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FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

DEPARTMENT OF CROP SCIENCE

THE EFFECTS OF LEAF PRUNING SYSTEMS ON BIOMASS GROWTH AND YIELD OF TOMATO (*LYCOPERSICON ESCULENTUM)* IN A GREENHOUSE ENVIRONMENT

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DECLARATION

I Mashingaidze Chigonera do hereby declare that this dissertation was the result of my own original efforts and investigations, and such work has not been presented elsewhere for any degree or any university programme. All other supplementary sources of information have been acknowledged by means of references.

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CERTIFICATION OF THE DISSERTATION

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The undersigned certify that they have read and recommend to the Bindura University to accept a dissertation entitled: **THE EFFECTS OF LEAF PRUNING SYSTEMS ON BIOMASS GROWTH AND YIELD OF TOMATO (*LYCOPERSICON ESCULENTUM)* IN A GREENHOUSE ENVIRONMENT**

Submitted by

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In partial fulfilment of the requirements for the Bachelor of Science Honors Degree in Agriculture.

SUPERVISOR...

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DEDICATION

I dedicate this project to my Uncle Mr T. Magada, my mother Mrs Chimuza and my Father Mr Chimuza and personal effort exerted on this project. To God Almighty be the glory forever and ever.

ABSTRACT

An experiment was conducted to evaluate the effect of different leaf pruning systems on tomato plant growth and yield of tomatoes grown under greenhouse conditions at Greystone farm during the December to May 2023 growing season. The research was conducted with the objective of determining the effect of leaf pruning system on biomass growth and yield of tomato in a greenhouse environment. The experiment was performed with a randomized complete block design with three replicates and five treatments. No pruning (T1) which was treated as the control for the experiment, pruning one leaf below each cluster on a plant (T2), pruning one leaf above each cluster on a plant (T3), pruning one leaf above and one leaf below each cluster (T4) and pruning two leaves between two clusters and living one at the middle (T5). The plants whose leaves were pruned grew vegetatively quickly and produced better yields than the unpruned plants. It was also observed that the vegetative and reproductive growth of the plants was prolonged by the pruning. Although the plants with one leaf pruned above and one leaf below each cluster yielded a higher yield than all the other treatments, subsequent unpruned plant, was the least performer. Statistically significant differences were observed between growth and total yield. The difference in plant height, plant girth, leaf girth, leaf length, individual fruit weight and diameter between treatments also proved to be statistically significant. Since pruning of one leaf above and one leaf below each cluster proved to have best results across all parameters farmers can adopt it and implement in the greenhouse environment.

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CHAPTER ONE

1.0 Background

The Solanaceae family is one of the most varied plant families, with between 1500 and 2000 species (Saiful Islam et al., 2016). The tomato (*Lycopersicon esculentum*) is believed to have originated in the South American Andes, but after the Spanish conquest of the Americas, its use as food expanded from Mexico to other parts of the world (FAOSTAT, 2019). The Food and Agriculture Organization of the United Nations' statistics agency (Setiawati et al., 2022) estimates that the world's total tomato production is at 186 821 million tonnes per year, with a cultivable area of roughly 5 051 938 hectares. The top tomato-producing nations worldwide are China, India, the European Union, Egypt, the United States, and Turkey.

Tomatoes were introduced to Zimbabwe by European settlers' in the late 19th century and since then, the crop has become an important part of the country's agricultural sector. Today, tomatoes are grown throughout Zimbabwe, with the majority of production taking place in Mashonaland provinces, Midlands, and Manicaland. The production is largely dominated by small-scale farmers, who grow the crop for domestic consumption IFAD (2018)

Practically, every nation in the world grows tomato in greenhouses, net houses, and open fields. The tomato is a warm-season fruit vegetable that is susceptible to frost, and it is one of Zimbabwe's most cherished summer crops. The plant would suffer damage or be destroyed in winter. The majority of farmers in Zimbabwe do not have greenhouses, which is one solution to encounter the problem of frost. After producing 25 113 tonnes of tomatoes, Zimbabwe imported two tonnes and exported four tonnes in 2020, according to . The FAO estimates that the world's yearly tomato production is around 123 million tonnes with a total production area of roughly 4.5 million hectares. Zimbabwe's biggest tomato production was in 2015 when it produced 25 323 tonnes from 3 508 hecteres (*Topping and Spacing on Growth*, *Yield*, *and Fruit Quality of Tomato*, n.d.).

In Zimbabwe, tomatoes rank among the most significant and widely grown fruit vegetables in terms of their economic, dietary, and gastronomic benefits. Tomatoes can exhibit a blooming behavior an indeterminate which can continue to grow and produce fruit throughout the growing season or determinate that produces a set number of flowers and fruit usually within a shorter time period and the stop producing new fruit. The crop is suited for growing in both open fields and greenhouses due to its capacity for self-pollination. Although the amount of area used for tomato cultivation has significantly expanded over time, productivity in the nation is still very low. The variance in yield may result from varying climate factors and cultural traditions.

Fruit pruning, stem trimming, cultivar selection, and other factors can affect the output, quality, and size of tomatoes (Maboko et al., 2011). Typically, farmers use little or very little cross-cultural techniques, like leaf clipping, to cultivate tomatoes. Many studies support the advantages of trimming tomato crops under regulated circumstances. Nevertheless, cultivar and location have an impact on pruning requirements and how it affects productivity. According to some literature, tomato plants should be trimmed to one stem by cutting off any side branches (Lhamo et al., 2022a). On the other side, several individuals claimed that pruning to just two stems increased output (Maboko et al., 2011) . When pruned to two stems rather than one, (Mississipi State University, 2014) saw an increase in the yield/area of 10% to 15%. Hence, according to the research, the effectiveness of the pruning strategies varies by location and cultivar. In Zimbabwe, no such research was done, and farmers often produce tomatoes without using any kind of management techniques like pruning or leaf removal. In order to ascertain the effects of pruning strategies on particular plant growth and yield of tomatoes under a greenhouse management system, this study will be carried out.

Problem statement

Leaf pruning on a tomato plant is an agronomic operation that affects yield, and fruit-bearing. The quantity of tomato leaves can affect the plant height, stem girth, leaf length, leaf girth, tomato size, quantity and quality of *Lycopersicon esculentum* in a greenhouse environment. Tomato plants are known to grow vigorously, and without proper pruning, they can quickly become overcroweded and produce lower yields. There is lack of consensus on the most effective leaf pruning system. Therefore this leads to inconsistencies in yield and quality of the crop, which can result in economic losses for grower. Yield variation could occur due to different cultural practices of pruning: pruning side shoots, pinching the main stem before planting and spacing. The effect of the timing and amount of leaf pruning upon the rate of development of tomatoes has to be assessed to improve growth and yield. The purpose of this study is to come up with a pruning strategy that improves yields of tomatoes in the greenhouse environment.

Justification

It is important to conduct this study to improve fruit-bearing by pruning extra growth that diverts some nutrients away from developing fruits. Pruning excess growth redirects some nutrients back to the fruits and increase the tomato size, reducing flower and fruit shading. Fungal diseases and pest like white flies favours dense and humid environments. So if pruning is practised it allows the airflow within the tomato plants and the environment will be drier which is less favourable for fungal, and bacterial diseases and some pests to develop. Pruned tomatoes are easy to trellis and harvest. Farmers will benefit from the results of this study as they will boost their yield if they implement it and this will also increase the food security of the nation as a whole.

1.4 General Objective

The main objective of the study is to understand the effect of a leaf pruning system on selected tomato plant growth and yield of tomato (*Lycopersicon esculentum)*

1.5 Specific objectives

- To evaluate the effect of leaf pruning systems on growth parameters (plant height, stem girth, leaf area index, leaf length and leaf girth).
- To determine the effect of leaf pruning on final yield.

1.6 Hypothesis

H_0 - Leaf pruning system has no effect on plant height, stem girth, leaf area index, leaf length, and leaf girth.

H_0- Leaf pruning system has no effect on yield

CHAPTER TWO

2.1Introduction

The majority of tomato plants are grown from seeds, which are first sown in a nursery and then transplanted. To guarantee optimum output, intensive agronomic procedures like watering, weeding, pruning, training, and pest and disease management are used (Setiawati et al., 2022). The plant usually reaches a height of 1-3 meters and has a flimsy stem that frequently sprawls over the ground and climbs other plants; if untrained, it displays decumbence. Although it is frequently grown outside as an annual in temperate areas, it is perennial in its natural habitat. A typical tomato fruit weighs about 100 grams on average. The crop works well in tropical and subtropical climes, where temperatures between 15 and 30 °C and moderate rainfall of about 1000 mm are common (Saiful Islam et al., 2016). With extensive research on elite germplasm, cultivation techniques such production in protected environments and processing, the tomato business is one of the most dynamic horticulture sub-sector globally (Setiawati et al., 2022). The appeal stems from the idea that greenhouse tomatoes might be more profitable than more traditional agronomic or horticultural crops.

