GROWTH AND YIELD OF CUCUMBER (*Cucumis sativus*) INFLUENCED BY STEM PRUNING AND FOLIAR APPLICATION OF ZINC

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BY

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CERTIFICATE

This is to certify that the thesis entitled ***"GROWTH AND YIELD OF CUCUMBER (Cucumis sativus) INFLUENCED BY STEM PRUNING AND FOLIAR APPLICATION OF ZINC"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***HORTICULTURE,*** *embodies the results of a piece of bona fide research work carried out by* ***SHABUJ KUMAR BISWAS,*** *Registration. No.* ***11-04288*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

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ABSTRACT

An experiment was conducted during the period of April to June 2016 at Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh to evaluate the effect of stem pruning and foliar application of Zn on growth and yield of cucumber. The experiment was laid out in the Randomized Complete Block Design with three replications. Treatment as four levels of zinc application i.e. Z_0=No spray, Z_1= 20 mg/l, Z_2= 30 mg/l, Z_3= 50 mg/l; and three levels of stem pruning i.e. P_0= No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches which in combination made 12 treatment combination. Application of zinc resulted the highest vine length, number of leaves, number of fruits, individual fruit weight, fruit yield (36.44 t ha^{-1}) from Z_2 treatment. In case of pruning the highest vine length, number of leaves, number of fruits, individual fruit weight, fruit yield ((37.16 t ha^{-1}) from P_1 treatment. The combined effect of P_1Z_2 gave the best result for all vegetative and reproductive growth and development i.e. vine length (179.03cm), total number of fruits (20.49) and fruit yield (40.66 t ha^{-1}). So the combination of P_1Z_2 found better to cultivate cucumber.

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AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
Co	Cobalt
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAE	Department of Agricultural Extension
DAS	Days after sowing
et al.	And others
FAO	Food and Agriculture Organization
HI	Harvest Index
MoP	Muriate of Potash
NS	Non significant
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
Wt.	Weight

CHAPTER I

INTRODUCTION

Cucumber *(Cucumis sativus)* is an annual trailing vine vegetable belongs to the family cucurbitaceae. It is a vine that bears cucumiform fruits that are used as vegetables. There are three main varieties of cucumber: slicing, pickling, and seedless. Within these varieties, several cultivars have been developed. The cucumber is originated from South Asia, but now grows on most continents. Many different types of cucumber are traded on the global market.

Most cucumber cultivars, however, are seeded and require pollination. Thousands of hives of honey bees are annually carried to cucumber fields just before bloom for this purpose. Cucumbers may also be pollinated by bumble bees and several other bee species. Most cucumbers that require pollination are self-incompatible, so pollen from a different plant is required to form seeds and fruit. Some self-compatible cultivars exist that are related to the 'Lemon' cultivar. Symptoms of inadequate pollination include fruit abortion and misshapen fruit. Partially pollinated flowers may develop fruit that are green and develop normally near the stem end but are pale yellow and withered at the blossom end. Traditional cultivars produce male blossoms first then female in about equivalent numbers. Newer gynoecious hybrid cultivars produce almost all female blossoms. They may have a pollenizer cultivar interplanted, and the number of beehives per unit area is increased, but temperature changes induce male flowers even on these plants, which may be sufficient for pollination to occur. In a 100-gram serving, raw cucumber (with peel) is 95% water, provides 67 kilojoules (16 kilocalories) and supplies low content of essential nutrients, as it is notable only for vitamin K at 16% of the Daily Value.

Foliar spraying of microelements is very helpful when the roots cannot provide necessary nutrients. According to Kołota and Osińska,(2001) foliar feeding is an effective method of supplying nutrients during the period of intensive plant growth when it can improve plants mineral status and increase crop yield. Narimani *et al.* (2010) reported that foliar application of microelements improves the effectiveness of microelements. Amino acids accumulated in plant tissues and protein synthesis decline by zinc deficit. Zn is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes. Zinc also plays an important role in the production of biomass. Furthermore, Zinc may be required for chlorophyll production, pollen function and fertilization. Moghaddasi *et al*. (2017) suggested that shoot and root growth as well as yield was higher for zinc application. Proper supply of zinc helped to get higher vegetative growth as well as yield in cucumber crop (Deshmukh, 2014). Kazemi (2013) stated that the foliar application of zinc directly involved in vegetative and reproductive growth, fruit quality and yield of cucumber plants. Dominy (2010) reported that zinc and manganese have long been considered as essential micronutrients to plant growth, yet the interactions of the two nutrients on growth and development of plants have not been elucidated in their entirety.

Unmarketable fruit is the problems for cucumber production in Bangladesh due to lower pollen production, fertilization and yield reduction. The growth of plants and other factors can be modified by pruning according to human desires (Jarrick, 1986). There are many purposes for vine pruning treatments in cucumber, such as mechanical harvesting, hybrid seed production, to easily control insect and diseases, to use the higher plant population without significant yield reduction and to obtain uniform fruits (Humphries and Vermillion, 1994). Vine pruning directly helped in the growth and yield of cucumbers in acid soil (Mardhiana *et al*., 2017). Vine pruning increased total yield, yield per plant, number of fruits per plant, average fruit weight per plant in cucumber crops (Khoshkam, 2016). Data on fruit number, fruit mass, unmarketable yield, marketable yield and total yield was higher in vine pruning area (Maboko *et al*., 2011). McFadyen *et al*. (2011) stated that total stem, fruit set and non-structural carbohydrates (TNSC) over time and yield were maximum in vine pruning treated plots. The unpruned plants produced the highest total number of fruits, marketable and non-marketable fruits while the weight, length and diameter of fruits were highest on one stem pruning (Ekwu and Utobo, 2010). Utobo *et al*.

(2010) reported that the significant differences in some vegetative growth parameters were found between the cucumber varieties due to vine pruning.

OBJECTIVES

Considering the above facts, the present experiment was undertaken with the following objectives:

1. To evaluate the effect of foliar spraying of Zn on the growth, yield, fruit quality of cucumber fruit.
2. To evaluate the effect of stem pruning on flowering, fruiting and quality fruit production of cucumber.
3. To study the interactions between different Zn doses and pruning on flowering, fruiting and yield of cucumber.

CHAPTER II

REVIEW OF LITERATURE

3.1 Effect of Zinc

Finding of Moghaddasi *et al*. (2017) suggested that the zinc oxide-engineered nanoparticles (ZnO ENPs) have received the most attention in recent years. This increasing interest has been directed towards studying the environmental fate and effects of ZnO ENPs on ecological terrestrial species. In this study, ZnO NPs were synthesized by atmospheric pressure solution evaporation method and were coated or uncoated with humic acid (HA). The root uptakes of uncoated and HA-coated ZnO NPs and zinc (Zn) were investigated by gel-grown cucumber. Two ZnO levels (1 and 200 μM) were applied in the form of coated (T_3) and non-coated (T_2) NPs or bulk particles (T_1). The results showed that coating NPs by HA increases zeta potential of NPs and decreases their aggregation size due to the increase in the repulsion forces among the particles. Addition of 1 mgl^{-1} ZnO into gel chamber enhanced root and shoot biomass; however, the shoot growth was higher in the presence of NPs compared to its bulk counterpart. Moreover, greater phytotoxicity of ZnO from the source of NPs than bulk particles in shoot was observed. Scanning electron microscopy results showed a clear evidence of the penetration of NPs into root cells.

Küçükyumuk *et al*. (2014) reported that three levels of zinc fertilization (0, 5, 10 mg/kg) and an arbuscular mycorrhizal (AM) fungus Glomus intraradices were tested for their potential to control Pythium deliense on inoculated cucumber seedlings. Plant Zn, N, P, K, Mg, Ca, Fe, Mn, Cu contents, dry and fresh weights of plant and roots and disease severity were determined in the study. Resistance to Pythium rot was determined with the application of mycorrhiza with increasing doses of zinc. Zinc and mycorrhizal fungus applications had significant effects on plant nutrition except for K and Cu. While the highest N and P concentrations were noted under Zn0 conditions, the values obtained under Zn_1 and Zn_2 conditions showed differences depending on G. intraradices and P. delicense treatments. Leaf Ca concentration reached up to highest level with

$Zn_2GI_0Pd_1$ treatment and the lowest Ca content was recorded under GI_0Pd_0 for all Zn applications. Lower level of zinc together with GI_0Pd_0 applications resulted in the highest leaf Mg concentration. The highest micronutrient concentrations were analysed on cucumber plants grown under Zn deficient conditions without GI but with P deliense. Plant dry weight, root fresh and root dry weights were higher in cucumber plants challenged with AM fungus and P. deliense under zinc applied conditions. It was observed that certain rates of zinc and mycorrhiza based-treatments had positive effects on disease factors by suppressing Pythium rot and can be used for biological control.

An experiment was conducted at Fruit Research Station, Lalbaug, Department of Horticulture, J.A.U., Junagadh during summer season 2012, to study the "Effect of zinc and boron on growth and quality of cucumber (*Cucumis sativus* L.) cv. Gujarat cucumber-1". The soil of the experimental field was clayey in texture having medium to poor drainage, medium in available nitrogen, low in available phosphorus but high in available potassium. The experiment was laid out in Randomized Block Design with thirteen treatments consisting of two micronutrients viz., T_1 (Control), T_2 (Bo @ 3 kg/ha soil application), T_3 (Bo @ 6 kg/ha soil application), T_4 (Bo @ 9 kg/ha soil application), T_5 (Bo @ 2 ppm foliar spray), T_6 (Bo @ 4 ppm foliar spray), T_7(Bo @ 6 ppm foliar spray), T_8 (Zn @ 5 kg/ha soil application), T_9 (Zn @ 7.5 kg/ha soil application), T_{10} (Zn @ 10 kg/ha soil application), T_{11} (Zn @ 0.25% foliar spray), T_{12} (Zn @ 0.50% foliar spray), T_{13} (Zn @ 0.25% foliar spray) and the same was replicated thrice. The results of present investigation revealed that the maximum length of main axis (158.33 cm) was recorded in treatment T_4 which was at par with the treatments T_{10}. The number of branches per vine (16.07) was observed in treatment T_4 which was at par with treatment T_{10} and T_{12}. Maximum number of total flowers per vine (78.78) was recorded in treatment T_4 which was at par with T_{10}, T_6 and T_{12} respectively. The effect of different treatment showed no significant effect over female male flower ratio. Significantly higher percentage of fruit set (90.41) was observed in treatment T_4 which was at par with the treatments T_{10}, T_6, and T_{12}. Maximum number of fruits per vine (15.83) was recorded at treatment T_4

and which was at par to T_{10}. The fruit length (24.72 cm) and girth (10.19 cm) recorded maximum with treatment T_4. Fruit length was at par with T_{10}, while fruit girth was at par with treatment T_{10}, T_6, and T_{12}. Significantly the minimum percentage of fruit drop (13.77%) was observed in the treatment T_4 (Bo @ 9 kg/ha soil application), which was found at par with the treatments T_6 and T_{10}. The lowest percentage of bitter fruit (2.73%) was recorded with treatment T_4 which was at par with T_{10}. Significantly the maximum average fruit weight (247.23 g) were recorded at treatment T_4 which was at par with T_{10}. Similarly, significantly the highest fruit yield per vine (3.81 kg) was recorded in treatment T_4 which was at with treatment T_{10}. The maximum fruit yield per hectare of cucumber (19.60 t/ ha) was recorded in treatment T_4 (Bo @ 9 kg/ha, soil application) and was found at par with the treatments T_{10}, and T_6. The results further revealed that quality parameters viz., volume of fruit (165.16 ml), TSS (5.050Brix), total sugars (9.56%), non-reducing sugars (4.49%) and reducing sugars (5.07%) were significantly increased with treatment T_4 (Bo @ 9 kg/ha, soil application). But, the treatment T_1 (control) registered the highest Vitamin C (11.74 mg/ 100g). The maximum zinc content (175.89 ppm) was observed in T_{10} which was at par with T9 (171.23 ppm). The maximum boron content in leaves of cucumber (134.98 ppm) was recorded in T_4 which was at par with T_3 (129.85 ppm) and T_7 (126.65 ppm). Treatment T_4 (Bo @ 9 kg/ha, soil application) gave the maximum net realization of Rs. 65940.42 /ha with a CBR of 1:3.05 and was followed by the treatment T_6 which recorded the net realization of Rs. 56875.67 /ha and a CBR of 1:3.01 On the basis of experimental results, it can be concluded that soil application of Boron @ 9 kg/ha in cucumber should be done for getting higher yield, good quality of fruit as well as higher net realization from cucumber crop (Deshmukh, 2014).

Zhao *et al*. (2013) stated that with the dramatic increase in nanotechnologies, it has become increasingly likely that food crops will be exposed to excess engineered nanoparticles (NPs). In this study, cucumber plants were grown to full maturity in soil amended with either CeO_2 or ZnO NPs at concentrations of 0, 400, and 800 mg/kg. Chlorophyll and gas exchange were monitored, and physiological markers were recorded. Results showed that, at the concentrations tested, neither CeO_2 nor ZnO NPs impacted cucumber plant growth, gas exchange and chlorophyll content. However, at 800 mg/kg treatment, CeO_2 NPs reduced the yield by 31.6% compared to the control ($p \leq 0.07$). ICP-MS results showed that the high concentration treatments resulted in the bioaccumulation of Ce and Zn in the fruit (1.27 mg of Ce and 110 mg Zn per kg dry weight). μ-XRF images exhibited Ce in the leaf vein vasculature, suggesting that Ce moves between tissues with water flow during transpiration. To the authors' knowledge, this is the first holistic study focusing on the impacts of CeO_2 and ZnO NPs in the life cycle of cucumber plants.

The objective an experiment was conducted by Tzerakis *et.al*.(2013) to estimate the uptake of manganese (Mn) and zinc (Zn) by cucumber in closed hydroponic systems at different Mn and Zn concentrations in the recycled nutrient solution under Mediterranean climatic conditions. The obtained data might be used to manage Mn and Zn supply in closed hydroponic crops of cucumber grown in Mediterranean greenhouses and avoid their accumulation to toxic levels. Four Mn levels (10, 40, 80, 120 μM) at a standard Zn concentration (6 μM) and four Zn levels (6, 20, 40, 60 μM) at a standard Mn concentration (10 μM) in the solution supplied to compensate for nutrient and water uptake by plants were applied as experimental treatments. The actual uptake concentrations of Mn and Zn were estimated by applying two different methods. The first method was based on the removal of Mn, Zn, and water from the recycling nutrient solution, whereas the second method was based on the total quantities of Mn and Zn that were recovered in plant biomass in combination with the total water uptake. Both methods gave similar uptake concentrations for Mn in the low-Mn supply level and Zn in all Zn levels. However, in the three higher Mn supply levels, the values estimated on the basis of nutrient removal from the recirculating nutrient solution were significantly higher than those found by measuring the total Mn content in plant biomass. These discrepancies in the three high-Mn treatments were possibly caused by partial immobilization of Mn by oxidizing bacteria in the nutrient solution (Tzerakis *et al*., 2013).

