EFFECT OF LEAF PRUNING AND GA_3 ON GROWTH AND YIELD OF SQUASH (*Cucurbita pepo*)

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EFFECT OF LEAF PRUNING AND GA_3 ON GROWTH AND YIELD OF SQUASH (*Cucurbita pepo*)

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF LEAF PRUNING AND GA$_3$ ON GROWTH AND YIELD OF SQUASH (Cucurbita pepo)"submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in HORTICULTURE,embodies the result of a piece ofbona fideresearch work carried out byTANZINA BABY,Registration No.: 12-04992, under my supervision and guidance. No part of the 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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TO

MY BELOVED PARENTS

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BY

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ABSTRACT

The field experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, during the period from November 2017 to February 2018. The seed of Sunny House-F_1 hybrid squash was used as planting materials. Three levels of pruning as P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (days after transplanting) (1st and 2nd leaves) and P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves) and four levels GA_3 application as G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3 and G_3 = 300 ppm GA_3 were considered as treatments for the present study. The experiment was laid out in a Randomized Complete Block Design with three replications. In case of pruning, the highest yield (21.14 t/ha) was found from P_1 treatment, whereas the lowest yield (16.05 t/ha) from P_0 treatment. For GA_3 treatments, maximum yield (24.51 t/ha) was recorded from G_1 treatment, while the minimum yield (14.41 t/ha) from G_0 treatment. Due to combined effect the highest yield (29.14 t/ha) was observed from P_1G_1 treatment combination, while the lowest yield (11.30 t/ha) from P_0G_0 treatment combination. So, it revealed that the P_1G_1 treatment combination appeared to be the best for achieving the higher growth and yield of squash cultivation.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
SAU	=	Sher-e-Bangla Agricultural University
M.S.	=	Master of Science
CRBD	=	Randomized Complete Block Design
DAT	=	Days After Transplanting
DMRT	=	Duncan's Multiple Range Test
GA	=	Gibberelic Acid
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization of the United Nation
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
mg	=	Miligram
m^2	=	Meter squares
ppm	=	Parts per Million
ha	=	Hactare
No.	=	Number
cm	=	Centimeter
var.	=	Variety
^oC	=	Degree Celcius
%	=	Percentage
N	=	Nitrogen
P	=	Phosphorus
K	=	Potassium
m	=	Meter
L	=	Litre
et al.,	=	And others
SS	=	Sum of Square
MS	=	Mean Square
DF	=	Degrees of Freedom
%	=	Percent

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Squash (*Cucurbita pepo* L) is one of the related species of genus *Cucurbita* which consists of about 30 species of annual, tendril-bearing plants of the family Cucurbitaceae (Hutchinson 1967). Four species are commonly cultivated: *Cucurbita maxima*, *Cucurbita mixta*, *Cucurbita moschata*, and *Cucurbita pepo*. Various cultivars of *Cucurbita pepo* are called summer squash, pumpkin, vegetable marrow, zucchini, and spaghetti squash (Purseglove, 1968), which are eaten as a vegetable, fed to livestock, or used for ornament (Cobley, 1976). The fruit of squash is large and variable in shape, size, color and markings with a peduncle that is large, soft and corky on the surface at maturity. The ideal temperature for squash growth is between 18° to 27°C and the required pH is 5.6-6.5.

Squash is one of the most versatile and delicious foods available throughout the world, and it packs a serious punch in terms of health and medicinal benefits. Squash is rich in carotenoids, beta carotene (a precursor to vitamin A), lutein, zeaxanthin, protein, vitamin C, vitamin B6, fiber, magnesium, potassium. Squash has been used in some cultures as a medicinal plant to treat diabetes, high blood pressure, cancer, high cholesterol, and inflammation (Caili *et al*., 2006).

Squash is now cultivating in all over the world; in 2016 this crop was planted on 15135 ha area of land that was able to be harvested on an average of 32.67 ton ha^{-1} in 2016 (FAOSTAT, 2016). Squash is commonly grown in the Philippines throughout the year. In 2009, the Philippines ranked 16^{th} in the world production of squash together with pumpkins and gourds with a production value of $ 43,441 at a volume of 247,759 metric tons (FAOSTAT, 2016). It is usually grown in home gardens and commercial scale for its immature fruits, young shoots, flowers, and seeds. Day by day the squash production is increasing in Bangladesh as squash has great demand. According to the statistical data of 2016, Bangladesh ranks 16^{th} position in quantity of squash, pumpkin and gourd production and the quantity was 290,835 tons (BBS, 2016). In the same year, the area harvested of pumpkins, squash and gourds was 28,625 hectare and it ranked 12 positions (FAOSTAT, 2016).

To increase the production of squash, various improved production technologies can be initiated. Pruning treatment and GA_3 application can be considered as important improved technologies for successful squash production. There is an imperative need for improvement of fruit quality in order to meet the change in market demand and making it available to the maximum extent by foliar spray of GA_3 and regular current season shoot pruning.

Pruning is a horticultural and silvicultural practice involving the selective removal of certain parts of the plant, such as leaf, branches, buds or roots. It helps both harvesting and increasing the yield or quality of flowers and fruits. Pruning is very effective for increased growth of squash. Its large leaves can quickly take up space in the garden and prevent fruits from receiving adequate sunlight. Pruning of squash leaf can help alleviate any overcrowding or shading issues. In addition, pruning can help stimulate additional squash growth. Squash plant leaves grow so large that they can often shade the plant itself and reduce sunlight to itself or surrounding plants. This is why cutting leaves to give squash more sunlight may be required. Gholipoori *et al.* (2007) reported that shoot pruning had a positive effect on fruit number per plant and seed yield in pumpkin. They also indicated that shoot pruning between nodes 10 to 14 would have a significant positive effect on the oil and fatty acid concentrations in the plant (Gholipouri and Nazarnejad, 2007). Hong (2000) reported that the topping of plant heads led to produce more fruit than plants whose top branch are not cut.

Gibberellins (GAs) are a large group of important diterpenoid acids among commercial phytohormones (Martin *et al.*, 2000). Gibberellins are tetracyclic diterpenoid acids that are involved in a number of developmental and physiological processes in plants (Crozier *et al*., 2000). These processes include seed germination, seedling emergence, stem and leaf growth, floral induction and flower and fruit growth (King and Evans, 2003 and Sponsel, 2003). Gibberellins are also implicated in the promotion of root growth, root hair abundance, and inhibition of floral bud differentiation in woody angiosperms, regulation of vegetative and reproductive bud dormancy and delay of senescence in many organs of a range of plant species (Reinoso *et al*., 2002). Gibberellic acid is such a plant growth regulator, which can manipulate a variety of growth and development phenomena in various crops. GA_3 enhances growth activities to plant, stimulates stem elongation and increases dry weight and yield (Deotale *et al*., 1998 and Maske *et al*., 1998). Gibberellins (GA_3) have been used in increasing stalk length and vegetative growth, flower initiation, increasing fruit size, hastening maturity and improving fruit quality in many crops. Gibberellins play an important role in enhancing the growth and flowering in fenugreek (Pariari *et al*., 2007). Exogenous growth regulator treatments – gibberellins (usually gibberellic acid; GA_3) have been shown to break dormancy in many seed species (Karam and Al-Salem, 2001).

However, very limited research was conducted to improve the growth and yield by pruning and GA_3 in squash. Therefore considering the above facts, the present experiment has been undertaken with the following objectives:

1. To identify the suitable pruning management practice for maximum growth and yield of Squash.
2. To optimize the level of GA_3 on growth and yield of Squash.
3. To determine the combined effect of pruning and GA_3 on growth and yield of squash.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Very few studies on the growth and yield of squash have been carried out in our country as well as many other countries of the world. Therefore, the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important informative works and research findings related to pruning and GA_3 on Squash so far been done at home and abroad have been reviewed in this chapter under the following headings.

2.1. Literature on pruning

Gholipouri and Nazarnejad (2007) conducted an experiment to investigate the effects of stem pruning (No heading, head pruning of stem after the formation of 10 and 14 nodes) and nitrogen levels (0, 50, 100 and 200 kg) ha^{-1} on the physical and chemical characteristic of pumpkin seed. Results showed that the stem pruning has a significant effect on traits such as seed oil, linoleic acid, and oleic acid content. Nitrogen levels also have a significant effect on seed dimension, seed oil, linoleic acid, and oleic acid content. The largest amount of oil and linoleic acid content was obtained by stem pruning after forming 14 nodes and 100 kg $ha^{(-1)}$ nitrogen in separately, but the interaction of treatments was not a significant difference for all of the traits.

Olasantan and Salau (2008) imposed pruning treatments on apically de-budded okra plants for 3 years to assess effects of removing a quarter, half or three-quarters of the primary branches and leaves on growth and fresh leaf and pod yields. Pruning significantly delayed fruiting by 8–10 days, extended length of harvest duration by 12–15 days and increased number of pods/plant by 10–40% and pod yield by 9–36% more than the control plants which had neither apical bud removal nor pruning. However, no difference in pod weight or pod length was found between these treatments and the control. Three-quarters pruning significantly ($P<0{\cdot}05$) increased fresh leaf yield by 29–49%, but not all the leaves were desirable for consumption because of high fibre content. Decreases were seen in the numbers of secondary branches, shoot dry weight and pod yields (by 40–57, 22–36 and 22–30%, respectively, more than a quarter or half pruning). Although early production of pods in the control plants is often important for early maturity and high market prices, the present study found that a delay in fruiting, an extension in length of harvest duration and an increase in pod yield in plants with a quarter or half pruning enhanced staggered production and maximal pod yield. This helps to ensure a better market price and to enable growers to avoid a glut on the market. A direct promotional effect of pruning on pod yields provides a possible strategy for growing okra for both leaf and pod harvests. A quarter or half pruning from the upper parts of the main stems of apically de-budded plants to ensure good production and quality of leaves and pods is therefore recommended if okra is to be grown for both leaf and pod yields.

Olasantan (2006) conducted field trials over three years to investigate the effects of harvesting 30 or 60 cm long apical shoots at 1-week intervals at population densities of 5,000, 10,000 and 15,000 plants ha^{-1}, or 30 cm long apical shoots at 1, 1½, and 2 week intervals in plants sown in late March, mid-April and early May on growth and apical shoot and fruit yields. Increasing plant population up to 15,000 plants ha^{-1} increased apical shoot yields. Fruit yields increased by 38% as the plant population increased to 10,000 plants ha^{-1}, beyond which it increased an additional 3%. Plants sown in mid-April produced greater numbers of apical shoots or fruit, and apical shoot and fruit yields by 5-35% than for plants sown in late March or early May. Harvesting 60-cm long apical shoots at 1-week intervals decreased numbers of fruit/plant and fruit yields by 15-33%, but increased apical shoot yields by 15-52%, compared with removing 30 cm long apical shoots at 1-week intervals. Harvesting 30 cm long apical shoots at 1-week intervals produced the greatest number of apical shoots and apical shoot yields, but significantly reduced numbers of fruit and total fruit yields by 20-50%, relative to harvesting 30 cm long apical shoots at 1½ or 2-week intervals. Harvesting 30 cm long apical shoots at 1½ week intervals and at an optimal target population of 10,000 plants ha^{-1}, and sowing in April is recommended if pumpkin is to be grown for the apical shoot and acceptable fruit yield.

Bahrami *et al*. (2009) carried out an experiment to evaluate the effects of planting methods (seed sowing and transplanting) and head pruning (no pruning, pruning after 12th node and pruning after 16th node) on yield and yield components such as number of branches (sub-branches) per plant, fruits per plant, growth, fruit size, weight of fresh fruit, weight of seeds per fruit, number of seeds per fruit and seed yield of medicinal pumpkin. Seedlings were grown in heated greenhouse and seedlings were at the four leaves stage, both seeds and seedlings were planted at the same time in the farm. Maintenance operations were done during the growing season. Head pruning treatments were done in the forecast time. The results showed that the planting methods had a significant effect on the number of ripening fruits per plant, fruits diameter, the weight of seeds per fruit, the weight of 1000 seeds and seed yield had no significant effect on the other traits. Also, the results indicated that head pruning treatments had significant effects on the number of branches per plant, growth and seed yield and no sign on the other traits. In this experiment the most seed yield 997.8 kg ha^{-1} obtained from the transplanting method with head pruning after 12th node and the least seed yield obtained from control.

Tripti (2017) conducted a field experiment from November 2015 to February 2016 to study the effect of leaf pruning and vermicompost on growth and yield of squash (*Cucurbita pepo*). Three different pruning practices; control (No pruning, P_0), P_1 (First and second leaf pruning at 20 DAT), P_2 (Third and fourth leaf pruning at 30 DAT) and four different doses of vermicompost; Control (No vermicompost, V_0), V_1 (5 t/ha), V_2 (10 t/ha) and V_3 (15 t/ha) were applied in the experiment. Maximum stem length (64.74 cm at harvest), leaf per plant (20.33), the highest female flowers per plant (8.62), number of fruits plant^{-1} (5.12), individual fruit weight (318.67 gm), fruit length (21.35 cm) and yield (21.07 t/ha) were found in P_1 treatment. The maximum stem length (68.26 cm), the leaf per plant (21.56), the female flower (8.11), the total number of fruit (5.11), the individual fruit weight (383.67 gm), the length of fruit (21.61 cm), the diameter of fruit (5.19 cm) and the yield (39.20 t/ha) were found in V_2 treatment. First pruning at 20 DAT and 10 t/ha vermicompost combination gave the highest yield (48.33 t/ha) and the lowest yield was recorded from P_0V_0 treatment combination. So, P_1V_2 is a suitable combination for the better growth and yield of squash.

