FOLIAR APPLICATION OF SALICYLIC ACID AND ZINC SULPHATE LEVELS ON GROWTH AND YIELD OF SQUASH UNDER NET HOUSE CONDITION

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CERTIFICATE

*This is to certify that the thesis entitled **"FOLIAR APPLICATION OF SALICYLIC ACID AND ZINC SULPHATE LEVELS ON GROWTH AND YIELD OF SQUASH UNDER NET HOUSE CONDITION"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by **SAYMA KABIR**, Registration No.: **19-10179,** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

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TO

MY BELOVED PARENTS

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ABSTRACT

A field experiment was conducted at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2020 to February 2021. The experiment was laid out in a Randomized Complete Block Design with three replications. The experiment had two factors (Different levels of salicylic acid, S_0= No salicylic acid (control), S_1= 60 ppm of salicylic acid, S_2= 90 ppm of salicylic acid and different levels of zinc, Z_0= No zinc sulphate (control), Z_1= 25 ppm of zinc sulphate, Z_2= 50 ppm of zinc sulphate. Different levels of salicylic, zinc sulphate and also their combinations showed significant influence on different growth, yield contributing parameters and yield of squash. The treatment, S_2 showed highest results in fruit yield per plant (2.42 Kg), fruit yield per plot (9.68 kg) and fruit yield per ha (37.83 t) compared to control. In case of zinc treatments, the highest results in fruit yield per plant (2.59 Kg), highest fruit yield per plot (10.38 kg) and highest fruit yield per ha (31.74 t) were found from Z_1 compared to control. Likewise, the treatment combination of S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) gave the highest fruit yield per plant (3.04 Kg) fruit yield per plot (12.18 kg) and highest yield per ha (47.57 t) where the lowest results were found from the treatment combination of S_0Z_0 (control). The highest gross return (Tk 1189425), net return (Tk 881669) and BCR (3.86) were obtained from the treatment combination of S_2Z_1 where the lowest was obtained from S_0Z_0. It can be concluded that from economic point of view, S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination is suitable for squash cultivation than other treatment combination.

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LIST OF ABBREVIATIONS

ABBREVIATION	**FULL WORD**
AEZ	Agro-Ecological Zone
Agri.	Agriculture
BCR	Benefit Cost Ratio
cm	Centimeter
CV	Coefficient of variation
DAT	Days After Transplanting
et al.	And others (*at elli*)
Kg	Kilogram
Kg/ha	Kilogram/hectare
g	gram
LSD	Least Significant Difference
m	Meter
pH	Hydrogen ion conc.
RCBD	Randomized Complete Block Design
t/ha	ton/ hectare
%	Percentage

CHAPTER I

INTRODUCTION

Squash (*Cucurbita pepo* L) is one of the most important vegetable crops that belongs to the Cucurbitceae family. It is one of the largest families in the plant kingdom which consists of largest number of edible plant species. This family also consists of about 30 species of annual, tendril-bearing plants of the family *Cucurbitaceae*. Four species which are commonly cultivated: *Cucurbita maxima*, *Cucurbita mixta*, *Cucurbita moschata,* and *Cucurbita pepo.* Summer squash, pumpkin, vegetable marrow, zucchini, and spaghetti squash etc are the different cultivars of *Cucurbita pepo* 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 P^H is 5.6- 6.5.

Squash is one of the most versatile and delicious foods available all over the world, which packs a serious punch in health and medicinal benefits. That why, In Bangladesh, this relatively new crop is increasingly gaining high levels of economic importance both in generation of income and provision of nutritional value. This delicious vegetable has various health benefits to human as well as medicinal potentials (Dursun *et al*., 2009). It is rich in nutrients and bioactive compounds contents such as phenolics, flavonoids, vitamins (including β-carotene, vitamin A, vitamin B2 , Vitamin B6, α- tocopherol, vitamin C, and vitamin E), lutein, zeaxanthin, protein, amino acids, carbohydrates and minerals (especially potassium), magnesium, potassium. And it is low in energy content (about 17 Kcal/100 g of fresh pumpkin) and has large amount of fiber Tamer *et al*. (2010). 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). It is usually grown in home gardens and commercial scale for its delicious immature fruits, young shoots, flowers, and seeds. Day by day the squash production is also increasing in Bangladesh. According to the statistical data of 2016, Bangladesh ranks 16th position in quantity of squash, pumpkin and gourd production and the quantity was 290,835 tons. In Bangladesh squash is mainly grown in limited area like at Pabna, Rangpur, Bogura, Joypurhat and Natore but the production could be increased by means of some practice.

Squash is cultivated in our country during the winter season when rainfall is scanty and for its growth and development optimum temperature requirement is within 18-28^{o}C. Most of the time irrigation and weed management increases the total cost of production of crops and ultimately growers can be frustrated. To increase the production of this vegetable some management practices can be followed. Foliar spray of different micronutrients and plant growth regulators can play a great role in these practices.

Foliar spraying of microelements is very helpful when the roots cannot provide necessary nutrients and this foliar feeding is an effective method of supplying nutrients during the period of intensive plant growth when it can improve plants mineral status and increase crop yield Kołota and Osinska (2001).

Zinc sulphate is one of the first micronutrients that is recognized as essential for plants and taken up by the plant in ionic form (Zn^{2}). Zinc is a cofactor of over 300 enzymes and also the constituent of many proteins that are involved in cell division, nucleic acid metabolism and protein synthesis. Zinc deficiency causes new leaves emerge white in color, older leaves may die, and plant severely dwarfs Singh and Gangwar (1991). Cakmak (2000) stated that Zn deficiency may inhibit the activities of a number of antioxidant enzymes. Zinc is essential for the synthesis of tryptophan, a precursor of IAA which is essential for normal cell division and other metabolic processes and helps in the formation of chlorophyll Wear and Hagler (1968). Availability of zinc might have stimulated the metabolic and enzymatic activities thereby increasing the plant growth parameters Kasturikrishana and Ahlawat (2003). It helps in the composition of the essential amino acids and resides low concentrations in the bark which may affects many vital operations of the plant and play a role in the formation of some important enzymes such as Oxide Reductase, Transferase, Hydrolase, Isomerase and Ligase as well as it has many impact in stimulating the metabolism of proteins, carbohydrates and safety of nucleic acids and cell membranes Lalelou *et al*. (2014)

Plant growth regulators are now widely used as a magic substance in modem farming. Plant hormone influence the growth and development of the plant including plant cell division, enlargement and differentiation, photosynthesis, flowering and fruiting of plant. In addition, abiotic and biotic stresses are being alleviated with numerous plant growth regulator i.e., abscisic acid, cytokinin, auxin, gibberellin, jasmonate, salicylic acid etc.

Salicylic acid (from Latin salix, willow tree) is a monohydroxy benzoic acid, and a type of phenolic acid also a beta hydroxyl acid. The formula is $C_7H_6O_3$. This colorless crystalline organic acid is mostly used in organic synthesis and functions as a plant growth regulators Grimes (1999) which is derived from the metabolism of silicon. These phenolic phyto hormone is found in plants which have roles in plant morphology and development, photosynthesis, transpiration, ion uptake and transport. Salicylic acid also induces some changes in leaf anatomy and chloroplast structure. Salicylic acid is also involved in endogenous signaling, mediating in plant defense against pathogens. It plays an important role in the resistance to pathogens by inducing the production of pathogenesis-related proteins Kawano *et al*. (2004). Its synthesis in cells, which can move freely in an out of cells, tissues and organ. This movement is finely regulated by reactive oxygen species (ROS) Chen and Kuc (1999). The exogenous salicylic acid application may enhance the activities of antioxidant enzyme activity as well as the enzyme of nitrate metabolism under stressful environment.

Therefore, salicylic acid improved morphological growth, development and yield of squash. However, very limited research was conducted to improve the growth and yield by foliar application of salicylic acid and zinc sulphate in squash. Therefore, considering the above facts, the present experiment has been undertaken with the following objectives:

- To find out the effect of different levels of salicylic acid on the growth, yield of squash
- To evaluate the effect of foliar spraying of different levels of zinc sulphate on morpho-physiological and yield contributing characters and yield of squash.
- To determine the combined effect of salicylic acid and zinc sulphate on growth and yield of squash.

CHAPTER II

REVIEW OF LITERATURE

Squash is becoming an important crop worldwide which is receiving much attention among the researcher throughout the world to develop production management technology. Among those research work, investigations have been made in different part of the world to select the suitable dose of zinc and salicylic acid for application. In maximum case, we observed that these techniques for Cucurbitaceae family crops as definitely squash is not so a new crop throughout the world. However, the combination effects of zinc and salicylic acid have not been yet defined clearly. In Bangladesh, though squash cultivation has not started in wide rang but this lovely vegetable is gaining popularity for its taste. Extensive information is not yet available on the growth, yield and nutrient content in the plant like squash which is both affected by foliar application of zinc sulphate and salicylic acid (SA). In this chapter, attempts have been made to review some important findings pertinent to effect of salicylic acid (SA) and zinc sulphate on the growth, yield and nutrient content in the squash.