The aim of study of Kazemi (2013) was to evaluate the effects of the foliar application of zinc (15, 30 and 50 mg/l) and iron (50 and 100 mg/l) and their combination on vegetative, reproductive growth, fruit quality and yield of cucumber plants. Results indicated that different applied treatments significantly increased vegetative and reproductive growth, fruit quality of cucumber plants. Results indicated that Zn at 50 mg/l and Fe at 100 mg/l increased chlorophyll content and yield. The effect of Zn and Fe was promoting too, as 50 mg/l and at 100 mg/l of Zn and Fe led to significant increments of vegetative factors, chlorophyll and leaf NK content and fruit quality. However, the best results were found when Zn was applied accompanied by Fe.

Aydin *et al*. (2012) conducted an experiment to find out the characterization of stress induced by copper and zinc on cucumber (*Cucumis sativus* L.) seedlings by means of molecular and population parameters. Contamination of plants with heavy metals could result in damage in DNA, such as mutations and cross-links with proteins. These altered DNA profiles may become visible in changes such as the appearance of a new band, or loss of an existing band, in the random amplified polymorphic DNA (RAPD) assay. In this study, various concentrations of copper and zinc salts were applied to cucumber seedlings during germination. Results displayed abnormalities in germination and also changes in root elongation, dry weight and total soluble protein level. All treatment concentrations (40, 80, 160, 240, 320, and 640mg/l) used in the study caused a decrease/delay in germination of the cucumbers to different extents. Inhibition or activation of root elongation was considered to be the first effect of metal toxicity in the tested plants. Application of the metal salts and the combined solutions on cucumber (*Cucumis sativus* L.) seedlings revealed similar consequences for total soluble protein level, dry weight and ultimately in inhibitory rates as well. The data obtained from RAPD band-profiles and genomic template stability (GTS) showed results that were consistent with the population parameters. In this regard, they conclude that molecular marker assays can be applied in combination with population parameters to measure genotoxic effects of heavy metals on plants.

Tzerakis *et al*. (2012) suggested that a standard and a high manganese (Mn) level (10 and 160 μM) were combined with a standard and a high zinc (Zn) level (4 and 64 μM) in the nutrient solution supplied to cucumber in closed-cycle hydroponic units to compensate for nutrient uptake. The concentrations of all nutrients except Mn and Zn were identical in all treatments. The objectives of the experiment were to establish critical Zn and Mn levels in both nutrient solutions and leaves of cucumber grown hydroponically, to assess the impact of gradual Zn and/or Mn accumulation in the external solution on nutrient uptake and gas exchange and to find whether Mn and Zn have additive effects when the levels of both ions are excessively high in the root zone. The first symptoms of Mn and Zn toxicity appeared when the concentrations of Mn and Zn in the leaves of cucumber reached 900 and 450 $mg\,kg^{-1}$ in the dry weight, respectively. Excessively high Mn or/and Zn concentrations in the leaves reduced the fruit biomass production due to decreases in the number of fruits per plant, as well as the net assimilation rate, stomatal conductance and transpiration rate, but increased the intercellular CO_2 levels. Initially, the Mn or Zn concentrations in the recirculating nutrient solution increased rapidly but gradually stabilized to maximal levels, while the corresponding concentrations in the leaves constantly increased until the end of the experiment. The uptake of Mg, Ca, Fe, and Cu was negatively affected, while that of K and P remained unaffected by the external Mn and Zn levels. The combination of high Mn and Zn seems to have no additive effects on the parameters investigated.

Dominy (2010) reported that zinc and manganese have long been considered as essential micronutrients to plant growth, yet the interactions of the two nutrients on growth and development of plants have not been elucidated in their entirety. Silicon is not classed as an essential element but has been found to improve growth of a number of crops, particularly of the Poaceae family. A simple water culture hydroponic system was developed to monitor the growth and development of a fruit crop (Cucumber – *Cucumis sativus*) under deficient, adequate and excessive applications of zinc and manganese. Plant growth parameters were monitored including leaf growth, plant height, plant fresh and dry mass, yield, fruit size and fruit mass. Nutrient uptake was also measured using inductively coupled plasma emission spectroscopy, whilst chlorophyll was determined spectrophotometrically. Plant nutrient analyses were also conducted using inductively coupled plasma emission spectroscopy. Silicon was found to have a beneficial effect on the growth of cucumbers and was incorporated as a treatment for this crop along with zinc and manganese since foliar silicon sprays were able to correct the occurrence of mineral deficiency symptoms. Along with plant growth measurements, nutrient uptake, plant nutrient analysis and chlorophyll determination, plant tissue was also analysed using transmission electron microscopy to establish the impact of silicon applications on the cell ultra-structure of cucumbers. Electron micrographs showed an increased presence of plasmodesmata in treatments excluding silicon. Such increased plasmodesmata connections under silicon deficient conditions could increase translocation of cell solutes due to reduced cell longevity. Results also confirmed the essentiality of zinc and manganese on plant growth and development as typical deficiency symptoms were observed. Typical toxicity symptoms were also recorded. Rates of uptake of nutrients corresponded with leaf growth and enlargement as well as yield. The chlorophyll concentration was not a clear indicator of nutrient application level. Typically, manganese and zinc interacted with iron, magnesium, calcium and potassium, affecting their uptake into the plant dependent on the level of manganese and zinc applied. Although non-essential, silicon improved plant growth, but had neither a relationship with the other nutrients evaluated nor affected the physical growth and development of the plants. Manganese and zinc, as essential to plant growth and development, affect the visual appearance of the plant as well as affect the plant biochemically due to their involvement in many growth and development processes.

Kietsermkajorn *et al*. (2010) suggested that from the trial on zinc and magnesium fertilization for growing Japanese cucumber on basic soil with high residual phosphorus and potassium was conducted at Huai Luek Royal Project Development Centre, Chiang Mai province. It was aimed at examining the effect of Mg and Zn applied at different rates on yield of Japanese cucumber and the uptake of some plant nutrients by this plant. The experiment was in randomized complete block design (RCBD) which 10 treatments of different rates of Mg and Zn fertilizers and their combination, each with four replications. Results showed that the use of Mg and Zn fertilizers at three different rates, the yield of fresh Japanese cucumber fruits was not higher than that of the control. The lowest yield of 12.6 t/ha was obtained from treatment with the application of 0.1 g $ZnSO_4.7H_2O$. Addition of Mg plus Zinc at the rate of 3:0.3 g tended to give the highest yield of 22.9 t/ha. However, there was no statistical difference in yield among treatments. Application of Mg and Mg plus Zn at the highest rates significantly increased plant P uptake (0.6 and 0.7 percent, respectively) into leaves as compared to the control, similar to K uptake into leaves in all added Mg and Zn fertilizers. There was no correlation between addition of Mg and Mg uptake. Nevertheless, the accumulation of Zn in leaves tended to be higher when applied with Zn fertilizer at the highest rate.

Marschner *et al*. (1990) reported based on results from water culture experiments with tomato and cucumber plants where severe leaf chlorosis and depression in flower and fruit formation occurred without silicon (Si) supply, Si is an essential mineral element for these two-plant species. Using the same nutrient solution which was high in phosphorus (P) but low in zinc (Zn) they could confirm these results. Severe chlorosis occurred in cucumber when Si was omitted, and the addition of Si prevented these visual symptoms. Simultaneously the concentrations of P drastically decreased in the leaves and the proportions of water extractable Zn increased. Normal growth and absence of chlorosis were also obtained without the addition of Si when either the external concentration of P was lowered or of Zn was increased. Short-term experiments revealed that Si has no direct effect on uptake or translocation of P to the shoot. According to these results, the experimental evidences so far are insufficient for the classification of Si as an essential mineral element for cucumber. Instead, Si may act as beneficial element under conditions of nutrient imbalances, for example, in P and Zn supply and corresponding P-induced Zn deficiency. The mechanism by which Si increases the physiological availability of Zn in leaf tissue is not yet clear.

3.2 Effect of pruning

An experiment conducted by Mardhiana *et al*. (2017) and reported that, in recent years, cucumber production in Tarakan, North Kalimantan only reaches 20 tons $ha^{-1.}$ In fact, cucumber production potential could reach 49 tons ha^{-1}. Several factors that limit the low productivity of cucumbers in Tarakan are acid soil and cultivation techniques which are still limited. This study aimed to determine the effect of pruning on the growth and yield of cucumbers in acid soil in Tarakan. The study was conducted using Randomized Complete Block Design with the treatment of without pruning (P_0), shoot of prunings on the main stem (P_1), pruning of whole lateral branches above the third section (P_2), and pruning of 2 lateral branches that emerged first above the third section (P_4). The results showed that plant height was 16.17% (P_1) and 2.26% (P_2) lower also 0.13% higher (P_3) than the control (P_0). The highest number of leaves was found in treatment P_1 (16.19%) compared to P_0. The best fruit diameter was also found in P1 treatment with 4.93% difference compared to P_0. Furthermore, a highly significant and the best result on weight per fruit were also obtained by P_1 treatment. The results showed that the fruit weight of P_1 treatment (11.39%) was higher than P_0. This study provided new information that the pruning treatment of shoots on the main stem of cucumber variety Mercy in acid soil could increase the diameter and weight of cucumber.

Pruning and planting density plays an important role in the growth and yield of greenhouse cucumber. In order to the effect of pruning and plant density on yield of cucumber factorial experiment in a randomized complete block design with three replications was conducted. Factors planting density that densities of 30,000, 35,000 and 40,000 plants per hectare. Pruning in three methods of

Pruning No. 1 (after 40-30 cm height, a fruit and a leaf on each branch was kept and then the terminal bud branches were cut). Pruning No. 2 (after the 40-35 cm height, 25 cm at the top of leaves on each branch was kept a cucumber and a terminal bud branches were cut and then second at 25 cm on each branch 2 cucumbers and 2 leaves and 25 cm 3 cucumbers and three leaves on each branch holds the third and delete the residues, and so up until four fruits and the plant will be pulled down. This procedure is repeated pruning and pruning (3) (all branches on the main stem at an angle of each leaf is removed and allowed only one fruit grow from the main stem), Karim on the company Gavrish the major crops and export region, were studied. Data recorded includes total yield per unit area, yield per plant, average fruit weight, fruit number, length and fruit diameter measurements were analyzed. Data analysis with SAS statistical software and means were compared using Duncan test. The results showed significant differences among the three methods of pruning and density was relation to the total yield, yield per plant, number of fruits per plant, average fruit weight per plant. In this study it was found that the highest performance and most desirable in pruning fruit quality was No. 3 with a density of 35,000 plants per hectare.Vine pruning increased total yield, yield per plant, number of fruits per plant, average fruit weight per plant in cucumber crop (Khoshkam, 2016).

Maboko *et al*. (2011) reported that a study was conducted in 2009 to 2010 and 2010 to 2011 to investigate the effect of plant population, fruit and stem pruning of hydroponically grown tomatoes in a 40% (black and white) shade-net structure at the ARC-Roodeplaat VOPI. An open bag hydroponic system containing sawdust as a growing medium was used in this experiment. Tomato plants were subjected to three plant populations (2, 2.5 or 3 plants/m^2), two stem pruning treatments (one stem and two stems) and three fruit pruning treatments (four fruits, six fruits per truss, and no fruit pruning). Experimental layout was a complete randomized block design with three replicates. Data on fruit number, fruit mass, unmarketable yield, marketable yield and total yield was collected from 10 plants for all treatments. Plants pruned to two stems with zero fruit pruning or pruned to six fruits produced significantly higher marketable and total yield, as compared to the other treatments. Plant population of 3 plants/m^2, resulted in significantly higher marketable yield of tomatoes, compared to 2.5 and 2 plants/m^2. Results showed that tomato yield and quality can be effectively manipulated by plant population and stem pruning, while fruit pruning had only a limited effect.

McFadyen *et al*. (2011) conducted an experiment to find out the post-pruning shoot growth increases fruit abscission and reduces stem carbohydrates and yield in macadamia. They stated that, there was good evidence for deciduous trees that competition for carbohydrates from shoot growth accentuates early fruit abscission and reduces yield but the effect for evergreen trees is not well defined. Here, whole-tree tip-pruning at anthesis was used to examine the effect of post-pruning shoot development on fruit abscission in the evergreen subtropical tree macadamia (*Macadamia integrifolia*, *M. integrifolia* × *tetraphylla*). Partial-tree tip-pruning was also used to test the localization of the effect. In the first experiment (2005/2006), all branches on trees were tip-pruned at anthesis, some trees were allowed to re-shoot (R treatment) and shoots were removed from others (NR treatment). Fruit set and stem total non-structural carbohydrates (TNSC) over time, and yield were measured. In the second experiment (2006/2007), upper branches of trees were tip-pruned at anthesis, some trees were allowed to re-shoot (R) and shoots were removed from others (NR). Fruit set and yield were measured separately for upper (pruned) and lower (unpruned) branches. In the first experiment, R trees set far fewer fruit and had lower yield than NR trees. TNSC fell and rose in all treatments but the decline in R trees occurred earlier than in NR trees and coincided with early shoot growth and the increase in fruit abscission relative to the other treatments. In the second experiment, fruit abscission on upper branches of R trees increased relative to the other treatments but there was little difference in fruit abscission between treatments on lower branches. This study was the first to demonstrate an increase in fruit abscission in an evergreen tree in response to pruning. The effect appeared to be related to competition for carbohydrates between post-pruning shoot growth and fruit development and was local, with shoot growth on pruned branches having no effect on fruit abscission on unpruned branches.

A field trial was conducted to evaluate the effect of pruning and staking on the vegetative growth and yield of cucumber (*Cucumis sativus* L.). The experiment was a 3 x 2 factorial laid out in Randomized Complete Block Design (RCBD) with five replications. The results showed that vine length, number of flowers, total number of fruits and the number of non-marketable fruits were higher on the nonstaked treatment while staking resulted in a higher number of marketable fruits, weight, length and diameter of fruits. The unpruned plants produced the highest total number of fruits, marketable and non-marketable fruits while the weight, length and diameter of fruits were highest on one stem pruning. Staking, pruning and their interaction had no significant effect on the number of days to 50% anthesis. In Abakaliki agro-ecological zone, non-staking and non-pruning treatments produced optimum marketable yield of cucumber (Ekwu and Utobo, 2010).

Utobo *et al*. (2010) reported that the effect of pruning on the growth and yield of four cucumber varieties was evaluated using a$_4$ x 2 factorial laid out in a Randomized Complete Block Design (RCBD). Market more 76, Marketer and Point-sett varieties produced significantly ($p<0.05$) higher total and marketable yield than Market more 70. Similar trend was observed for total and marketable fruit weight, and marketable fruit number per plant. Significant differences in some vegetative growth parameters were found between the cucumber varieties. Market more 76 and Marketer varieties had similar but significantly ($p<0.01$) shorter days to 50% anthesis than Market more 70 followed by Point-sett. Marketer had significantly ($p<0.05$) longer stem length than the other cucumber varieties. Market more 76 and Marketer varieties produced similar, but significantly ($p<0.05$) higher number of branches per plant than Market more 70 and Point Sett. Significant differences ($p<0.05$) in terms of yield and yield components were found between the two pruning treatments. The no pruning treatment produced the highest total yield and total fruit number per plant. The pruning treatment produced the highest marketable fruit yield, total and marketable fruit weight, and marketable fruit number per plant. Pruning significantly ($p<0.05$) affected the days to 50% anthesis and stem length. Unpruned cucumber varieties took shorter days of 26 for the 50% of the plants to flower while pruned cucumber varieties produced longer stem lengths of 18.46 than the non-pruned treatment.