Mardhiana *et al.* (2017) carried an experiment on growth and yield of cucumber *(Cucumis sativus*) affected by pruning on Mercy variety. It is proven by the fruit weight that is produced by the shoot of pruning on the main stem (P_1) gained higher weight in between 350-400 g per fruit compared to without pruning (P_0). Based on the result of the variance, it is known that the pruning treatment has a very significant effect on the cucumber length of at the age of 50 DAP. The treatment of pruning of two lateral branches that emerged first above the third section (P_3) showed the highest yield compared to other treatments of 272.45 cm, but not significantly different with the treatment of $P_{\mathbf{0}}$ and $P_{\mathbf{2}}$. Treatment of shoot pruning on the main stem (P_1) significantly resulted in the shorter plant than other treatments with no shoot pruning, but visually it was seen that the branch was longer than that of without pruning. Treatment of shoot pruning on the main stem (P_1) resulted in the highest number of leaves per plant (59.90 pieces of leaves) compared to other treatments. Treatment of shoot pruning on the main stem could increase the number of leaves by 16.19% compared to that of without pruning (P_0).

Ekwu *et al.* (2012) conducted an experiment and with comparing the performance of pruning bushes and no pruning and saw that the factors such as the number of leaves, number of flowers, days to 50% flowering on the main axis, the pruning treatments were performed better on it. The factors such as the number of fruits, fruit length, fruit diameter, fruit weight, fruit number of non-market-friendly and also more marketable fruits were obtained with pruning treatment.

Than (1997) conducted an experiment to study the effect of pruning on yield and quality of cucumber cultivars. The results showed that the removal of branches and main stem fourth node, or removal of branches and main stem of the flowers up to 30-40 cm and pruning of branches and leaves left after a fruit, increase the yield and marketable fruit. By applying this method, the number and weight of fruits per plant at the 1% level showed a significant difference. In this case, the pruning of fruit number and fruit weight was less than average.

Thang (1995) carried out an experiment on the effect of six different pruning methods on the yield of cucumber variety Poung (local). The treatments of the experiment were No pinching (M_0), Pinching branches on the main stem at node 10 up to down (M_1), Pinching branches on the main stem at node 15 up to down (M_2), No pruning (P_0) and pruning branches at node 4 (P_1). The highest yield (total yield = 19.72 t/ha, marketable yield = 14.93 t/ha, non-marketable yield = 4.79 t/ha, early stage yield = 3.28 t/ha) was obtained by the treatment M_0P_1 (with no pinching of branches on the main stem but pruning branches at node 4). The method of pruning branches had no significant effect on the character and fruit size except plant height. The pinching treatments had a low yield. This was resulted because of the absence of sufficient branches.

Nu (1996) evaluated the effect of pruning (pinching out the branches on the main stem at node 4 up to the bottom and prune when lateral shoots on the main stem set fruit on first on the second node of lateral shoot) on yield and fruit quality of four cucumber varieties, namely; Lanna-5 (F_1), Nopakao (F_2), Lan-Laem (F_3) and Poung (F_4) included no pruning treatment. The no pruning treatment produced the highest total yield 22.18 ton/ha as well as highest nonmarketable yield 7.70 t/ha while the pruning treatment produces low nonmarketable 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.

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.

Zarei *et al*. (2016) conducted an experiment to evaluate the effect of head pruning and different nutritional systems (chemical, biological and integrated) on yield and seed oil content in medicinal pumpkin *(Cucurbita pepo* L.). The experimental treatments consisted of two levels - no head pruning, control (C_0) and head pruning (C_1) allocated to the main plots. Four levels of different fertilizing systems - control (without fertilizer) (T_0), chemical (T_1), biological (a combination of nitrogen-fixing bacteria, *Azospirillum brasilense* and *Glomus mosseae)* (T_2), and integrated fertilizing system (biological fertilizer + 50% chemical fertilizer) (T_3) were assigned to the sub-plots. The highest grain yields of 53 and 50 g per square meter were obtained in integrated and chemical fertilizing systems, respectively while no pruning was applied. The highest fruit yields of 3,710 and 3,668 kg per hectare were produced by chemical and integrated fertilizing systems, respectively.

Esmaielpour and Hokmalipour (2014) carried out a study to investigate the effect of pruning and potassium nutrition on pumpkin grain yield and quality. Experimental factors include potassium nutrition in three level (0, 75 and 150 kg/ha from potassium sulfate) and stem pruning (without pruning, pruning after 8th node formation and pruning after the 12th node formation). Results indicated that stem pruning decreased grain number in fruit and fresh/dry weight of grain per fruit, 1000 grain weight, grain germination, seedling growth criteria and increased fresh/dry weight of grain per plot. Potassium increased grain number in fruit, fresh/dry weight of grain per fruit, 1000 grain weight, grain germination, and seedling growth criteria.

Mardhiana *et al*. (2017) conducted the study aimed to determine the effect of pruning on the growth and yield of cucumbers in acid soil. The study was conducted using the treatment of without pruning (P_0), the 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_3). 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 P_1 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.

Oga and Umekwe (2016) conducted the experiment to evaluate the effects of pruning and plant spacing on the growth and yield of watermelon (*Citrullus lanatus* L.). The treatment comprised of two pruning methods (pruning and non-pruning) and three different plant spacing (50 cm × 40 cm, 50 cm × 50 cm and 50 cm × 60 cm). Spacing at 50 cm × 60 cm was the adequate measurement for minimizing days to 50% flowering (37.19 days) and maximizing a total number of fruits (2.94), the weight of fruits (3.03 kg) and total yield (7.57 kg/ha). The pruned plants produced the longest vine (90.14 cm) number of leaves (15.78), number of flowers (10.31) and number of fruits (2.63). It is recommended that farmers should use the spacing 50 cm × 60 cm and adopt pruning as one of the cultural practices in raising the crop for maximum production.

Alam *et al*. (2016) carried out the study with BARI hybrid tomato 4, planted in BARI Gazipur, Bangladesh to find out the response of plants to some staking and pruning treatments on yield, fruit quality and cost of production of summer tomato. Plants were staked on inverted 'V' shaped staking, high platform and string. The plants were pruned to two stems, three stems, four stems and no pruning as control. Results showed that significantly the highest total number of fruits per plant (37.1), marketable fruits per plant (33.7), yield per plant (1.68 kg) and total yield (44.6 t/ha) were produced by the plants having the treatment string staking with four stems. The highest fruit set (43.50%) was found in the plants staking with a string having three stems. Plants were grown on string staking allowing two stems gave the maximum length (4.71 cm), diameter (4.83 cm) and weight (53.4g) of single fruit as well as maximum fruit firmness (3.43 kg-f cm^{-2}). From the economic point of view, it was apparent that summer tomato produced by string staking with four stem pruning exhibited better performance compared to other treatment combinations in relation to net return and BCR (2.10).

Goda *et al*. (2014) carried out this investigation within the two successive seasons of 2012 and 2013 on husk tomato (Local variety) to study the response of husk tomato to some pruning treatments on growth, yield and fruit quality. Plants were trained on thread and pruned as follows: plants were left to grow without pruning (Pr.0) as acontrol, plants were pruned to three shoots on the main stem (Pr.3), plants were pruned to six shoots on the main stem (Pr.6) and plants were pruned to nine shoots on the main stem (Pr.9). Results showed that all pruning treatments improved vegetative growth. Data recorded that the pruning treatments have a positive effect on average fruit weight, size, and diameter while fruit firmness decreased during the two seasons compared with the control (Pr.0). The parameters of total soluble solids (T.S.S. %), vitamin C (ascorbic acid), total sugar, total carotenoids, and dry matter increased due to pruning treatments. Fruit yield was differ according to treatments.

Alsadon *et al*. (2013) performed two experiments to study the effect of pruning systems on vegetative growth, yield and quality traits of three hybrid bell pepper cultivars: 'Pasodoble', 'Lirica' and 'Sondela'. Cultivars were grown under greenhouse conditions in drip fertigated soil culture and plants were pruned leading to one main branch, two and four side branches. Vegetative growth, yield, and quality traits were affected by cultivars or pruning systems and their interactions. 'Pasodoble' F_1 yellow cultivar had the highest early and total yields due to the relatively rapid fruit set and fruit number. 'Lirica' F_1 yellow cultivar had large fruit size (heavier, longer, wider and thicker pericarp fruits). Meanwhile, 'Sondela' F1 red cultivar exhibited superior fruit quality (vitamin C, titratable acidity, total soluble solids, and total sugars). Pepper plants pruned to one branch resulted in a significant increase in early yield, fruit size and internal fruit quality with a decrease in total fruit yield followed by plants pruned to two branches. However, plants pruned to four branches produced the highest yield, due to the higher number of fruits plant^{-1}. The best fruit number and total yield were obtained by pruning 'Pasodoble' F_1 plants to 4 branches. On the other hand, pruning 'Lirica' F_1 plants to one branch improved fruit weight, fruit size and gave thicker flesh width. Regarding fruit quality traits; 'Sondela' F_1 red pepper, especially under one branch pruning system represented a vital source of vitamin C.

2.2. Literature on GA_3

Tsiakaras *et al.* (2014) carried out an experiment to find out the effect of both nitrogen application rate and gibberellic acid (GA_3) on yield and earliness of production and marketability (plant height and leaf color) of lettuce. During cultivation, four nitrogen rates (0, 150, 300 and 450 mg L^{-1} of N) and two foliar sprays of two concentrations of GA_3 (0 and 50 mg L^{-1} for the first and second sowing and 0 and 25 mg L^{-1} for the third sowing) were applied. Results revealed that total fresh and dry weight significantly decreased and increased, respectively, by GA_3 application, especially in the second sowing date, whereas high nitrogen rates (300 and 450 mg L^{-1}) resulted in higher fresh weight (by 11.2%) and lower dry weight (by 7.5%) respectively. Plant height was significantly increased by GA_3 application, except for cv. ‘Adranita’ in the third sowing date, whereas nitrogen application did not affect plant height for all the cultivars studied. The application of GA_3 and high nitrogen rates resulted in an increase in the total number of leaves per plant and a decrease of chlorophyll content of leaves during the first sowing date and third sowing date.

Mahmoody and Noori (2014) reported that exogenous GA_3 on culture medium was used to increase the height of *Dyckiam aritima* shoots to facilitate In vitro manipulation. Grapevine fruits (Thompson seedless) treated with GA_3 had increased its size and production. Results revealed that foliar application of and GA_3 nutrients had improved the productivity and quality of lily cut flowers. Stimulation of the enzyme protein synthesis by GA_3 stimulates the overall protein synthesis.

Kumar *et al.* (2014) were conducted with the objective to determine the effects of Gibberellic acid (GA_3) on growth, fruit yield, and quality of tomato. The experiment consisted of one tomato variety Golden, and six treatments with five levels of gibberellic acid (GA_3-10 ppm, 20 ppm, 30 ppm, 40 ppm, and 50 ppm),.

The highest plant height, number of leaves, number of fruits, fresh fruit weight, ascorbic acid and total soluble solids (TSS) was found from GA_3 350 ppm.

Ayyub *et al.* (2013) asserted that the effectiveness of GA_3 applied as a foliar application for enhanced vegetative and reproductive growth of okra. First foliar application of GA_3 (100 mg kg^{-1}) was performed after 3 weeks from sowing while the next three applications with regular interval of one week. Their experiment results revealed that the increase in a number of foliar application of GA_3 substantially improved the vegetative as well as reproductive growth of okra comparing to control plants. It was found that application at different growth stages of okra predominantly boosted the stem elongation, number of leaves per plant, number of fruits per plant, number of seeds per fruit, seed weight and seed yield. Therefore it can be concluded that the foliar application of GA_3 may be an effective strategy for maximizing the growth and yield of okra.

Jadon *et al.* (2012) conducted a field experiment to study the effect of gibberellic acid, IBA and NAA as a foliar spray of cauliflower. Among growth regulators, GA_3 was most promising in effect followed by NAA and IBA. The growth regulator GA_3 at 150 ppm slowed significantly higher performance over the remaining treatment in all the growth characters *viz*., plant height, etc. Growth regulator GA_3 at 150 ppm performed significantly better than the other treatments regarding the yield and yield attribute characters. Growth regulator GA_3 at 15 ppm with recommend fertilizer dose of NPK gave the highest additional net profit over control followed by GA_3 at 100 ppm.

Emongor and Ndambole *et al.* (2011) examined the effects of GA_3 on the growth, development and seed yield of cowpeas (*Vigna unguiculata*). Three field trials were carried out to evaluate the exogenous application of GA_3, 7 days after emergence at 0, 100, 200 or 300 mg L^{-1} significantly increased cowpea plant height, first node height, leaf area and leaf number $plant^{-1}$, nodulation, plant dry matter, pod length, pod number plant^{-1}, seed number pod^{-1}, 100-seed weight, harvest index, and seed yield.