2.2 The importance and utilization of tomato

The main use of tomato is to make soups, juice, ketchup, pickles, sauces, preserved puree, paste, powder, and other goods, it is quite popular as a raw salad (Kim et al., 2014). In addition to being delicious, tomato fruits are healthful since they are a high source of vitamins A and C. In addition to supporting immune system control and maintaining the surface linings of the eyes, respiratory, urinary, and digestive tracts, vitamin A is crucial for bone formation, cell division, and differentiation. Collagen, a protein that provides structures to bones, cartilage, muscle, and blood vessels, is formed with the help of vitamin C. Moreover, it promotes the absorption of iron and supports the health of bones, teeth, and capillaries (Mitchell et al., 2019). Tomatoes include carotenoids, phytosterols, and minerals that are necessary for human nutrition. Lycopene is the most prevalent carotenoid found in tomatoes, followed by beta-carotene, gamma-carotene, litein, phytoene, and other minor carotenoids having anti-cancer potential (Sultana et al., 2016)

2.3 Effects of pruning on vegetative growth of tomatoes

It has been shown that the pruning approach helps farmers produce larger yields and higher-quality of fruits; hence it is advised that tomato growers employ pruning techniques to produce more marketable crops. The impact of pruning on the division of vegetative biomass causes partitioning which is a subject of significant disagreement in the literature (Sultana et al., 2016). (Jo & Shin, 2020) The transfer and division of assimilate across plant organs determine the relationship between pruning levels and yield. Partitioning refers to the ratio by which assimilates are distributed among the many sinks, whereas translocation refers to the movement of photo-assimilates from the producing organs, or sources, to the recipient organs, or sinks (Thakur et al., 2018). The two processes are essential in figuring out how much dry matter accumulates in fruits, which impacts the final yield (Max et al., 2016). Since one organ can serve as both a source and a sink, the distinction between the two is not always evident. Furthermore, according to (Jo & Shin, 2020) both physical and molecular properties, each organ has a certain sink strength, being more or less capable of attracting the products of photosynthesis (Li et al., 2015).

According to (Lhamo et al., 2022a), pruning expands the plant canopy from the perspective of plant protection, which may lessen the prevalence of foliar diseases since better air circulation dries out moisture on leaf surfaces. In tomato plots, pruning also made the mechanically transmitted bacterial canker (Clavibacter michiganensis) more severe (Saiful Islam et al., 2016). According to (Olasantan & Salau, 2008), pruning makes it easier to treat and harvest insecticides, which increases the amount of marketable fruits on clipped trees. (Decognet et al., 2010) demonstrated an inverse correlation between pruning and fruits with the abiotic cuticle cracking condition, which was possibly caused by a reduction in the amount of foliage that was shielded from sunlight. Pruning may also have an impact on the frequency of the abiotic tomato condition.

(Lhamo et al., 2022a) found out that pruning boosted early yield but decreased total yield. To achieve the desired yield and quality attributes, it is essential to gain solid knowledge of pruning tomato plants. This requires careful consideration of the most appropriate training and pruning methods, intensities, growth stages, and crop seasons in regard to tomatoes. According to (Sultana et al., 2016), tomato plants can be extensively trimmed without the production being impacted.

Pruning frequency has an impact on yield and vegetative development. Tomato stem diameter, vigor, fruit number, and yield all dropped or increase depending on pruning levels. According to (Mitchell et al., 2019) pruning maintains better root system balance and typically yields greater fruit than if the plant were allowed to develop into a bush (Thakur et al., 2018).

According to (Gatahi, 2020) pruning tomatoes raised the mean dry mass of the stems, petioles, and lamina by up to 43% and by up to 22%, respectively, as well as the dry mass of the fruit (up to 42 per cent).According to (Mbonihankuye et al., 2013), pruning accelerates an increase in photosynthetic efficiency, which leads to early fruiting and maturity in addition to efficient glucose partitioning. According to (Thakur et al., 2018), a crop's total dry matter is the result of net photosynthesis. It mostly depends on the size or activity of the photosynthesis system as well as the length of the growth phase during which photosynthesis is active. As (Thakur et al., 2018), photosynthesis is the primary cause of the rise in plant dry matter. Except for polyphenol oxidase activity, crude fiber, sugar, and moisture content, (Thakur et al., 2018).

According to (Max et al., 2016), weak pruning can result in more leaf assimilate production, which can boost fruit quality. Low leaf area reduces photosynthetic rate when the canopy is pruned, allowing more light to enter. Because of this, there is an optimal ratio between leaves and light penetration into the canopy in double branch or pyramidal pruning, increasing the amount of nutrients in the fruits. According to (Rutledge, 2017), pruning enables some control over fruit size and flowering. By eliminating the axillary branches and controlling the amount of fruits per cluster, fruit size can be increased. The amount of assimilates available to all the fruits is sufficient to support the growth of the majority of fruits because the canopy's ability to utilize light is not constrained by a lot of foliage that increases shade.

2.4 Effect of side shoots pruning on tomato plant

Side shoot pruning exerted a strong influence on yield and growth of the tomato plant. Tomato production, quality, and fruit size are all controlled by a variety of variables, including cultivar selection, fruit pruning, stem pruning, and tomato yield (Maboko et al., 2011). Little basal branches can be pruned to help keep the balance between vegetative and reproductive biomass in tomatoes, according to (Gatahi, 2020).

The plants that were clipped to a single leader system produced the maximum yield. (Lhamo et al., 2022a) discovered that for the first and second harvests, the yield from pruning plants to a single leader and double leader was significantly higher than the yield from unpruned plants, even if the yields of single leader and double leader system plants did not differ significantly. (Mbonihankuye et al., 2013) was found that plants with single stems produced significantly fewer flowers than those with two stems and no pruning. Because of this, the single leader system produced relatively fewer but heavier and larger fruits. According to (Mbonihankuye et al., 2013), single stem plants had the maximum fruit set, followed by two stem and unpruned plants.

According to (Saiful Islam et al., 2016), while comparing plants of indeterminate tomato cultivars with single stem and non-pruned plants, the two stem pruning strategy produced the maximum commercial output. (Falodun & Ogedegbe, 2019) reported that pruning had no effect on fruit length and mean fruit weight. Pruned tomatoes had a higher fruit weight than unpruned ones. (Santos, 2008) found that side shoot removal had a positive effect on the overall yield of tomatoes. Similarly, pruning side shoots below floral clusters could have a profound effect on the crop. It has been suggested that side shoots reduced the number of marketable fruit carried on each cluster and increased the leaf area index and total fruit yield of determinate cultivars (Demers et al., 2007). According to (Appolloni et al., 2023), pruning one or two basal tomato stems increased the proportion of "cat-faced" fruit compared to non-pruned systems. (Kim et al., 2014)discovered that tomato plants with one stem pruned had the longest tomato fruits and more fruits overall.

2.5 Effect of pruning on leaf growth

Pruning is a common agronomic technique for growing tomatoes. Before the plant is harvested, leaves below a cluster are removed, with the timing and intensity determined by the producer's management decisions (Li et al., 2015).Removal of the basal leaves may also have an impact on production by lessening the effect of the lower canopy's less-lit leaves and encouraging the accumulation of assimilates in growing fruits.

According to (Li et al., 2015)'s research, in conditions of high planting density (about 30 cm between plants per row), basal leaves appear to face intense competition for light, making them into sink organs that contribute little to the plants' net photosynthesis. Pruning prior to harvest is not advantageous for fruit development since a bigger spacing (about 50 cm of spacing on the row) can considerably contribute to the generation of assimilates (Roman & Sideman, 2022).

(Demers et al., 1998) found that the photosynthetic flow from sources outpaces sink requirements and that the partial removal of tomato leaves is offset by an increase in the net assimilation rate of the remaining leaves, leaving fruit growth unaffected. There are significant variances regarding the impact of removing leaves and shoots on tomato yield, according to a number of reports. The current study aims to determine whether pruning regime, leaf removal at the fruit turning stage and non-removal along with two lighting regimes control grown in natural light. One that uses supplemental light emitting diode light treatment can significantly alter the function of basal leaves and, as a result, the yield and quality of tomato production will increase. By using the leaf-area control to maximize light transmission in the canopy, it is possible to decrease fruit drop and boost fruit output (Kumar et al., 2019).