2.1. Effect of salicylic acid

Janda *et al*. (2020) carried out a research on Salicylic acid (SA) which is ubiquitously distributed in the whole plant kingdom. The basal level of SA differs widely among species. It is generally present either in the free fraction or in the form of glycosylated, methylated, glucose-ester, or amino acid conjugates. In plants, SA can be synthesized via two distinct and compartmentalized enzymatic pathways, both requiring the primary metabolite chorismate. L-phenylalanine, derived from chorismate, can be converted into SA via the precursor’s free benzoic acid, benzoyl glucose, or ortho-hydroxy-cinnamic acid, depending on the plant species. Chorismate can also be converted into SA via isochorismate in the chloroplast. Several physiological processes in which SA may play a role have been reported, including seed germination, growth regulation, flower induction, thermogenesis, and especially, the regulation of plant responses under biotic or abiotic stress conditions. SA may be involved in different signaling processes. For example, various hormones involved in plant defence mechanisms crosstalk with SA, and both negative and positive interactions have been reported. SA signaling also leads to the reprogramming of gene expression and protein synthesis. It may affect the ant oxidative metabolism, and it modulates cellular redox homeostasis. However, in spite of the extensive work on SA-related processes, the exact mode of action is poorly understood.

Fereshteh *et al*. (2019) carried a study to investigate the effect of Salicylic acid on Physiological and morphological traits of Cucumber (*Cucumis sativus* L). The aim of this study was to determine the changes in the SA concentration over time in response to the spraying in leaves of cucumber. Based on the results, the highest stem length was obtained by seed priming with 0.01mM salicylic acid. Salicylic acid increases some growth regulators such as auxins Sharikova *et al*. (2003). These results can be attributed to the effect of salicylic acid on increasing cell division in the terminal meristem, cell lengthen and consequently, increasing growth Seyed Hajizadeh (2013)

Nada *et al*. (2019) observed the Influence of salicylic acid on cucumber plants under different irrigation levels. The result of the study was that increasing salicylic acid levels increased significantly plant height, leaf number, leaf chlorophyll content etc characters in both seasons compared to the control. The biggest values of these criteria were registered by using salicylic acid at 0.30 g/l and followed by 0.45 g/l. This could be attributed to the water shortage led to the oxidative damage inevitably by producing reactive oxygen species (ROS) which resulted oxygen reduction.

Salicylic acid prevents the high activity of ROS, improving cell division and elongation of plants tissues, activate translocation of soluble carbohydrates, ion uptake and membrane permeability which reflected in on more growth and development.

Kazemi. (2014) observed that salicylic acid (0.25 mM) and calcium chloride (2.5 mM) spray either alone or in combination (0.25 mM SA+2.5 mM Ca) affected on vegetative and reproductive growth, significantly. Mean comparisons indicated yield, and quality of tomato plants was developed in low salicylic acid and calcium chloride concentration. So salicylic acid and calcium chloride application can be helpful for yield improvement and prevent of decreasing yield.

Ali and Adel (2012) reported that four concentrations of salicylic acid (0, 50, 100 and 150 ppm) were assigned to the main plots. While, four foliar application concentrations of zinc (0, 300, 400 and 500 ppm) were applied to the sub-plots. The results showed that foliar application of salicylic Acid (SA) raised significantly ($p \leq 0.05$) plant height, number of branches plant-1, number of pods plant-^{1,} number of seeds pod^{-1}, 1000 seeds weight, seed weight plant-1 and seed yield ha^{-1} as compared with control (untreated plants) and the superiority was due to the high SA concentration (150 ppm). Significant ($p \leq 0.05$) improvement in all above mention traits were occurred with foliar application of zinc as compared with untreated plants. Furthermore, the highest values of those traits were registered at application of 500 ppm zinc which showed insignificant difference at application of 400 ppm zinc. Also, the investigation showed that the interaction between salicylic acid and zinc nutrient had a significant effect on all studied traits. Application of 150 ppm SA with 500 or 400 ppm zinc produced the highest significant seed yields ha-1 significantly.

Khandaker *et al*. (2011) reported that salicylic acid (SA) was applied at three different concentrations (10-3, 10-4 and 10-5 M), three times during the vegetation at 7-day intervals one week after sowing. Growth parameters such as (plant height, stem length, number and size of leaves, root length) and yield (fresh and dry matter weight) were recorded from treated and control plants on 28 days after sowing. Among bioactive compounds, betacyanins, chlorophyll, total 14 polyphenol and antioxidant activity were the determined from the leaves of treated ones and control plants. All of the doses of SA application improved the plant growth, yield and leaf's bioactive compounds compared to the control. The highest yield, antioxidant activity, amount of betacyanins, chlorophyll and total polyphenol occurred in 10-5 M SA treatment.

Khan *et al*. (2010) found that foliar spraying of salicylic acid (0.10, 0.50, and 1.00 mM) under 50 mM NaCl stressed mung bean decreased Na^+, Cl^-, H_2O_2, and 21 thiobarbituric acid reactive substances, and electrolyte leakage. SA treatment exhibit increased N, P, K, and Ca content, activity of antioxidant enzymes, glutathione content, photosynthesis, and yield under control and saline condition. Application of 0.50 mM SA alleviate the negative effects of NaCl on decreased the content of leaf Na+ , Cl– , H_2O_2 , and electrolyte leakage, and increased leaf N, P, K, and Ca content, and activity of antioxidant enzymes and glutathione. This treatment resulted in reduced negative effects of salt stress on growth, photosynthesis, and yield while 1.00 mM salicylic acid proved inhibitory or there were no additional benefits.

Lee *et al*. (2010) reported that high concentration of salicylic acid affects the seed germination in salt induced conditions. In contrast, lower level of salicylic acid concentration increased the seed germination rate, also decrease H_2O_2 level by reducing oxidative damage under salt stress condition. So, salt induced negative effects were significantly diminished by salicylic acid pretreatment of the plants.

Mady (2009) was carried an experiment to study the effect of foliar application of 50 & 100 ppm of salicylic acid (SA). Results indicated that, various applied treatments significantly enhanced all studied growth parameters as number of branches and leaves per plant, leaf area per plant and leaves dry weight as well. Also improved photosynthetic pigments, NPK, Fe, Zn, Mn, total carbohydrates and crude protein concentrations in leaves of treated plants as compared with those of untreated ones. The highest early and total yields were obtained from salicylic acid 50ppm followed by SA 100ppm, respectively. In addition, chemical composition of minerals and some bio constituents like carbohydrates, vitamin C, total soluble solids in tomato fruits were also increased at the same treatments.

Dursun and Yildirim (2009) investigated that plants which were treated with foliar SA applications at different concentrations (0.00, 0.25, 0.50 and 1.00 mM). SA was applied with spraying four times during the vegetative growth stage at 10-day intervals two weeks after planting. From the study, it was determined that foliar applications of SA showed positive effect on some fruit characteristics, plant growth, 15 chlorophyll content in leaves, early yield and total yield. SA treatments had no effect on pH, AA and TA of tomato. Total soluble solids (TSS) increased with foliar SA applications. The greatest stem diameter, leaf dry matter and chlorophyll content were obtained from 0.50 mM SA treatment. SA treatments increased the early yield of tomato compared to the control. The yield of tomato was significantly influenced by foliar SA applications. The highest yield occurred in 0.50 mM SA treatment. According to our results, applications of 0.50 mM SA should be recommended in order to improve yield.

Hayat *et al.* (2007) indicated that salicylic acid is a plant growth regulator that increases plant bio-productivity. Experiments conducted with ornamental or horticultural plants in greenhouse conditions or in the open have clearly demonstrated that they respond to this compound. Moreover, lower quantities of SA are needed to establish positive responses in the plants. The effect on ornamental plants is expressed as the increase in plant size, the number of flowers, leaf area and the early appearance of flowers. In horticultural species, the effect reported is the increase of yield without affecting the quality of the fruits. It is proposed that the increase in bio-productivity is mainly due to the positive effect of SA on root length and its density.

Yildirim *et al*. (2007) reported that cucumber seedlings were treated with foliar salicylic acid (SA) applications at different concentrations (0.0, 0.25, 0.50, and 1.00 mM). Salinity treatments were established by adding 0, 60, and 120 mM of sodium chloride (NaCl) to a base complete nutrient solution. The SA was applied two times as before and after transplanting. 16 However, foliar applications of SA are resulted that in greater shoot fresh weight, shoot dry weight, root fresh weight, and root dry weight as well as higher plants under salt stress. Shoot diameter and leaf number per plant also increased with SA treatments under salt stress. The greatest chlorophyll content was found with 1.00 mM SA treatment in both saline and non-saline conditions. Leaf water relative content (LWRC) was reduce in response to salt stress while SA raised LWRC of salt stressed cucumber plants. Salinity treatments induced significant increases in electrolyte leakage. Plants treated with foliar SA had found the lower values of electrolyte leakage than non-treated ones. In regard to nutrient content, it can be interfered that foliar SA applications increased almost all nutrient content in leaves and roots of cucumber plants under salt stress. Generally, the greatest values were obtained from 1.00 mM SA application. Based on these findings, the SA treatments may help alleviate the negative effect of salinity on the growth of cucumber.