Akter *et al.* (2007) conducted an experiment in pot-house at BINA, Mymensingh, Bangladesh to evaluate the effects of Gibberellic Acid (GA_3) on growth, and yield of mustard *var*. Bina sarisha-3. Four concentrations *viz*., 0, 25, 50 and 75 ppm of GA_3 were sprayed on the canopy at 30 days after sowing. Results revealed that GA_3 at 50 ppm significantly increased plant height, number of fertile siliqua/plant, number of flowers/plant, setting of siliqua/plant (%), dry matter yield, number of seeds/siliqua, and harvest index, while the number of flowers/plant was significantly increased with the application of 75 ppm GA_3. The highest seed yield/plant was recorded from the application of 50 ppm GA_3 at optimum harvest date. The seed yield/plant was positively correlated with plant height, number of seeds/siliqua, number of fertile siliqua/plant and % of setting siliqua/plant.

Bora and Sarma (2006) carried out a study on the effect of Gibberellic acid (GA_3) and Cycocel on growth, yield and protein content of pea (*cv*. Aparna and Azad-P-1). GA_3 irrespective of concentrations was most effective in promoting shoot growth while cycocel at all concentrations tried reduced shoot growth. The number of branches per plant was increased with both the hormones. In both, the varieties chlorophyll contents were decreased by higher concentrations of GA_3 while cycocel increased it. Both the hormones significantly affected the yield characteristics. GA_3 at 250 pg mL^{-1} produced a maximum number of pods per plant, seed yield, seed index and protein content in seeds in both the varieties. Their study clearly showed that the judicious application of GA_3 and cycocel can increase yield and protein content in seeds of a pea.

Hoque and Haque (2002) investigated two varieties of mungbean to study the effects of seed treatment and foliar application of GA_3 at 0, 50, 100 and 200 ppm on the growth, yield and yield contributing characters. Seed treatment with GA_3 at

50 ppm increased plant height, number of leaves, fresh and dry weight. Foliar application of GA_3 at 200 ppm had higher plant height and number of leaves, while that at 100 ppm greater number of pods, higher fresh and dry weight of pod, number of seeds whereas 50 ppm GA_3 resulted in higher pod length and ultimately seed yield. The mungbean variety V_2 performed better than V_2 with foliar application of GA_3. This study indicates high potentiality to increase the yield of mungbean in Bangladesh by the application of GA_3.

Chaudhary *et al*. (2017) carried out this investigation with ten treatments *viz*., T_1 (Control), T_2 (GA_3 10 ppm), T_3 (GA_3 20 ppm), T_4 (GA_3 30 ppm), T_5 (Ethrel 50 ppm), T_6 (Ethrel 100 ppm), T_7 (Ethrel 150 ppm), T_8 (Ethrel 25 ppm), T_9 (NAA 50 ppm) and T_{10} (NAA 100 ppm) in round melon *(Praecitrullus fistulosus)*. The results revealed that, the maximum length of the main vine at 60 and 90 DAS (225.07 and 268.21 cm), respectively, and number of leaves per plant at 60 and 90 days after sowing (205.78 and 332.17) and produced the maximum number of male flower (228.56) were recorded with treatment (T_4) GA_3 30 ppm. Treatment (T_7) Ethrel 150 ppm proved to be most effective for produced the minimum number of sub-vine at 60 and 90 DAS (7.78 and 9.22), lower node number at which first female flower appears (5.60), lower node number per plant at main vine (24.11), lower internodal length (9.56 cm), maximum total leaf area per plant (92.39 cm^2), number of female flower (45.78) and fruit set percent (66.18), numbers of fruits (28.78), fruit weight (68.00 g/fruit), fruit yield per plant (2.59 kg), fruit yield per plot (18.14 kg) and higher fruit yield per hectare (129.33 q/ha). The lowered sex ratio was recorded in treatment (T_6) Ethrel 100 ppm i.e. (1: 4.06).

Taha (2012) carried outthis investigation during the two successive seasons of 2008-2009 and 2009-2010 to study the effect of different concentrations of gibberellins (GA_3), cycocel (CCC) and Alar on the growth, flowering and bulb production of iris plants. In this study, the plants of iris were sprayed three times with 0, 250, 500 and 750 ppm of GA_3, 250, 500 and 1000 ppm of CCC and 125, 250 and 500 ppm of Alar. Results showed that GA_3 treatments significantly increased leaf length, while, CCC and Alar treatments significantly decreased the leaf length compared to control treatment. GA_3 treatments shortened significantly the time taken from planting to flowering, while CCC and Alar treatments significantly delayed the flowering date compared to control. Also, the flowering stalk length was increased by application of GA_3 at the three used concentrations, while, CCC and Alar at the same concentrations led to a decrease in the flowering stalk length. The positive or negative effects of GA_3 or CCC and Alar were gradually increased by increasing their concentrations. All treatments of GA_3, CCC and Alar led to increased flowering stalk diameter, fresh and dry weights of the flowering stalk and fresh weight of inflorescence/plant compared to control. The best results were obtained by using of high concentration of GA_3, CCC, and Alar. All GA_3, CCC, and Alar treatments had a stimulatory effect on the formation of new bulbs and bulblets compared to the control treatment. The highest of fresh weight of new bulbs and bulblets/plant and the highest number of bulblets/plant were obtained by the application of GA_3 at 750 ppm, CCC at 1000 ppm and Alar at 500 ppm.

Roy and Nasiruddin (2011) conducted a research work to study the effect of GA_3 on growth and yield of cabbage. Single factor experiment consisted of four concentrations of GA_3, *viz*., 0, 25, 50 and 75 ppm. Significantly the minimum number of days to head formation (43.54 days) and maturity (69.95 days) was recorded with 50 ppm GA_3 and 50 ppm GA_3 gave the highest diameter (23.81 cm) of cabbage head while the lowest diameter (17.89 cm) of cabbage head was found in control (0 ppm GA_3) treatment. The application of different concentrations of GA_3 as influenced independently on the growth and yield of cabbage. Significantly the highest yield (45.22 kg/plot and 104.66 t/ha) was found from 50 ppm GA_3.

Shafeek *et al*. (2016) conducted a study to survey the reply of squash plants (*Cucurbita pepo* L.) to foliar exercise of several bio-regulators (GA_3) at several concentrations (15, 30, 45 and 60 mg/L) or Ethereal at the levels of (150, 200 and 250 mg/L) and foliar spraying with water (control) to the effect of impact plant growth sex expression, proportion of fruit set, fruits yield and nutritional supplement of squash fruits c.v. Eskandarani. The concise outcome gained from this field research that, mounting the concentrations of growth regulators (GA_3 or Ethereal) fulfilled tallest plant, highest number of leaves and branches, heaviest fresh and dry weight of leaves, branches, leaf area/plant and fruit set percentage as well as total yield and highest values of the percentage of N, protein, dry matter, TSS and vitamin C (mg/100g F.W.) in squash fruit tissues.

Chormule and Patel (2017) conducted investigation entitled "Effect of spacing and plant growth regulators on plant growth parameters, seed yield and its attributes of okra variety GJO3 for two consecutive seasons (Kharif 2015 and kharif 2016). Seeds were treated with aqueous solution of growth regulators *viz*., GA_3, IBA and NAA, each at 50, 100 and 150 ppm concentrations and without growth regulators (water soaking). The growth regulators were applied as seed soaking treatment for 8 hours. Treated seeds were grown with three plant spacing (S_3 : 45 cm × 30 cm, S_2 : 60 cm × 30 cm and S_3 : 60 cm × 45 cm) during Kharif 2015 and 2016. Interactions effects of spacing and seed treatments (S×T) with growth regulators were found significant for field emergence, a number of branches per plant, fruit length and fruit thickness during Kharif 2015; for fruit length and fruit thickness during Kharif 2016; and for field emergence in pooled over years. Wider spacing of 60 cm × 45 cm (S_3) and seeds treated with GA_3 150 ppm (T_3) recorded significantly the maximum values for growth parameters *viz*., plant height, stem diameter and number of branches per plant: seed yield and yield attributes *viz*., seed yield per plant, number of fruits per plant, fruit thickness, length and number of seeds per fruit. A combination of wider plant spacing 60 cm × 45 cm and seed treatment of GA_3 @ 150 ppm before sowing (S_3T_3) was found best suited combination, as it has good field emergence and produced significantly and/or comparatively the maximum plant height, stem diameter, number of branches per plant, number of fruits per plant, fruit length, fruit thickness, number of seeds per fruit and seed yield per plant.

Dalai *et al.* (2015) conducted an experiment was conducted to assess the effect of various doses of GA_3, NAA, and their combined dose. Total of eight treatments were tried in RBD with three replications. Out of these, a dose of GA_3 20 ppm + NAA 100 ppm was found significantly superior in terms of growth parameters i.e. Vine length plant^{-1} (cm), Number of primary branches plant^{-1}, Number of leaves plant^{-1}, as compared to control and other applied treatment. Similarly, a positive effect was also reported in various flowering, yield and yield attributing characters with GA_3 20 + NAA 100 ppm. In the context of yield, a dose of GA_3 20 + NAA 100 ppm was produced the highest yield of cucumber as compared to control and other treatments during experimentation.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2017 to February 2018 to study the effect of pruning and GA_3 on growth and yield of squash. The details of the materials and methods have been presented below:

3.1 Experimental location

The present piece of research work was conducted in the horticultural farm at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´ E longitude and 23°77´N latitude with an elevation of 8.2 m from sea level. Location of the experimental site was presented in Appendix I.

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon . The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. The details of morphological and chemical properties of the initial soil of the experiment plot were presented in Appendix II.

3.3 Climate

The climate of the experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. Details on the meteorological data of airtemperature, relative humidity, rainfall and sunshine hour during the period of the experiment were collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix III.

3.4 Plant materials

The vegetable crop; squash was considered for the present study. Seeds of Sunny House F_1 hybrid squash variety was used.

3.5 Experimental details

3.5.1 Treatments

The experiment comprised of two factors.

Factor A: Leaf pruning – Three levels

1. P_0 = No pruning (control)
2. P_1 = 1st pruning at 20 DAT (1st and 2nd leaves)
3. P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

Factor B: GA_3 – Four levels

1. G_0 = No GA_3 (control)
2. G_1 = 100 ppm GA_3
3. G_2 = 200 ppm GA_3
4. G_3 = 300 ppm GA_3

Treatment combinations –Twelve (12) treatment combinations as follows:

P_0G_0, P_0G_1, P_0G_2, P_0G_3, P_1G_0, P_1G_1, P_1G_2, P_1G_3, P_2G_0, P_2G_1, P_2G_2, and P_2G_3.

3.5.2 Experimental design and layout

The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of pruning and different GA_3 levels. The 12 treatment combinations of the experiment were assigned at random into 36 plots. The size of each unit plot 1 m × 1 m. Plant spacing was 50 cm × 50 cm. The distance between blocks and plots were 0.5 m respectively. The layout of the experiment field is presented in Appendix IV.

3.6 Raising of seedlings

The land selected for the nursery bed was well drained and were sandy loam type soil. The area was well prepared and converted into loose friable and dried mass to obtain fine tilth. All weeds and dead roots were removed and the soil was mixed with well rotten cowdung at the rate of 5 kg/bed. Seedbed size was 3m × 1m raised above the ground level. The bed was prepared for raising the seedlings. Thirty (30) grams of seeds were sown in the seedbed on 7 November 2017. After sowing, the seeds were covered with light soil. Complete germination of the seeds took place with 5 days after seed sowing. Necessary shading was made by bamboo mat (chatai) from scorching sunshine or rain. No chemical fertilizer was used in the seedbed.

3.7 Preparation of the main field

The plot selected for the experiment was opened in the 20 November 2017 with a power tiller and was exposed to the sun for a few days, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for transplanting.The land operation was completed on 24 November 2017. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

3.8 Fertilizers and manure application

The N, P, K, and S fertilizer were applied according to Krishi Projukti Hat Boi (BARI, 2015) through urea, Triple superphosphate (TSP), MoP and Gypsum, respectively. Cowdung also used as organic manure. Nitrogen (N) was applied through urea as per treatment. Nutrient doses used through fertilizers under the present study are presented as follows:

Nutrients	Manures/fertilizers	Doses ha^{-1}
-	Cowdung	10 ton
N	Urea	170 kg
P	TSP	170 kg
K	MoP	150 Kg
S	Gypsum	100 kg

One third (1/3) of the whole amount of Urea and the full amount of TSP, MoP, and Gypsum were applied at the time of final land preparation. The remaining Urea was top dressed in two equal installments- at 25 and 35 days after transplanting (DAT) respectively.

3.9 Transplanting of seedlings

Healthy and uniform sized 18 days old seedlings were taken separately from the seedbed and were transplanted in the experimental field on 25 November 2017. Plant spacing 50 cm × 50 cm was maintained for transplanting. The seedbed was watered before uprooting the seedlings so as to minimize the damage of the roots. This operation was carried out during late hours in the evening. The seedlings were watered after transplanting. Shading was provided by a piece of banana leaf sheath for three days to protect the seedlings from the direct sun. A strip of the same crop was established around the experimental field as border crop to do gap filling and to check the border effect.

3.10 Intercultural operation

After the establishment of seedlings, various intercultural operations were accomplished for better growth and development of squash.

3.10.1 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gaps filling were done by healthy plants from the border whenever it was required. Weeds of different types were controlled manually as and when necessary.

3.10.2 Irrigation

The first irrigation was given in the field at 25 days after transplanting (DAT) through irrigation channel. Second irrigation was given at the stage of maximum vegetative growth stage (30 DAT).