Suthar *et al*. (2006) found that, pruning and Ethrel [ethephon] treatments, viz. pruning of side shoots up to 5th node, and 10 and 25 ppm, respectively, were assessed for maximum cucumber (cultivars Pusa Sanyog, Stimora and Rani) production under polyhouse environment. Maximum height was recorded in Rani with pruning, while foliar spray of Ethrel decreased the plant height. Pruning produced maximum number of fruits per vine (16.9 and 15.7) in Stimora. Foliar application of Ethrel 25 ppm exhibited maximum number of fruits (13.9 and 12.5). Rani recorded maximum individual fruit weight (136.9 and 147.3). Pruning in all cucumber genotypes induced maximum fruit weight, while Ethrel 25 ppm slightly improved this character. Pruning produced maximum fruit yield (2.2 kg/vine) in Rani. Fruit yield was also maximum (2.2 kg/vine) with Ethrel 25 ppm in Rani. Ethrel 25 ppm in combination with pruning produced maximum fruit yield.

Nu (1996) stated that the effect of pruning (pinching out the branches on main stem at node 4 up to the bottom and prune when lateral shoots on main stem set fruit on first on second node of lateral shoot) on yield and fruit quality of four cucumber varieties, namely; Lanna-5 (Fi), Nopakao (Fj), Lan-Laem (op) and Poung (op) was evaluated using a 4×2 factorial experimental design with no pruning treatment. The experiment was carried out at the ARC-AVRDC experimental field, located at Kasetsart University, Nakhon Pathom, Thailand form November 1996 to February 1997. The no pruning treatment produced the highest total yield 22.18 ton/ha as well as highest non- marketable yield 7.70 t/ha while the pruning treatment produce low non-marketable yield 5.16 t/ha and total yield 17.11. But, the number of branches, nodes and stem length was higher in the pruning treatment.

Thang (1995) reported that an experiment was carried out on the effect of six different pruning methods on the yield of cucumber variety Poung and evaluated from December 1995 to February 1996 at AVRDC-ARC experimental field, Kamphaengsaen, Nakhon Pathom, Thailand. The local cucumber variety Poung was chosen for the field experiment. The treatments of the experiment were no pinching (M_0), Pinching branches on main stem at node 10 up to down (M_1), Pinching branches on main stem at node 15 up to down (M_2), No pruning (P_0) and pruning branches at node 4. The highest yield (total yield = 19.72 t/ha) was obtained by the treatment MoP_1, with no pinching of branches on main stem but pruning branches at node 4. The method of pruning branches had no significant effect on horticultural character such as fruit size and plant height. The pinching treatments had low yield. This was resulted because of the absence of sufficient branches.

Gobeil and Gosselin (1989) conducted an experiment on the influence of pruning season of cucumber. They reported that summer pruning gave a high production of fruits.

Arora and Malik (1989) reported that pruning of ridge gourd plants to six primary branches with a medium spacing level (45 cm) produced the longest plants, gave maximum number of secondary branches, resulted in early appearance of pistillate flowers, lowered sex ratio and gave higher number and weight of fruits from early and total yield. The result of reduced sex ratio for pruning was due to more production of secondary branches on which pistillate flowers appeared in large number.

An experiment was conducted by Gobeil and Gosselin (1990) and reported that the cucumber plants (*Cucumis sativus* L. *cultivar 'Corona'*) were cultivated in a sequence cropping system from 24 April 1987 to 31 January 1988. They were supported on V-shaped structures and received 120 μmol m^{-2} s^{-1} of supplemental lighting from high-pressure sodium (HPS) lamps. Four pruning methods were compared, each at four levels of photosynthetic photon flux density (PPFD). The first method allowed the production of 12–14 fruits on the main stem. The second method prolonged production on short secondary suckers for a total of 18–20 fruits. Anticipated yield for the third method was 18–20 fruits on the main stem and on a long secondary sucker left near the top of the plant. The last method prolonged production on the main stem, which grew back down the support structure. The number of fruits produced per plant was not influenced by the level of PPFD. Pruning Method 1 yielded an average of 12.0 fruits per plant, whereas Methods 2, 3 and 4 produced an average of 16.5 fruits. Average fruit weight and daily yields of plants decreased with a reduction in daily PPFD. Methods 3 and 4 allowed yields of 225 fruits m^{-2} $year^{-1}$ and required only 10 successive crops. Method 2, which relies on the growth of secondary suckers, required 12 successive crops and was the most productive with an annual yield of 280 fruits m^{-2}.

CHAPTER III

MATERIALS AND METHOD

This chapter deals with the major information's that were considered to conduct the experiment.

3.1 Experimental site

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka. The experiment was carried out during the period from April to June 2016. The location of the site in 23°74" N latitude and 90°35" E longitude with an elevation of 8.2 meter from sea level (Anon, 1989).

3.2 Climate

The experimental site is located in subtropical region where climate is characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during rest of the month (Rabi season). The maximum and minimum temperature, humidity rainfall and soil temperature during the study period are collected from the Sher-e-Bangla Mini weather station (Appendix-1).

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract. Soil analysis report of the experimental area was collected from Khamarbari, Dhaka which was determined by Soil testing Laboratory (SRDI). The analytical data have been presented in appendix-II. The experimental site was a medium high land and pH of the soil was 5.4 to 5.6. AEZ No. 28 Soil series- Tejgaon General soil, Non -calcareous dark gray. The soil test report was shown in Appendix II.

3.4 Plant Materials

The cucumber cultivar i.e. Krishibid Hybrid Seed was used as a test crop.

3.5 Treatments of the Experiment

The experiment was designed to study the effects of varying zinc doses and shoot pruning practices on growth, flowering, fruiting and yield of cucumber. The experiment consisted of two factors as follows:

Factor A: Zinc doses

a. Z_0=No Zn spray
b. Z_1=20 mg/l
c. Z_2=30mg/l
d. Z_3=50mg/l

Factor B: Pruning

a. P_0=No pruning
b. P_1= Pruning to three primary branches
c. P_2= Pruning to five primary branches

Treatments combinations P_0Z_0, P_0Z_1, P_0Z_2, P_0Z_3, P_1Z_0, P_1Z_1, P_1Z_2, P_1Z_3, P_2Z_0, P_2Z_1, P_2Z_2 and P_2Z_3.

3.6 Experimental design and layout

It was a factorial experiment. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental area was divided into three equal blocks. Each block was divided into 12 plots. First blocks were treated as first replication (R_1) and 2nd block was as second replication (R_2) and last blocks was used as third replication (R_3). Every replication had twelve plots where 12 treatments were allotted at random. The size of each plot was 1.2 m × 1.0 m. The distance between two blocks and two of plots both were l.0 m.

3.7 Land preparation

The selected land for the experiment was opened 5 April, 2016 with the help of a power tiller and then it was kept open to sun for 4 days prior to further ploughing. Then the land was prepared well by ploughing and cross ploughing followed by well by laddering at 9 April, 2016. Weeds and stubble were removed and the basal doses of fertilizers were applied and mixed thoroughly with the soil before final land preparation. The unit plots were prepared by keeping l m spacing in between two plots and 50 cm drain was dug around the land. The space between two blocks and two plots were made as drain having a depth of about 30 cm.

3.8 Pit preparation in the plots

There were 2 pits in every plot. The pit size was 30 cm and 30 cm respectively. There was 20 cm depth in pits and 35 cm distance from the border of the plots. The pits were prepared with necessary manures and fertilizers in 10th April, 2016.

3.9 Application of manures and fertilizers

Following doses of manures and fertilizers were used for cucumber production (Fertilizer recommendation guide, 2012).

Fertilizers	**Doses pit^{-1}**
Cowdung	4 kg
Urea	30 g
TSP	20 g
MoP	8 g
Furadan 5G	6 g

A common dose of cow dung @ 4 kg per pit, urea @ 10 g per pit, TSP @ 20 g per pit and MP @ 8 g per pit was applied during pit preparation in the respective plots a week before seed sowing. The furadan 5G at 6 g in each pit was also applied during pit preparation to avoid the pest attack. Rest 50% urea (20 g) was applied as a top dressing at two installment before flowering.

3.10 Sowing of seeds and selection of seedlings

The seeds were sown directly in the pit on 21th April 2016. 2 to 3 seeds were sown in each pit at 2 to 3 cm depth when the seedlings attained 10-15 cm height and hard enough then one healthy seedling was selected to remain in each pit and others were thinned out. During seed sowing 60 cm × 60 cm spacing was maintained.

3.11 Application of pruning treatment

Primary branches on main stem were pruned according to treatments. When the branches were appeared from the main stem and became 2-3 cm long then that was pruned. Pruning was done from the basal nodes of the plants according to treatments. Pruning was done on 13^{th} may, 2016.

3.12 Intercultural Operations

3.12.1 Weeding

Weeding was done whenever necessary to keep the crop free from weeds.

3.12.2 Staking

When the seedlings were established, staking was given to each plant. Stick of bamboo was given to support the growing twig.

3.12.3 Vine management

For proper growth and development of the plants the vines were managed upward by hand and with the help of bamboo and plastic rope. So, the rainy and stormy weather could not damage the growing vines and fruits of the plants.

3.12.4 Irrigation

The experiment was done in summer season. So, irrigation was given when it is necessary. Sometimes rain was supplied sufficient water then irrigation was no need. When irrigation was supplied then it was given through drains of the plots.

3.12.5 Plant protection

Cucumber is a very sensitive plant to various insect pests and diseases. So, various protection measures were taken. Melathion 57 EC and Ripcord was applied @ 2 ml/l against the insect pests like beetle, fruit fly, fruit borer and other. The insecticide application was made fortnightly from 10 days after seed sowing to a week before first harvesting. During cloudy and hot weather precautionary measures against viral disease like mosaic of cucumber was taken by spraying. Furadan 5 G was also applied @ 6 g/pit during pit preparation as soil insecticide.

3.13 Harvesting

When the green fruits were in marketable condition then they were harvested.

3.14 Data collection

Data was collected for the following parameters

I. Vine length (cm)
II. Number of primary branches plant^{-1}
III. Number of secondary branches plant^{-1}
IV. Number of leaves plant^{-1}
V. Number of male flowers plant^{-1}
VI. Number of female flowers plant^{-1}
VII. Total number of fruits plant^{-1}
VIII. Fruits length (cm)
IX. Fruits girth (cm)
X. Individual fruit weight (g)
XI. Fruit weight plant^{-1} (g)
XII. Yield ha^{-1} (ton)

3.15 Data collection procedure

3.15.1 Vine length

Vine length was taken at three times and measured in centimeter from ground level to tip of the main stem from each plant of each treatment and mean value was calculated.

3.15.2 Number of primary branches per plant

Total number of primary branches was counted at three times at 20, 40 DAS and harvesting time from each plant of the treatment and mean value was calculated. The pruned branches number was also included in counting.

3.15.3 Number of secondary branches

Total number of secondary branches was counted at two times at 40 DAS and harvest time from each plant of the treatment.

3.15.4 Number of male and female flowers per plant

Number of female flower per plant was counted from first female flower appearance. Number of female flowers was recorded for each treatment. Number of male flowers was also counted from first flowering. Number of male flower was recorded from each treatment as like female flowers.

3.15.5 Number of fruit per plant

Number of fruit was counted from first harvest to last harvest. The total number of fruits per plant was counted and average number of fruit was recorded.

3.15.6 Fruit length and girth

Fruit length and girth was taken by measuring tape in centimeter. Girth i.e. breath of fruit was measured at the middle portion of fruits from each plot and their average was taken. Average length of same fruits was also taken.

3.15.7 Yield of fruits

To estimate yield, all the plants in every plot and all the fruits in every harvest were considered. Thus, the average yield per plot was measured. The yield per hectare was calculated considering the area covered by the all plants.

3.16 Statistical analysis

The recorded data on different parameters were statistically analyzed using Statistix 10 software and mean separation was done by Tukey HSD test at 5% level of probability.

CHAPTER IV

RESULTS AND DISSCUSIONS

This chapter represent the results and discussions of the present study. Summary of mean square values at different parameters are also given in the appendices.

4.1 Influence of zinc and branch pruning of cucumber

4.1.1 Vine length

4.1.1.1 Influence of zinc

Application of zinc showed significantly positive influence on vine length of cumber at different days after sowing (DAS). Vine length ranged from 27.15-38.35 cm, 67.66-79.47 cm and 140.98-151.92 cm at 30, 40 DAS and at harvesting, respectively (Figure 1, Appendix III). The highest value of vine length (38.35 cm, 79.47 cm and 151.92 cm at 20, 40 DAS and harvesting time, respectively) was recorded for Z_2 and the lowest (27.15 cm, 67.66 cm and 140.98 cm at 20, 40 DAS and harvesting time, respectively) for Z_0. The fact that, application of Zn help to get higher vegetative growth in cucumber plant. The present finding is agreed with the finding of Moghaddasi *et al*. (2017) and Küçükyumuk *et al*. (2014).

4.1.1.2 Influence of pruning

Pruning activities significantly influence on vine length and showed that P_1 produced highest vine length where control produced lowest vine length (Figure 1, Appendix III). Result indicated that P_1 produced 54.69 cm, 101.95cm and 173.69 cm vine length at 20, 40 DAS and harvesting time, respectively. The control treatment (P_0) produced 15.95 cm, 68.95 cm and 124.00 cm, respectively. This might be due to that, pruning helped for proper vegetative growth of cucumber plant. Mardhiana *et al*. (2017), Khoshkam (2016), Maboko *et al*. (2011), McFadyen *et al*. (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010) and Suthar *et al*. (2006) also reported the similar result.