2.2 Effect of Zinc sulphate

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

Reddy *et al*. (2014) found that the 2% zinc spray recorded maximum plant height over the lower concentrations. Maximum plant height due to higher concentration of zinc might be its role in synthesis of proteins.

Kucukyumuk *et al*. (2014) reported that three levels of zinc fertilization (0, 5, 10 mg/kg) and an arbuscular mycorrhiza (AM) fungus Glomus intra radices were tested for their potential to control Pythium delicense on inoculated cucumber seedlings. Plant Zn, N, P, K, Mg, Ca, Fe, Mn, Cu contents, dry and fresh weights of plant and roots and disease severity were determined in the study. Resistance to Pythium rot was determined with the application of mycorrhiza with increasing doses of zinc. Zinc and mycorrhizal fungus applications had significant effects on plant nutrition except for K and Cu. While the highest N and P concentrations were noted under Zn0 conditions, the values obtained under Zn_1 and Zn_2 conditions showed differences depending on G. intra radices and P. delicense treatments. Leaf Ca concentration reached up to highest level with 5 $Zn_2GI_0Pd_1$ treatment and the lowest Ca content was recorded under GI0Pd0 for all Zn applications. Lower level of zinc together with GI0Pd0 applications resulted in the highest leaf Mg concentration. The highest micronutrient concentrations were analyzed on cucumber plants grown under Zn deficient conditions without GI but with P delicense. Plant dry weight, root fresh and root dry weights were higher in cucumber plants challenged with AM fungus and P. delicense under zinc applied conditions. It was observed that certain rates of zinc and mycorrhiza based-treatments had positive effects on disease factors by suppressing Pythium rot and can be used for biological control.

Maurya and Kumar (2014) reported that significantly the maximum number of leaves per plant (7.89) was recorded with the spraying of Zn @ 300 mg l–1 followed by spraying of B @ 300 mg l–1 (7.83). The minimum number of leaves per plant (6.50) was recorded with water sprayed in control (T_1). They reported that the increased in number of leaves per plant may be due to cell division in plants.

An experiment was conducted at Fruit Research Station, Lalbaug, Department of

Horticulture, J.A.U., and Junagadh during summer season 2012, to study the "Effect of zinc and boron on growth and quality of cucumber (*Cucumis sativus* L.) cv. Gujarat cucumber-1". Significantly higher percentage of fruit set (90.41) was observed in treatment T_4 which was at par with the treatments T_{10}, T_6, and T_{12}. Maximum number of fruits per vine (15.83) was recorded at treatment and which was at par to T_{10}. The fruit length (24.72 cm) and girth (10.19 cm) recorded maximum with treatment T4. Fruit length was at par with T_{10}, while fruit girth was at par with treatment T_{10}, T_6, and T_{12}. Significantly the minimum percentage of fruit drop (13.77%) was observed in the treatment T_4 (Bo @ 9 kg/ha soil application), which was found at par with the treatments T_6 and T_{10}. The lowest percentage of bitter fruit (2.73%) was recorded with treatment T_4 which was at par with T_{10}. Significantly the maximum average fruit weight (247.23 g) was recorded at treatment T_4 which was at par with T_{10}. Similarly, significantly the highest fruit yield per vine (3.81 kg) was recorded in treatment T_4 which was at with treatment T_{10}. The maximum fruit yield per hectare of cucumber (19.60 t/ ha) was recorded in treatment T_4 (Bo @ 9 kg/ha, soil application) and was found at par with the treatments T_{10}, and T_6. The results further revealed that quality parameters viz., volume of fruit (165.16 ml), TSS (5.050Brix), total sugars (9.56%), non-reducing sugars (4.49%) and reducing sugars (5.07%) were significantly increased with treatment T_4 (Bo @ 9 kg/ha, soil application). But, the treatment T_1 (control) registered the highest Vitamin C (11.74 mg/ 100g). The maximum zinc content (175.89 ppm) was observed in T_{10} which was at par with T_9 (171.23 ppm). The maximum boron content in leaves of cucumber (134.98 ppm) was recorded in T_4 which was at par with T_3 (129.85 ppm) and T_7 (126.65 ppm). Treatment T_4 (Bo @ 9 kg/ha, soil application) gave the maximum net realization of Rs. 65940.42 /ha with a CBR of 1:3.05 and was followed by the treatment T6 which recorded the net realization of Rs. 56875.67 /ha and a CBR of 1:3.01 On the basis of experimental results, it can be concluded that soil application of Boron @ 9 kg/ha in cucumber should be done for getting higher yield, good quality of fruit as well as higher net realization from cucumber crop Deshmukh (2014).

Zhao *et al*. (2013) stated that with the dramatic increase in nanotechnologies, it has become increasingly likely that food crops will be exposed to excess engineered nanoparticles (NPs). In this study, cucumber plants were grown to full maturity in soil amended with either CeO_2 or ZnO NPs at concentrations of 0, 400, and 800 mg/kg. Chlorophyll and gas exchange were monitored, and physiological markers were recorded. Results showed that, at the concentrations tested, neither CO_2 nor ZnO NPs impacted cucumber plant growth, gas exchange and chlorophyll content. However, at 800 mg/kg treatment, CO2 NPs reduced the yield by 31.6% compared to the control ($p \leq 0.07$). ICP-MS results showed that the high concentration treatments resulted in the bioaccumulation of Ce and Zn in the fruit (1.27 mg of Ce and 110 mg Zn per kg dry weight). μ-XRF images exhibited Ce in the leaf vein vasculature, suggesting that Ce moves between tissues with water flow during transpiration. To the authors' knowledge, this is the first holistic study focusing on the impacts of CeO2 and ZnO NPs in the life cycle of cucumber plants.

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

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

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

Tzerakis *et al*. (2012) reported that a standard and a high manganese (Mn) level (10 and 160 μM) were combined with a standard and a high zinc (Zn) level (4 and 64 μM) in the nutrient solution supplied to cucumber in closed-cycle hydroponic units to compensate for nutrient uptake. The concentrations of all nutrients except Mn and Zn were identical in all treatments in the study. The objectives of the study were to establish critical Zn and Mn levels in both nutrient solutions and leaves of cucumber grown hydroponically, to assess the impact of gradual Zn and/or Mn accumulation in the external solution on nutrient uptake and gas exchange and to find whether Mn and Zn have additive effects when the levels of both ions are excessively high in the root zone. The toxicity symptoms of Mn and Zn were appeared when the concentrations of Mn and Zn in the leaves of cucumber reached 900 and 450 mg kg–1 in the dry weight, respectively. Excessively high Mn or/and Zn concentrations of the leaves reduced the fruit biomass production due to decreases in the number of fruits per plant, as well as the net assimilation rate, stomatal conductance and transpiration rate, but increased the intercellular CO2 levels. Initially, the Mn or Zn concentrations in the recirculating nutrient solution which increased rapidly but gradually stabilized to maximal levels, while the corresponding concentrations in the leaves constantly increased until the end of the experiment. The uptake of Mg, Ca, Fe, and Cu was negatively affected, while that of K and P remained unaffected by the external uptake of Mn and Zn levels. The combination of high Mn and Zn seems to have no additive effects on the parameters of investigation.

Dominy (2010) reported that zinc and manganese have long been considered as essential micronutrients to plant growth, yet the interactions of these two nutrients on growth and development of plants have not been elucidated in their entirety. Silicon is not noted as an essential element but has been found to improve growth of a number of crops, particularly of the Poaceae family. In a simple water culture hydroponic system was developed to monitor the growth and development of a fruit crop (Cucumber – *Cucumis sativus*) under deficient, adequate and excessive applications of zinc and manganese. Plant growth parameters were monitored like leaf growth, plant height, plant fresh and 10 dry mass, yield, fruit size and fruit mass. Nutrient uptake was also measured by using inductively coupled plasma emission spectroscopy, whilst chlorophyll was determined spectrophotometrically. Plant nutrient analyses were also conducted using inductively coupled plasma emission spectroscopy. Silicon have many beneficial effect on the growth of cucumbers and was incorporated as a treatment for this crop along with zinc and manganese since foliar silicon sprays were able to correct the deficiency symptoms which occurred due to lack of certain minerals. Along with plant growth measurements, nutrient uptake, plant nutrient analysis and chlorophyll determination, also plant tissue was analyzed using transmission electron microscopy to establish the impact of silicon applications on the cell ultra-structure of cucumbers. Electron micrographs showed that an increased presence of plasmodesmata in treatments excluding silicon. Such increased plasmodesmata under silicon deficient conditions can increase the translocation of cell solutes due to reduced cell longevity. Results also confirmed that the essentiality of zinc and manganese on plant growth and development as typical deficiency symptoms were observed. Typical toxicity symptoms were also recorded. Rates of uptake of nutrients corresponded with leaf growth and enlargement as well as yield. The chlorophyll concentration was not a clear indicator of nutrient uptake level. Typically, manganese and zinc interacted with iron, magnesium, calcium and potassium, affecting their uptake into the plant which may depended on the level of manganese and zinc applied. Although nonessential, silicon improved plant growth, but had neither a relationship with the other nutrients evaluated nor affected the physical growth and development of the plants. Manganese and zinc, as essential to plant growth and development, affect the visual appearance of the plant also affect the plant biochemically due to their involvements in many growth and development processes.