3.10.3 Plant protection

The insects were controlled successfully by spraying Malathion 57 EC @ 2ml /L water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting.

3.11 Harvesting and cleaning

Fruits were harvested during the maturity stage. Harvesting was started from 15 January 2018 and completed by 20 February 2018.

3.12 Data collection

The following parameters were recorded during the study:

1. Stem length
2. Number of leaves plant^{-1}
3. Stem base diameter
4. Number of male flowers
5. Number of female flowers
6. Number of fruits plant^{-1}
7. Fruit length
8. Fruit diameter

9. Individual fruit weight
10. % fruit dry weight
11. Fruit yield plant^{-1}
12. Fruit yield ha^{-1}

3.13 Procedure for recording data

3.13.1 Stem length

The stem length was recorded in centimeter (cm) at different days after transplanting of crop duration with a meter scale. Data were recorded from each plot. The length was measured from the ground level to the top of the stem. Data was taken at 30 and 45 days after transplanting (DAT) and at harvest.

3.13.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} was counted at different days after sowing of crop duration. Leaves number plant^{-1} was recorded from each plot and mean was calculated. Data was taken at 30 and 45 days after transplanting (DAT) and at harvest.

3.13.3 Stem base diameter

The diameter of stem base in centimeter (cm) was recorded from each plant of each plot at different days after transplanting (at 30 DAT and 45 DAT and at harvest at the base portion of the plant with slide calipers. The average value is termed as stem diameter.

3.13.4 Number of male flowers

Number of male flowers was counted from each plant of each plot and the mean was calculated.

3.13.5 Number of female flowers

Number of female flowers was counted from each plant of each plot and the mean was calculated.

3.13.6 Number of fruits plot^{-1}

Total number of fruits was counted from the first harvest to the last harvest and the total number was recorded plot-wise.

3.13.7 Fruit length

The length of the fruit was measured with a meter scale in centimeter from the neck of the fruit to the bottom of the fruit. It was measured from each plot and their average was calculated in centimeter.

3.13.8 Fruit diameter

Breadth of the fruits was measured at the middle portion of marketable fruits from each plot with the meter scale ribbon in centimeter and their average was taken as the breadth of the fruits.

3.13.9 Individual fruit weight

From the first harvest to last harvest total fruit number and fruit weight was counted from each plant of each plot to determine single fruit weight. Single fruit weight was calculated from total fruit weight dividing by a total number of fruits.

3.13.10 Percent (%) fruit dry weight

Fresh 100 g sample fruit from each plot were taken and placed in an oven maintained at 70^0 C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The average dry weight of the sample was taken and recorded as percent (%) dry matter.

3.13.11 Fruit yield plant^{-1}

Total fruit weight was measured from each plant of each plot from 1st to last harvest and the average weight was calculated as a fruit yield per plant.

3.13.12 Fruit yield ha^{-1}

After collection of per plot yield, it was converted to ton per hectare by the following formula:

$$\text{Fruit yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg)} \times 10000\ m^2}{\text{Plot size } (m^2) \times 1\,000\ \text{kg}}$$

3.14 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the SPSS computer package program. The mean values of all the characters were calculated and analysis of variance was performed by F (variance ratio) test. The differences between the treatment means were evaluated by DMRT test at 1% or 5% probability.

Chapter IV
Result and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The results of the study were presented by evaluating the effect of pruning and GA_3 on growth and yield of squash. The analysis of variance (ANOVA) of the data on different growth and yield parameter are presented in Appendix V-XXII. The experimental findings regarding growth and yield attributes have been presented under the following headings:

4.1 Growth parameters

4.1.1 Stem length

Significant variation was observed on stem length at different growth stages influenced by different pruning levels (Fig. 1 and Appendix V, VI and VII). The highest stem length (22.96, 47.79 and 62.74 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment P_1 (1^{st} pruning at 20 DAT; 1^{st} and 2^{nd} leaves) where the lowest stem length (19.66, 44.45, and 60.23 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the control treatment P_0 (no pruning) which was statistically identical with P_2 (2^{nd} pruning at 30 DAT; 3^{rd} and 4^{th} leaves) at all growth stages. A similar result was also observed by Thang (1995) on cucumber which supported the present study.

Stem length was significantly influenced by different levels of GA_3 at different growth stages (Fig. 2 and Appendix V, VI and VII). The highest stem length (23.40, 48.27 and 63.31 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment G_1 (100 ppm GA_3) which was statistically identical with G_2 (200 ppm GA_3) at the time of harvest. The lowest stem length (19.08, 43.77 and 58.72 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the control treatment G_0 (0 ppm GA_3) which was significantly different from all other treatments. Similar result was also observed by Mahmoody and Noori (2014)

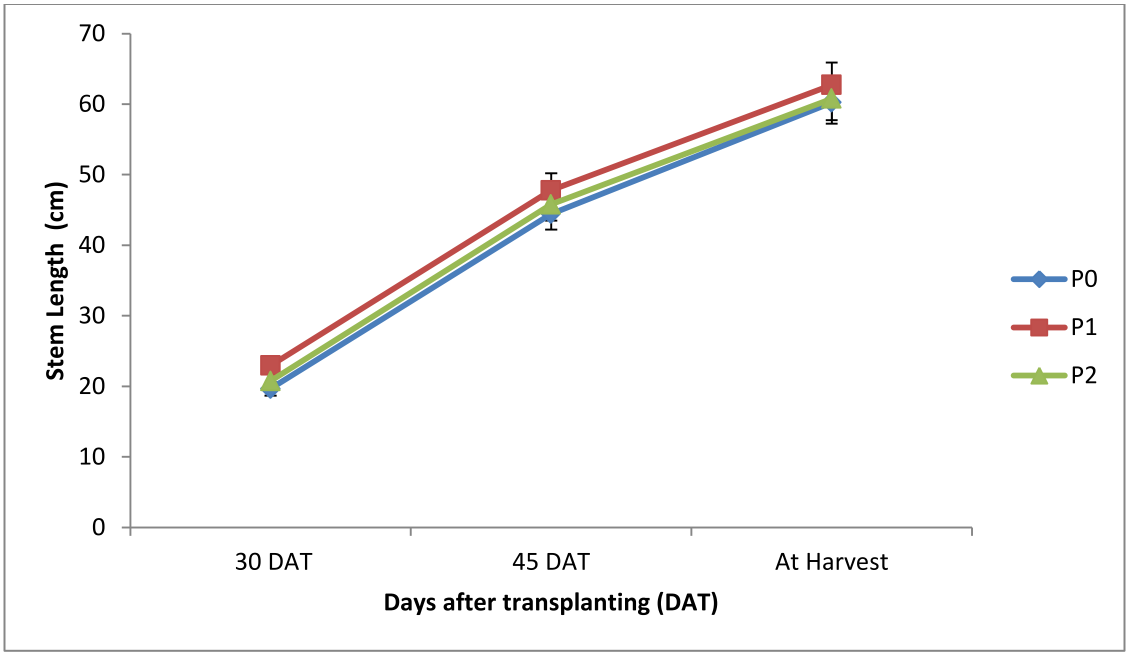

Fig. 1. Effect of pruning on stem length of squash at different days after transplanting (DAT)

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

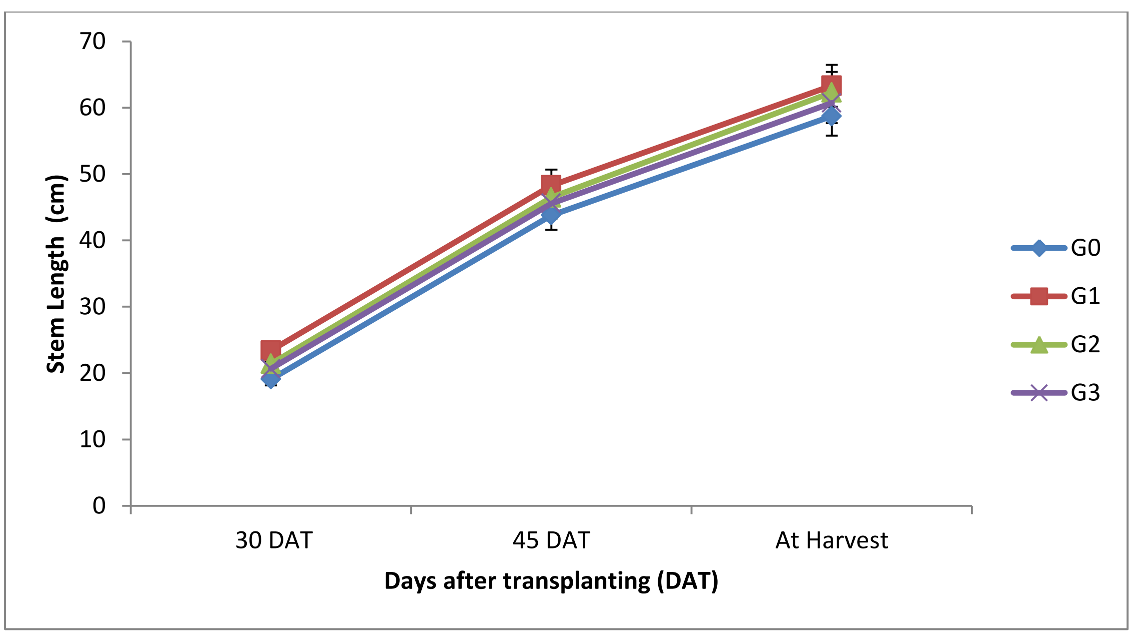

Fig. 2. Effect of GA_3 on stem length of squash at different days after transplanting (DAT)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

in *Dyckiam aritima* and Tsiakaras *et al.* (2014) on lettuce which supported the present study. Mahmoody and Noori (2014) found that exogenous GA_3 was contributed to increase the height of *Dyckiam aritima* shoots.

Table 1. Combined effect of pruning and GA_3 on stem length (cm) of squash at different days after transplanting (DAT)

Treatments combination	Stem length (cm)		
	At 30 DAT	At 45 DAT	At harvest
P_0G_0	17.88 h	42.27 j	57.22 h
P_0G_1	21.69 c	46.62 d	61.74 e
P_0G_2	19.70 efg	44.66 g	61.27 cd
P_0G_3	19.36 fg	44.24 h	60.72 de
P_1G_0	20.47 de	45.22 f	60.24 ef
P_1G_1	25.28 a	49.73 a	64.73 a
P_1G_2	23.43 b	48.45 b	64.35 a
P_1G_3	22.67 b	47.76 c	61.65 c
P_2G_0	18.88 g	43.81 i	58.71 g
P_2G_1	23.24 b	48.46 b	63.45 b
P_2G_2	21.02 cd	46.26 e	61.24 cd
P_2G_3	19.86 ef	44.69 g	59.74 f
Standard Error(±)	1.76	2.52	3.11
Significance	0.000	0.000	0.000

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

The recorded data on stem length at different growth stages was significantly influenced by the combined effect of pruning and GA_3 (Table 1 and Appendix V, VI and VII). Result revealed that the highest stem length (25.28, 49.73 and 64.73 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment combination of P_1G_1 which was statistically identical with the treatment combination of P_1G_2 at the time of harvest. The lowest stem length (17.88, 42.27

and 57.22 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment combination of P_0G_0.

4.1.2 Number of leaves plant^{-1}

There was significant variation on a number of leaves plant^{-1} influenced by different pruning levels at different growth stages (Fig. 3 and Appendix VIII, IX and X). The highest number of leaves plant^{-1} (13.59, 20.12 and 21.85 at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment P_1 (1st pruning at 20 DAT; 1st and 2nd leaves) which was significantly different from all other treatments. The lowest number of leaves plant^{-1} (10.79, 16.94 and 19.07 at 30 DAT, 45 DAT and at harvest, respectively) was found from the control treatment P_0 (no pruning) which was also significantly different from all other treatments. A similar result was also observed in okra by Olasantan and Salau (2008).

Significant variation was observed on a number of leaves plant^{-1} at different growth stages influenced by different levels of GA_3 (Fig. 4 and Appendix VIII, IX and X). The highest number of leaves plant^{-1} (14.24, 19.98 and 21.77 at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment G_1 (100 ppm GA_3) which was statistically similar with G_2 (200 ppm GA_3) at 45 DAS and at harvest. The lowest number of leaves plant^{-1} (10.13, 16.73 and 19.68 at 30 DAT, 45 DAT and at harvest, respectively) was found from the control treatment G_0 (0 ppm GA_3) which was statistically identical with G_2 (200 ppm GA_3) at the time of harvest. Tsiakaras *et al.* (2014) also found similar result in lettuce which supported the the present study.