However, too much foliar pruning treatments resulted in a reduction in total yield compared to the unpruned control due to a reduced leaf area index that reduced net biomass production in tomatoes. (Lhamo et al., 2022b) reported that plants pruned to two leaves above the raceme produced the greatest number of fruit. According to a study by (Mbonihankuye et al., 2013), tomato plants that have been staked and pruned produce flowers two to three weeks earlier than plants that have not been pruned, which causes fruit to mature and set earlier.

(Kim et al., 2014) noted that pruning raises production costs for plants, improves light penetration within the plant canopy, boosts photosynthetic productivity, and enhances fruit yield. It has been suggested that a greater fruit: leaf ratio produced on fewer leaves, through pruning may boost fruit yield output in a plant. (Mitchell et al., 2019) observed that pruning resulted in a higher flower-fruit ratio in general. Pruning regulates carbon partition, which impacts the ratio and, ultimately, tomato fruitfulness (Richardson, 2012). Early leaf pruning boosted biomass partitioning to the fruit from 57 to 61%, according to (Kempen & Advisor, n.d.). However, in both instances, pruning treatments decreased total yield when compared to the unpruned control because a lower leaf area index decreased the formation of tomato net biomass. According to (Li et al., 2015), yield increased by 40% by postponing the removal of old leaves and raising the leaf area index from 3 to 4. However, beyond a leaf area index of 4, there was minimal difference in gross photosynthesis and maintenance respiration, indicating that tomato producers should prune their plants to maintain a leaf area index of no more than 4. Studies on tomato plants have looked at leaf removal or pruning to promote more even, quick, and robust growth (Decognet et al., 2010).

Pruning old leaves lowers the leaf area index of the entire plant, increasing the leaf area of young leaves, which improves nutrient uptake, generation, and transport of photosynthetic assimilates (Nipa et al, 2020). Moreover, leaf pruning has been shown to hasten the growth of new leaves, advance the time of fruit setting, and hasten fruit ripening by 1.2 days (Gatahi, 2020). Leaf pruning can therefore increase tomato plant strength, growth rate, and output while also enhancing fruit quality (Gatahi, 2020). Moreover, trimming leaves increases both water and fertilizer use effectiveness (Richardson, 2012) The ideal LAI for tomato production is between 3 and 4 (Li et al., 2015). Senescent older leaves should also be removed because doing so prevents weak infections from colonizing them and perhaps spreading to nearby healthy tissues (Jarvis, 1980). Leaf pruning may also increase airflow and alter the microenvironment to make it less favorable for the growth of infections that depend on humidity (Mitchell et al., 2019). Leaf removal speeds up fruit development by increasing their exposure to light, which in turn helps with plant training and fruit harvest.philippe.nicot@avignon.inra.fr.

2.6 Effect of pruning on tomato yield

If the number of side stems and leaves is not restricted, tomato plants will continue to grow vegetatively, suppressing generative growth, which will result in more smaller-sized fruits and lower yields as well as delayed fruit setting (Decognet et al., 2010). If not removed, older leaves increase transpiration that, in turn, inhibits root activity leading in wilting and fruit falling. According to (Thakur et al., 2018), pruning tomato plants could lower production costs, boost yields, and enhance the quality of the fruits. Early pruning of tomato plants (when lateral shoots were 5–10 cm long), delayed pruning (when lateral shoots were 30–36 cm long) or living the plant unpruning resulted in higher early season yields. (Li et al., 2015) emphasized that the quantity of fruit (sinks) per truss has a significant impact on the assimilate translocation in tomato plants to the fruit.

(Olasantan & Salau, 2008) found that the effect of pruning improved both the qualitative and quantitative characteristics of tomato fruits by restricting vegetative development and allowing more light penetration. The main production issue is now the quantity of pruning. From the first fruit cluster ripening until the conclusion of the season, leaves are routinely plucked from the lowest section of the stems (Saiful Islam et al., 2016). This helps maintain an optimal balance between distribution to the harvestable organs (fruit) and other parts of the plant (vegetative).As a result, it assists in preserving an ideal balance between the division of the plant into harvestable organs (fruit) and other plant parts (vegetative).

According to (Kim et al., 2014), the increased availability of nutrients, water, and light to plants made possible by pruning which may be responsible for the longer growth of tomato plants. They reported a maximum individual fruit weight (108.40g) from a single pruned plant (coupled with staking), while unpruned plants had a minimum fruit weight of 69.13g (with staking). According to (Li et al., 2015), reported a maximum individual fruit weight (108.40g) from a single stemmed plant (coupled with staking), while unpruned plants had a minimum fruit weight of 69.13g (with staking). Larger and higher-quality fruits were produced on pruned plants compared to unpruned plants as a result of the greater reproductive efficiency brought on by less competition and more nutrients being transferred to the sink (fruit) (Saiful Islam et al., 2016).

According to (Saunyama & Knapp, 2004), Unpruned plants produced a greater number of fresh, ripe fruits. Yet the pruned tomatoes with two stems at the closest spacing (75 x 75 cm) produced the highest yield (96.08 tons per ha). (Lee & Kennedy, 2020) reported the effect of pruning on tomatoes that increased yield per hectare in the first two or three weeks. (Lee & Kennedy, 2020), also adding that in most experiments early pruning reduced yield per hectare and there will be not increased unless the plants were pruned were closer together than the unpruned. (Appolloni et al., 2023) reported from an experiment that two and three leaf pruned plants gave the best yield than other single leaf pruned plants. (Lhamo et al., 2022a) reported that unpruned plants gave the highest yield (58.09 t/ha) and 43.47 t/ha for pruned plants whose shoots were pinched at 3 months.

Lack of air between leaves and the delay in fruit ripening caused by leaf shade contribute to an increase in disease concerns (Li et al., 2015). According to (Lhamo et al., 2022a), pruning had no discernible impact on tomato yield. Only improved quality and plant health were derived from tomato pruning. The average fruit weight increased significantly when the plants were grown only when two leaves were pruned between two clusters and only one remained at the middle treatment (Li et al., 2015) achieved maximum fruit weight (89.19g) in single-leaf pruned plants, while fruit weight was lowest in unpruned plants (63.07). Therefore, it is believed that proper pruning can affect tomato production.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Site

The experiment was conducted in a greenhouse at Greystone farm, at 23 km peg from Harare CBD along Seke road. The soil of the area is Alfisol. The site is situated at an altitude of approximately 1600m above the sea level, with coordinates of (-18.04504482S) and (31.15748232 E). The annual rainfall amount in the region ranged from 500 to 1000mm with an average annual amount of 545.9mm (Metrological Services, Harare 2007). The average annual temperature is 18 Degrees Celsius. The area is in agro-ecological region II in Mashonaland East Province in Seke district. The terrain is relatively flat with a slope of less than or equal to 2 % making it suitable for greenhouses insulation.

3.2 Experimental design

(The experiment was conducted in a greenhouse with dimensions of (8x7) m which can carry about 600 plants). The trial was laid out in a Randomised Complete Block Design (RCBD) with three replications and five treatments. The five treatments were comprised of different pruning systems:

TI =Control-no pruning

T2 =pruning one leaf below each cluster on a plant

T3=pruning one leaf above each cluster on a plant

T4=pruning one leaf above and one leaf below each cluster

T5= pruning two leaves and living one leaf between two clusters

Table 1 experimental layout

T3	
T1	

T4	R1
T5	
T2	
T4	R2
T5	
T2	
T3	
T1	
T1	R3
T5	
T4	
T2	
T3	

TREATMENT INFORMATION

TI =Control no pruning

T2 =pruning one leaf below each cluster on a plant

T3=pruning one leaf above each cluster on a plant

T4=pruning one leaf above and one leaf below each cluster

T5= pruning two leaves between two clusters and living one at the middle

3.4 EXPERIMENTAL PROCEDURE:

3.4.1 Procurement of seedlings

Candela F1 seedlings were purchased from Blooming Gardens, which is a reputable nursery farm known for selling high-quality seedlings and is located along Mutoko road.