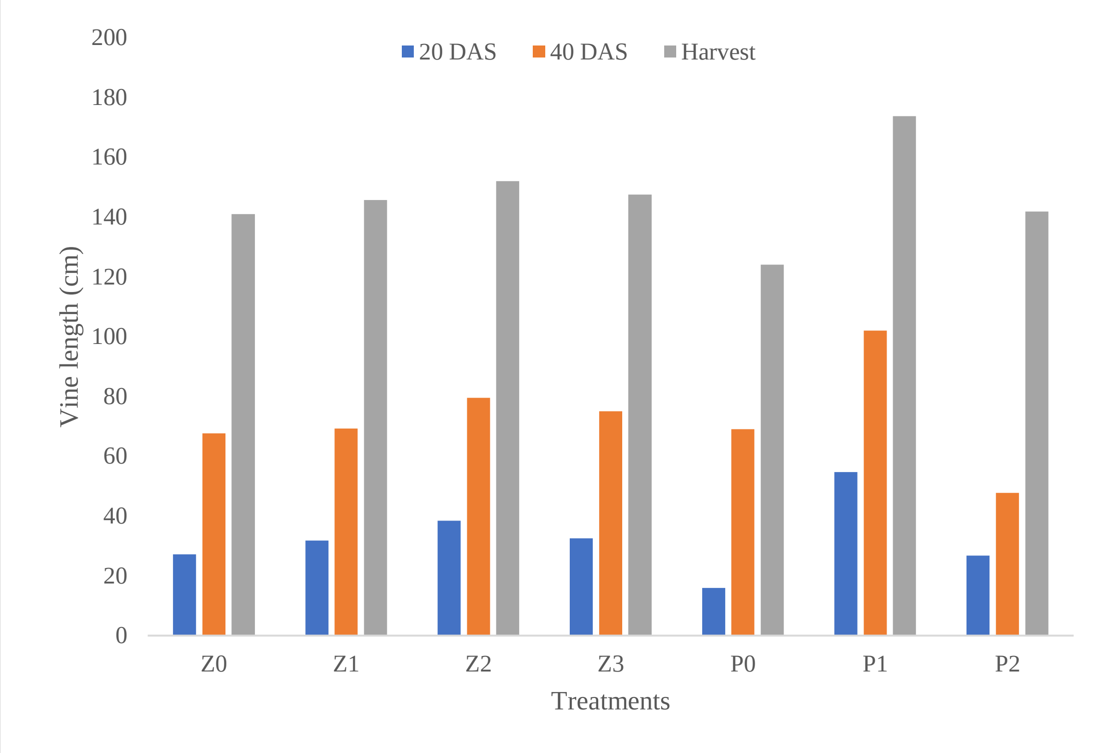

Figure 1. Influence of zinc and pruning on vine length of cucumber

DAS=Days after sowing; Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.1.3 Combined effect of zinc and pruning

Positively significant variation of vine length was observed due to combine effect of zinc application and branch pruning of cucumber (Table 1, Appendix III). The highest vine length was found in P_1Z_2 treatment combination compared to other treatments at 20 DAS, 40 DAS and at harvesting.

Table 1. Combined effect of zinc and pruning on vine length of cucumber

Treatment	Vine length (cm) at		
	20 DAS	40 DAS	Harvesting
P_0Z_0	12.57 i	65.05 g	119.13 j
P_0Z_1	16.62 hi	58.83 h	122.62 i
P_0Z_2	19.60 gh	77.98 e	128.27 g
P_0Z_3	14.97 i	73.96 f	125.98 h
P_1Z_0	47.19 c	95.55 d	168.67 c
P_1Z_1	51.13 c	100.53 c	173.15 b
P_1Z_2	62.88 a	108.03 a	179.03 a
P_1Z_3	57.56 b	103.67 b	173.91 b
P_2Z_0	21.70 fg	42.37 k	135.15 f
P_2Z_1	27.48 e	48.42 j	141.13 e
P_2Z_2	32.55 d	52.40 i	148.47 d
P_2Z_3	24.98 ef	47.40 j	142.61 e
SE (±)	1.054	0.537	0.510
CV (%)	4.44	1.16	0.51

DAS=Days after sowing; Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.2 Number of primary branches plant^{-1}

4.1.2.1 Influence of zinc

Number of primary branches plant^{-1} was significantly influenced by zinc application in cucumber at all sampling dates (Figure 2, Appendix IV). The highest number of primary branches was recorded in Z_2 (6.44, 8.73, and 7.23 at 20 DAS, 40 DAS and harvesting, respectively). The lowest values of this trait were found in Z_0 (4.29, 6.07 and 4.50 at 20 DAS, 40 DAS and at harvesting, respectively). The fact that, application of Zn helped to get higher vegetative growth in cucumber plant. The present finding is agreed with the finding of Moghaddasi *et al*. (2017), Küçükyumuk *et al*. (2014), Kazemi (2013) and Tzerakis *et al*. (2012).

4.1.2. Influence of pruning

The positively significant effect of pruning was observed in number of primary branches plant^{-1} (Figure 3, Appendix IV). The ranged of primary branches were

3.22 to 7.66 at 20 DAS, 5.87 to 8.89 at 40 DAS and 4.01 to 7.69 at harvesting. The maximum number of primary branches plant^{-1} was found in P_1 treatment (7.66, 8.89 and 7.69 at 20 DAS, 40 DAS and harvesting, respectively) compared to other treatments. This might be due to that, pruning helped for proper vegetative growth of cucumber plant. Khoshkam (2016), Maboko *et al*. (2011), Suthar *et al*. (2006), Nu (1996), Thang (1995), Gobeil and Gosselin (1989), Arora and Malik (1989), Gobeil and Gosselin (1990) were also reported the similar result.

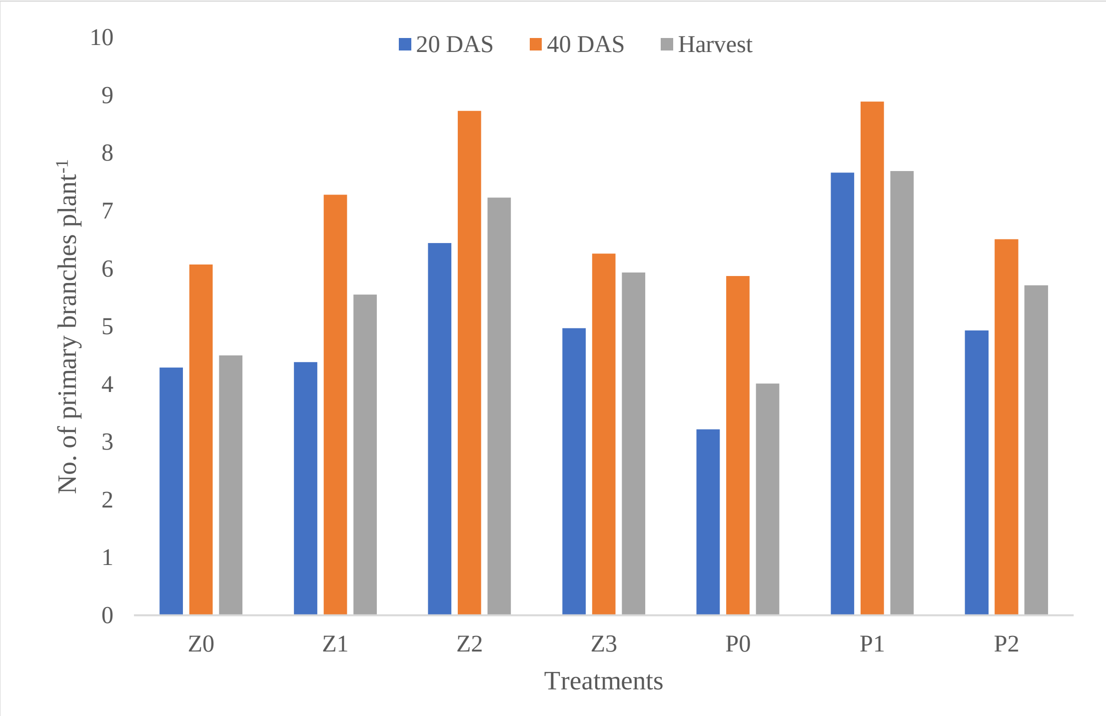

Figure 2. Influence of zinc and pruning on number of primary branches plant^{-1} of cucumber

DAS=Days after sowing; Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.2.3 Combined effect of zinc and pruning

Combine effect of zinc and pruning showed a wide ranged of variation for number of primary branches plant^{-1} at all sampling dates except at 20 DAS

(Table 2, Appendix IV). The highest number of primary branches plant^{-1} was found in P_1Z_2 treatment combination (8.93, 10.50 and 9.23 at 20, 40 DAS and at harvesting time, respectively) compared to other combinations. McFadyen *et al*. (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010), Suthar *et al*. (2006), Nu (1996), Gobeil and Gosselin (1990) were also reported the similar result.

Table 2. Combined effect of zinc and pruning on number of primary branches plant^{-1} of cucumber

Treatment	No of primary branches plant^{-1} at		
	20 DAS	40 DAS	Harvesting
P_0Z_0	2.13	4.17 i	3.23 g
P_0Z_1	3.20	6.47 fg	4.23 f
P_0Z_2	4.26	7.50 de	5.27 e
P_0Z_3	3.27	5.33 h	3.30 g
P_1Z_0	6.56	8.57 bc	6.16 d
P_1Z_1	7.67	9.30 b	7.19 c
P_1Z_2	8.93	10.50 a	9.23 a
P_1Z_3	7.47	7.18 ef	8.16 b
P_2Z_0	4.16	5.49 h	4.11 f
P_2Z_1	5.27	6.09	5.22 e
P_2Z_2	6.13	8.19 cd	7.19 c
P_2Z_3	4.16	6.28 g	6.33 d
SE (±)	NS	0.222	0.156
CV (%)	4.96	3.61	3.45

DAS=Days after sowing; Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.3 Number of secondary branches plant^{-1}

4.1.3.1 Influence of zinc

Application of zinc showed significantly positive influence on number of secondary branches plant^{-1} of cumber at different days after sowing (DAS). The number of secondary branches plant^{-1} ranged from 8.14 to 11.23 at 20 DAS and 16.18 to 19.14 at harvesting (Figure 3, Appendix V). The highest value of number of secondary branches plant^{-1} was recorded for Z_2 and lowest for Z_0. This might be due to proper supply of Zn help to improve vegetative growth of plant.

The present finding is agreed with the finding of Moghaddasi *et al*. (2017), Küçükyumuk *et al*. (2014Tzerakis *et al*. (2012), Dominy (2010).

4.1.3.2 Influence of pruning

Pruning activities significantly influenced on number of secondary branches plant^{-1} and showed that P_1 produced highest number of secondary branches plant^{-1} where control produced lowest number of secondary branches plant^{-1} (Figure 3, Appendix V). Result indicated that P_1 produced 13.78, and 22.66 number of secondary branches plant^{-1} at 40 DAS and harvesting time, respectively. The control treatment (P_0) produced 6.69 and 11.66, at 40 DAS and harvesting time, respectively. This might be due to that, pruning help for proper vegetative growth of cucumber plant. Mardhiana *et al*. (2017), Khoshkam (2016), Utobo *et al*. (2010) and Suthar *et al*. (2006) were also reported the similar result.

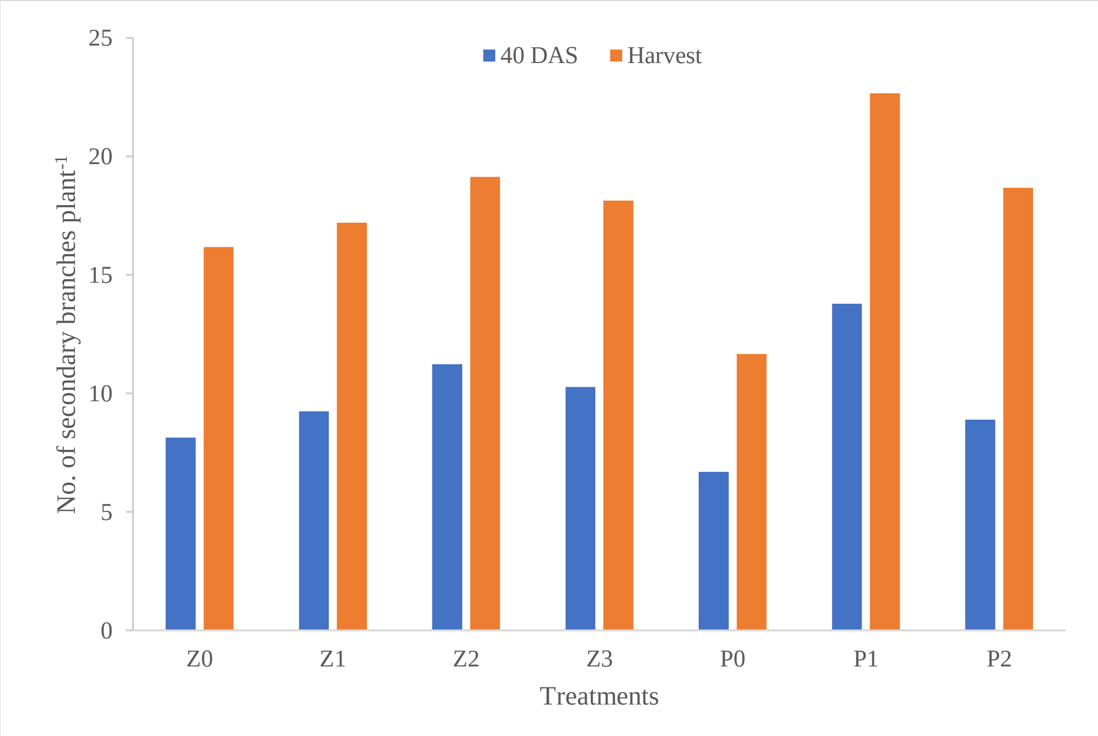

Figure 3. Influence of zinc and pruning on number of secondary branches plant^{-1} of cucumber

DAS=Days after sowing; Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.3.3 Combined effect of zinc and pruning

The non-significant variation of number of secondary branches plant^{-1} was observed due to combined effect of zinc application and branch pruning of cucumber (Table 3, Appendix V). In spite of having non-significant effect, the highest number of secondary branches plant^{-1} was found in P_1Z_2 treatment combination compared to other treatments at 20 DAS, 40 DAS and harvesting time.

Table 3. Combine effect of zinc and pruning on number of secondary branches plant^{-1} of cucumber

Treatment	No of secondary branches plant^{-1} at	
	40 DAS	Harvesting
P_0Z_0	5.10	10.15
P_0Z_1	6.33	11.22
P_0Z_2	8.17	13.15
P_0Z_3	7.17	12.11
P_1Z_0	12.19	21.12
P_1Z_1	13.26	22.19
P_1Z_2	15.32	24.15
P_1Z_3	14.34	23.16
P_2Z_0	7.13	17.27
P_2Z_1	8.14	18.19
P_2Z_2	10.19	20.12
P_2Z_3	9.29	19.15
SE (±)	NS	NS
CV (%)	1.27	0.31

DAS=Days after sowing; Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.4 Number of leaves plant^{-1}

4.1.4.1 Influence of zinc

Number of leaves plant^{-1} was significantly influenced by zinc application in cucumber at all sampling dates (Figure 4, Appendix VI). The highest number of leaves was recorded in Z_2 (14.41, 45.25 and 30.46 at 20 DAS, 40 DAS and harvesting, respectively). The lowest values of this trait were found in Z_0 (10.67, 35.14 and 24.17 at 20 DAS, 40 DAS and harvesting, respectively). The fact that, application of Zn helped to get higher vegetative growth in cucumber plant. The present finding is agreed with the finding of Küçükyumuk *et al*. (2014), Deshmukh (2014), Zhao *et al*. (2013) and Dominy (2010).

4.1.4.2 Influence of pruning

The positively significant effect of pruning was observed in terms of number of leaves plant^{-1} (Figure 4, Appendix VI). The ranged of number leaves plant^{-1} were 8.67 to 15.56 at 20 DAS, 30.88 to 51.02 at 40 DAS and 17.55 to 37.63 at harvesting. The maximum number of leaves plant^{-1} was found in P_1 treatment (15.56, 51.02 and 37.63 at 20 DAS, 40 DAS and harvesting, respectively) compared to other treatments. This might be due to that, pruning helped for proper vegetative growth of cucumber plant. Mardhiana *et al*. (2017), Khoshkam (2016), Maboko *et al*. (2011), McFadyen *et al*. (2011), Ekwu and Utobo (2010) and Utobo *et al*. (2010), Suthar *et al*. (2006) were also reported the similar result.