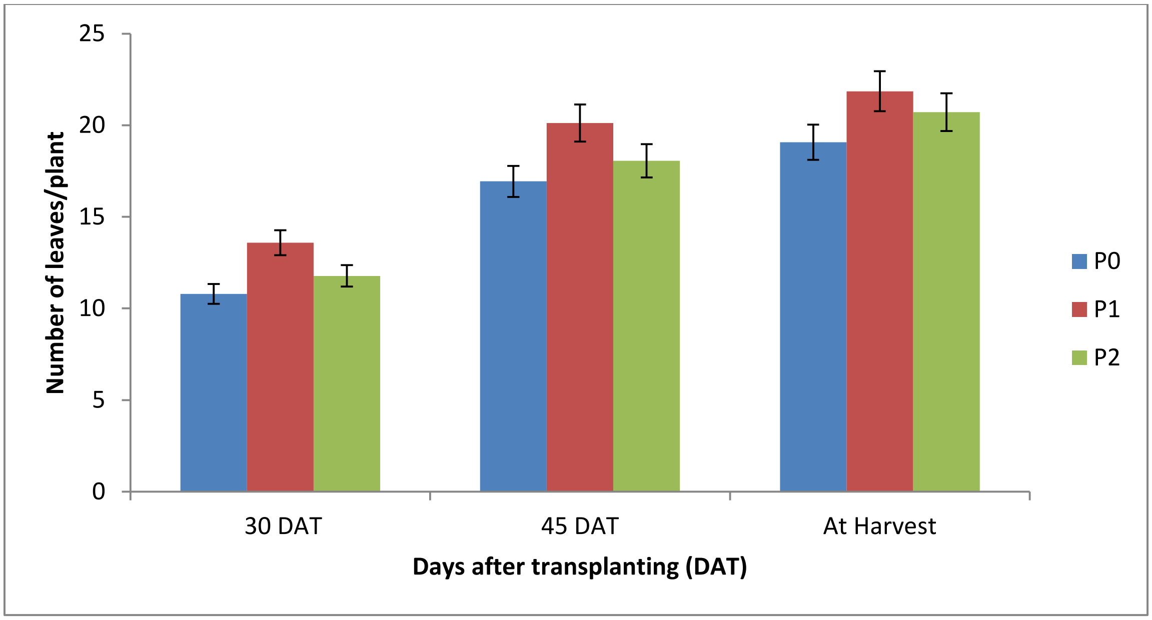

Fig. 3. Effect of pruning on number of leaves plant^{-1} of squash at different days after transplanting (DAT)

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

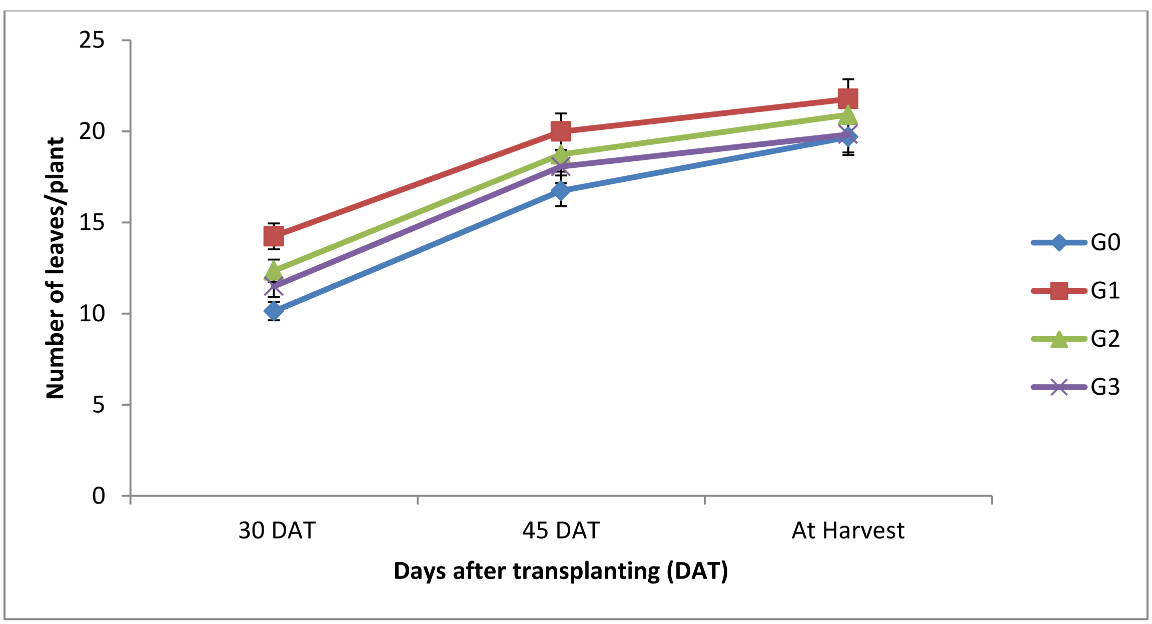

Fig. 4. Effect of GA_3 on number of leaves plant^{-1} of squash at different days after transplanting (DAT)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

The recorded data on a number of leaves plant^{-1} at different growth stages were significantly influenced by the combined effect of pruning and GA_3 (Table 2 and Appendix VIII, IX and X). The highest number of leaves plant^{-1} (15.75, 21.27 and 23.59 at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment combination of P_1G_1 which was significantly different from all other treatment combinations followed by the treatment combination of P_1G_2. The lowest number of leaves plant^{-1} (9.31, 15.24 and 17.26 at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment combination of P_0G_0 which was significantly different from all other treatment combinations.

Table 2. Combined effect of pruning and GA_3 on number of leaves plant^{-1} of squash at different days after transplanting (DAT)

Treatments Combination	No. of leaves		
	At 30 DAT	**At 45 DAT**	**At harvest**
P_0G_0	9.31 j	15.24 f	17.26 h
P_0G_1	12.67 e	18.79 d	20.58 de
P_0G_2	10.86 g	17.11 e	19.43 fg
P_0G_3	10.38 h	16.63 e	19.02 g
P_1G_0	11.33 f	18.23 d	19.96 ef
P_1G_1	15.75 a	21.27 a	23.59 a
P_1G_2	13.92 c	20.35 bc	22.57 b
P_1G_3	13.38 d	20.65 ab	21.28 cd
P_2G_0	9.766 i	16.74 e	21.83 c
P_2G_1	14.37 b	19.88 c	21.15 cd
P_2G_2	12.26 e	18.73 d	20.69 de
P_2G_3	10.72 gh	16.89 e	19.17 g
Standard Error(±)	1.36	1.52	2.11
Significance	0.000	0.000	0.000

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

4.1.3 Stem base diameter

Stem base diameter was not significantly influenced by different pruning levels at different growth stages (Fig. 5 and Appendix XI, XII and XIII). However, the highest stem base diameter (1.16, 1.41 and 1.99 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment P_1 (1^{st} pruning at 20 DAT; 1^{st} and 2^{nd} leaves) and the lowest stem base diameter (1.13, 1.39 and 1.94 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the control treatment P_0 (no pruning). This result from present finding indicated that leaf proning had no influence on stem base diameter.

There was a significant variation on stem base diameter was found influenced by different levels of GA_3 at different growth stages (Fig. 6 and Appendix XI, XII and XIII). The highest stem base diameter (1.16, 1.44 and 2.05 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment G_1 (100 ppm GA_3) which was significantly different from all other treatments where the lowest stem base diameter (1.12, 1.35 and 1.91 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the control treatment G_0 (0 ppm GA_3) which was also significantly different from all other treatments. This result pointed out that GA_3 had influence on stem base diameter to a certain level but with the increasing level of GA_3 stem base diameter migt be decreased.

The recorded data on stem base diameter at different growth stages were significantly influenced by the combined effect of pruning and GA_3 (Table 3 and Appendix XI, XII and XIII). The highest stem base diameter (1.18, 1.45 and 2.09 cm at 30, 45 DAT and at harvest, respectively) was found from the treatment combination of which was statistically identical with the treatment combination of P_2G_1 at harvest but P_1G_2 was statistically similar with P_1G_1 at 30 and 45 DAT. The lowest stem base diameter (1.11, 1.35 and 1.90 cm at 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment combination of P_0G_0 which was statistically identical with the treatment combination of P_2G_0 and statistically similar with the treatment combination of P_1G_0 and P_2G_3.

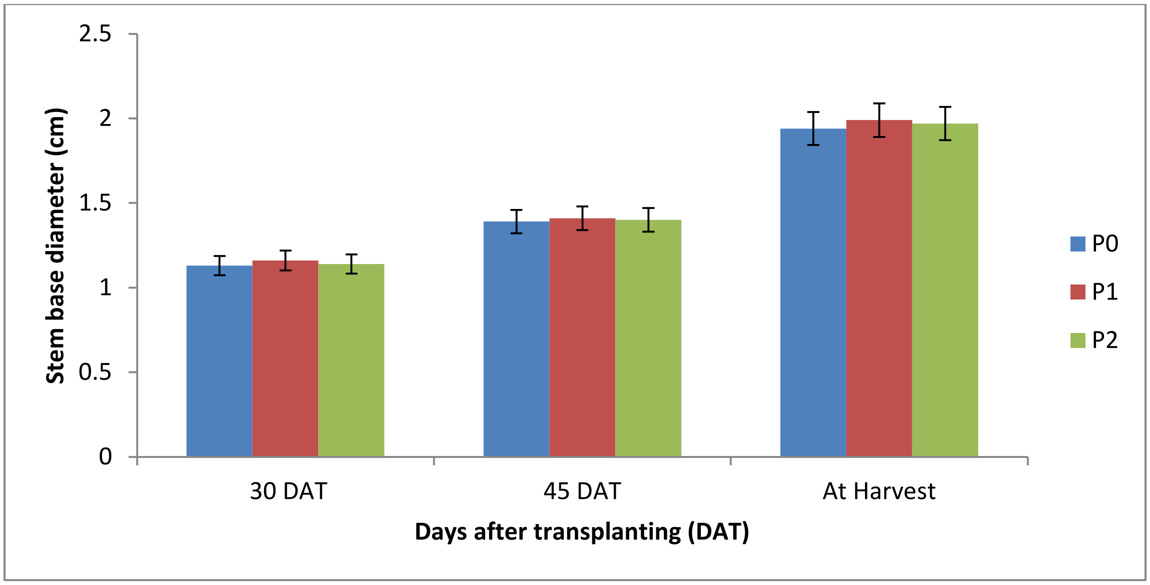

Fig. 5. Effect of pruning on stem base diameter of squash at different days after transplanting (DAT)

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

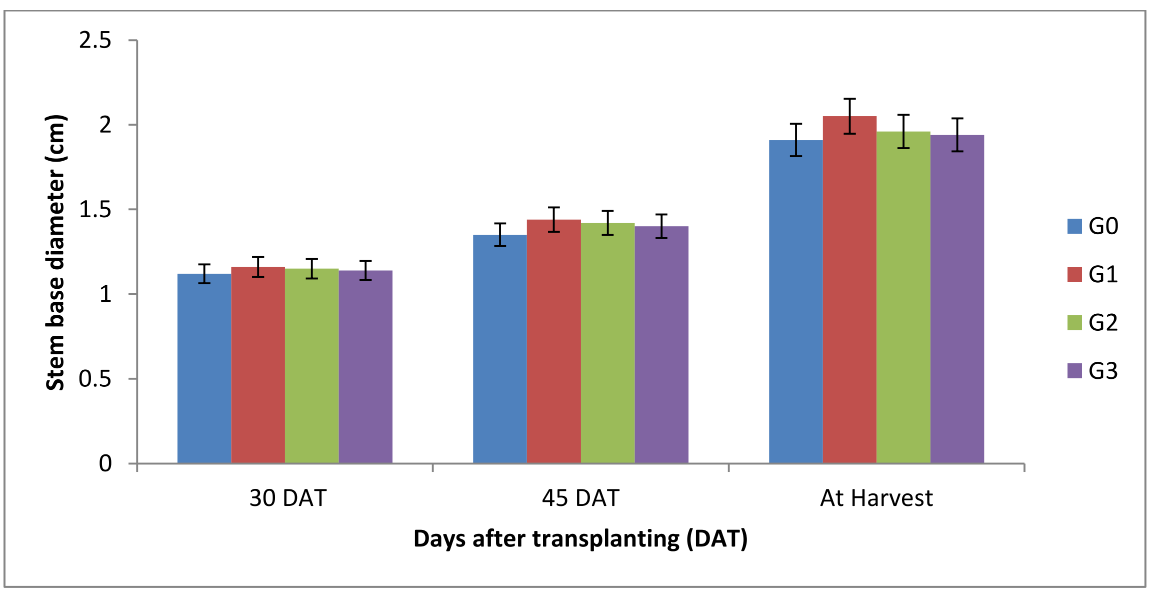

Fig. 6. Effect of GA_3 on stem base diameter of squash at different days after transplanting (DAT)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

Table 3. Combined effect of pruning and GA_3 on stem base diameter of squash at different days after transplanting (DAT)

Treatments Combination	Stem base diameter (cm)		
	At 30 DAT	At 45 DAT	At harvest
P_0G_0	1.11 d	1.35 de	1.90 e
P_0G_1	1.15 bc	1.45 ab	1.97 bc
P_0G_2	1.15 bc	1.42 abc	1.96 bcd
P_0G_3	1.15 bc	1.42 abc	1.94 cde
P_1G_0	1.13 cd	1.36 de	1.93 de
P_1G_1	1.18 a	1.45 a	2.09 a
P_1G_2	1.16 ab	1.43 ab	1.98 b
P_1G_3	1.15 b	1.41 bc	1.96 bcd
P_2G_0	1.12 d	1.35 de	1.91 e
P_2G_1	1.15 b	1.41 bc	2.08 a
P_2G_2	1.15 b	1.41 bc	1.95 bcd
P_2G_3	1.13 cd	1.39 cd	1.93 de
Standard Error(±)	0.28	0.36	0.44
Significance	0.000	0.000	0.000

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

4.2 Yield contributing parameters and yield

4.2.1 Number of male flowers plant^{-1}

Remarkable variation was observed on number of male flowers plant^{-1} influenced by different pruning levels (Table 4 and Appendix XIV). The highest number of male flowers plant^{-1} (7.39) was found from the treatment P_1 (1st pruning at 20 DAT; 1st and 2nd leaves) where the lowest number of male flowers plant^{-1} (4.99) was found from the control treatment P_0 (no pruning) which was statistically identical with P_2 (2^{nd} pruning at 30 DAT; 3^{rd} and 4^{th} leaves). This result indicated that at least one pruning significantly increased male flower but after 2^{nd} pruning, male flowering was decreased.