3.4.2 Land preparation

The land was prepared by digging and leveling to make a fine tilth. The stations for planting were designated a day before transplanting. During transplanting, holes were dug in the middle of a ridge and mono potassium phosphate was applied at a rate of 80 kg per hectare. The tomatoes were grown on a large raised ridge, which are divided into fifteen plots by smaller ridges running between them, 18 meters long by 0.8 meters wide results in a gross plot size of 14.4 meters and a net plot area of 18 meters. In order to make weeding, harvesting, pruning, trellising, spraying, and other operations easier, path between plots measuring 0.3 m by 0.5 m has been left the ridges.

3.4.3 Transplantation

Tomato seedlings were transplanted when they were 15 cm tall, with 4 leaves, and 0.5 cm in diameter. The seedlings were planted at 8 cm deep. In order to prevent transplanting shock, each plant was watered within a short period of time at a field capacity. Only strong, uniform, and healthy seedlings were transplanted into the field to ensure their survival.

3.4.4 Water and fertilizer application

Plants were watered using drip irrigation, and water tanks were elevated above the field level to enable natural flow of water, chemicals and nutrients. From week one to week four, mono ammonium phosphate fertilizer 80kg per hectare, ammonium nitrate 30kg per hectare, and winstart 20 kg per hectare were applied. From week five to week ten, mono potassium phosphate at 80kg per hectare, calcium nitrate 30kg per hectare, magnesium sulphate 45kg per hectare, and winbloom were applied. By this point, the plant had reached the flowering stage. At the harvesting stage, potassium nitrate 45kg per hactare, calcium nitrate 30kg per hectare, and winbloom 40kg per hactare were administered starting from week eleven.

3.4.5 Pest and disease control

The primary pests found in the greenhouse were the white fly (*Bemisia tabaci*), caterpillar American boll worm (*helicoverpa spp.*, *heliothis punctigera*), and leaf miners (*Tuta absoluta*). To manage these pests, imdachloprid, methomyl, acaterid cartap, and belt, were utilized. Non-chemical methods such as irrigating with clean water, controlling moisture levels, and properly disposing of plant residues, were employed to reduce pests and diseases. The use of pesticides carried out in accordance with pest identification. Copper oxychloride 80grams per 16 litre, chlorothalonil 30ml / 16 litre, chemlaxyl 50grams / 16 litre and tebuconazole 14ml / 16 litre were rotated on weekly basis to control diseases like fusarium wilt (*Fusarium lycopersicum*), septoria leaf spot (*Septoria lycopersici*), fusarium crown (*Fusarium oxysporum sp*) and other related fungal diseases . Every sixth weeks, Kobe 8ml/16L, amistar top 8ml/16L, and wettable sulphur for spore kill were sprayed.

3.4.6 Pruning

Leaf and sucker pruning was carried out sequentially at fortnightly interval in accordance with the treatments starting, from three weeks after the plant had established.

Figure 3.1 shows the presenter during pruning

3.4.7 Weeding

As drip irrigation exclusively focused on providing water directly to the plant station, there were less weeds as a result of the water shortage to the weeds. A hoe and hand pulling were used to control a flush of weeds which that were more than 5 cm tall because other mechanical weeding would harm the roots and impede plant growth.

3.4.8 Trellising

Two weeks after transplantation, trellising was carried out. To prevent tomato winding, a string was connected at beams of the greenhouse and clipped to the bottom of each plant. To maintain the upright posture of the entire plant, a string was wound around the stem.

3.4.9 Harvesting

Harvesting commenced when the tomato fruit turned pink, red, or green breaker and it was carried out continuously harvested throughout the cycle. To preserve the health of the plants harvesting was done by hands and it was carried out twice a week. Tomatoes were sorted by size and color to maintain uniformity.

3.5 Data collection

Three weeks after transplanting data collection from each plot began. Three randomly selected plants in each plot were tagged for repeated measurements.

3.5.1 Plant height:

The plant height was measured using tape measure from the ground to the tip of the main stem

3.5.2 Stem girth and leaf girth:

A Vernie caliper was used to measure the stem girth and leaf girth of all the selected plants, and the total was divided by number of tagged plants.

3.5.3 Leaf area index (LAI):

A ruler to measure the length and width of several tomato leaves within the canopy was used. A Length and width measurements was multiplied to obtain the area. Sum of the areas of all the leaves in a canopy was divided by the ground area covered by the canopy to obtain the LAl.

3.5.4 Number of Flowers per plant:

The number of flowers were counted from lower, middle and upper cluster and then divided by the number of selected plants.

3.5.5 Number of Fruit per plant:

The total numbers of fruits on all the tagged plants were counted and then divided that total by number of selected plants.

3.5.6 Fruit Diameter (cm):

Six fruits of different sizes (very large, large, medium, small and very small) were chosen from each tagged plant and the diameter of each fruit was measured by using vernier caliper.

3.5.7 Weight of Fruit (g):

This was obtained by dividing total fruit fresh mass per plant by the total number of fruit per plant.

3.5.8 Yield per Hectare (Ton):

The total yield per hecter was obtained by converting the fruit yield obtained from the gross plot size of (32.4 m^2) into hectare. At each harvest, all the fruits were harvested from the net harvest area and the total fruit yield of successive harvests was converted into hectare.

3.6 Data analysis

Data were subjected to ANOVA to detect least significant differences (LSD) between the means using GenStat 12th edition. Means were separated by LSD at 95% level of significance.

TABLE 2 SKELETAL ANOVA TABLE

	Degrees of freedom	**Sum of squares**	**Mean squares**	**F value**	**probability**
Replication	**3-1=2**				
Treatment	**5-1=4**				
Error	**14-6=8**				
total	**14**				

CHAPTER FOUR

Results

The objective of the experiment was to determine the effects of leaf pruning on tomato plant growth and productivity.

4.1 Plant height growth rate

Leaf pruning had a significant effect on plant height growth rate. (p0.001) leaf pruning treatments of *Lycopersicon esculentum* **(Figure 4.1)**

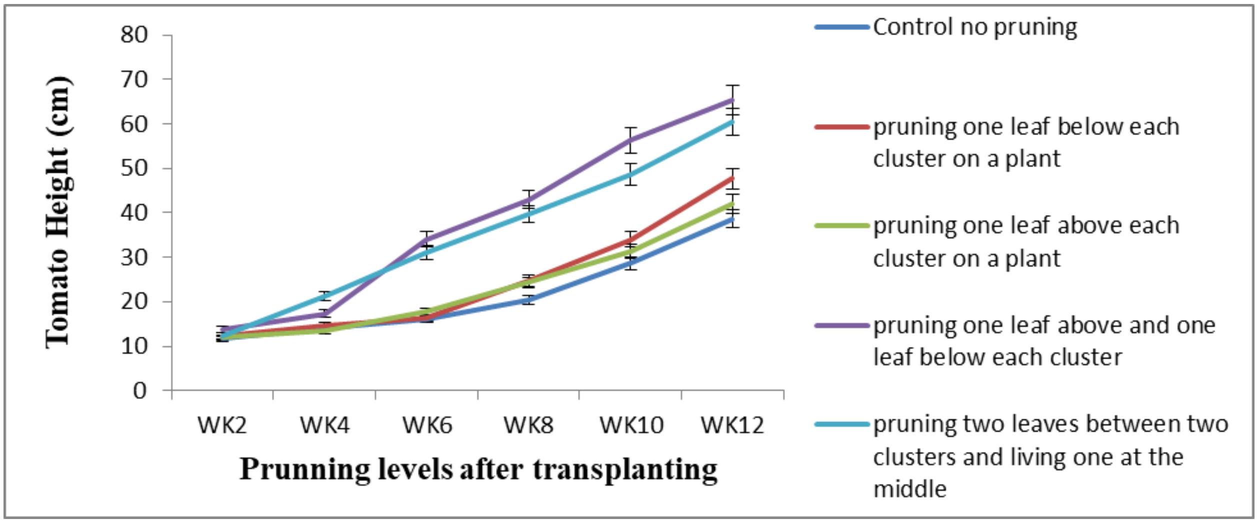

Figure 4.1 Effect of leaf pruning on plant height

Plant height was varied significantly due to leaf pruning from week two, three, four five and six except at week one. At week two, treatments were statistically similar across all the treatments. The longest (12.67) plant height was recorded from pruning one leaf above and one leaf below each cluster and the shortest (12) plant height was found from pruning two leaves between two clusters and living one at the middle. At week four, the shortest (13.5) plant height was recorded from pruning one leaf above each cluster on a plant and the longest (21.33) plant height was recorded from pruning two leaves between two clusters and living one at the middle. Shortest (16) at eighth week, (20.33) at tenth week and (28.67) was recorded from unpruned (control) while longest (34) at fourth week, (43) at tenth week and (56.33) at twelfth week was recorded from pruning one leaf above and one leaf below each cluster.