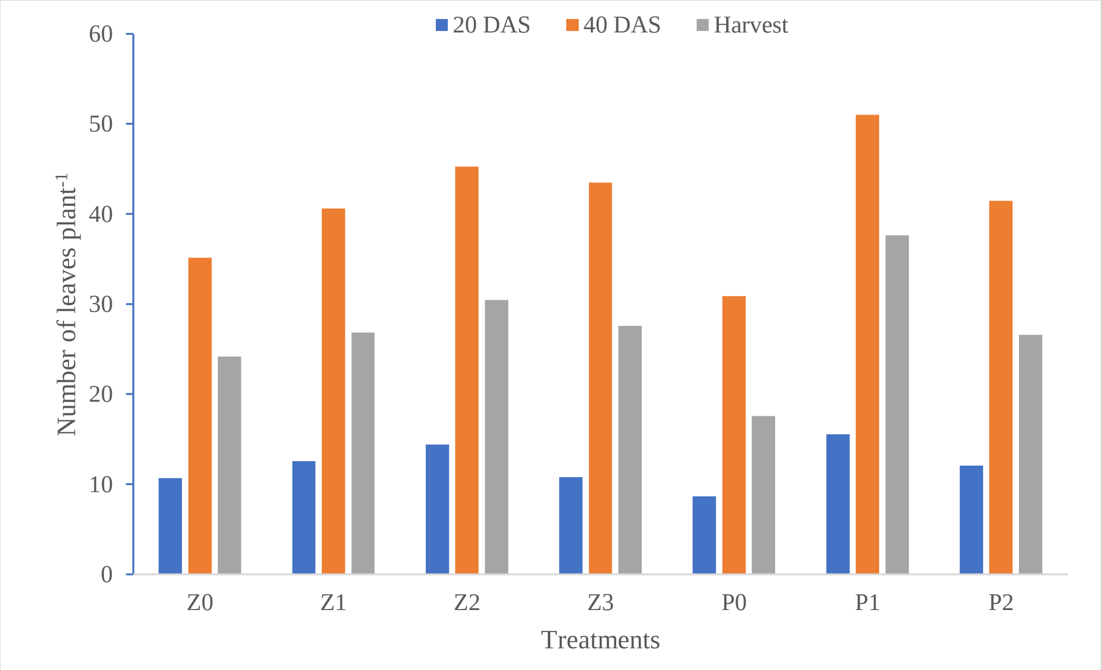

Figure 4. Influence of zinc and pruning on number of leaves plant^{-1} of cucumber

DAS=Days after sowing; Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.4.3 Combined effect of zinc and pruning

Combined effect of zinc and pruning showed a wide ranged of variation for number of leaves plant^{-1} at all sampling dates except at 20 DAS (Table 4, Appendix VI). The highest number of leaves plant^{-1} was found in P_1Z_2 treatments (18.57, 55.25 and 40.53 at 20 DAS, 40 DAS and harvesting time, respectively) compared to other combinations.

Table 4. Combined effect of zinc and pruning on number of leaves plant^{-1} of cucumber

Treatment	No of leaves plant^{-1} at		
	20 DAS	40 DAS	Harvesting
P_0Z_0	7.33 g	24.93 j	15.33 k
P_0Z_1	9.32 ef	30.23 i	18.32 j
P_0Z_2	10.33 de	35.22 g	20.33 i
P_0Z_3	7.67 fg	33.12 h	16.33 k
P_1Z_0	14.33 b	45.37 d	34.70 d
P_1Z_1	17.00 a	50.34 c	37.03 c
P_1Z_2	18.57 a	55.25 a	40.53 a
P_1Z_3	12.33 c	53.10 b	38.27 b
P_2Z_0	10.34 de	35.13 g	22.46 h
P_2Z_1	11.35 cd	41.28 f	25.10 g
P_2Z_2	14.32 b	45.29 d	30.52 e
P_2Z_3	12.33 c	44.18 e	28.30 f
SE (±)	0.404	0.152	0.335
CV (%)	5.39	0.49	1.27

DAS=Days after sowing; Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.5 Number of male flowers plant^{-1}

4.1.5.1 Influence of zinc

Application of zinc showed significant influence on number of male flowers plant^{-1} of cumber at different days after sowing (DAS). Number of male flowers plant^{-1} ranged from 27.81 to 37.94 (Figure 5, Appendix VII). The highest value of number of male flowers plant^{-1} was recorded in Z_2 (37.94) and the lowest in Z_0 (27.81). The fact that, adequate supply of Zn helped to get reproductive development of cucumber plant. The present finding is agreed with the finding of Zhao et al. (2013), Tzerakis *et al.* (2013), Kazemi (2013), Aydin *et al.* (2012) and Tzerakis *et al.* (2012).

4.1.5.2 Influence of pruning

Pruning activities significantly influenced on number of male flowers plant^{-1} and showed that P_1 produced highest number of male flowers plant^{-1} where control produced lowest number of male flowers plant^{-1} (Figure 5, Appendix VII). Result indicated that P_1 produced highest number of male flowers plant^{-1} (46.02). The control treatment (P_0) produced 21.18 number of male flowers plant^{-1}. This might be due to that, pruning helped for proper reproductive development of cucumber plant. Mardhiana *et al*. (2017), Khoshkam (2016), Maboko *et al*. (2011), McFadyen *et al*. (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010), Suthar *et al*. (2006), Gobeil and Gosselin (1990) were also reported the similar result.

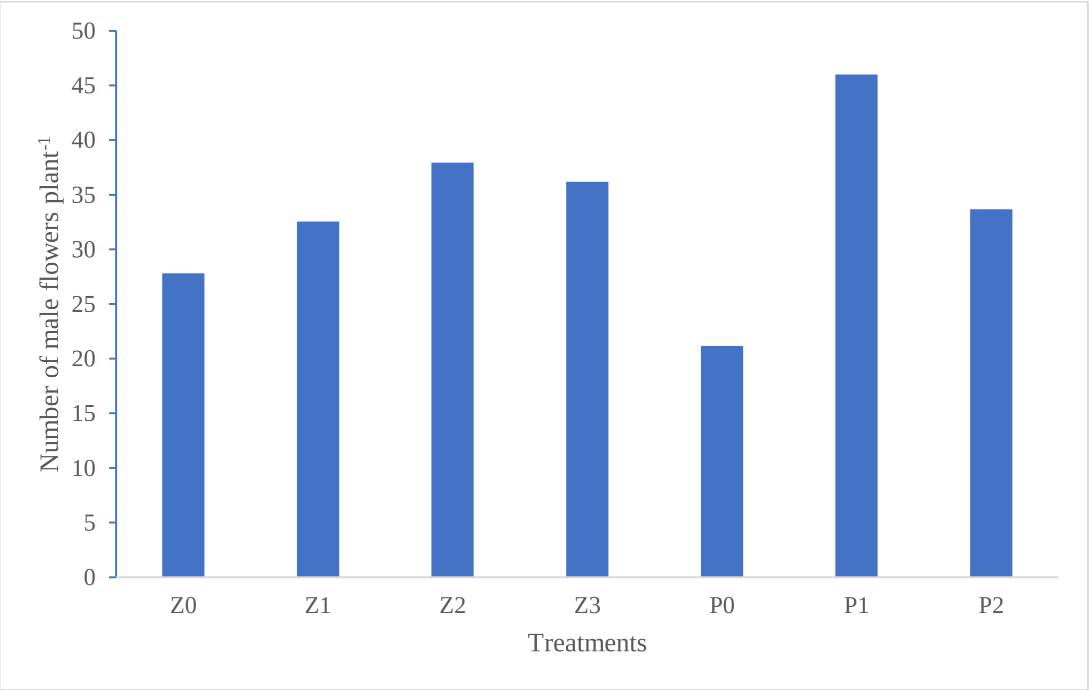

Figure 5. Influence of zinc and pruning on number of male flowers plant^{-1} of cucumber

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.5.3 Combined effect of zinc and pruning

Positively significant variation of number of male flowers plant^{-1} was observed due to combine effect of zinc application and branch pruning of cucumber (Table 5, Appendix VII). The highest number of male flowers plant^{-1} was found in P_1Z_2 (50.48) treatment combination compared to other treatments.

Table 5. Combined effect of zinc and pruning on number of male flowers plant^{-1} of cucumber

Treatments	No. of male flowers/plant
P_0Z_0	15.13 l
P_0Z_1	20.24 k
P_0Z_2	25.15 i
P_0Z_3	24.19 j
P_1Z_0	40.19 d
P_1Z_1	45.26 c
P_1Z_2	50.48 a
P_1Z_3	48.14 b
P_2Z_0	28.12 h
P_2Z_1	32.12 g
P_2Z_2	38.19 e
P_2Z_3	36.23 f
SE (±)	0.151
CV (%)	0.53

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.6 Number of female flowers plant^{-1}

4.1.6.1 Influence of zinc

Number of female flowers plant^{-1} was significantly influenced by zinc application in cucumber (Figure 6, Appendix VII). The highest number of primary branches was recorded in Z_2 (34.51). The lowest values of this trait were found in Z_0 (24.82). The fact that, adequate supply of Zn helped to get reproductive development of cucumber plant. The present finding is agreed with the finding of Moghaddasi *et al*. (2017), Tzerakis *et al.* (2013), Kazemi (2013), Aydin *et al*. (2012), Tzerakis *et al*. (2012), Dominy (2010), Kietsermkajorn *et al*. (2010) and Marschner *et al*. (1990).

4.1.6.2 Influence of pruning

The positively significant effect of pruning was observed in Number of female flowers plant^{-1} (Figure 6, Appendix VII). The ranged of primary branches were 18.38 to 42.16. The maximum number of primary branches plant^{-1} was found in P_1 treatment (42.16) compared to others treatments. This might be due to that, pruning helped for proper reproductive development of cucumber plant. Khoshkam (2016), Maboko *et al*. (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010), Suthar *et al*. (2006), Nu (1996), Thang (1995), Gobeil and Gosselin (1990) were also reported the similar result.

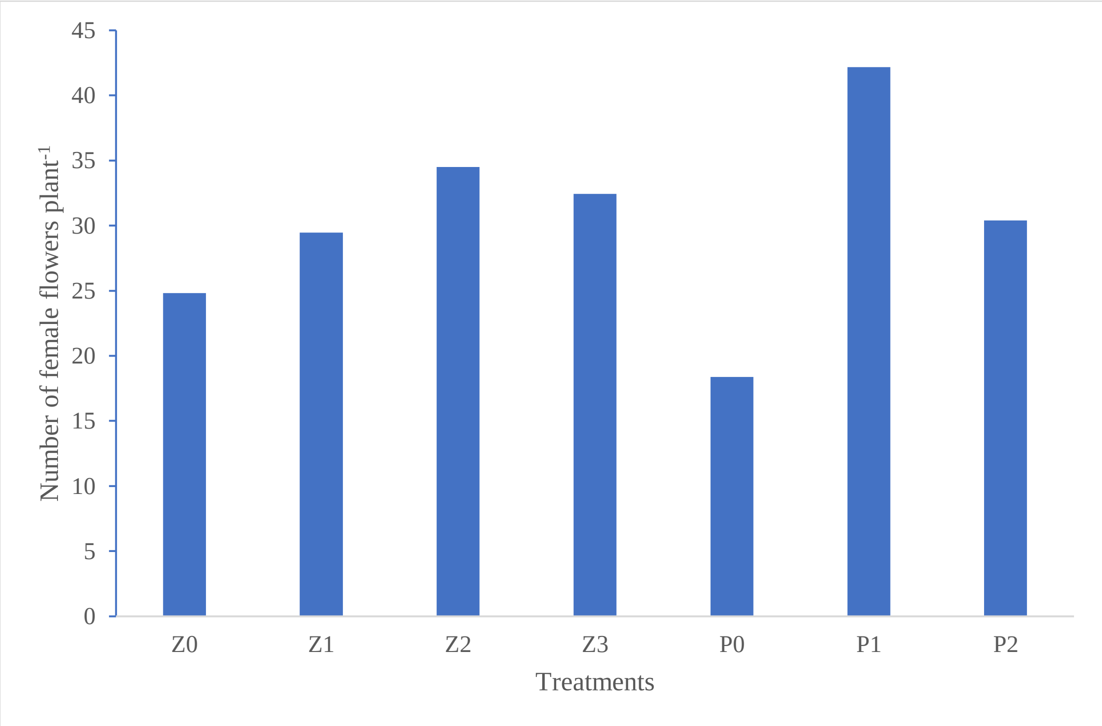

Figure 6.Influence of zinc and pruning on number of female flowers plant^{-1} of cucumber

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.6.3 Combined effect of zinc and pruning

Positively significant variation of number of female flowers plant^{-1} was observed due to combine effect of zinc application and branch pruning of cucumber (Table 6, Appendix VII). The highest number of female flowers plant^{-1} was found in P_1Z_2 treatment combination (46.16) compared to other treatments. The lowest values of number of female flowers plant^{-1} was recorded in P_0Z_0 (12.12).

Table 6. Combined effect of zinc and pruning on number of female flowers plant^{-1} of cucumber

Treatments	No. of female flowers/plant
P_0Z_0	12.12 l
P_0Z_1	17.11 k
P_0Z_2	23.18 i
P_0Z_3	21.09 j
P_1Z_0	37.13 d
P_1Z_1	41.15 c
P_1Z_2	46.16 a
P_1Z_3	44.19 b
P_2Z_0	25.19 h
P_2Z_1	30.12 g
P_2Z_2	34.20 e
P_2Z_3	32.09 f
SE (±)	0.077
CV (%)	0.17

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.7 Total number of fruits plant^{-1}

4.1.7.1 Influence of zinc

Application of zinc showed significantly positive influence on total number of fruits plant^{-1} of cucumber at different days after sowing (DAS). The total number of fruits plant^{-1} ranged from 12.56-15.73 (Figure 7, Appendix VIII). The highest value of total number of fruits plant^{-1} was recorded for Z_2 (1573) and lowest for Z_0 (12.56). The fact that, adequate supply of Zn helped to get reproductive development of cucumber plant. The present finding is agreed with the finding of Zhao *et al*. (2013), Tzerakis *et al.* (2013), Kazemi (2013), Aydin *et al*. (2012) and Tzerakis *et al*. (2012).

4.1.7.2 Influence of pruning

Pruning activities significantly influenced on total number of fruits plant^{-1} and showed that P_1 produced highest total number of fruits plant^{-1} where control produced lowest total number of fruits plant^{-1} (Figure 7, Appendix VIII). This might be due to that, pruning help for proper reproductive development of cucumber plant. Mardhiana *et al*. (2017), Khoshkam (2016), Maboko *et al*. (2011), McFadyen *et al*. (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010), Suthar *et al*. (2006), Nu (1996), Thang (1995), Gobeil and Gosselin (1989), Arora and Malik (1989), Gobeil and Gosselin (1990) were also reported the similar result.