Significant influence was noted on a number of male flowers plant^{-1} affected by different levels of GA_3 (Table 4 and Appendix XIV). The highest number of male flowers plant^{-1} (7.26) was found from the treatment G_1 (100 ppm GA_3) which was statistically identical with G_2 (200 ppm GA_3) where the lowest number of male flowers plant^{-1} (4.25) was found from the control treatment G_0 (0 ppm GA_3). A similar result was also observed by Chaudhary *et al*. (2017) and they found that the maximum number of male flower (228.56) were recorded from GA_3 at 30 ppm in round melon.

Number of male flowers plant^{-1} was significantly influenced by the combined effect of pruning and GA_3 (Table 5 and Appendix XIV). The highest number of male flowers plant^{-1} (8.69) was found from the treatment combination of P_1G_1 which was statistically identical with the treatment combination of P_1G_2. The lowest number of male flowers plant^{-1} (3.47) was found from the treatment combination of P_0G_0 which was statistically identical with the treatment combination of P_2G_0.

4.2.2 Number of female flowers plant^{-1}

Significant variation was remarked on a number of female flowers plant^{-1} as influenced by different pruning levels (Table 4 and Appendix XV). The highest number of female flowers plant^{-1} (6.17) was found from the treatment P_1 (1^{st} pruning at 20 DAT; 1^{st} and 2^{nd} leaves) where the lowest number of female flowers plant^{-1} (4.69) was found from the control treatment which was statistically identical with P_0 (no pruning) P_2 (2^{nd} pruning at 30 DAT; 3^{rd} and 4^{th} leaves). Tripti (2017) also found similar result with the present study and observed that the maximum number of female flower (8.62) in squash was achieved from first and second leaf pruning at 20 DAT.

Number of female flowers plant^{-1} was found significant with the application of different levels of GA_3 (Table 4 and Appendix XV). The highest number of female flowers plant^{-1} (6.48) was found from the treatment G_1 (100 ppm GA_3) which was significantly different from all other treatments. The lowest number of female flowers plant^{-1} (4.20) was found from the control treatment G_0 (0 ppm GA_3) which was also significantly different from all other treatments. This result indicated that GA_3 influenced squash plant to increase female flower but comparatively lower doses of GA_3 showed maximum female flower where with the increasing of GA_3 application it was decreased.

Remarkable variation was identified on a number of female flowers plant^{-1} due to the combined effect of pruning and GA_3 (Table 5 and Appendix XV). The highest number of female flowers plant^{-1} (7.52) was found from the treatment combination of P_1G_1 which was significantly different from all other treatment combinations. The lowest number of female flowers plant^{-1} (3.85) was found from the treatment combination of P_0G_0 which was statistically identical with the treatment combination of P_2G_0 and statistically similar with the treatment combination of P_0G_2 and P_2G_3.

4.2.3 Total number of fruits plant^{-1}

A variation on a total number of fruits was influenced by different pruning levels (Table 4 and Appendix XVI). The highest total number of fruits plant^{-1} (4.95) was found from the treatment P_1 (1st pruning at 20 DAT; 1st and 2nd leaves) which was statistically similar with P_2 (2nd pruning at 30 DAT; 3rd and 4th leaves) where the lowest total number of fruits plant^{-1} (4.27) was found from the control treatment P_0 (no pruning). Tripti (2017) also observed maximum number of fruits plant^{-1} (5.12) from the treatment of first and second leaf pruning at 20 DAT which was in agreement with the findings of Bahrami *et al*. (2009) in pumpkin and Alam *et al*. (2016) in summer tomato.

The recorded data on a total number of fruits plant^{-1} was significant with the application of different levels of GA_3 (Table 4 and Appendix XVI). The highest number of fruits plant^{-1} (5.37) was found from the treatment G_1 (100 ppm GA_3) which was significantly different from all other treatments. The lowest total number of fruits plant^{-1} (3.85) was found from the control treatment G_0 (0 ppm GA_3). Shafeek *et al.* (2016) also found similar result in squash which supported the present study. Ayyub *et al.* (2013) also asserted that foliar application of GA_3 may be an effective strategy for maximizing number of fruits per plant in okra and they found that foliar application of GA_3 (100 mg Kg^{-1}) resulted maximum number of fruits per plant in okra.

Table 4. Main effect of pruning and GA_3 on yield contributing parameters of squash

Treatments	Yield contributing parameters		
	Male flowers plant^{-1} (No.)	**Female flowers plant^{-1} (No.)**	**Fruits plant^{-1} (No.)**
Effect of pruning			
P_0	4.99 b	4.69 b	4.27 b
P_1	7.39 a	6.17 a	4.95 a
P_2	5.74 b	4.90 b	4.49 ab
Standard Error (±)	0.48	0.62	0.77
Significance	0.000	0.001	0.033
Effect of GA_3			
G_0	4.25 c	4.20 c	3.85 c
G_1	7.26 a	6.48 a	5.37 a
G_2	7.02 a	5.20 b	4.62 b
G_3	5.63 b	5.14 b	4.44 b
Standard Error (±)	0.58	0.74	0.68
Significance	0.000	0.000	0.000

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

Table 5. Combined effect of pruning and GA_3 on yield contributing parameters of squash

Treatments	Yield contributing parameters		
	Male flowers plant^{-1} (No.)	Female flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)
P_0G_0	3.47 e	3.85 e	3.69 e
P_0G_1	6.14 c	5.52 cd	4.82 b
P_0G_2	5.50 cd	4.48 de	4.17 d
P_0G_3	4.86 d	4.91 d	4.39 cd
P_1G_0	5.63 cd	4.87 d	4.19 d
P_1G_1	8.69 a	7.52 a	5.74 a
P_1G_2	8.32 a	6.18 bc	5.05 b
P_1G_3	6.92 b	6.10 bc	4.85 b
P_2G_0	3.64 e	3.88 e	3.69 e
P_2G_1	6.96 b	6.40 b	5.55 a
P_2G_2	7.26 b	4.94 d	4.65 bc
P_2G_3	5.11 d	4.41 de	4.10 de
Standard Error(±)	1.27	1.48	1.44
Significance	0.000	0.000	0.000

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

Significant influence was noted on total number of fruits plant^{-1} affected by the combined effect of pruning and GA_3 (Table 5 and Appendix XVI). The highest toal number of fruits plant^{-1} (5.74) was found from the treatment combination of P_1G_1 which was statistically identical with the treatment combination of P_2G_1. The lowest number of fruits plant^{-1} (3.69) was found from the treatment combination of P_0G_0 which was statistically identical with the treatment combination of P_2G_0.

4.2.4 Fruit length

Signification variation was not observed on fruit length influenced by different pruning levels (Table 6 and Appendix XVII). However, the highest fruit length (21.18 cm) was found from the treatment P_1 (1^{st} pruning at 20 DAT; 1^{st} and 2^{nd} leaves) and the lowest fruit length (20.16 cm) was found from the control treatment P_0 (no pruning). Tripti (2017) also obtained highest fruit length (21.35 cm) from the treatment of first and second leaf pruning at 20 DAT and this result was in agreement with the findings of Bahrami *et al.* (2009) in medicinal pumpkin.

Significant influence was noted on fruit length affected by different levels of GA_3 (Table 6 and Appendix XVII). The highest fruit length (22.15 cm) was found from the treatment G_1 (100 ppm GA_3) where the lowest fruit length (19.15 cm) was found from the control treatment G_0 (0 ppm GA_3) which was statistically identical with G_3 (300 ppm GA_3). The result obtained from the present study was similar to the findings of Chormule and Patel (2017) and Hoque, *et al.* (2002). Hoque *et al.* (2002) obtained highest fruit length in mungbean with 50 ppm GA_3 where Chormule and Patel (2017) found highest fruit length in okra with 150 ppm GA_3.

Fruit length was found significantly varied due to the combined effect of pruning and GA_3 (Table 7 and Appendix XVII). The highest fruit length (22.42 cm) was found from the treatment combination of P_1G_1 which was significantly different from all other treatment combinations. The lowest fruit length (18.83 cm) was found from the treatment combination of P_0G_0 which also was significantly different from all other treatment combinations.

4.2.5 Fruit diameter

Significant variation was remarked on fruit diameter as influenced by different pruning levels (Table 6 and Appendix XVIII). The highest fruit diameter (5.83 cm) was found from the treatment P_1 (1^{st} pruning at 20 DAT; 1^{st} and 2^{nd} leaves) where the lowest fruit diameter (3.83 cm) was found from the control treatment P_0 (no pruning). The result obtained from the present study was similar with the findings of Ekwu *et al.* (2012) in cucumber and Alam *et al*. (2016) in tomato. They found leaf pruning showed higher fruit diameter.

Fruit diameter was found not significant with the application of different levels of GA_3 (Table 6 and Appendix XVIII). However, the highest fruit diameter (5.41 cm) was found from the treatment G_1 (100 ppm GA_3) and the lowest fruit diameter (4.44 cm) was found from the control treatment G_0 (0 ppm GA_3). The result obtained from the present study was similar to the findings of Chaudhary *et al*. (2017) and they found that GA_3 application resulted higher fruit diameter in round melon.

Remarkable variation was identified on fruit diameter due to the combined effect of pruning and GA_3 (Table 7 and Appendix XVIII). The highest fruit diameter (6.15 cm) was found from the treatment combination of P_1G_1 which was statistically similar to the treatment combination of P_1G_2 and P_1G_3. The lowest fruit diameter (3.19 cm) was obtained from the treatment combination of P_0G_0 which was statistically identical with the treatment combination of P_0G_2 and P_0G_3.

4.2.6 Individual fruit weight

Non significant variation on individual fruit weight was recorded by different pruning levels (Table 6 and Appendix XIX). However, the highest individual fruit weight (419.60 g) was found from the treatment P_1 (1^{st} pruning at 20 DAT; 1^{st} and 2^{nd} leaves) and the lowest individual fruit weight (371.00 g) was found from the control treatment P_0 (no pruning). This result indicated that leaf pruning is not necessary for individual fruit weight but leaf pruming had significant effect on other yield contributing parameters like fruit diameter, number of fruits plant^{-1} etc.

The recorded data on individual fruit weight was significant with the application of different levels of GA_3 (Table 6 and Appendix XIX). The highest individual fruit weight (455.50 g) was recorded from the treatment G_1 (100 ppm GA_3) where the lowest individual fruit weight (375.13 g) was found from the control treatment G_0 (0 ppm GA_3) followed by G_2 (200 ppm GA_3) and G_3 (300 ppm GA_3). This result pointed out that GA_3 had positive response to increase individual fruit weight but this response was positive to a certain level and after that individual fruit weight was decreased with the increasing of GA_3.

Significant influence was noted on individual fruit weight affected by the combined effect of pruning and GA_3 (Table 7 and Appendix XIX). The highest individual fruit weight (507.66 g) was found from the treatment combination of P_1G_1 which was statistically similar to the treatment combination of P_2G_0 and P_0G_1. The lowest individual fruit weight (305.66 g) was found from the treatment combination of P_0G_0 .

Table 6. Effect of pruning and GA_3 on yield contributing parameters of squash

Treatments	Yield contributing parameters		
	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)
Effect of pruning			
P_0	20.16	3.83 c	371.00
P_1	21.18	5.83 a	419.60
P_2	20.51	4.79 b	405.72
Standard Error (±)	0.24	0.17	6.48
Significance	0.112	0.000	0.190
Effect of GA_3			
G_0	19.15 c	4.44	375.13 b
G_1	22.15 a	5.41	455.50 a
G_2	20.90 b	4.78	396.01 b
G_3	20.26 c	4.65	368.46 b
Standard Error (±)	0.41	0.22	7.33
Significance	0.000	0.186	0.000

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

Table 7. Combined effect of pruning and GA_3 on yield contributing parameters of squash

Treatments Combination	Yield contributing parameters		
	Fruit length (cm)	Fruit diameter (cm)	Individual fruits weight (g)
P_0G_0	18.83 l	3.19 e	305.66 g
P_0G_1	21.84 c	4.94 cd	447.50 abc
P_0G_2	20.12 g	3.71 e	369.33 defg
P_0G_3	19.87 h	3.49 e	361.53 defg
P_1G_0	19.45 j	5.40 bc	336.73 fg
P_1G_1	22.42 a	6.15 a	507.66 a
P_1G_2	21.61 d	5.96 ab	430.33 bcd
P_1G_3	21.23 e	5.83 ab	403.66 cdef
P_2G_0	19.17 k	4.73 d	483.00 ab
P_2G_1	22.19 b	5.14 cd	411.33 cde
P_2G_2	20.99 f	4.66 d	388.36 cdef
P_2G_3	19.68 i	4.64 d	340.20 efg
Standard Error(±)	0.72	0.42	12.96
Significance	0.000	0.000	0.000

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

4.2.7 Percent fruit dry weight

The considerable influence was not observed on % fruit dry weight persuaded by different pruning levels (Table 8 and Appendix XX). However, the highest % fruit dry weight (6.09%) was found from the treatment P_1 (1st pruning at 20 DAT; 1st and 2nd leaves) and the lowest % fruit dry weight (5.80%) was found from the control treatment P_0 (no pruning). The result obtained from the present study was similar to the findings of Ekwu *et al.* (2012) and they obtained higher % fruit dry weight with leaf pruning of cucumber compared to control.