4.2 Stem girth growth rate

The results on stem girth showed a significant effect ($p<0.001$) between leaf pruning treatments of *Lycopersicon esculentum* **(Figure 4.2).**

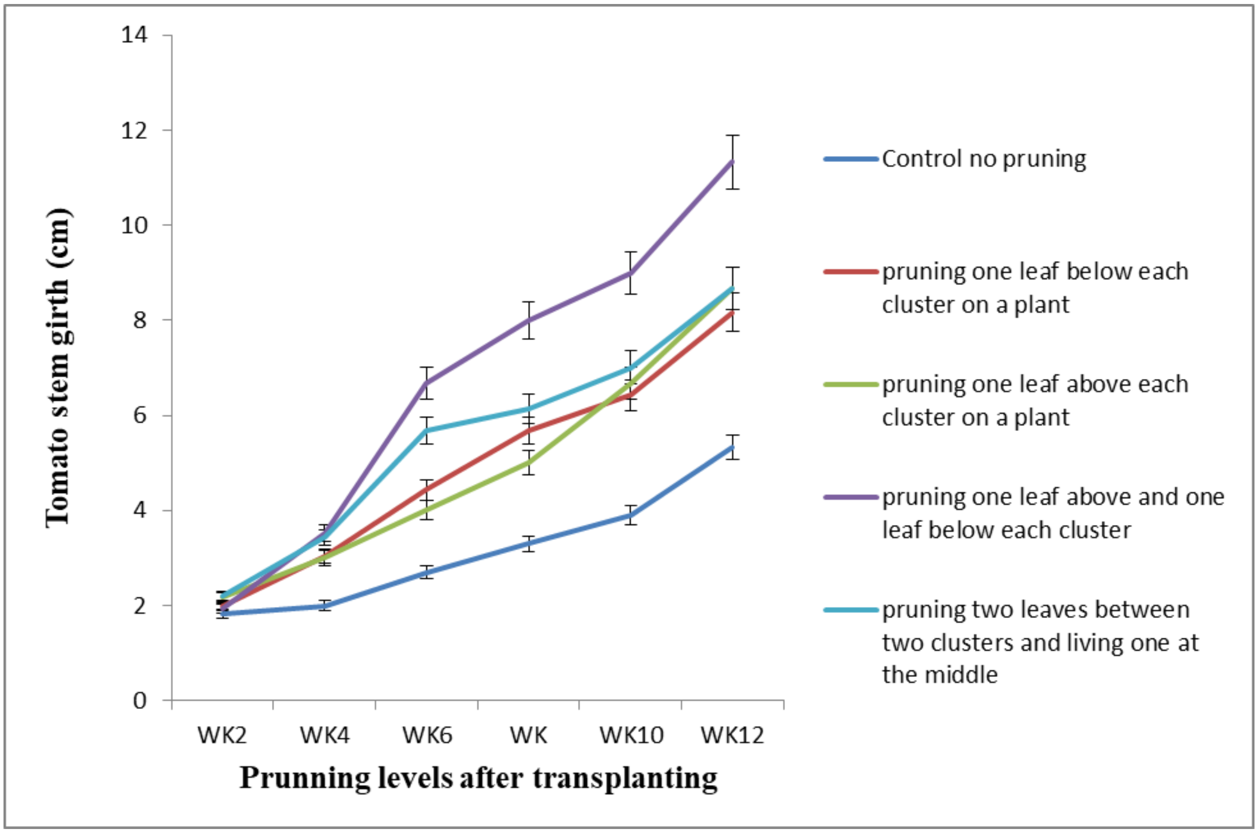

Figure 4.1 Effect of leaf pruning on plant girth

The stem thickness of each plant varied significantly due to leaf pruning except at week one which were statistically identical. At week one, the thickest 2.7 stem girth was recorded from pruning one leaf above each cluster on a plant and thinnest 1.93 stem girth was recorded from pruning two leaves between two clusters and living one at the middle. Thinnest (2.7) at week two, (3.3) at week third week, (3.9) at fourth week and (5.33) sixth week stem girth were recorded from unpruned and thickest (3.53) at week two, (6.67) at week third week, (8) at fourth week, (9) at fifth week and (11.33) at sixth week stem girth were recorded from (pruning one leaf above and one leaf below each cluster).

4.3 Leaf length growth rate

The results on leaf length showed a significant effect ($p<0.001$) between leaf pruning treatments of *Lycopersicon esculentum* **(Figure 4.3).**

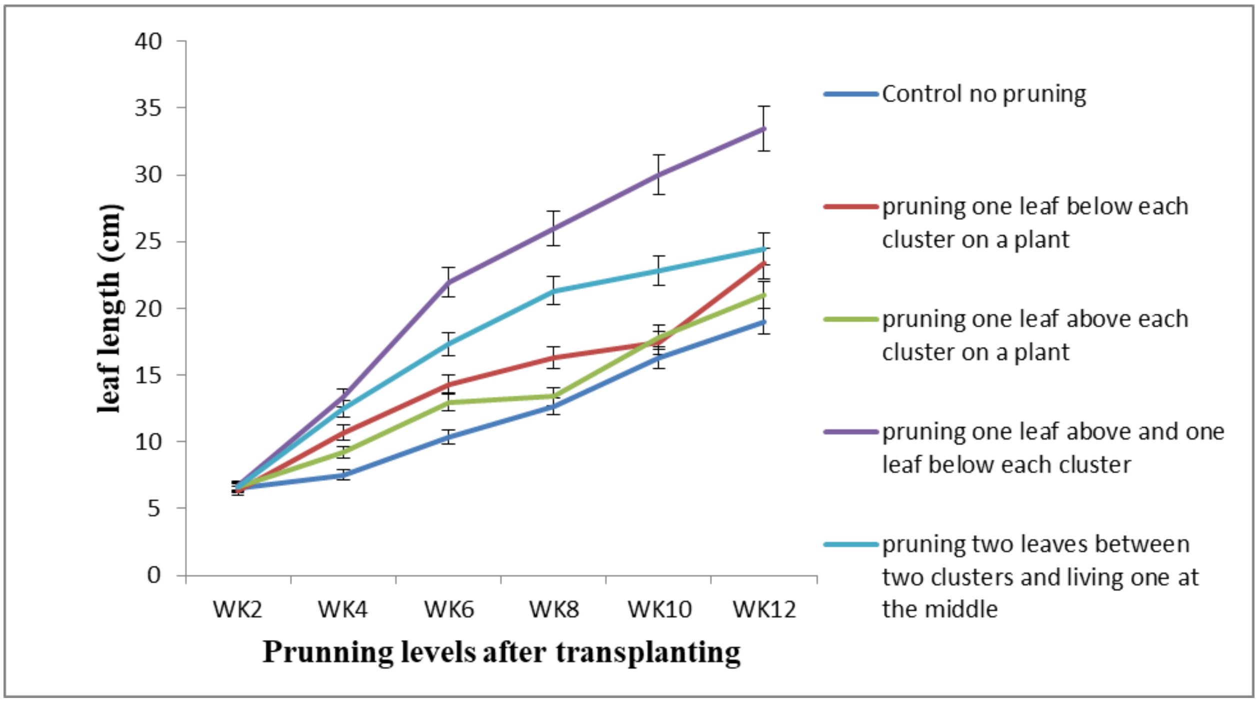

Figure 4.2 Effect of leaf pruning on leaf length

Leaf length was varied significantly due to leaf pruning week four, six, eight, ten and twelve except at week two. At week two the shortest 6.3 leaf length was recorded from pruning two leaves between two clusters and living one at the middle and longest 6.7) leaf length was recorded from pruning one leaf above each cluster on a plant. Shortest (7.5) at week four, (10.33) at week six, (12.67) at week eight, (16.33) at week ten and (19) at week twelve leaf length were recorded from control treatment (unpruned) and longest (13.33) at week four, (22) at week six, (26) at week eight, (30) at week ten and (33.5) at week twelve leaf length were recorded on pruning one leaf above and one leaf below each cluster.

