques significantly influenced fruit diameter and length, with the largest fruit diameter observed in the interaction between Single Sucker Pruning and V-shape Staking during the main season, as well as in the combinations of Single Sucker Pruning with V-shape Staking and Multiple Sucker Pruning with V-shape Staking. Staking and pruning may have facilitated improved aeration and exposure of the foliage, thereby enhancing photosynthetic activity, which could be responsible for increased fruit size. Hesamil et al. (2012) reported in their study on tomatoes that the fruit size increased as a result of the removal of lateral branches. The findings from staking and pruning cucumber are consistent with Kumar et al. (2001), who observed increased fruit diameter in staked tomato. The current findings also align with Mardhiana et al. (2017), who reported that pruning significantly influences plant height, leaf number, fruit diameter, and fruit weight.

Pruning and staking had a substantial impact on fruit yield during the primary season. This may be attributed to the enhanced availability of nutrients to plants through pruning and anchoring, coupled with improved solubilization of organic manures in the soil, ultimately leading to the production and translocation of sufficient amounts of photosynthates from the foliage to the reproductive organs. The results align with the findings of Mardhiana et al. (2017), who reported that pruning diminishes unproductive components, thereby facilitating a greater allocation of photosynthetic assimilates to promote cell enlargement. The non-significant variations in produce yield may be attributed to the climatic conditions prevailing during the cropping season. Fruits and vegetables cultivated in mild temperate regions are significantly at risk from rising temperatures during arid seasons, which may impact plant physiology and phenology by hindering the accumulation of certain nutrients essential for crop growth and development. The results of this study are consistent with those of Menzel (2021), who observed that elevated temperatures adversely impact key agronomic fruit characteristics, such as size and weight, by impairing normal plant functions and decreasing sugar accumulation.

The harvest index denotes the proportion of the crop that is utilized for economic purposes relative to the entire crop (Herridge et al., 2022). The highest harvest index observed in the interaction between multiple sucker pruning and T-trailer staking seasons may reflect the ability of staking and pruning practices to alter water utilization patterns and biomass allocation. In a study conducted by Burroughs et al. (2023), it was noted that the harvest index (HI) differed among soybean genotypes as a result of genetic and environmental influences. The research indicated that genotypes exhibiting higher harvest indices demonstrated greater productivity potential and exhibited increased efficiency in utilizing photosynthetic assimilates.

The significant and positive correlation between vine length and fruit yield during the main season suggests that lengthier vines could effectively enhance cucumber fruit production. This aligns with the findings of Musara and Chitamba (2014) and Chinatu et al. (2017), who documented a significant positive correlation between vine length and cucumber produce. Similarly, the number of leaves was strongly and positively correlated with fruit yield during the minor season, indicating that an increase in the number of cucumber leaves enhanced fruit production. This may be ascribed to the fact that leaves are responsible for photosynthesis, which generates the energy (sugars) necessary for the plant's growth and fruit production. Therefore, an increase in leaf quantity results in enhanced photosynthetic activity, which subsequently leads to greater energy generation and resource allocation for fruit development, thereby producing a higher fruit yield (Siregar et al., 2017). Stem diameter was also significantly and positively correlated with fruit yield during the minor season; a greater stem diameter in plants typically indicates enhanced vigor and overall health. A strong stem offers superior structural support and promotes efficient transportation of nutrients and water throughout the plant, ultimately resulting in increased fruit production and higher fruit yield, as reported by Yang et al. (2022).

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study assessed the growth and yield of cucumber affected by pruning and staking. Based on the results of the studies obtained, the following conclusions were drawn:

Objective 1:

- Multiple sucker pruning and V-shape staking individually significantly had shorter days to 50% flowering and number of fruit set
- The interaction of Multiple sucker pruning + V-shape staking significantly had shorter days to 50% flowering and fewer number of fruit sets

Objective 2:

- Multiple sucker pruning and V-shape staking individually and interactively improved the vine length of cucumber at both major and minor seasons.
- Single sucker pruning + T-trailer staking produced more number of leaves per plant.
- V-shape staking produced wider or thicker stems during the major season than the other staking methods and also longer vines.
- Multiple sucker pruning + V-shape staking produced thicker stems, but Single sucker pruning + Single plant staking rather produced heavier dry shoots.

Objective 3:

- Multiple sucker pruning and T-trailer staking individually and interactively improved the marketable fruit weight per plot and fruit yield of cucumber during the minor season.

- Single sucker pruning and V-shape staking individually and interactively produced longer and wider fruits than the other interactions.

6.2 Recommendations

Based on the experimental results, it is recommended that:

- Multiple sucker pruning and T-trailer staking are recommended for adoption by farmers for higher fruit yield of Pointsett cucumber.
- Also, Single sucker pruning and V-shape staking are recommended for longer and wider fruits of Poinsett cucumber.
- Further studies should consider the use of improved varieties to determine if its phenology, growth and yield will be influenced by pruning and staking.
- The treatments should be tested in the different agro-ecological zones in Ghana, where farming is common among resource-poor farmers.

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