Remarkable variation was identified on % fruit dry weight due to the effect of different levels of GA_3 (Table 8 and Appendix XX). The highest % fruit dry weight (6.50%) was obtained from the treatment G_1 (100 ppm GA_3) which was significantly different from all other treatments. The lowest % fruit dry weight (5.29%) was found from the control treatment G_0 (0 ppm GA_3). Chormule and Patel (2017) found similar result with the present study. Chormule and Patel (2017) found highest % fruit dry weight in okra with 150 ppm GA_3 compared to control.

Significant variation was found on % fruit dry weight influenced by the combined effect of pruning and GA_3 (Table 9 and Appendix XX). The highest (%) fruit dry weight (6.61%) was found from the treatment combination of P_1G_1 which was significantly different from all other treatment combinations where the lowest % fruit dry weight (5.15%) was found from the treatment combination of P_0G_0 which was statistically identical with the treatment combination of P_1G_0.

4.2.8 Fruit yield plant^{-1}

A significant variation on the weight of fruits plant^{-1} was remarked as influenced by different pruning levels (Table 8 and Appendix XXI). The highest weight of fruits plant^{-1} (2114.38 g) was found from the treatment P_1 (1st pruning at 20 DAT; 1st and 2nd leaves) which was statistically similar with P_2 (2nd pruning at 30 DAT; 3rd and 4th leaves). The lowest weight of fruits plant^{-1} (1605.59 g) was found from the control treatment P_0 (no pruning). This result indicated that at least one pruning of leaves is important for increased per plant yield and this result was in agreement with the findings of Bahrami *et al*. (2009) in pumpkin, Alam *et al*. (2016) in summer tomato and Tripti (2017) in squash.

The considerable influence was observed on the weight of fruits plant^{-1} persuaded by different levels of GA_3 (Table 8 and Appendix XXI). The highest weight of fruits plant^{-1} (2451.21 g) was found from the treatment G_1 (100 ppm GA_3) which was significantly different from all other treatments where the lowest weight of fruits plant^{-1} (1441.50 g) was found from the control treatment G_0 (0 ppm GA_3). Similar result was also observed by Chaudhary *et al*. (2017) in round melon.

Remarkable variation was identified on the weight of fruits plant^{-1} due to the combined effect of pruning and GA_3 (Table 9 and Appendix XXI). The highest weight of fruits plant^{-1} (2914.33 g) was found from the treatment combination of P_1G_1 followed by P_2G_1 where the lowest weight of fruits plant^{-1} (1130.30 g) was found from the treatment combination of P_0G_0 which was statistically similar with the treatment combination of P_2G_3, P_1G_0 and P_0G_2.

4.2.9 Fruit yield ha^{-1}

Significant variation was remarked on fruit yield ha^{-1} as influenced by different pruning levels (Table 8 and Appendix XXII). The highest fruit yield ha^{-1} (21.14 t) was found from the treatment P_1 (1st pruning at 20 DAT; 1st and 2nd leaves) which was statistically similar with P_2 (2nd pruning at 30 DAT; 3rd and 4th leaves). The lowest fruit (16.05 t) was found from the control treatment P_0 (no pruning). This result indicated that leaf pruning had significant effet on yield of squash. Under the present study, it was observed that yield contributing parameters like number of male flowers, female flowers, fruit diameter, fruits plant^{-1} etc. were also influenced by leaf pruning and in case of these parameters, P_1 (1st pruning at 20 DAT; 1st and 2nd leaves) gave the best result. So, with these supports highest yield ha^{-1} was also achieved from P_1 treatment. The result obtained from the present study was similar to the findings of Bahrami *et al*. (2009) in pumpkin, Ekwu *et al.* (2012) in cucumber and Alam *et al*. (2016) in summer tomato. Tripti (2017) also found similar result with the present study and observed that the maximum yield (21.07 t/ha) in squash was achieved from first and second leaf pruning at 20 DAT..

The recorded data on fruit yield ha^{-1} was significant with the application of different levels of GA_3 (Table 8 and Appendix XXII). The highest fruit yield ha^{-1}

(24.51 t) was found from the treatment which was significantly different from all other treatments. The lowest fruit yield ha^{-1} (14.41 t) was found from the control treatment G_0 (0 ppm GA_3) which was statistically similar to G_3 (300 ppm GA_3). Under the present study, G_1 (100 ppm GA_3) showed the highest yield because yield contributing parameters like number of male and female flowers, fruits $plant^{-1}$, fruit length, yield $plant^{-1}$ etc. were also achieved from the same treatment. The result obtained from the present study was similar to the findings of Chaudhary *et al*. (2017) and they found that GA_3 application resulted higher fruit diameter in round melon. This result was in agreement with the findings of Chormule and Patel (2017) and they found highest fruit yield in okra with 150 ppm GA_3 compared to control.

Table 8. Effect of pruning and GA_3 on yield contributing parameters and yield of squash

Treatments	Yield contributing parameters and yield		
	Percent (%) fruit dry weight	**Fruit yield $plant^{-1}$ (g)**	**Fruit yield (t ha^{-1})**
Effect of pruning			
P_0	5.80	1605.59 b	16.05 b
P_1	6.09	2114.38 a	21.14 a
P_2	5.85	1816.24 ab	18.16 ab
Standard Error (±)	0.29	7.86	1.03
Significance	0.269	0.000	0.45
Effect of GA_3			
G_0	5.29 c	1441.50 c	14.41 c
G_1	6.50 a	2451.21 a	24.51 a
G_2	6.03 b	1842.17 b	18.42 b
G_3	5.83 b	1646.72 bc	16.46 bc
Standard Error (±)	0.37	8.55	1.13
Significance	0.000	0.000	0.000

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

Significant influence was noted on fruit yield (t ha^{-1}) influenced by the combined effect of pruning and GA_3 (Table 9 and Appendix XXII). The highest fruit yield (29.14 t ha^{-1}) was found from the treatment combination of P_1G_1 which was significantly different from all other treatment combinations followed by the treatment combination of P_2G_1. The lowest fruit yield (11.30 t ha^{-1}) was found from the treatment combination of P_0G_0 which was statistically similar to the treatment combination of P_1G_0 and P_2G_3.

Table 9. Combined effect of pruning and GA_3 on yield contributing parameters and yield of squash

Treatments Combination	Yield contributing parameters and yield		
	Percent (%) fruit dry weight	Fruit yield plant^{-1} (g)	Fruit yield (t ha^{-1})
P_0G_0	5.15 j	1130.30 f	11.30 f
P_0G_1	6.39 c	2159.15 bc	21.59 bc
P_0G_2	5.88 g	1544.66 def	15.44 def
P_0G_3	5.77 h	1588.26 de	15.88 de
P_1G_0	5.42 j	1410.90 ef	14.10 ef
P_1G_1	6.61 a	2914.33 a	29.14 a
P_1G_2	6.24 d	2174.72 bc	21.74 bc
P_1G_3	6.09 e	1957.56 bcd	19.57 bcd
P_2G_0	5.30 k	1783.31 cde	17.83 cde
P_2G_1	6.50 b	2280.15 b	22.80 b
P_2G_2	5.98 f	1807.14 cde	18.07 cde
P_2G_3	5.65 i	1394.35 ef	13.94 ef
Standard Error(±)	0.62	13.58	1.96
Significance	0.45	0.000	0.000

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0 = No pruning (control), P_1 = 1st pruning at 20 DAT (1st and 2nd leaves), P_2 = 2nd pruning at 30 DAT (3rd and 4th leaves)

G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3, G_3 = 300 ppm GA_3

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was carried out at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November 2017 to February 2018. The seed of Sunny House F_1 hybrid squash was used as planting materials. The experiment consisted of two factors: Factor A: three levels of pruning as P_0 = No pruning (control), P_1 = 1^{st} pruning at 20 DAT (1^{st} and 2^{nd} leaves) and P_2 = 2^{nd} pruning at 30 DAT (3^{rd} and 4^{th} leaves) and Factor B: four levels GA_3 application as G_0 = No GA_3 (control), G_1 = 100 ppm GA_3, G_2 = 200 ppm GA_3 and G_3 = 300 ppm GA_3. The experiment was laid out in a Randomized Complete Block Design with three replications. Data on different growth, yield contributing parameters and yield were recorded and statistically analyzed using the SPSS computer package program. Different pruning and GA_3 treatments and also their combinations showed a significant influence of different growth, yield contributing parameters and yield of squash.

Considering growth parameters, pruning treatment had a significant effect on growth, yield contributing parameters and yield of squash except for stem base diameter and individual fruit weight. However, the highest stem length (22.96, 47.79 and 62.74 cm at 30 DAT, 45 DAT and at harvest, respectively), number of leaves plant^{-1} (13.59, 20.12 and 21.85 at 30 DAT, 45 DAT and at harvest, respectively) and stem base diameter (1.16, 1.41 and 1.99 cm at 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment P_1 (1^{st} pruning at 20 DAT; 1^{st} and 2^{nd} leaves). Regarding yield contributing parameters and yield the highest number of male flowers plant^{-1} (7.39), number of female flowers plant^{-1} (6.17), total number of fruits plant^{-1} (4.95), fruit length (21.18 cm), fruit diameter (5.83 cm), individual fruit weight (419.60 g), % fruit dry weight (6.09%), fruit yield plant^{-1} (2114.38 g) and fruit yield ha^{-1} (21.14 t) were also found from the treatment P_1 (1^{st} pruning at 20 DAT; 1^{st} and 2^{nd} leaves). Similarly, the lowest stem length (19.66, 44.45 and 60.23 cm at 30 DAT, 45 DAT and at harvest, respectively), number of leaves plant^{-1} (10.79, 16.94 and 19.07 at 30, 45 and at harvest, respectively) and stem base diameter (1.13, 1.39 and 1.94 cm at 30 DAT, 45 DAT and at harvest, respectively) were found from the control treatment P_0 (no pruning). The lowest number of male flowers plant^{-1} (4.99), number of female flowers plant^{-1} (4.69), total number of fruits plant^{-1} (4.27), fruit length (20.16 cm), fruit diameter (3.83 cm), individual fruit weight (371.00 g), % fruit dry weight (5.80%), fruit yield plant^{-1} (1605.59 g) and fruit yield ha^{-1}(16.05 t) were also found from the control treatment P_0 (no pruning).

Regarding GA_3 treatments, growth and yield parameters were significantly influenced except fruit diameter. However, the results on growth parameters like stem length (23.40, 48.27 and 63.31 cm at 30 DAT, 45 DAT and at harvest, respectively), number of leaves plant^{-1} (14.24, 19.98 and 21.77 at 30 DAT, 45 DAT and at harvest, respectively) and stem base diameter (1.16, 1.44 and 2.05 cm at 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment G_1 (100 ppm GA_3). Likewise, regarding yield contributing parameters and yield, the highest number of male flowers plant^{-1} (7.26), number of female flowers plant^{-1} (6.48), total number of fruits plant^{-1} (5.37), fruit length (22.15 cm), fruit diameter (5.41 cm), individual fruit weight (455.50 g), % fruit dry weight (6.50%), fruit yield plant^{-1} (2451.21 g) and fruit yield ha^{-1}(24.51 t) was found from the treatment G_1 (100 ppm GA_3). The lowest stem length (19.08, 43.77 and 58.72 cm at 30 DAT, 45 DAT and at harvest, respectively), number of leaves plant^{-1} (10.13, 16.73 and 19.68 at 30, 45 and at harvest, respectively), stem base diameter (1.12, 1.35 and 1.91 cm at 30 DAT, 45 DAT and at harvest, respectively), number of male flowers plant^{-1} (4.25), number of female flowers plant^{-1} (4.20), total number of fruits plant^{-1} (3.85), fruit length (19.15 cm), fruit diameter (4.44 cm), individual fruit weight (375.13 g), % fruit dry weight (5.29%), fruit yield plant^{-1} (141.50 g) and fruit yield ha^{-1} (14.41 t) were found from the control treatment G_0 (0 ppm GA_3)

In terms of the combined effect of pruning and GA_3 treatments, all the studied growth and yield parameters were significantly influenced. The highest stem length (25.28, 49.73 and 64.73 cm at 30 DAT, 45 DAT and at harvest, respectively), number of leaves plant^{-1} (15.75, 21.27 and 23.59 at 30, 45 and at harvest, respectively), stem base diameter (1.18, 1.45 and 2.09 cm at 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment combination of P_1G_1. Again, the highest number of male flowers plant^{-1} (8.69), number of female flowers plant^{-1} (7.52), total number of fruits plant^{-1} (5.74), fruit length (22.42 cm), fruit diameter (6.15 cm), individual fruit weight (507.66 g), % fruit dry weight (6.61%), fruit yield plant^{-1} (2914.33 g) and fruit yield ha^{-1} (29.14 t) were also found from the treatment combination of P_1G_1. Similarly, the lowest stem length (17.88, 42.27 and 57.22 cm at 30 DAT, 45 DAT and at harvest, respectively), number of leaves plant^{-1} (9.31, 15.24 and 17.26 at 30 DAT, 45 DAT and at harvest, respectively), stem base diameter (1.11 cm, 1.35 cm and 1.90 cm at 30 DAT, 45 DAT and at harvest, respectively), number of male flowers plant^{-1} (3.47), number of female flowers plant^{-1} (3.85), total number of fruits plant^{-1} (3.69), fruit length (18.83 cm), fruit diameter (3.19 cm), individual fruit weight (305.66 g), % fruit dry weight (5.15%), fruit yield plant^{-1} (1130.30 g) and fruit yield ha^{-1} (11.30 t) was found from the treatment combination of P_0G_0.