4.4 Leaf area index

The results on leaf area index showed a significant effect ($p<0.001$) between leaf pruning treatments of *Lycopersicon esculentum* **(Figure 4.4).**

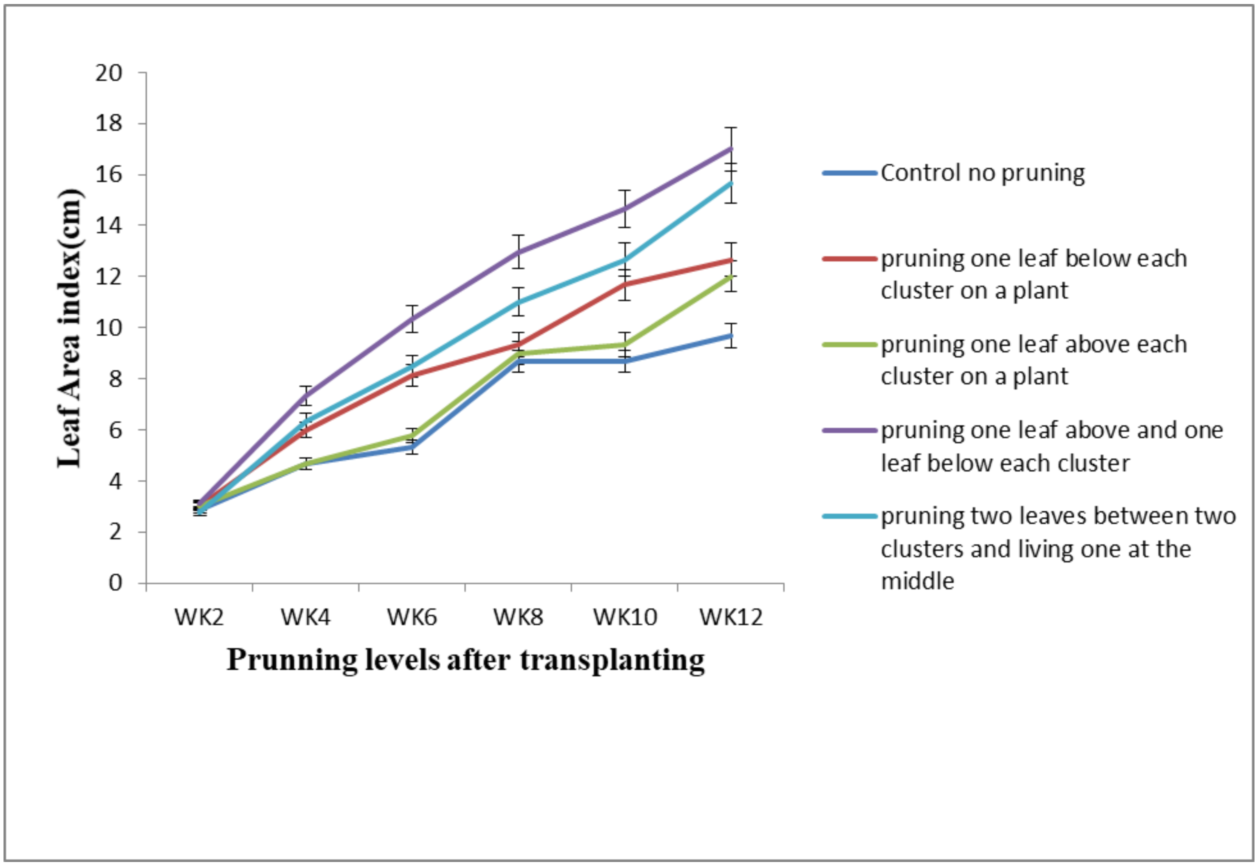

Figure 3.4 Effect of leaf pruning on leaf area index

The leaf area index of tomato was significantly affected by leaf pruning except at week two where there was statistically similar across all the treatments. At second week, the lowest (2.7) leaf area index obtained from pruning two leaves between two clusters and living one at the middle and highest (3.1) leaf area index was found from pruning one leaf above each cluster on a plant. At week four lowest (4.67) leaf area index, recorded from unpruned and from pruning one leaf above each cluster on a plant and the highest (7.33) was recorded from pruned one leaf above and one leaf below each cluster. The lowest 5.33 at week eight, (8.67) at week ten and (9.67) leaf area index at sixth were recorded from unpruned and highest (10.33) at week six, (12.97) at week eight, (14.67) and (17) leaf area index at week twelve were recorded from pruned one leaf above and one leaf below each cluster.

4.5 Fruit diameter

The results on fruit diameter showed a significant effect ($p<0.001$) between leaf pruning treatments of *Lycopersicon esculentum* **(Figure 4.5).**

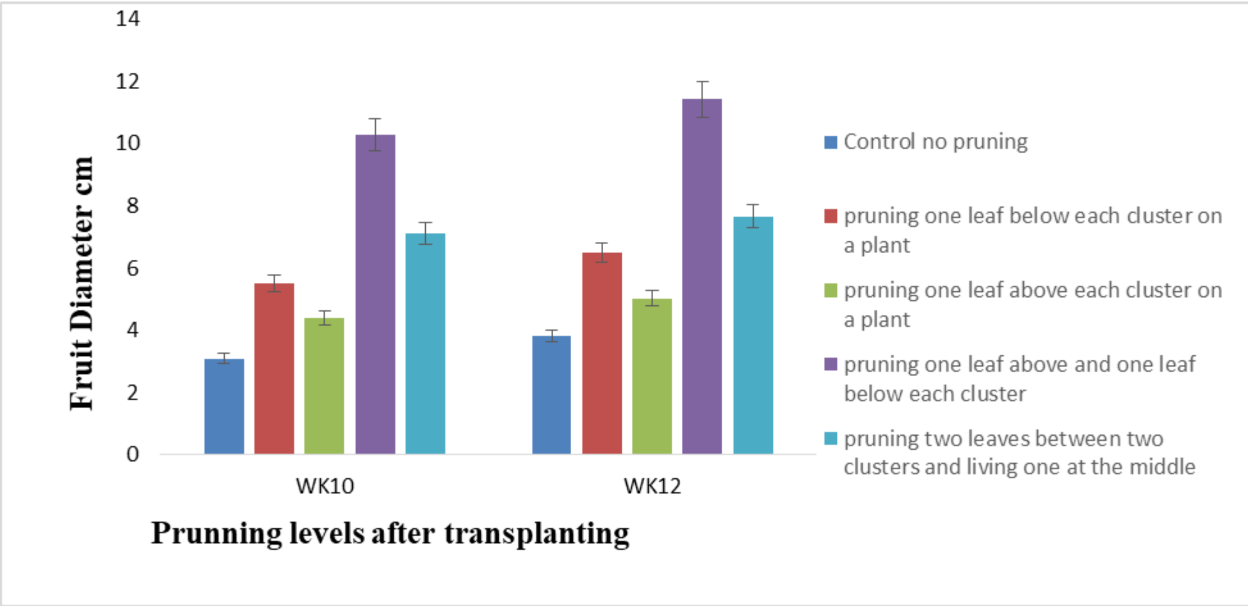

Figure 4.4 Effect of leaf pruning on fruit diameter

Diameter of fruit showed significant differences across all the treatments due to leaf pruning. The highest (10.27) fruit diameter at week ten and (11.43) at week twelve, diameter were recorded from treatment pruned one leaf above and one leaf below each cluster, while the smallest (3.1) at week ten and (3.83) at week twelve diameter were recorded on from unpruning and treatment 5 (pruning two leaves between two clusters and living one at the middle) showed moderate (7.67) recorded at six week fruit diameter.