Kietsermkajorn *et al*. (2010) suggested that from the trial on zinc and magnesium fertilization for growing Japanese cucumber on basic soil with high amount of residual phosphorus and potassium was conducted at Huai Luek Royal Project Development Centre, Chiang Mai province. It was aimed at examining the effect of Mg and Zn which were applied at different rates on yield of Japanese cucumber and the 11 uptake of some plant nutrients by this plant. The experiment was done in randomized complete block design (RCBD) for which 10 treatments of different rates of Mg and Zn fertilizers and their combination, each with four replications. Results showed that the use of Mg and Zn fertilizers at three different amounts, the yield of fresh Japanese cucumber fruits was not higher than that of the control. The lowest yield of 12.6 t/ha was obtained from treatment with the application of 0.1 g $ZnSO_4.7H_2O$. Addition of Mg plus Zinc at the rate of 3:0.3 g tended to give the highest yield of 22.9 t/ha. However, there was no statistical difference in yield among the different level of treatments. Application of Mg and Mg plus Zn at the highest rates significantly enhanced plant P uptake (0.6 and 0.7 percent, respectively) into leaves as compared to the control, similar to K uptake into leaves in all added Mg and Zn fertilizers. There was no correlation between addition of Mg and Mg uptake. Nevertheless, the accumulation of Zn in leaves tended to be higher when applied with Zn fertilizer at the highest rate.

Marschner *et al*. (1990) reported based on results from water culture experiments with tomato and cucumber plants where severe leaf chlorosis and depression in flower and fruit formation occurred lack of silicon (Si) supply, Si is an essential mineral element for these two-plant species. By using the same nutrient solution which was high in phosphorus (P) but low in zinc (Zn) they could confirm these results. Simultaneously the concentrations of P drastically decreased in the leaves and the proportions of water extractable Zn increased. Normal growth and absence of chlorosis were also obtained without the addition of Si when either the external concentration of P was lowered or of Zn was increased. Short-term experiments revealed that Si has no direct effect on uptake or translocation of P to the shoot. According to these results, the experimental evidences so far are insufficient for the classification of Si as an essential mineral element for cucumber. Instead, Si may act as beneficial element under conditions of nutrient imbalances, for example, in P and Zn supply and corresponding P-induced Zn deficiency. The mechanism 12 by which Si increases the physiological availability of Zn in leaf tissue is not yet clear.The essentiality of Zn as a nutrient requirement for higher plants. Plants absorb zinc in the form of Zn^{+2}. The functional role of Zn includes auxins metabolism, nitrogen metabolism, influence on the activities of enzymes (e.g., dehydrogenase and carbonic anhydrase, proteinases and peptidases), and cytochrome C synthesis, stabilization of ribosomal fractions and protection of cells against oxidative stress.

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 2020 to February 2021 to study the effect of salicylic acid and zinc sulphate 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 characteristics

The soil of the experimental site belongs to the Tejgaon series under the Agro ecological Zone, Madhupur Tract (AEZ- 28) (Appendix II) and the general soil type is Shallow Red Brown Terrace soil. A composite soil sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of silty clay with pH and organic matter 5.8 and 1.16 respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay, which have been presented in Appendix II.

3.3 Climate and weather

The climate of the experimental area was subtropical region, which characterized by three individual 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 air, temperature, 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 Planting materials

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

3.5 Experimental details

3.5.1 Treatments

The experiment comprised of two factors.

Factor A: Salicylic acid (Levels)

S_0 = No Salicylic acid (control)

S_1 = 60 ppm Salicylic acid

S_2 = 90ppm Salicylic acid

Factor B: Zinc sulphate (Levels)

Z_0 = No Zinc (control)

Z_1 = 25 ppm Zinc sulphate

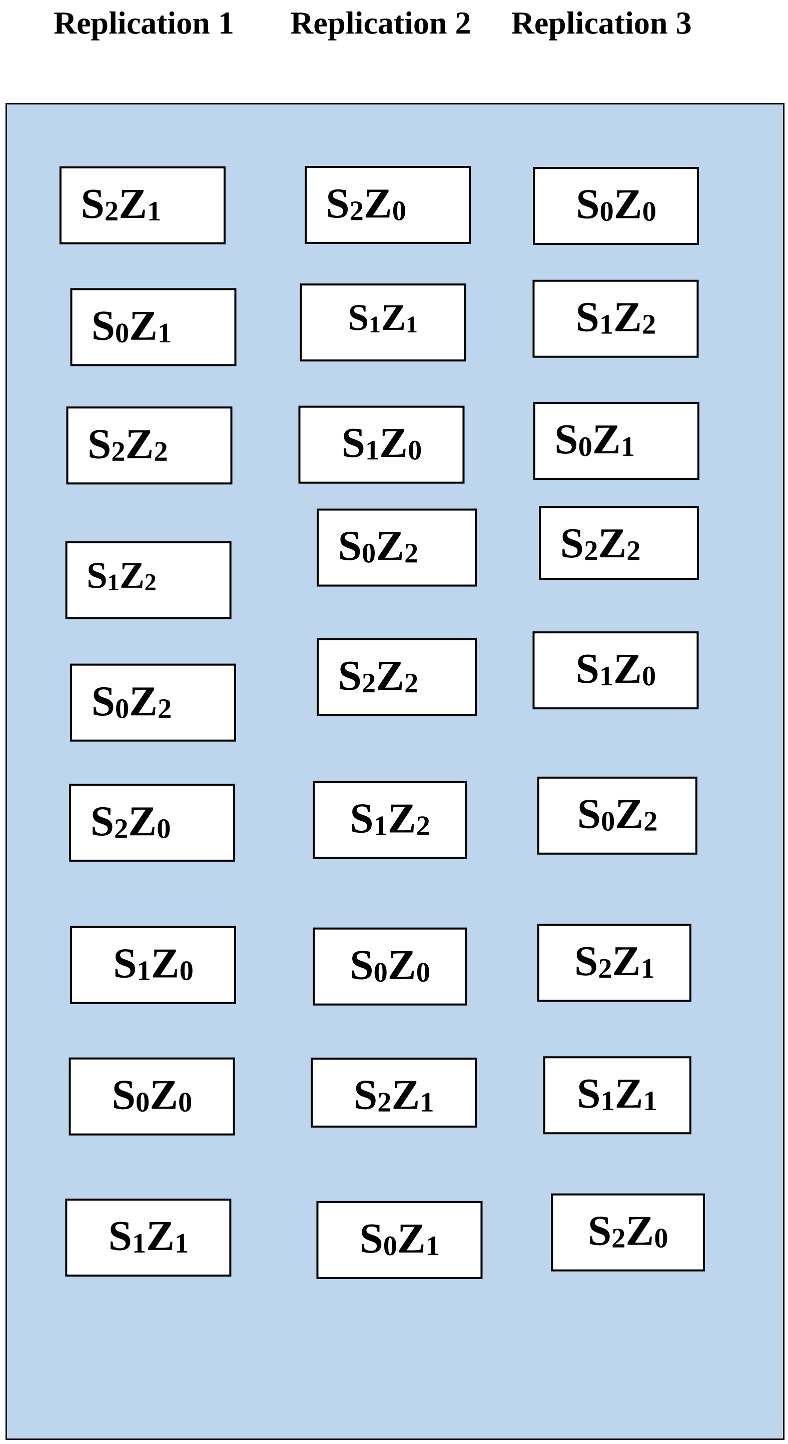
Z_2 = 50 ppm Zinc sulphate

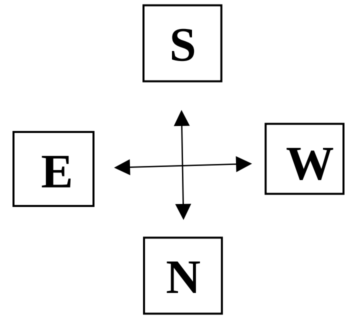
Treatment combinations –Nine (9) treatment combinations as follows:

S_0Z_0, S_0Z_1, S_0Z_2, S_1Z_0, S_1Z_1, S_1Z_2, S_2Z_0, S_2Z_1, S_2Z_2.

3.5.2 Experimental design and layout

The 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 salicylic acid and zinc levels. The 9 treatment combinations of the experiment were assigned at random into 27 plots. The size of each unit plot 1.6 m × 1.6 m. The distance between blocks to blocks and plots to plots were 1.0 m and 0.5 m respectively.