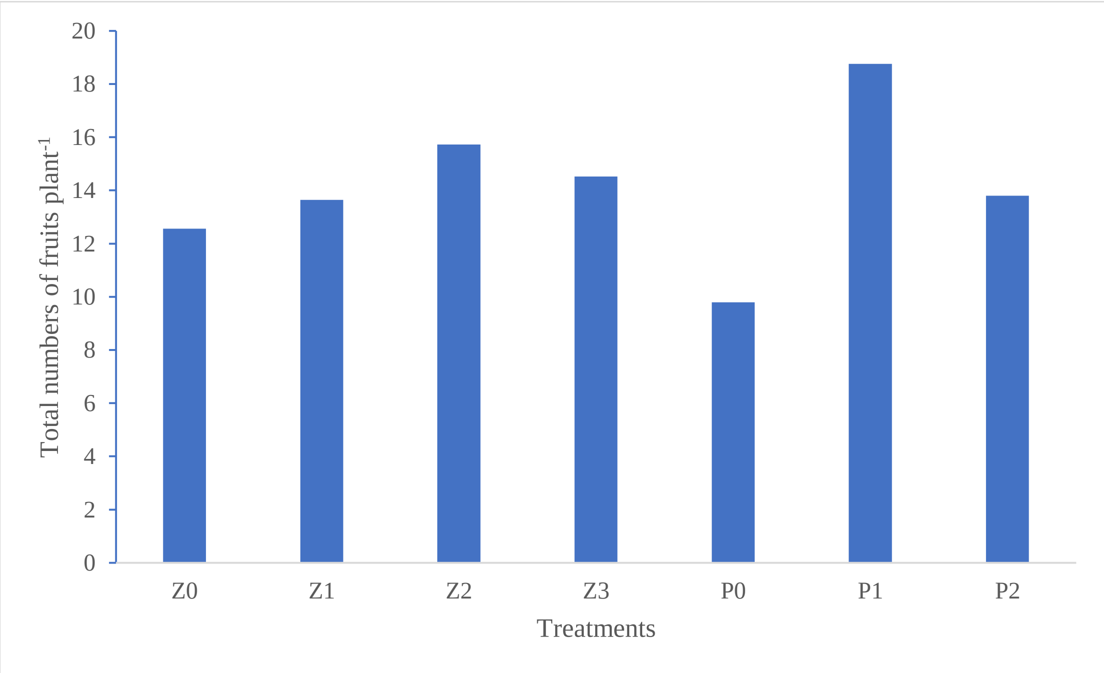

Figure 7. Influence of zinc and pruning on total number of fruits plant^{-1} of cucumber

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.7.3 Combined effect of zinc and pruning

Total number of fruits plant^{-1} showed non-significant variation due to combine effect of zinc application and branch pruning of cucumber (Table 7, Appendix VIII). But, the highest total number of fruits plant^{-1} was found in P_1Z_2 (20.49) treatment combination compared to others combinations.

Table 7. Combined effect of zinc and pruning on total number of fruits of cucumber

Treatments	No. of total fruits/plant
P_0Z_0	8.28
P_0Z_1	9.35
P_0Z_2	11.32
P_0Z_3	10.19
P_1Z_0	17.19
P_1Z_1	18.21
P_1Z_2	20.49
P_1Z_3	19.13
P_2Z_0	12.21
P_2Z_1	13.36
P_2Z_2	15.38
P_2Z_3	14.23
SE (±)	NS
CV (%)	1.35

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.8 Individual fruit length

4.1.8.1 Influence of zinc

Individual fruit length was significantly influenced by zinc application in cucumber (Figure 8, Appendix VIII). With the application of zinc, the highest value of fruit length was recorded in Z_2 (16.22 cm). The lowest value of the individual fruit length was found in Z_0 (13.59 cm). The fact that, adequate supply of Zn help to get reproductive development of cucumber plant. The present finding is agreed with the finding of Moghaddasi *et al*. (2017), Küçükyumuk *et al*. (2014), Deshmukh (2014), Zhao *et al*. (2013), Tzerakis *et al.* (2013), Kazemi

(2013), Aydin *et al*. (2012), Tzerakis *et al*. (2012), Dominy (2010), Kietsermkajorn *et al*. (2010) and Marschner *et al*. (1990).

4.1.8.2 Influence of pruning

The positively significant effect of pruning was observed in individual fruit length of cucumber (Figure 8, Appendix VIII). The ranged of individual fruit length was 10.28 cm to 19.71 cm. The highest individual fruit length was found in P_1 treatment (19.71 cm) compared to other treatments. This might be due to that, pruning helped for proper reproductive development of cucumber plant. Mardhiana *et al*. (2017), Khoshkam (2016), Maboko *et al*. (2011), McFadyen *et al*. (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010), Suthar *et al*. (2006), Nu (1996), Thang (1995), Gobeil and Gosselin (1989), Arora and Malik (1989), Gobeil and Gosselin (1990) were also reported the similar result.

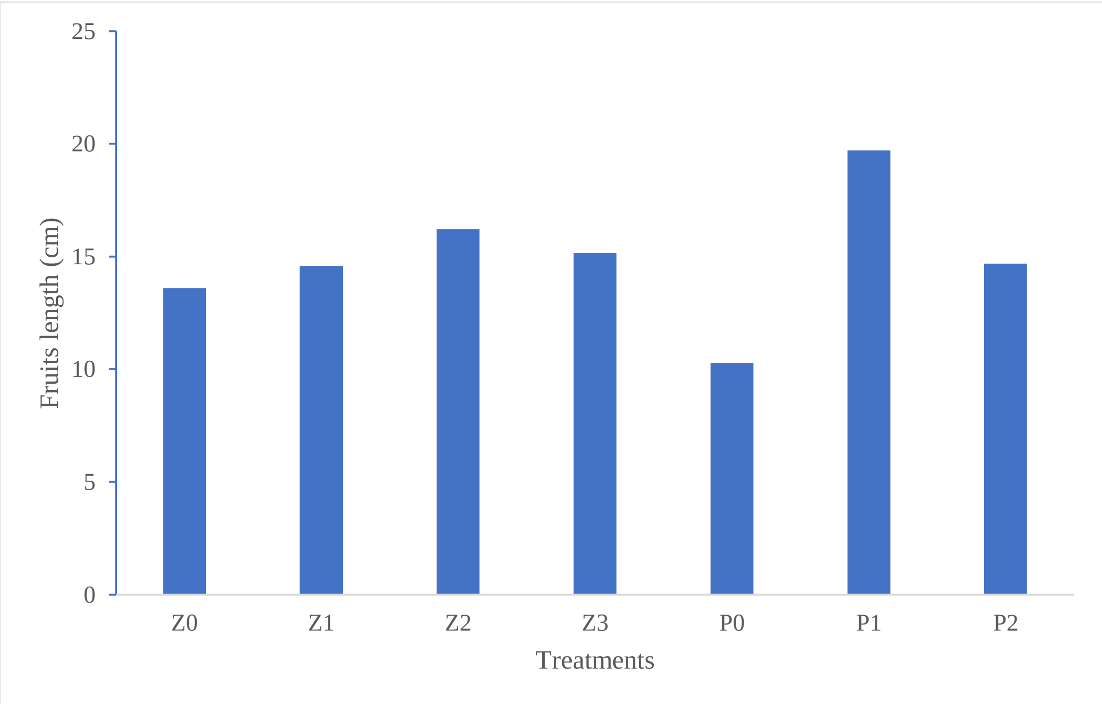

Figure 8. Influence of zinc and pruning on fruits length of cucumber

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.8.3 Combined effect of zinc and pruning

Combined effect of zinc and pruning showed a wide ranged of variation for individual fruit length (Table 8, Appendix VIII). The highest Individual fruit length was found in P_1Z_2 treatments (21.14 cm) compared to other combinations where the lowest individual fruit length was recorded in P_0Z_0 (9.37 cm).

Table 8. Combined effect of zinc and pruning on fruits length of cucumber

Treatments	Individual fruits length (cm)
P_0Z_0	9.37 k
P_0Z_1	10.30 j
P_0Z_2	11.32 i
P_0Z_3	10.12 j
P_1Z_0	18.28 d
P_1Z_1	19.24 c
P_1Z_2	21.14 a
P_1Z_3	20.20 b
P_2Z_0	13.11 h
P_2Z_1	14.20 g
P_2Z_2	16.19 e
P_2Z_3	15.19 f
SE (±)	0.131
CV (%)	0.46

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.9 Fruit girth

4.1.9.1 Influence of zinc

Zinc application in cucumber showed significant influence on fruit girth. The fruit girth ranged from 10.91 cm to 14.50 cm (Figure 9, Appendix VIII). The treatment Z_2 produced highest fruit girth (14.50 cm) and lowest was recorded for Z_0 (10.91 cm). The fact that, adequate supply of Zn help to get reproductive development of cucumber plant. The present finding is agreed with the finding of Moghaddasi *et al*. (2017), Küçükyumuk *et al*. (2014), Deshmukh (2014), Zhao *et al*. (2013), Tzerakis *et al.* (2013), Kazemi (2013), Aydin *et al*. (2012), Tzerakis *et al*. (2012), Dominy (2010), Kietsermkajorn *et al*. (2010) and Marschner *et al*. (1990).

4.1.9.2 Influence of pruning

The pruning activities of cucumber showed positively significant effect on fruit girth. Result indicated that P_1 produced 14.96 cm fruit girth. The control treatment (P_0) produced the minimum (9.95) cm fruit girth. This might be due to that, pruning help for proper reproductive development of cucumber plant. Mardhiana *et al*. (2017), Khoshkam (2016), Maboko *et al*. (2011), McFadyen *et al*. (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010), Suthar *et al*. (2006), Nu (1996), Thang (1995), Gobeil and Gosselin (1989), Arora and Malik (1989), Gobeil and Gosselin (1990) were also reported the similar result.

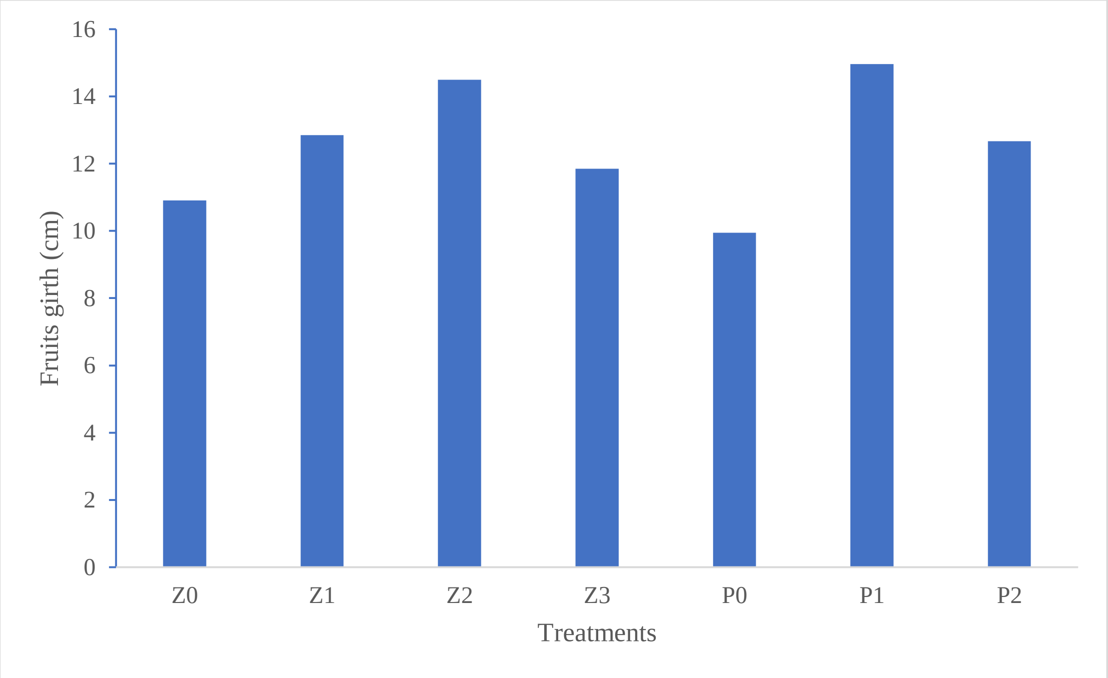

Figure 9. Influence of zinc and pruning on fruits girth of cucumber

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.9.3 Combined effect of zinc and pruning

Significant variation of fruit girth was observed due to combined effect of zinc application and branch pruning of cucumber (Table 9, Appendix VIII). The highest fruit girth was found in P_1Z_2 treatment combination (17.12 cm) compared to other treatments. The treatment combination P_0Z_0 produced lowest fruit girth (8.27 cm) of cucumber.

Table 9. Combined effect of zinc and pruning on fruits girth of cucumber

Treatments	Fruits girth (cm)
P_0Z_0	8.27 I
P_0Z_1	10.19 g
P_0Z_2	12.19 e
P_0Z_3	9.16 h
P_1Z_0	13.27 d
P_1Z_1	15.22 b
P_1Z_2	17.12 a
P_1Z_3	14.24 c
P_2Z_0	11.18 f
P_2Z_1	13.15 d
P_2Z_2	14.18 c
P_2Z_3	12.17 e
SE (±)	0.107
CV (%)	0.64

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.10 Individual fruit weight

4.1.10.1 Influence of zinc

Individual fruit weight showed significant variations for zinc application in cucumber (Figure 10, Appendix IX). The highest individual fruit weight was recorded in Z_2 (163.25 g). The lowest individual fruit weight was recorded in Z_0 (150.82 g). The fact that, adequate supply of Zn helped to get reproductive development of cucumber plant. The present finding is agreed with the finding of Moghaddasi *et al*. (2017), Küçükyumuk *et al*. (2014), Deshmukh (2014), Zhao *et al*. (2013), Tzerakis *et al.* (2013), Kazemi (2013), Aydin *et al*. (2012), Tzerakis *et al*. (2012), Dominy (2010), Kietsermkajorn *et al*. (2010) and Marschner *et al*. (1990).

4.1.10.2 Influence of pruning

The pruning showed a significant effect on individual fruit weight of cucumber (Figure 10, Appendix IX). The individual fruit weight ranged was 124.39 g to 191.71 g. The highest individual fruit weight was found in P_1 treatment (191.71 g) compared to others treatments and lowest was found in P_0 (124.39 g). This might be due to that, pruning help for proper reproductive development of cucumber plant. Mardhiana *et al*. (2017), Khoshkam (2016), Maboko *et al*. (2011), McFadyen *et al*. (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010), Suthar *et al*. (2006), Nu (1996), Thang (1995), Gobeil and Gosselin (1989), Arora and Malik (1989), Gobeil and Gosselin (1990) were also reported the similar result.