4.6 Flower number

The results on number of flowers showed a significant effect ($p<0.001$) between leaf pruning treatments of *Lycopersicon esculentum* **(Figure 4.6).**

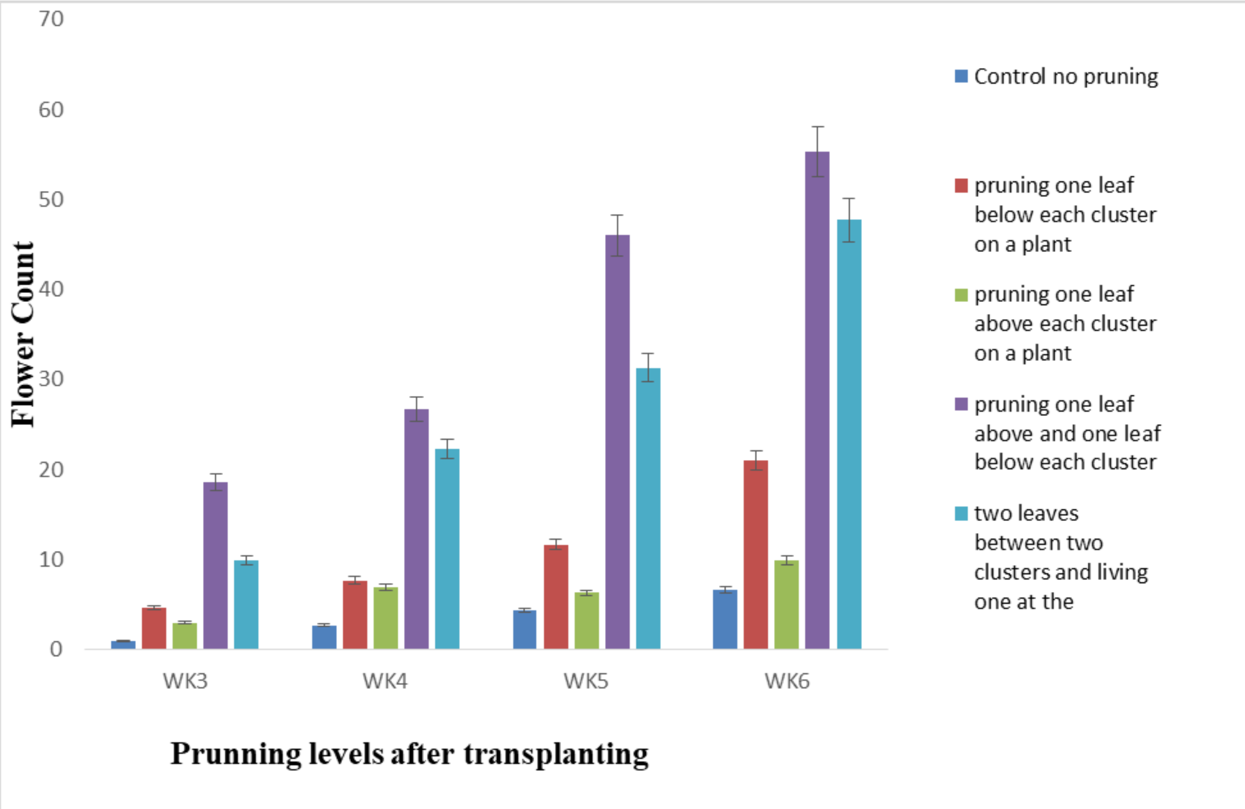

Figure 4.5 Effect of leaf pruning on flower number

Number of flowers per plant varied significantly due to leaf pruning. The minimum (2.7) at week eight, (4.33) at week ten and (6.7) at week twelve number of flowers per plant was recorded from control (no pruning), while the maximum (26.7) at week eight, (46) at week ten and (55.3) at week twelve number of flowers per plant was recorded from pruning one leaf below each cluster and one leaf above each clusters and pruning two leaves between two clusters and living one at the middle was at average across all the treatments.

4.7 Fruit number

The results on fruits number showed a significant effect ($p<0.001$) between leaf pruning treatments of *Lycopersicon esculentum* **(Figure 4.7).**

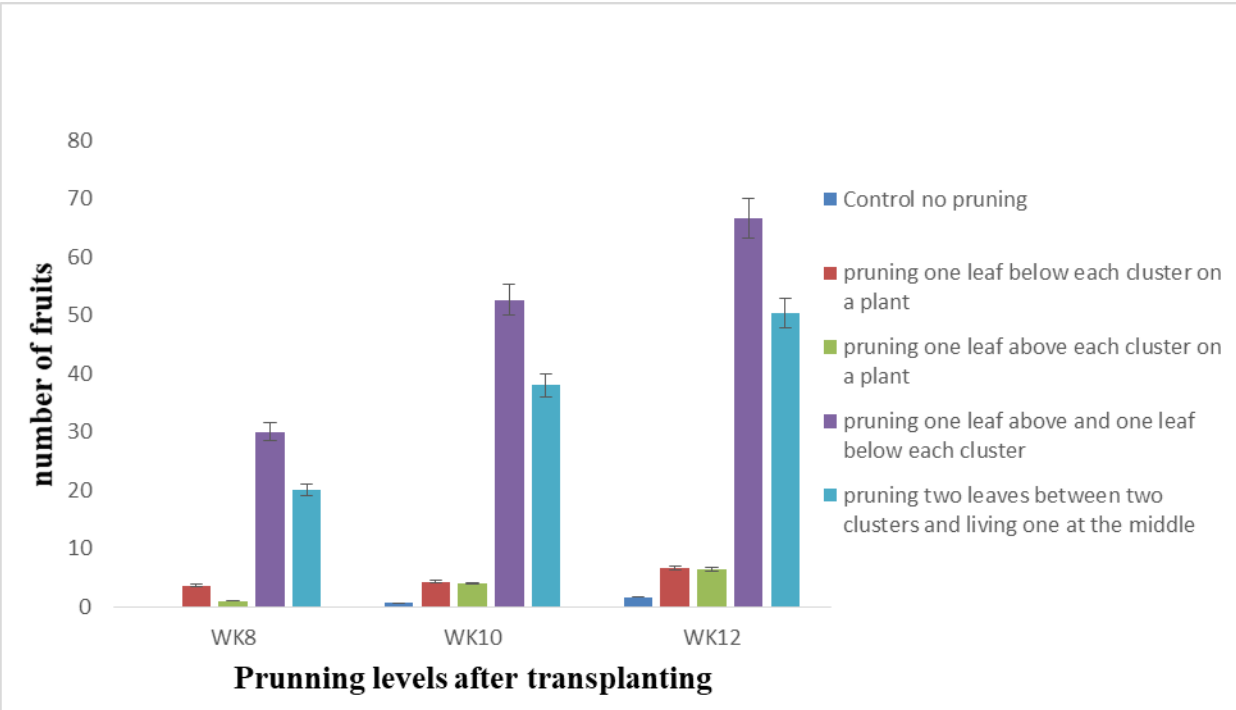

Figure 4.6 Effect of leaf pruning on fruit number

Number of fruits per plant varied significantly due to leaf pruning. No fruit was recorded at week eight, (0.67) at ten week and (1.67) at week twelve was recorded from unpruned (control). Pruning one leaf below each cluster on a plant (treatment 2) and pruning one leaf above each cluster on a plant (treatment 3) were statistically similar at week ten T2 (4.33), T3 (4) and at week twelve T2 (6.67) and T3(6.33) were recorded. The maximum (30) at week eight, 52.67 at week ten and 66.67 at week twelve was found from pruned one leaf above and one leaf below each cluster.

4.8 Yield

The results on yield showed a significant effect ($p<0.001$) between leaf pruning treatments of *Lycopersicon esculentum* **(Figure 4.8).**