Factor A: Salicylic acid (Three levels)
S_0=No Salicylic acid (control)
S_1 = 60 ppm Salicylic acid
S_2 = 90ppm Salicylic acid

Factor B: Zinc sulphate (three levels)
Z_0 =No Zinc sulphate (control)
Z_1 = 25 ppm Zinc sulphate
Z_2 = 50 ppm Zinc sulphate

Plot size: 1.6 m X 1.6 m

Plot spacing: 0.5m X 0.5m

Block to block distance: 1m

Fig. 1. Layout of the experiment field

3.6 Raising of seedlings

3.6.1 Preparation of polybags

Seeds were sown in one-time plastic glass which was used as polybags. And it was filled with loose friable, dead roots free, sandy loam soil previously mixed with well rotten cow dung.

3.6.2 Seed sowing

The polybags were kept in the bed for raising the seedlings. Seeds were sown in the polybags on 22 November, 2020. Each polybag contained two seeds of squash. After sowing, the seeds were covered with light soil after sowing watering was done by water cane regularly. Complete germination of the seeds took place with 5 days after seed sowing. Necessary shading was made by using white polythene to protect the seedlings from scorching sunshine or rain. No chemical fertilizer was used in the polybags which was used for sowing seed.

3.7 Preparation of the main research field

The plot which selected for the experiment was opened in the first week of December, 2020 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 and followed by laddering to get a good tilth. Weeds and stubble were removed from the plot and finally obtained a desirable tilth of soil for transplanting the seedlings. The land operation was completed on 13 December 2020. The individual plots were made for transplanting the seedlings by raising soil (20 cm high) from the ground level.

3.8 Fertilizers and manure application

The N, P, K fertilizer were applied according to Krishi Projukti Hat Boi through urea, Triple super phosphate (TSP) and MoP respectively. Crowdung also used as source of organic manure. Urea was applied to fulfil nitrogen (N) requirement as per treatment. Nutrient doses used through fertilizers under the present study are presented as follows:

Manures and fertilizers	Doses ha^{-1}
Cowdung	15 ton
Urea	170 Kg
TSP	170 Kg
MoP	150 Kg

Full amount of TSP, MoP, and well rotten cowdung were applied at the time of final land preparation by following some research work on squash was done in abroad and BARI recommendation for *cucurbitaceous* crop. Urea was applied in two equal installments at 25 and 35 days after transplanting (DAT), respectively.

3.9 Preparation of spray

60 ppm and 90 ppm salicylic acid solution was prepared by mixing 60 mg of salicylic acid in 1 liter of water and 90 mg of salicylic acid in 1 liter of water. By this way, 25 ppm and 50 ppm of zinc sulphate solution was also prepared by mixing 25 mg and 50 mg of zinc sulphate in 1 liter of water separately.

3.10 Transplanting of seedlings

Healthy and uniform sized 16 days old seedlings were taken separately from the seedbed and were transplanted in the experimental field on 15 December, 2020. Plant spacing 40 cm × 40 cm was maintained for transplanting. The seedbed was watered properly before uprooting the seedlings so as to minimize the damage of the roots of young seedlings. This operation was carried out during late hours in the evening to minimize the shock of transplanting. The seedlings were watered after transplanting. Shading was provided by using a piece of banana leaf sheath for three days to protect the seedlings from the direct sun. A strip of seedling of same crop was established around the experimental field as border crop to do gap filling.

3.11 Intercultural operation

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

3.11.1 Gap filling and weeding

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

3.11.2 Irrigation

Light irrigation was given immediately after transplanting around each seedling by garden water spray bottle for their better establishment. Watering was done up to five days until they become capable of establishing on their own root system. Irrigation was given by observing the soil moisture condition.

3.11.3 Plant protection

The insects were controlled successfully by spraying Malathion 57 EC @ 2ml /L water and Emitap 20 SL @ 2mL/L. The insecticide was sprayed according to the direction from a week after transplanting to a week before first harvesting.

3.12 Harvesting and cleaning

Squash was harvested when the fruit size was 7–8-inch, tenderness of rind and internal tissue, overall firmness, a glossy light yellow skin color. Harvesting was started from 30 January 2021 and completed by 2 March 2021.

3.13 Data collection

The following parameters were recorded during the study:

1. Plant height (cm)

2. Number of leaves per plant

3. Leaf length (cm)

4. Leaf breadth (cm)

5. Stem base diameter (cm)

6. Days to 1st male flowering

7. Days to 1st female flowering

8. Number of male flowers

9. Number of female flowers

10. Number of fruits per plant

11. Fruit length (cm)

12. Fruit diameter (cm)

13. Dry matter (%) of fruit

14. Fruit yield per plant (gm)

15. Fruit yield per plot (Kg)

16. Fruit yield per ha (t)

17. SPAD value (%)

18. Beta carotene content

19. Economic analysis

3.14 Procedure for recording data

3.14.1 Plant height (cm)

The stem length was recorded in centimeter (cm) at different days after transplanting of crop duration by using a meter scale. Data were recorded from each plot. The length was measured from the ground level to o the tip of the longest leaf. Data was taken at 20, 40 and 60 days after transplanting (DAT).

3.14.2 Number of leaves per plant

Number of leaves per plant was counted at different days after sowing of total crop duration. Leaves number per plant was recorded from each plot and mean was calculated. Data was taken at 20, 40 and 60 days after transplanting (DAT).

3.14.3 Stem base diameter (cm)

The diameter of stem base in centimeter (cm) was measured from each plant of each plot at different days after transplanting at 20 DAT, 40 DAT and 60 DAT at the base portion of the plant with slide calipers. The average value is considered as stem diameter.

3.14.4 Leaf length (cm)

The length of leaf was measured by using a meter scale. The measurement was taken from base of the leaf to tip of the petiole. Average length of leaves was taken from four random selected leaves from each plant from each plot of the experiment. Data was recorded from 20, 40 and 60 days after transplanting (DAT). Mean was recorded in centimeter (cm).

3.14.5 Leaf breadth (cm)

The breadth of leaf was measured by using a meter scale. Average breadth of leaves was taken from four random selected leaves from each plant from each plot of experiment. Data was recorded from 20 to 60 DAT at 20 days interval. Thus mean was recorded and expressed in centimeter (cm).

3.14.6 Days to 1st male flowering

Number of days from transplanting to 1^{st} male flower was observed from every plant and the average value was calculated.

3.14.7 Days to 1st female flowering

Number of days from transplanting to 1^{st} female flower opening was observed from every plant and the average value was calculated.

3.14.8 Number of male flowers

Number of male flowers was counted from each plant of each plot and the mean was calculated to get the data about number of male flower. Male flower was selected based on the absence of initial oval shape fruit like structure at the base of flower which found in female flower.

3.14.9 Number of female flowers

Number of female flowers was recorded from each plant of each plot and the mean was calculated. Female flowers were selected on the basis of initial oval shape fruit like structure at the base of flower.

3.14.10 Number of fruits

Total number of fruits in every squash plant was recorded from and thus the total number of fruits per plot was counted and average number of fruit was also counted.

3.14.11 Fruit length (cm)

The length of the fruit was measured by using 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.

3.14.12 Fruit diameter (cm)

Breadth of the fruits was measured at the middle portion of fruits from each plot with the slide caliper and their average was taken as the breadth of the fruits.

3.14.13 Dry matter (%) of fruit

Fresh 100 g sample fruit from each plot were taken and cut into some small pieces. Then sample was dried under room temperature for one day after that those fruit sample was dried under direct sunshine for 2 days and then was dried in an oven maintained at 70^0 C for 72 hours. The sample which was then transferred into desiccators and allowed to cool down at room temperature. The dry matter (%) of fruit was calculated by the following formula:

$$\text{Dry matter (\%) of fruit} = \frac{\text{Dry weight of fruit}}{\text{Fresh weight of fruit}} \times 100$$

3.14.14 Fruit yield per plant (g)

Total weight of fruit was measured from each plant from 1st to last harvest and the average weight was calculated in Gram (g) as a fruit yield per plant.

3.14.15 Fruit yield per plot (kg)

Total fruit of squash was collected from 1st harvest to last harvest from each plot and weighted. The total weight of fruit was considered as fresh fruit yield per plot and which was expressed in kilogram (kg).

3.14.16 Fruit yield per hectare (t)

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

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

3.14.17 SPAD value (%)

SPAD reading Leaf for chlorophyll content was measured by using a hand-held chlorophyll content SPAD meter (CCM-200, Opti-Science, USA). For this reason, three leaves from different positions of per plant was selected, then their SPAD value was recorded. The average of the value from each plant was used for analysis.

3.14.18 Beta carotene content

Beta carotene was measured by High Performance Liquid Chromatography method. For measuring beta carotene, after grinding squash it was taken in a beaker, 240ml of ethanol and 100ml of water was added to make a solution. After that 10ml of squash extract and 10 ml petroleum ether was taken in a separating funnel and after mixing the properly there was two layers. Upper layer was taken in the cuvette and placed in the spectrophotometer. And finally, beta carotene was extracted.

3.15 Economic analysis

Economic analysis was done to find out the cost effectiveness of different treatments combinations.