Conclusion

From the above results, it can be concluded that among the different treatment combination of pruning and GA_3 treatments, P_1G_1 (1^{st} pruning at 20 DAT; 1^{st} and 2^{nd} leaves with G_1 = 100 ppm GA_3) have significant positive effect on growth and yield of squash and resulted in highest fruit yield ha^{-1} (29.14 t ha^{-1}) compared to all other treatment combinations.

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Appendices

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

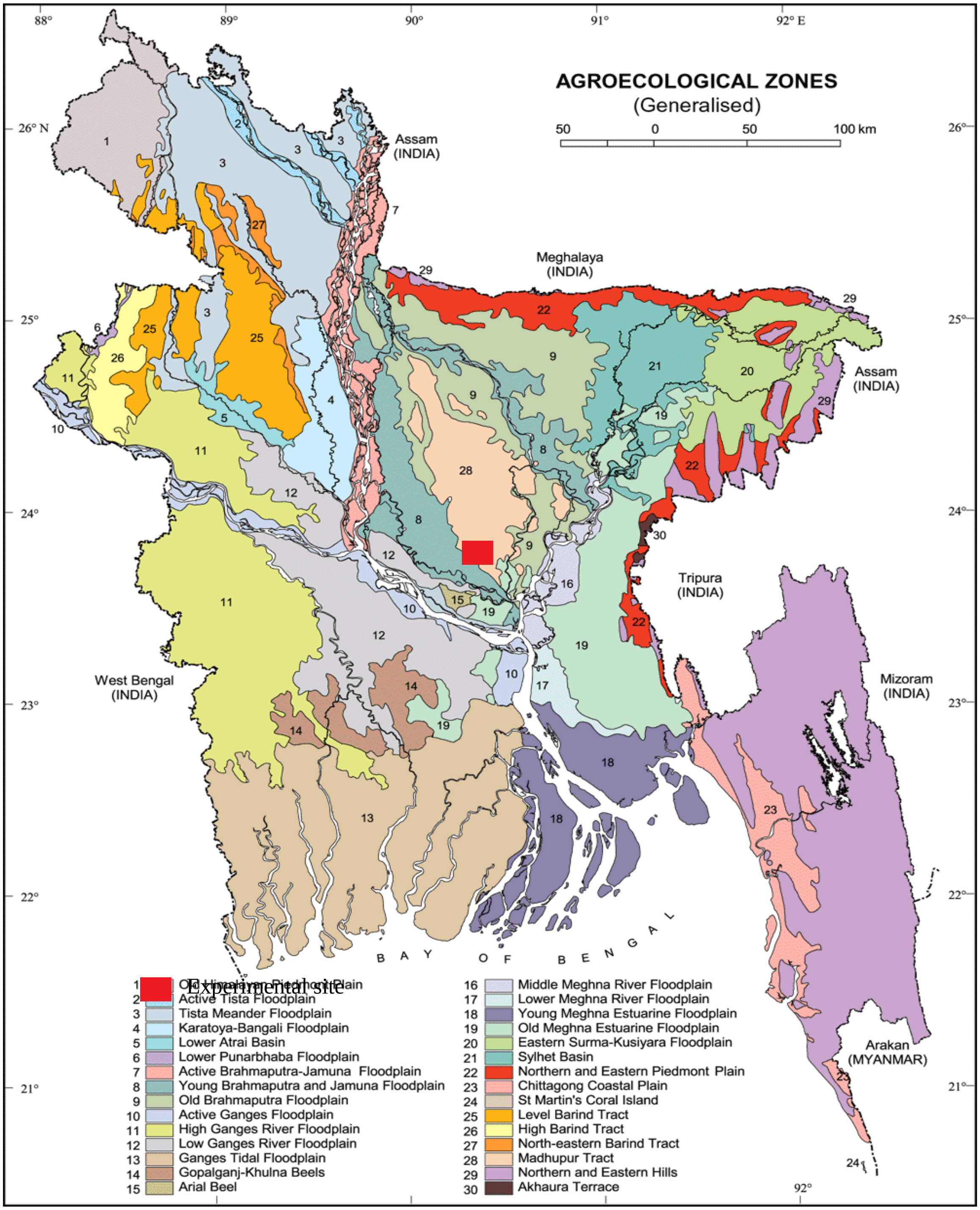

Fig. 7 . Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2017 to Februrary 2018.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2017	November	28.60	8.52	18.56	56.75	14.40
2017	December	25.50	6.70	16.10	54.80	0.00
2018	January	23.80	11.70	17.75	46.20	0.00
2018	February	22.75	14.26	18.51	37.90	0.00

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI).

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Layout of the experiment field

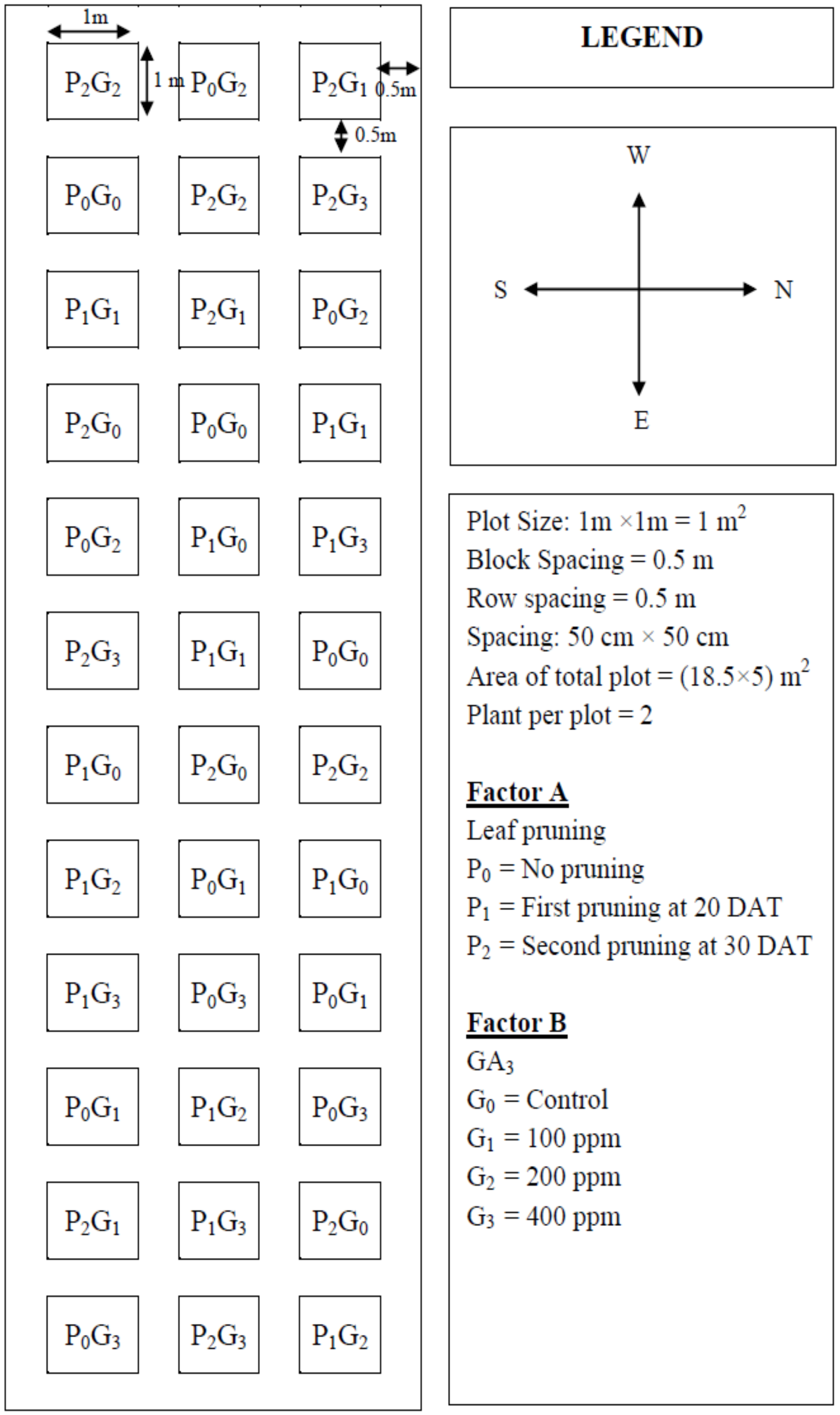

Fig. 8 . Layout of the experimental plot

Appendix V. Analysis of variance on stem length at 30 DAT

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	68.025	2	34.012	11.872	0.000
GA_3	87.192	3	29.064	12.339	0.000
Pruning×GA_3	157.434	11	14.312	66.917	0.000

Appendix VI. Analysis of variance on stem length at 45 DAT

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	67.759	2	33.879	11.284	0.000
GA_3	94.807	3	31.602	14.040	0.000
Pruning×GA_3	166.201	11	15.109	571.475	0.000

Appendix VII**.** Analysis of variance on stem length at harvest

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	41.687	2	20.844	5.709	0.007
GA_3	107.968	3	35.989	21.250	0.000
Pruning×GA_3	159.835	11	14.530	149.739	0.000

Appendix VIII. Analysis of variance on leaf number at 30 DAT

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	48.611	2	24.306	9.473	0.001
GA_3	79.748	3	26.583	15.890	0.000
Pruning×GA_3	131.661	11	11.969	177.278	0.000

Appendix IX. Analysis of variance on leaf number at 45 DAT

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	62.479	2	31.240	17.277	0.000
GA_3	49.532	3	16.511	7.276	0.001
Pruning×GA_3	118.264	11	10.751	66.418	0.000

Appendix X. Analysis of variance on leaf number at harvest

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	46.756	2	23.378	13.991	0.000
GA_3	26.027	3	8.676	3.659	0.022
Pruning×GA_3	97.609	11	8.874	49.656	0.000

Appendix XI. Analysis of variance on stem base diameter at 30 DAT

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	0.002	2	0.001	3.534	0.041
GA_3	0.007	3	0.002	13.234	0.000
Pruning×GA_3	0.009	11	0.001	8.153	0.000

Appendix XII. Analysis of variance on stem base diameter at 45 DAT

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	0.004	2	0.002	1.488	0.241
GA_3	0.033	3	0.011	23.305	0.000
Pruning×GA_3	0.039	11	0.004	9.104	0.000

Appendix XIII. Analysis of variance on stem base diameter at harvest

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	0.014	2	0.007	1.997	0.152
GA_3	0.090	3	0.030	23.817	0.000
Pruning×GA_3	0.120	11	0.011	25.273	0.000

Appendix XIV. Analysis of variance on total number of male flowers

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	36.045	2	18.023	9.879	0.000
GA_3	52.684	3	17.561	12.900	0.000
Pruning×GA_3	91.222	11	8.293	39.605	0.000

Appendix XV. Analysis of variance on total number of female flowers

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	15.307	2	7.653	8.147	0.001
GA_3	23.757	3	7.919	11.238	0.000
Pruning×GA_3	41.007	11	3.728	16.885	0.000

Appendix XVI. Analysis of variance on total number of fruits

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	2.946	2	1.473	3.773	0.033
GA_3	10.487	3	3.496	20.948	0.000
Pruning×GA_3	14.415	11	1.310	22.280	0.000

Appendix XVII. Analysis of variance on fruit length

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	6.365	2	3.183	2.341	0.112
GA_3	42.343	3	14.114	50.820	0.000
Pruning×GA_3	51.084	11	4.644	759.927	0.000

Appendix XVIII. Analysis of variance on fruit diameter

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	24.133	2	12.066	41.087	0.000
GA_3	4.661	3	1.554	1.705	0.186
Pruning×GA_3	30.827	11	2.802	22.443	0.000

Appendix XIX. Analysis of variance on fruit weight

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	15035.651	2	7517.825	1.745	0.190
GA_3	42325.993	3	14108.664	3.929	0.017
Pruning×GA_3	122443.162	11	11131.197	7.682	0.000

Appendix XX. Analysis of variance on dry weight (%)

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	0.575	2	0.288	1.365	0.269
GA_3	6.775	3	2.258	95.911	0.000
Pruning×GA_3	7.480	11	0.680	341.910	0.000

Appendix XXI. Analysis of variance on fruit yield plant^{-1}

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	1568490.269	2	784245.135	3.406	0.045
GA_3	5126595.468	3	1708865.156	13.535	0.000
Pruning×GA_3	7849743.239	11	713613.022	13.005	0.000

Appendix XXII. Analysis of variance on yield ha^{-1}

Source of Variance	SS	DF	MS	F Value	Significance
Pruning	156.849	2	78.425	3.406	0.045
GA_3	512.660	3	170.887	13.535	0.000
Pruning×GA_3	784.974	11	71.361	13.005	0.000