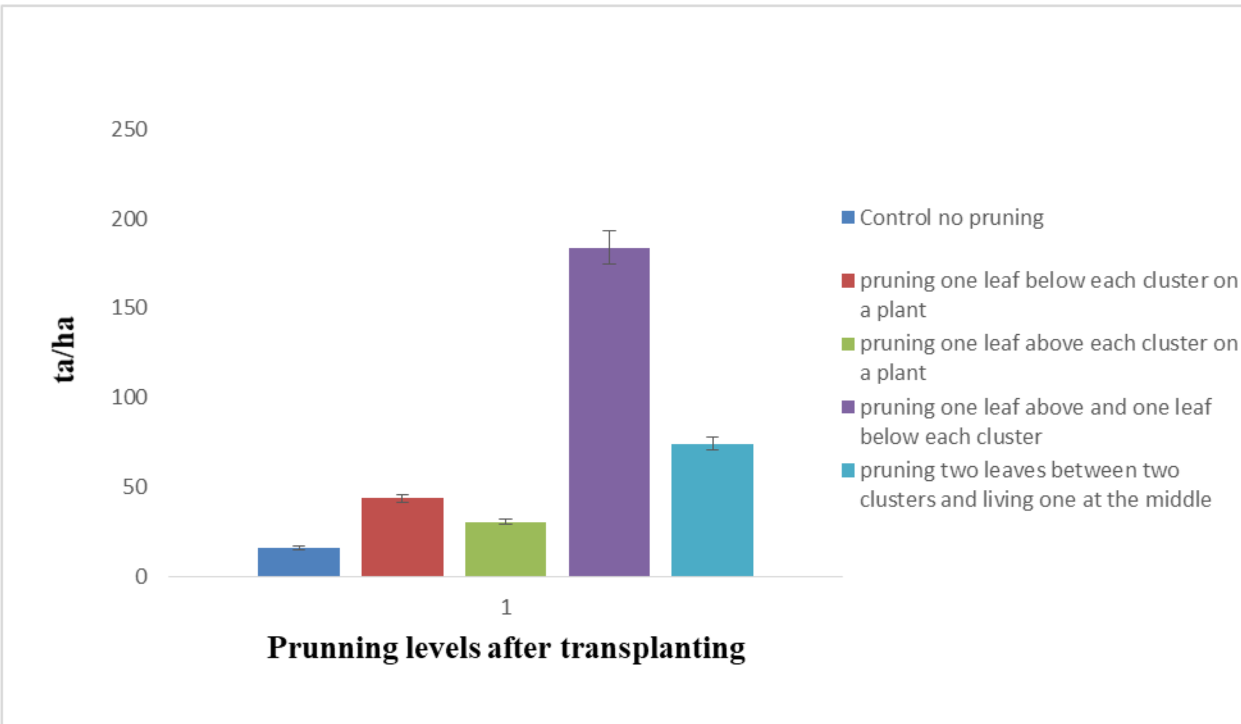

Figure 4.7 Effect of leaf pruning on yield

Yield per hectare showed significant differences due to leaf pruning of tomato plant. The highest (183.8 t/ha) yield was recorded from pruned one leaf above and one leaf below each cluster, while the lowest (16 t/ha) yield was recorded from control treatment (no pruned) which was not evenly statistically identical to all other treatments.

CHAPTER FIVE

5.0 Discussions

5.1 Plant height growth

Shortest (16 cm) at eighth week, (20.33 cm) at tenth week and (28.67 cm) was recorded from unpruned (control) while longest (34 cm) at fourth week, (43 cm) at tenth week and (56.33 cm) at twelfth week was recorded from pruning one leaf above and one leaf below each cluster. Leaf pruning gives best results on plant height by improved light interception, improved stress tolerance, increased biomass and because of carbohydrate metabolism, which caused higher sugar content and lower acidity in the fruit. From the plant physiology, plant pruning led to increased root growth and water uptake which maintain water balance.

5.2 Stem growth and leaf girth

Stems girth and leaf girth became thicker due to the accumulation of assimilated products when pruning tomatoes grown in greenhouse conditions. The stem was the main sink organ for nutrient uptake from the source leaf. Although the accumulation of assimilation products may differ depending on the cut of the tomato leaves and treatment 4 (pruned one leaf above and one leaf below each cluster), which could have reduced the sink-to-source ratio of the vegetative organ. Treatments 5 (pruning two leaves between two clusters and living one at the middle) showed intermediate performance across all parameters.

5.3 Leaf length

Pruning level affected the size of leaf, pruning one leaf above and one leaf below each cluster having the longest leaf, and no pruned plants having the shortest leaf. This shows that leaf pruning encourages the growth due to the photosynthetic efficiency, as in pruned plants, many leaves were removed, there was limited competition between leaves, leading to good assimilation and hence to bigger leaf length. In unpruned plants there was competition within canopy resulting in reduced leaf length. This situation shows that the more plant leaves, the smaller the leaf size becomes. The results show that the pruning one leaf above and one leaf below each cluster might probably increase the period of vegetative and productive stages in tomato plants by making available more assimilates for the fruit set period on tomato plants because of reduced completion within the plant stems.

5.4 Leaf area index

Pruning directly stimulates the formation of enlarged leaves pruned one leaf above and one leaf below each cluster, increases mesophyll size and moisture content as well as lengthens the period of stomata opening this was said by (Santos, 2008). Furthermore, prune one leaf above and one leaf below each cluster showed pruned tomatoes produced the highest fruit weight per plant because of the photosynthetic flux from the sources exceeds the needs of the sink and that the partial removal of tomato leaves is compensated by an increase in the net assimilation rate of the remaining leaves. In contrast to previous research showing that many leaves do not contribute to crop photosynthesis (Li et al., 2015), we believe that pruning one leaf below each cluster on a plant significantly increased fruit production as leaves below each cluster are parasitic to fruits.

5.5 Fruit diameter

Fruit diameter of tomato was significantly affected by the interaction effects of stage treatments and intensity of leaf pruning. The pruned one leaf above and one leaf below each cluster from transplanting up to harvesting stage produced fruit with the thickest while the control gave the least. Providing all fruit with assimilates is sufficient to sustain most fruit growth. Heuvelink and Buiskool (1995) emphasized that the assimilation translocation of a tomato plant to fruit depends strongly on the number of leaves per panicle.

5.6 Flower number

The reduction in the number of flowers per plant under severely defoliated conditions has been hypothesized to be due to reduced production of assimilation and translocation through a reduction in leaf area. When the leaves are trimmed, it reduces the plant's overall leaf area and the amount of photosynthetic surface area available for the production of carbohydrates. Reduction in carbohydrate production causes the plant to shift its focus to reproduction growth, and resulting in an increase in flower number. The reduction of leaf area decreases the rate of transpiration and this leads to an increase in the concentration of abscisic acid in the plant tissue and ABA also associated with flower formation.

5.7 Fruit number

Therefore, we hypothesize that the number of leaves had a greater impact on the size of fruits affected by both fruit set and translocation than on the number of flowers. This agrees with (Mbonihankuye et al., 2013) who also found that the more pruning, the fewer the number of flowers per plant, but the larger the fruit. Leaf pruning maintains a better balance with the root system and usually produces larger fruits than growing the plant into a bush. Fruit counts appear to be low in the no-pruning control treatments, and yield responses differ by leaf count. Therefore, pruned one leaf above and one leaf below each cluster showed that pruning the number of leaves is the most important as it improves light penetration into the crop canopy, and increases photosynthetic efficiency and fruit yield. These observations support the findings of (Thakur et al., 2018), the effect of pruning on the quantitative and qualitative traits of tomatoes showed that pruning restricted vegetative growth, allowing greater light penetration and thus improving the qualitative and quantitative traits of tomato fruit.

5.8 Yield

Treatment 5 (pruning two leaves between two clusters and living one at the middle) showed that aggressive leaf pruning alters the source/sink ratio of vegetative growth to fruit production. While sufficient levels of vegetative growth are required for photosynthesis which was shown by treatment 4(pruned one leaf above and one leaf below each cluster), overgrowth can waste plant productivity. Pruning two leaves between two clusters and living one at the middle on the main stem proved a moderate profit. This helps maintain an optimal balance between distribution to the harvestable organs (fruit) and other parts of the plant (vegetative).

Leaf pruning increase the ratio of cytokinins to auxins in the plant tissue. Cytokinins to auxins increases, it favors the development of floral buds over vegetative growth. Cytokininis are hormones that promote cell division and are associated with the development of floral which is the component of yield the reduction in leaf area increases the plant conopy, which stimulates the production of gibberellin that promotes stem elongation and vegetative growth, but when there is insufficient carbohydrate production to support vegetative growth, the plant shifts its focus to reproductive growth.

CHAPTER SIX

6.1 Conclusion

In the autumn experiment, growth and yield of tomato plants were mainly influenced by the number of leaves per plant but also by the number of leaves between the clusters. In general, leaf area index, leaf girth, leaf length, number of flowers, number of fruits and stem thickness progressively increased with decreasing number of leaves per plant. In treatments where one leaf was pruned above and one leaf below each cluster area, fruit weight and individual fruit diameter increased as the number of leaves decreased. On control treatment (unpruned), was produced poor results across all parameters.

6.2 RECOMMENDATONS

Farmers are recommended to adopt pruning one leaf above and one leaf below each cluster since it have some positive effects. Farmers are recommended to start pruning at transplanting when they are young up until harvesting stage, as this will help the plant to develop a strong structure and produce more fruits. Prune one leaf above and one leaf blow each cluster as on treatment two, reduces parasitic leaves, that using up valuable resources that could be used to produce much and bigger fruits. Pruning one leaf above and one leaf below each cluster increases water use efficient as it is expose tiny stomata of flowers, fruits and other leaves and could not close for longer period unlike on unpruned treatment. Not pruning some leaves as on unpruned treatment will keep dense air around the plant, of which pruning increases carbon dioxide circulation needed for the process of photosynthesis to produce glucose, the primary source of energy for plant. Higher levels of carbon dioxide circulation can also increase the rate of photosynthesis, leading to faster plant growth and more yield.

Table1. Shows a timeline on the activities done during the course of the research

MONTH	Nov	Dec	Jan	Feb	Mar	April	May
ACTIVITIES							
Preparation and Sowing							
Spraying and weeding							
Other agronomic aspects							
Data collection							
Data analysis and submission							