3.15.1 Analysis of total cost of production

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production. The interest was calculated @ 15% for six months per year and miscellaneous cost as 5% of the total input cost and the price of one kg squash was considered to be Tk 25/-

3.15.2 Gross income

Gross income was calculated on the basis of sale of marketable fruit. The price of squash was assumed to be Tk. 30 /kg basis of current market value of Kawran Bazar, Dhaka at the time of harvesting.

3.15.3 Net return

Net return was calculated by deducting the total production cost from gross income for each treatment combination.

3.15.4 Benefit cost ratio (BCR)

The Benefit Cost Ratio (BCR) was calculated as follows:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

3.16 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using Statix-10 software. 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 LSD test at 5% probability.

CHAPTER IV

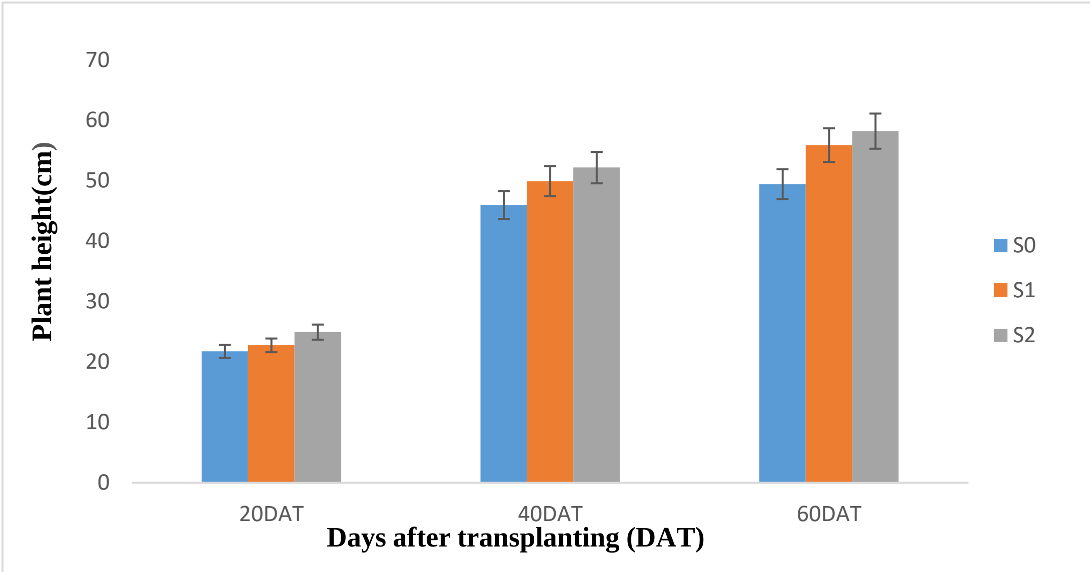
RESULTS AND DISCUSSION

The experiment was carried out to find out the influence of mulches and phosphorus on the growth and yield performance of squash (*Cucurbita pepo* L). The analysis of variance (ANOVA) of the data on different growth and yield parameter are presented in Appendix IV-VII. The results have been presented and discussed, and possible interpretations were given under the following headings:

4.1. Plant height

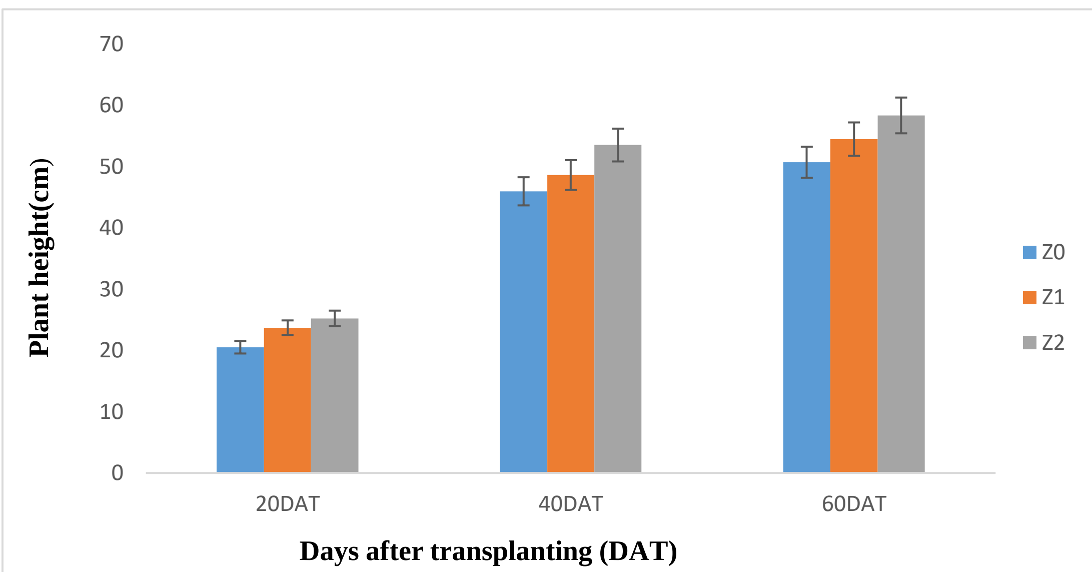
Plant height is an important growth characteristic of a plant, which may closely relate to proper growth and development. Plant height of squash was significantly varied due to the application of different concentrations of salicylic acid at 20, 40 and 60 DAT (Fig 2 and Appendix IV, VIII). At 60 DAT, the highest plant height (58.20 cm) was found from the treatment S_2 (90 ppm of salicylic acid) where the lowest plant height (49.43cm) was found from the control treatment S_0 (control). Hayat *et al*. (2005) concluded that salicylic acid application help to increase cell division and cell enlargement. Increased cell division and enlargement of cell ultimately help to increase plant height. (Dursun and Yildirim, 2009) also found the similar results which was conduct on cucumber.

Application of zinc sulphate also showed significantly positive influences on the plant height at 20, 40 and 60 days after transplanting (DAT) (Fig 3 and Appendix IV, VIII). At 60 DAT, the highest plant height (58.34 cm) was measured from Z_2 (50 ppm of zinc sulphate) treatment and the lowest plant height (50.69 cm) was recorded from Z_0 (control) treatment. Nariman *et al*. (2010) and Prasad and Yadav (2003) also showed in their study the same result that foliar application of zinc increase the plant height. The fact that, application of zinc sulphate helps to get higher vegetative growth in plant. The present finding from the study is agreed with the finding of Moghaddasi *et al*. (2017) and Kucukyumuk *et al*. (2014).



S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid

Fig.2. Effect of different levels of salicylic acid on plant height (cm) at different days after transplanting (DAT) of squash.



Here, Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate

Fig. 3. Effect of different levels of zinc sulphate on plant height (cm) at different days after transplanting (DAT) of squash.

Table 1. Combined effect of different levels of salicylic acid and zinc sulphate on plant height at different days after transplanting (DAT) of squash.

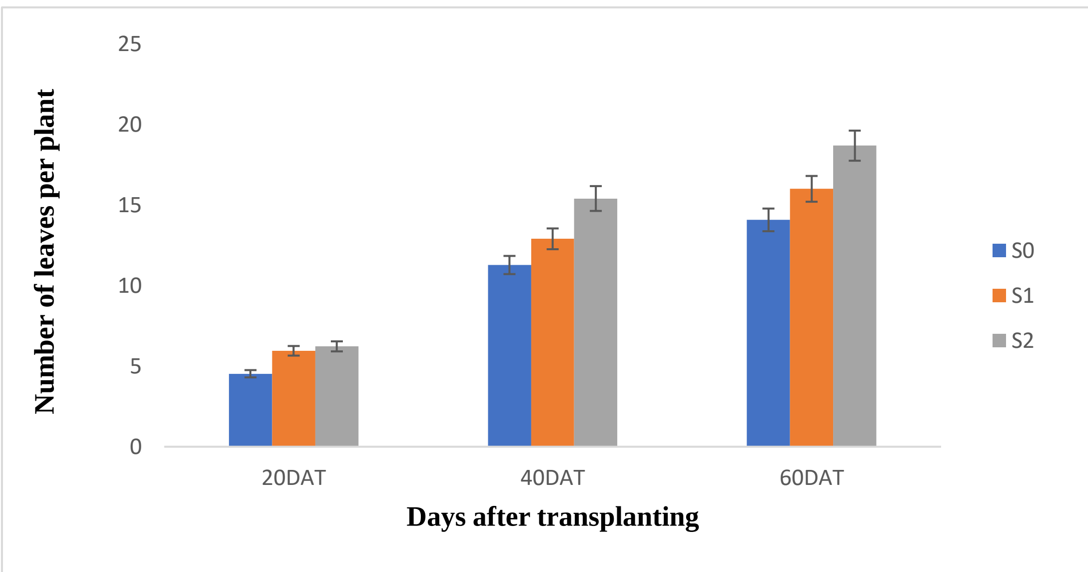
Treatment combinations	Plant height (cm)		
	20DAT	40DAT	60DAT
S_0Z_0	19.26 e	42.36 f	46.20 e
S_0Z_1	22.28 bcde	45.34 ef	50.38 de
S_0Z_2	23.74 abcd	50.26 bcd	51.71 cde
S_1Z_0	20.34 de	46.76 de	52.26 cd
S_1Z_1	23.08 bcd	49.23 cde	55.83 bcd
S_1Z_2	24.83 abc	53.81 ab	59.57 ab
S_2Z_0	21.95 cde	48.76 cde	53.63 cd
S_2Z_1	25.76 ab	51.28 bc	57.23 bc
S_2Z_2	27.12 a	56.46 a	63.75 a
CV%	9.18	5.12	5.96
$LSD_{(0.05)}$	2.67	2.06	1.61

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

Combined effects of salicylic acid and zinc sulphate has a significant influence on plant height at different days after transplanting (DAT) (Table 1 and Appendix IV). At 60 DAT, the tallest plant height (63.75 cm) was obtained from Z_2S_2 (90 ppm of salicylic acid and 50 ppm of zinc sulphate) treatment combination which was statistically similar to S_1Z_2 treatment combination and the shortest plant height (46.20 cm) was found from Z_0S_0 (control) treatment combination which was statistically similar to S_0Z_1 and S_0Z_2 treatment combination.