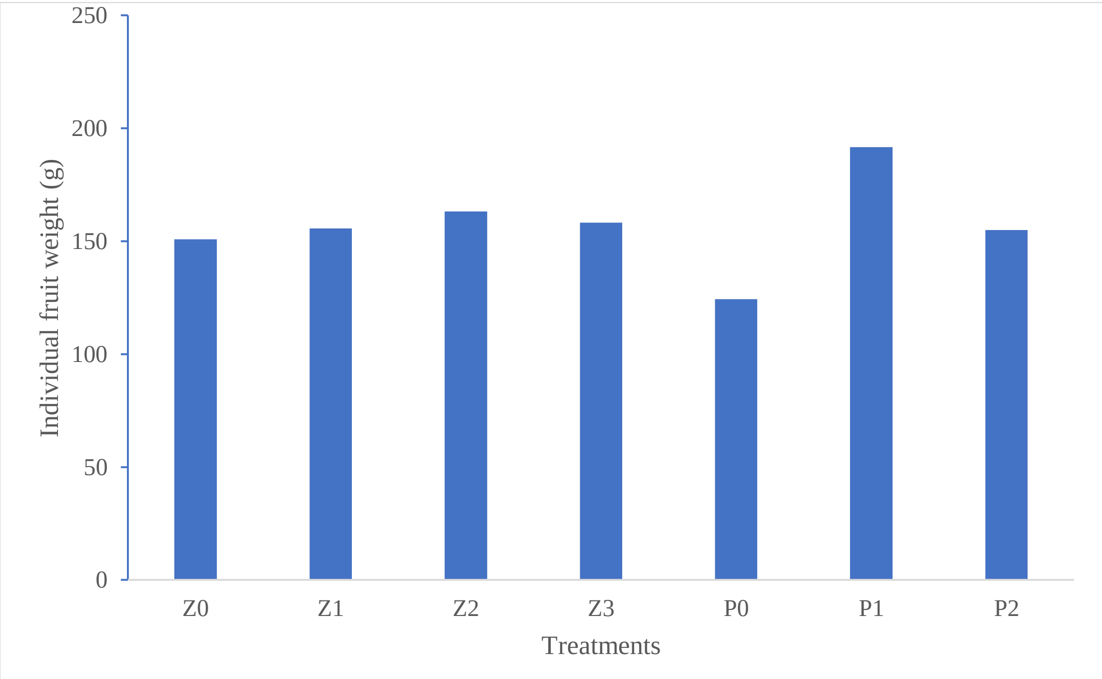

Figure 10. Influence of zinc and pruning on individual fruit weight of cucumber

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.10.3 Combined effect of zinc and pruning

The combined effect of zinc and pruning showed a non-significant variation individual fruit weight of cucumber (Table 10, Appendix IX). But the highest individual fruit weight was found in P_1Z_2 treatments (197.53 g) and lowest was found in P_0Z_0 (118.47 g) compared to others combinations.

Table 10. Combined effect of zinc and pruning on fruits weight and yield of cucumber

Treatments	Individual fruit weight (g)
P_0Z_0	118.47
P_0Z_1	122.85
P_0Z_2	130.61
P_0Z_3	125.63
P_1Z_0	185.23
P_1Z_1	190.52
P_1Z_2	197.53
P_1Z_3	193.54
P_2Z_0	148.75
P_2Z_1	153.68
P_2Z_2	161.61
P_2Z_3	155.69
SE (±)	NS
CV (%)	0.39

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.11 Fruit weight plant^{-1}

4.1.11.1 Influence of zinc

A significant influence was found due to application of zinc on fruit weight plant^{-1} (Figure 11, Appendix IX). The fruit weight plant^{-1} widely ranged from 412.04 g to 429.79 g. The highest fruit weight plant^{-1} (429.79 g) was recorded in Z_2 and the lowest fruit weight (412.04 g) was in Z_0. The fact that, adequate supply of Zn helped to get reproductive development of cucumber plant. The present finding is agreed with the finding of Moghaddasi *et al*. (2017), Küçükyumuk *et al*. (2014), Deshmukh (2014), Zhao *et al*. (2013), Tzerakis *et al.* (2013), Kazemi (2013), Aydin *et al*. (2012), Tzerakis *et al*. (2012), Dominy (2010), Kietsermkajorn *et al*. (2010) and Marschner *et al*. (1990).

4.1.11.2 Influence of pruning

The significant effect of pruning on fruit weight plant^{-1} was found and data showed that P_1 produced highest fruit weight plant^{-1} where control produced lowest fruit weight plant^{-1} (Figure 10, Appendix IX). Result indicated that P_1 produced 492.73 g fruit weight plant^{-1}. This might be due to that, pruning help for proper reproductive development of cucumber plant. The control treatment (P_0) produced 324.30 g. Mardhiana *et al*. (2017), Khoshkam (2016), Maboko *et al*. (2011), McFadyen *et al*. (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010), Suthar *et al*. (2006), Nu (1996), Thang (1995), Gobeil and Gosselin (1989), Arora and Malik (1989), Gobeil and Gosselin (1990) also reported the similar result.

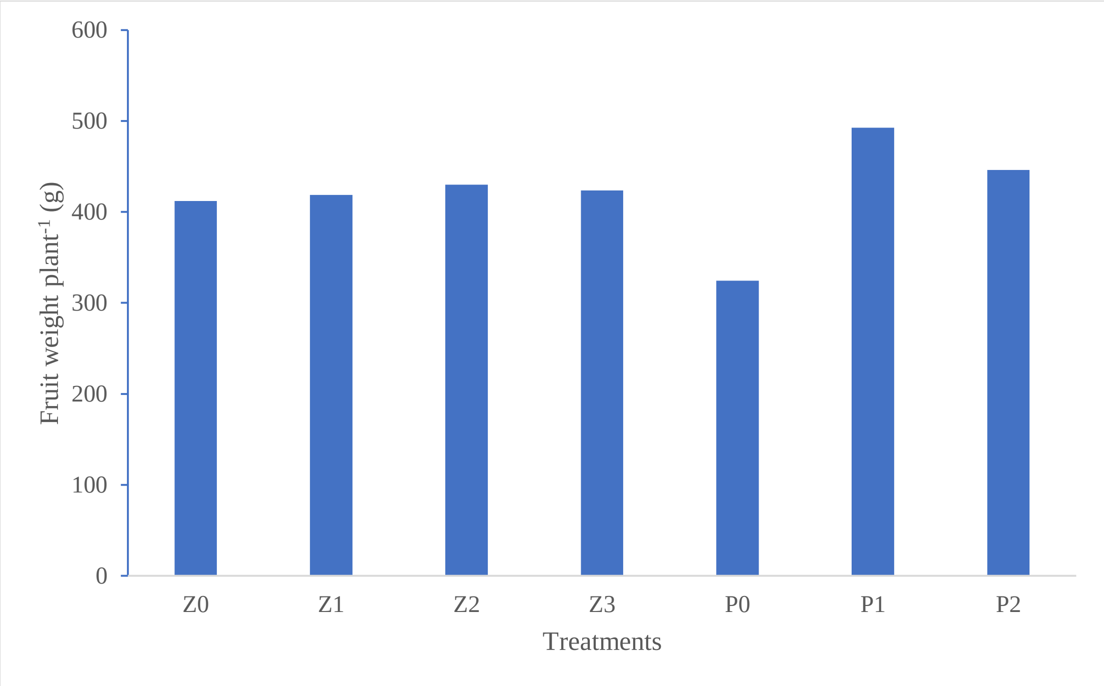

Figure 11. Influence of zinc and pruning on fruit weight plant^{-1} of cucumber

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.11.3 Combined effect of zinc and pruning

Positively significant variation of fruit weight plant^{-1} was observed due to combine effect of zinc application and branch pruning of cucumber (Table 11, Appendix IX). The highest fruit weight plant^{-1} (500.29 g) was found in P_1Z_2 treatment combination compared to others treatments. The treatment combination P_0Z_0 produced the lowest fruit weight plant^{-1} (317.17 g).

Table 11. Combined effect of zinc and pruning on fruits weight plant^{-1} cucumber

Treatments	Fruit weight plant^{-1} (g)
P_0Z_0	317.17 l
P_0Z_1	322.57 k
P_0Z_2	331.20 i
P_0Z_3	326.25 j
P_1Z_0	483.64 d
P_1Z_1	491.35 c
P_1Z_2	500.29 a
P_1Z_3	495.64 b
P_2Z_0	435.31 h
P_2Z_1	442.58 g
P_2Z_2	457.88 e
P_2Z_3	448.64 f
SE (±)	0.592
CV (%)	0.15

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.12 Fruit yield ha^{-1}

4.1.12.1 Influence of zinc

The fruit yield ha^{-1} was significantly influenced by zinc application in cucumber (Figure 12, Appendix IX). The highest fruit yield ha^{-1} was recorded in Z_2 (36.44 t ha^{-1}). The lowest value of fruit yield ha^{-1} was found in Z_0 (30.91 t ha^{-1}) compared to other treatments. The fact that, adequate supply of Zn helped to get reproductive development of cucumber plant. The present finding is agreed with the finding of Moghaddasi *et al*. (2017), Küçükyumuk *et al*. (2014), Deshmukh (2014), Zhao *et al*. (2013), Tzerakis *et al.* (2013), Kazemi (2013), Aydin *et al*. (2012), Tzerakis *et al*. (2012), Dominy (2010), Kietsermkajorn *et al*. (2010) and Marschner *et al*. (1990).

4.1.12.2 Influence of pruning

The positively significant effect of pruning was observed in fruit yield ha^{-1} (Figure 12, Appendix IX). The ranged of fruit yield ha^{-1} for pruning was 33.95 t ha^{-1} to 100.02 t ha^{-1}. The maximum value of fruit yield ha^{-1} was found in P_1 treatment (37.16 t ha^{-1}) and lowest was found in P_0 (28.68 t ha^{-1}) compared to others treatments. This might be due to that, pruning help for proper reproductive development of cucumber plant. Mardhiana *et al*. (2017), Khoshkam (2016), Maboko *et al*. (2011), McFadyen *et al.* (2011), Ekwu and Utobo (2010), Utobo *et al*. (2010), Suthar *et al*. (2006), Nu (1996), Thang (1995), Gobeil and Gosselin (1989), Arora and Malik (1989), Gobeil and Gosselin (1990) were also reported the similar result.

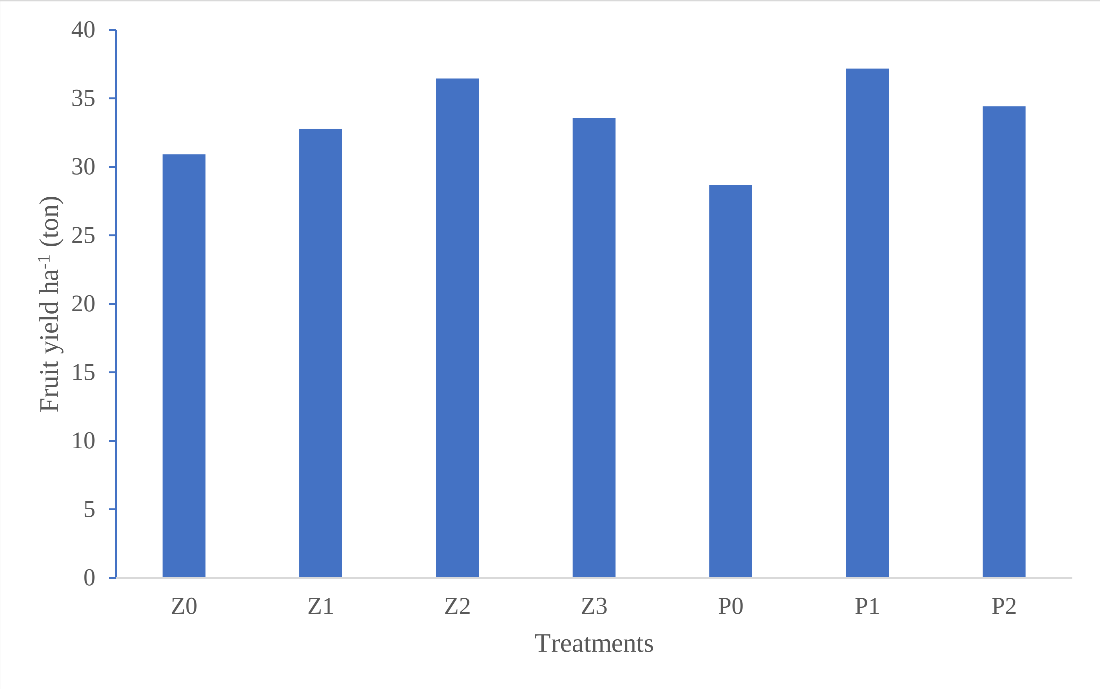

Figure 12. Influence of zinc and pruning on fruit yield ha^{-1} of cucumber

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

4.1.12.3 Combined effect of zinc and pruning

Combined effect of zinc and pruning showed a wide ranged of variation in terms of fruit yield ha^{-1} (Table 12, Appendix IX). The highest fruit yield ha^{-1} was found in P_1Z_2 treatments (40.66 t ha^{-1}) while P_0Z_0 produced lowest value of fruit yield (26.75 t ha^{-1}) compared to others combinations.

Table 12. Combined effect of zinc and pruning on fruits yield ha^{-1} of cucumber

Treatments	Fruit yield ha^{-1} (ton)
P_0Z_0	26.75 f
P_0Z_1	27.01 f
P_0Z_2	32.12 c-e
P_0Z_3	29.03 ef
P_1Z_0	35.00 bc
P_1Z_1	37.00 ab
P_1Z_2	40.66 a
P_1Z_3	36.06 b
P_2Z_0	31.04 de
P_2Z_1	34.33 b-d
P_2Z_2	36.66 b
P_2Z_3	35.66 bc
SE (±)	1.071
CV (%)	3.93

Z_0=No Zn spray, Z_1=20 mg/l, Z_2=30mg/l, Z_3=50mg/l; P_0=No pruning, P_1= Pruning to three primary branches, P_2= Pruning to five primary branches

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University to find out Growth, flowering, fruiting and yield of cucumber *(Cucumis sativus)* influenced by foliar application of Zn and stem pruning during the period from April to June 2016. The cucumber cultivar i.e. Krishibid Hybrid Seed was used as a test crop.

Result revealed that vegetative growth and reproductive studied parameter were highest for zinc application and stem pruning.

Vine length ranged from 27.15-38.35 cm at 20 DAS, 67.66-79.47 cm at 40 DAS and 140.98-151.92 cm at harvest. The highest value of vine length was recorded for Z_2 and lowest for Z_0. For stem pruning P_1 produced 54.69 cm, 101.95cm and 173.69 cm vine length at all sampling dates. The control treatment (P_0) produced 15.95 cm, 68.95 cm and 124.00 cm, respectively. And for combine effect, the highest vine length was found in P_1Z_2 treatment combination compared to other treatments at 20 DAS, 40 DAS and harvest.

The highest number of primary branches was recorded in Z_2 (6.44, 8.73, and 7.23 at 20 DAS, 40 DAS and harvest, respectively). The lowest values of this trait were found in Z_0 (4.29, 6.07 and 4.50 at 20 DAS, 40 DAS and harvest, respectively). In case of stem pruning, the range of primary branches were 3.22 to 7.66 at 20 DAS, 5.87 to 8.89 at 40 DAS and 4.01 to 7.69 at harvest. The maximum number of primary branches plant^{-1} was found in P_1 treatment (7.66, 8.89 and 7.69 at 20 DAS, 40 DAS and harvest, respectively) compared to others treatments. Even for combine effect, the highest number of primary branches plant-1 was found in P_1Z_2 treatments (8.93, 10.50 and 9.23 at 20 DAS, 40 DAS and harvest time, respectively).