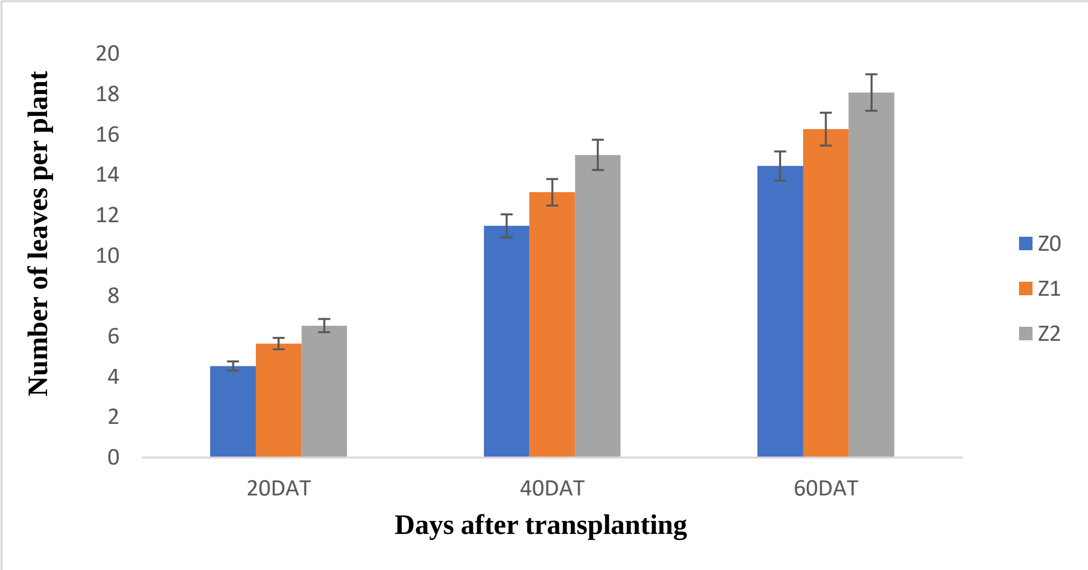
4.2 Number of leaves per plant

Number of leaves per plant is a vital part of crop plant because the primary function of a leaf is to keep the plant alive by producing food for plant through the photosynthesis process. These number of leaves per plant was significantly affected by different levels of salicylic acid treatment at 20 DAT to 60 DAT (Fig 4 and appendix V, IX). At 60 DAT, maximum number of leaves per plant (18.70) was obtained from S_2 (90ppm of salicylic acid) treatment and minimum of number of leaves per plant (11.63) from the S_0 (control) treatment. Similar result was obtained by Mady (2009) and Kazemi (2014) in their experiment. Which means that foliar application of salicylic acid increase the leaf number of plants.



Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic

Fig.4. Effect of salicylic acid on number of leaves at different days after transplanting (DAT) of squash



Here, Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate

Fig.5. Effect of zinc sulphate on number of leaves at different days after transplanting (DAT) of squash

Different levels of zinc sulphate treatments also significantly influence the number of leaves per plant at 20, 40 and 60 DAT in squash plant (Fig 5 and Appendix V, IX). At 60 DAT maximum number of leaves per plant (18.08) was recorded in treatment Z_2 (50 ppm of zinc sulphate) and minimum number of leaves per plant (14.47) was observed in Z_0 (control) treatment. Reddy *et al*. (2014) results also support the findings from this research outcomes. Dominy (2010) reported that zinc and manganese have long been considered as essential micronutrients to plant growth which have positive effect on plant leaves number.

The variation of number of leaves per plant was also observed at 20, 40 and 60 DAT due to the combined application of different level of salicylic acid and zinc sulphate on squash plant (Table 2 and Appendix V). At 60 DAT, maximum number of leaves (21.11) was observed in treatment combination Z_2S_2 (90 ppm of salicylic acid and 50 ppm of zinc sulphate) which was statistically similar with S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination and minimum in control (Z_0S_0) (3.47, 9.44 and 11.63) was found at 20, 40 and60 DAT.

Table 2. Combined effect of different levels of salicylic acid and zinc sulphate on number of leaves per plant at different days after transplanting (DAT) of squash.

Treatment combinations	Number of leaves per plant		
	20DAT	40DAT	60DAT
S_0Z_0	3.57 e	9.44 e	11.63 d
S_0Z_1	4.23 de	11.81cd	14.71 c
S_0Z_2	5.80 abcd	12.61 bcd	15.93 bc
S_1Z_0	4.94 cde	11.27 de	14.95 c
S_1Z_1	6.16 abc	12.81 bcd	15.88 bc
S_1Z_2	6.77 ab	14.66 b	17.22 bc
S_2Z_0	5.10 bcde	13.72 bc	16.76 bc
S_2Z_1	6.55 abc	14.81 b	18.23 ab
S_2Z_2	7.05 a	17.72 a	21.11 a
CV%	11.88	10.17	10.82
$LSD_{(0.05)}$	1.76	2.32	3.05

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

4.3 Stem diameter

Stem diameter of squash plant varied apparently due to the application of different levels of salicylic acid at 20, 40 and 60 DAT (Table 3). Result exhibited that foliar application of salicylic acid helps to increase the stem diameter of squash plant. At 60 DAT, the maximum stem diameter (2.56 cm) was found from the treatment S_2 (90 ppm of salicylic acid) and which is statistically similar to treatment S_1 (60 ppm of salicylic acid) while the minimum stem diameter (2.31 cm) was recorded in the treatment S_0 (control). Yildirim *et al*. (2007) and Kazemi (2014) reported that the application of salicylic acid help to increase the vegetative growth of the broccoli plant.

Table 3. Effect of salicylic acid and zinc sulphate on stem diameter at different days after transplanting (DAT) of squash.

Treatments	Stem diameter (cm)		
	20DAT	40DAT	60DAT
Effect of Salicylic acid			
S_0	1.11 b	2.10 b	2.31 b
S_1	1.4 a	2.24 ab	2.42 ab
S_2	1.5 a	2.35 a	2.56 a
LSD value (0.05)	0.17	0.19	0.15
Effect of Zinc sulphate			
Z_0	1.09 c	2.05 b	2.27 b
Z_1	1.36 b	2.22 b	2.38 b
Z_2	1.58 a	2.42 a	2.64 a
LSD value (0.05)	0.17	0.19	0.15

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid.
Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

In case of stem diameter, application of zinc sulphate also exhibited significant influences at 20 to 60 DAT. At 60 DAT, the maximum diameter of stem (2.64 cm) was obtained from the treatment Z_2 (50ppm). And the minimum (2.17cm) from the treatment Z_0 (control) which was identical to Z_1 treatment. Zhao Yong-hou (2006) reported that foliar application of zinc at different levels enhance the growth of broccoli stem.