The number of secondary branches plant^{-1} range from 8.14 to 11.23 at 20 DAS and 16.18 to 19.14 at harvest. The highest value of number of secondary branches plant^{-1} was recorded for Z_2 and lowest for Z_0. Result indicated that P_1 produced 13.78, and 22.66 number of secondary branches plant^{-1} at 40 DAS and harvest time, respectively. The control treatment (P_0) produced 6.69 and 11.66, at 40 DAS and harvest time, respectively. Combine effect having non-significant effect, but the highest number of secondary branches plant^{-1} was found in P_1Z_2 treatment combination compared to others treatments at 20 DAS, 40 DAS and harvest time.

The highest number of leaves was recorded in Z_2 (14.41, 45.25 and 30.46 at 20 DAS, 40 DAS and harvest, respectively). The lowest values of this trait were found in Z_0 (10.67, 35.14 and 24.17 at 20 DAS, 40 DAS and harvest, respectively). The range of number leaves plant^{-1} were 8.67 to 15.56 at 20 DAS, 30.88 to 51.02 at 40 DAS and 17.55 to 37.63 at harvest. The maximum number of leaves plant^{-1} was found in P_1 treatment (15.56, 51.02 and 37.63 at 20 DAS, 40 DAS and harvest, respectively) compared to others treatments. The highest number of leaves plant^{-1} was found in P_1Z_2 treatments (18.57, 55.25 and 40.53 at 20 DAS, 40 DAS and harvest time, respectively) compared to others combinations.

Number of male flowers plant^{-1} ranges from 27.81 to 37.94. The highest value of number of male flowers plant^{-1} was recorded for Z_2 (37.94) and lowest for Z_0 (27.81). Result indicated that P_1 produced highest number of male flowers plant^{-1} (46.02). The control treatment (P_0) produced 21.18 number of male flowers plant^{-1}. The highest number of male flowers plant^{-1} was found in P_1Z_2 (50.48) treatment combination compared to others treatments.

The highest values of umber of female flowers plant^{-1} was found in P_1Z_2 treatment combination (46.16) compared to others treatments. The lowest values of number of female flowers plant^{-1} was recorded in P_0Z_0 (12.12).

The highest value of total number of fruits plant^{-1} was recorded for Z_2 (15.73) and lowest for Z_0 (12.56). Result indicated that P_1 produced highest total number of fruits plant^{-1}. The control treatment (P_0) produced lowest values of total number of fruits plant^{-1}. The highest total number of fruits plant^{-1} was found in P_1Z_2 (20.49) treatment combination compared to others combinations.

The highest Individual fruit length was found in P_1Z_2 treatments (21.14 cm) compared to others combinations where the lowest individual fruit length was recorded in P_0Z_0 (9.37 cm).

The highest fruit girth was found in P_1Z_2 treatment combination (17.12 cm) compared to others treatments. The treatment combination P_0Z_0 produced lowest fruit girth of cucumber.

The highest individual fruit weight was recorded in Z_2 (163.25 g). The lowest individual fruit weight was recorded in Z_0 (150.82 g). The individual fruit weight range was 124.39 g to 191.71 g. The highest individual fruit weight was found in P_1 treatment (191.71 g) compared to others treatments and lowest was found in P_0 (124.39 g). The highest individual fruit weight was found in P_1Z_2 treatments (197.53 g) and lowest was found in P_0Z_0 (118.47 g) compared to others combinations.

The fruit weight plant^{-1} widely ranges from 412.04 g to 429.79 g. The highest fruit weight plant^{-1} was recorded in Z_2 and lowest in Z_0. Result suggested that P_1 produced 492.73 g fruit weight plant^{-1}. The control treatment (P_0) produced 324.30 g. The highest fruit weight plant^{-1} was found in P_1Z_2 treatment combination compared to others treatments. The treatment combination P_0Z_0 produced the lowest fruit weight plant^{-1}.

The highest fruit yield ha^{-1} was recorded in Z_2 (36.44 t ha^{-1}). The lowest value of fruit yield ha^{-1} was found in Z_0 (30.91 t ha^{-1}) compared to other treatments. The range of fruit yield ha^{-1} for pruning was 28.68 t ha^{-1} to 37.16 t ha^{-1}. The maximum value of fruit yield ha^{-1} was found in P_1 treatment (37.16 t ha^{-1}) and lowest was found in P_0 (28.68 t ha^{-1}) compared to others treatments. The highest fruit yield ha^{-1} was found in P_1Z_2 treatments (40.66 t ha^{-1}) while P_0Z_0 produced lowest value of fruit yield (26.75 t ha^{-1}) compared to others combinations.

It can be concluded that foliar application of Zn @30mg/l (Z_2) performed best in case of vegetative growth and reproductive development. The crop treated with P_1 (pruning to three primary branches) gave the best results in vegetative growth and reproduction. Better vegetative growth, reproduction and yield was found in cucumber treated with P_1Z_2.

This study was carried out only for one location even for one season. So, it is impossible to recommend this finding for farmer’s level. Thus, it can be concluded that, this experiment should have carried out in different locations of Bangladesh in different season.

REFERENCES

Anonymous, 1989. Annual Weather Report, IPSA. Meteorological Station, IPSA, Salna, Gazipur. P. 8-15.

Arora, S. K. and Malik, I. J. 1989. Effect of pruning and spacing levels on growth, flowering, earliness and fruit yield in Ridge gourd. *Haryana J. Hart. Sci.* **18**(1-2): 99-105.

Aydin, S. S., Gökçe, E., Büyük, İ. and Aras, S. 2012. Characterization of stress induced by copper and zinc on cucumber (*Cucumis sativus* L.) seedlings by means of molecular and population parameters. *Mutation Res. Genetic Toxicol. Environ. Mutagenesis,* **746**(1): 49-55.

Deshmukh, M. S. 2014. *Effect of zinc and boron on growth and quality of cucumber (Cucumis sativus* L.*) cv. GUJARAT CUCUMBER-1* (Doctoral dissertation, jau, junagadh). An M.Sc. thesis, Junagadh Agricultural University, Junagadh.

Dominy, A. P. 2010. *Studies of the Micronutrients Zinc, Manganese and Silicon in Cucumbers (Cucumis Sativus)*. Doctoral dissertation, University of University of KwaZulu-Natal, Pietermaritzburg.

Ekwu, L. G. and Utobo, E. B. 2010. Effect of Staking and Pruning on the Growth and Yield of Cucumber (*Cucumis sativus* L.). *Int. J. Agric. Rural Dev.*, **13**(2):01-08.

FAO. 1988. Production Year Book. Food and Agricultural of the United Nations. Rome, Italy. 42:190-193.

FRG (Fertilizer Recommendation Guide). 2012. Bangladesh Agricultural Research Council. Farmgate, Dhaka, Bangladesh. pp. 1-247.

Gobeil, G. and Goselin, A. 1989. The influence of pruning and season on fruit development in a crop of European cucumber. *Can J. Plant Sci.* **699** (3): 1037-1048.

Gobeil, G. and Gosselin, A. 1990. Influence of pruning and season on productivity of cucumber plants grown in a sequence cropping system. *Scientia hort.*, **41**(3), 189-200.

Humphries, E.G. 1994. Pickling cucumber vine pruning treatments and their implications for mechanical harvesting. **37** (1): *Tans- ASlA*. pp :71-75.

Jarrick, J. 1986. Training and pruning. *Hort. Sci.* p: 400.

Kazemi, M. 2013. Effect of foliar application of iron and zinc on growth and productivity of cucumber. *Bull. Env. Pharmacol. Life Sci.*, **2**(11), 11-14.

Khoshkam, S. 2016. The effect of pruning and planting density on yield of greenhouses cucumber in Jiroft. *IJSEAS*, ***2***: 212-227.

Kietsermkajorn, N., Anusontpornperm, S., Kheoruenromne, I. and Chulaka, P. 2010. Zinc and magnesium fertilization for growing Japanese cucumber on basic soil with high residual phosphorus and potassium. In *Proceedings of the 47th Kasetsart University Annual Conference, Kasetsart, 17-20 March, 2010. Subject: Plants* (pp. 145-152). Kasetsart University.

Kołota, E. and Osińska, M. 2001. Efficiency of foliar nutrition of field vegetables grown at different nitrogen rates. *Acta Hort.*, pp: 87–91.

Küçükyumuk, Z., özgönen, H., Erdal, I. and Eraslan, F. 2014. Effect of Zinc and Glomus intraradices on Control of Pythium deliense, Plant Growth Parameters and Nutrient Concentrations of Cucumber. *Not. Bot. Horti Agrobo.*, **42**(1): 138-142.

Maboko, M. M., Du Plooy, C. P. and Chiloane, S. 2011. Effect of plant population, fruit and stem pruning on yield and quality of hydroponically grown tomato. *Afr. J. Agric. Res.*, **6**(22): 5144-5148.

Mardhiana, M., pradana, A. P., adiwena, M., kartina, K., santoso, D., wijaya, R. and maliki, A. 2017. Effects of pruning on growth and yield of cucumber

(Cucumis sativus) Mercy variety in the acid soil of North Kalimantan, Indonesia. *Cell Biol. Dev.*, **1**(1), 13-17.

Marschner, H., Oberle, H., Cakmak, I. and Römheld, V. 1990. Growth enhancement by silicon in cucumber (Cucumis sativus) plants depends on imbalance in phosphorus and zinc supply. *Plant Soil*, **124**(2): 211-219.

McFadyen, L. M., Robertson, D., Sedgley, M., Kristiansen, P. and Olesen, T. 2011. Post-pruning shoot growth increases fruit abscission and reduces stem carbohydrates and yield in macadamia. *Ann. Botany*, **107**(6): 993-1001.

Moghaddasi, S., Fotovat, A., Karimzadeh, F., Khazaei, H. R., Khorassani, R. and Lakzian, A. 2017. Effects of coated and non-coated ZnO nano particles on cucumber seedlings grown in gel chamber. *Archives Agron. Soil Sci.*, **63**(8), 1108-1120.

Narimani, H., Rahimi, M.M., Ahmadikhah, A. and Vaezi, B. 2010. Study on the effects of foliar spray of micronutrient on yield and yield components of durum wheat. *Arch. Appl. Sci. Res*., pp:168-176.

Nu. T.T. 1996. Pruning effect on yield of different cucumber varieties, ARC Training Report 1996, Nakhon Pathom, Thailand.

Suthar, M. R., Arora, S. K., Bhatia, A. K. and Dudi, B. S. 2006. Effect of pruning and ethrel treatments on cucumber production in polyhouse. *Haryana J. Hort. Sci.*, **35**(3/4): 299-302.

Thang, D. X. 1995. Pruning Effect on yield of cucumber variety poung. ARC. Training Report, Nakhon Pathom, Thailand.

Tzerakis, C., Savvas, D. and Sigrimis, N. 2012. Responses of cucumber grown in recirculating nutrient solution to gradual Mn and Zn accumulation in the root zone owing to excessive supply via the irrigation water. *J. Plant Nutri. Soil Sci.*, **175**(1): 125-134.

Tzerakis, C., Savvas, D., Sigrimis, N. and Mavrogiannopoulos, G. 2013. Uptake of Mn and Zn by cucumber grown in closed hydroponic systems as influenced by the Mn and Zn concentrations in the supplied nutrient solution. *HortScience*, **48**(3): 373-379.

Utobo, E. B., Ekwu, L. G., Ogah, E. O. and Nwokwu, G. N. 2010. Growth and yield of cucumber varieties as influenced by pruning at Abakaliki Agricultural Area Southeastern Nigeria. Cont. *J. Agron.*, **4**: 23-27.

Zhao, L., Sun, Y., Hernandez-Viezcas, J. A., Servin, A. D., Hong, J., Niu, G. and Gardea-Torresdey, J. L. 2013. Influence of CeO_2 and ZnO nanoparticles on cucumber physiological markers and bioaccumulation of Ce and Zn: a life cycle study. *J. Agric. food Chem.*, **61**(49): 11945-11951.

APPENDIX

Appendix I. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from April to May 2016.

Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
April, 2016	32.5	20.4	64	65.8	5.9
May, 2016	35.7	26.6	75	180.3	6.2

Source: Sher-e-Bangla Agricultural University Weather Station

Appendix II. Physical characteristics & chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
pH	6.00-6.63
Organic mater	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41meq / 100 g soil

Source: Soil resource and development institute (SRDI), Dhaka

Appendix III. Anova of influence of zinc and pruning on vine length of cucumber

Sources of variation	Degrees of freedom	Mean square		
		Vine length (cm) at		
		20 DAS	40 DAS	Harvest
Replication	2	17.17	2.47	3.25
Pruning	2	4802.55	8981.00	7603.62
Zinc	3	190.05	265.03	184.77
Pruning*Zinc	6	21.66	46.64	3.43
Error	22	2.07	0.72	0.56

Appendix IV. Anova of influence of zinc and pruning on number of branches

Sources of variation	Degrees of freedom	Mean square		
		Number of branches at		
		20 DAS	40 DAS	Harvest
Replication	2	1.2953	1.0521	0.4358
Pruning	2	60.2019	30.3419	40.6265
Zinc	3	7.3366	13.3319	11.4116
Pruning*Zinc	6	0.2616	1.3835	0.9308
Error	22	0.0683	0.0653	0.0401

Appendix V. Anova of influence of zinc and pruning on number of secondary branches

Sources of variation	Degrees of freedom	Mean square	
		Number of secondary branches at	
		40 DAS	Harvest
Replication	2	0.546	0.247
Pruning	2	160.150	372.203
Zinc	3	15.884	14.500
Pruning*Zinc	6	0.016	0.007
Error	22	0.015	0.003

Appendix VI. Anova of influence of zinc and pruning on number of leaves

Sources of variation	Degrees of freedom	Mean square		
		Number of leaves at		
		20 DAS	40 DAS	Harvest
Replication	2	1.195	0.39	2.73
Pruning	2	142.489	1218.07	1213.97
Zinc	3	28.054	175.73	60.39
Pruning*Zinc	6	4.863	0.38	5.05
Error	22	0.426	0.04	0.12

Appendix VII. **Anova of influence of zinc and pruning on number of male and female flowers**

Sources of variation	Degrees of freedom	Mean square	
		Number of flowers	
		Male	Female
Replication	2	0.47	0.18591
Pruning	2	1851.10	1696.89
Zinc	3	180.47	159.498
Pruning*Zinc	6	0.52	1.25648
Error	22	0.03	0.03

Appendix VIII. **Anova of influence of zinc and pruning on fruits characters**

Sources of variation	Degrees of freedom	Mean square		
		Fruit characters		
		No. of total fruits	Fruits length (cm)	Fruits girth (cm)
Replication	2	0.737	0.522	0.3416
Pruning	2	242.242	267.656	75.5310
Zinc	3	16.221	10.896	21.1765
Pruning*Zinc	6	0.017	0.413	0.2168
Error	22	0.036	0.009	0.0064

Appendix IX. **Anova of influence of zinc and pruning on fruits weight**

Sources of variation	Degrees of freedom	Mean square		
		Fruit weight		
		Individual fruit weight (g)	Fruit weight plant^{-1} (g)	Fruit yield ha^{-1} (ton)
Replication	2	3.3	8.3	10.314
Pruning	2	13634.1	90761.8	224.564
Zinc	3	242.0	505.8	47.534
Pruning*Zinc	6	0.6	11.9	3.388
Error	22	0.4	0.4	1.723