Table 4. Combined effect of different levels of salicylic acid and zinc sulphate on Stem diameter at different days after transplanting (DAT) of squash

Treatment combinations	Stem diameter (cm)		
	20DAT	40DAT	60DAT
S_0Z_0	0.86 f	1.95 d	2.17 d
S_0Z_1	1.07 ef	2.07 cd	2.30 cd
S_0Z_2	1.39 bcd	2.29 abc	2.46 bc
S_1Z_0	1.13 def	2.09 cd	2.25 cd
S_1Z_1	1.48 abc	2.23 bcd	2.38 cd
S_1Z_2	1.61 ab	2.42 ab	2.65 ab
S_2Z_0	1.28 cde	2.12 bcd	2.39 bcd
S_2Z_1	1.54 abc	2.38 abc	2.47 bc
S_2Z_2	1.75 a	2.57 a	2.82 a
CV%	12.48	8.46	7.23
$LSD_{(0.05)}$	0.29	0.33	0.26

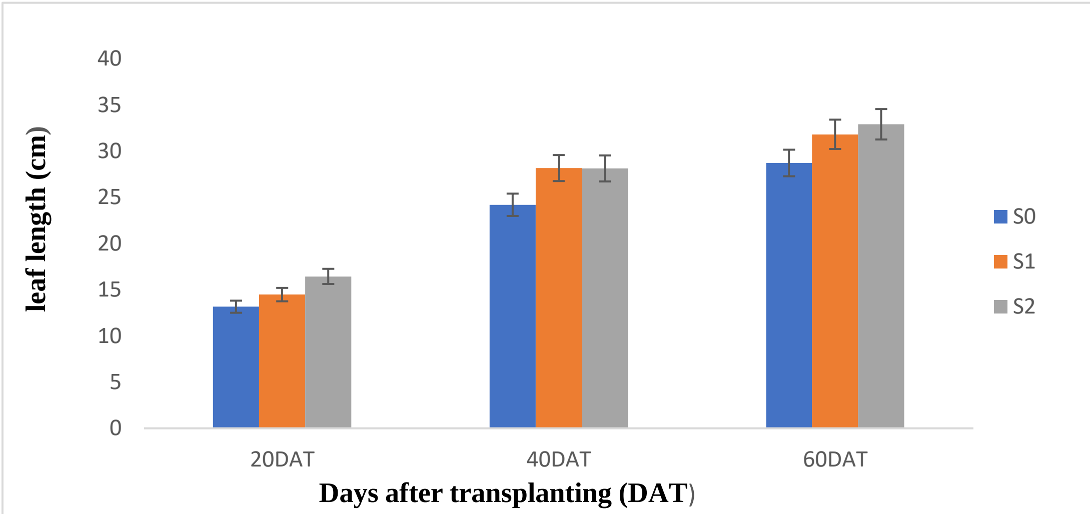
In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

Combined effect of different levels of salicylic acid and zinc sulphate revealed variation among the treatment combinations (table 4). At 60 DAT, the maximum stem diameter (2.82 cm) was found from the treatment combination of Z_2S_2 (90ppm of salicylic acid and 50 ppm of zinc sulphate) which is statistically similar with the treatment combination S_1Z_2. And minimum (2.17 cm) from the S_0Z_0 (control) treatment combination which was statistically similar to S_0Z_1, S_1Z_0, S_1Z_1 and S_2Z_0 treatment combination.

4.4 Leaf length

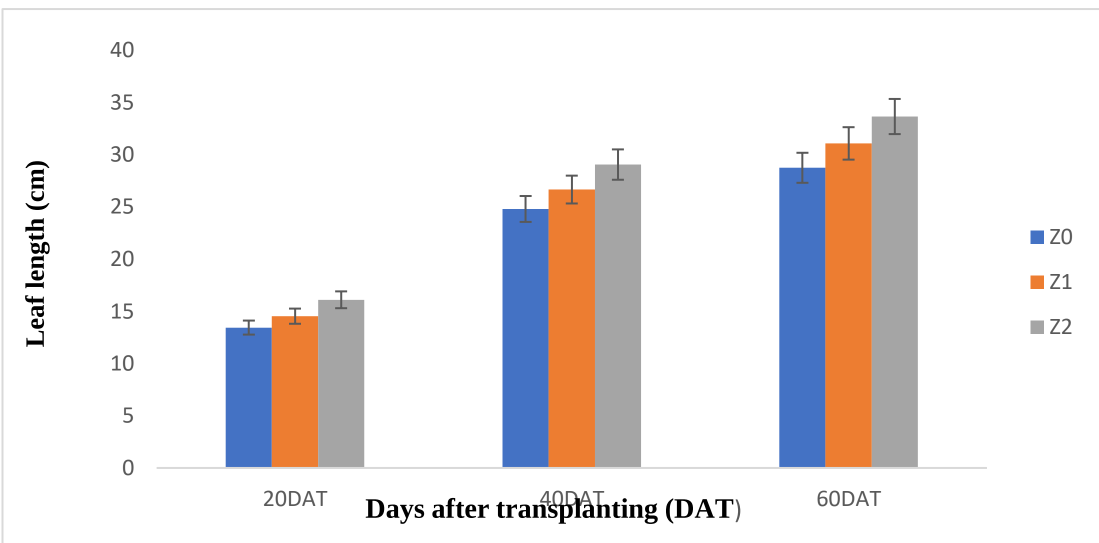
Salicylic acid had a significant influence on leaf length of squash at 20, 40 and 60 DAT (Fig 6 and Appendix X). At 60 DAT, the longest leaf (32.91 cm) was found from S_2 (90 ppm of salicylic acid) treatment and the lowest (28.73 cm) from the S_0 (control) treatment. Yildirim (2009) reported the same results in case of leaf length.

Leaf length is a key factor to influence the productivity of different filed crops, the photosynthesis system as well as on the length of time during, when it remains active.



S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid

Fig.6. Effect of salicylic acid on leaf length at different days after transplanting (DAT) of squash



Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate

Fig.7. Effect of zinc sulphate on leaf length at different days after transplanting (DAT) of squash

Leaf length of squash was significantly varied due to the zinc sulphate treatment at 20, 40 and 60 DAT (Fig 7 and Appendix X). At 60 DAT, the longest leaf length (33.64 cm) was recorded from the Z_2 (50 ppm of zinc sulphate) treatment and the shortest leaf length (28.73cm) was recorded from the Z_0 (control). Zinc is an important micronutrient which helps in the growth of plant leaves also. The result supports the findings of Lashkari *et al*. (2007).

Table 5. Combined effect of different levels of salicylic acid and zinc sulphate on leaf length at different days after transplanting (DAT) of squash

Treatment combinations	Leaf length (cm)		
	20DAT	40DAT	60DAT
S_0Z_0	12.11 e	22.98 f	26.36 e
S_0Z_1	12.95 de	24.02 ef	28.73 de
S_0Z_2	14.42 cd	25.58 de	31.08 bcd
S_1Z_0	13.43 de	26.18 cde	29.56 cde
S_1Z_1	14.09 cde	28.51 bc	31.82 bcd
S_1Z_2	15.90 bc	29.81 ab	34.08 ab
S_2Z_0	14.78 bcd	25.23 def	30.29 cd
S_2Z_1	16.55 ab	27.43 bcd	32.66 abc
S_2Z_2	17.98 a	31.74 a	35.78 a
CV%	7.91	5.34	5.97
$LSD_{(0.05)}$	2.01	2.48	2.12

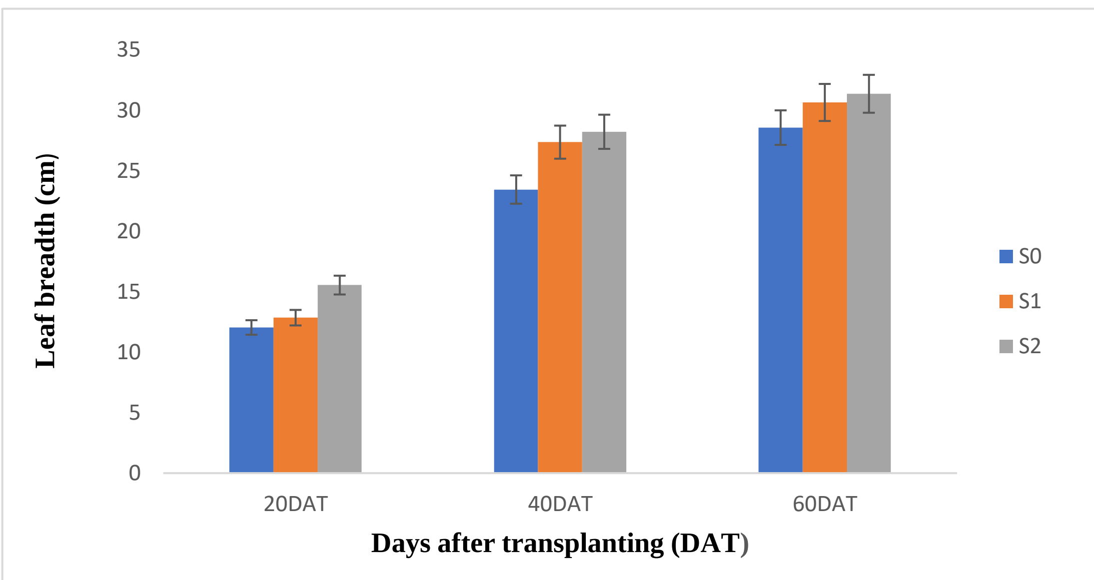
In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid.
Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

The combinations of salicylic acid and zinc sulphate of different levels of treatment also showed variation in case of leaf length at 20, 40, and 60 DAT (Table 5). At 60DAT, the largest leaf length (35.78 cm) was found from S_2Z_2 (90 ppm of salicylic acid and 50 ppm of zinc sulphate) treatment combination which is statistically similar to the treatment combination S_2Z_1 and S_1Z_2 and the smallest leaf length (26.36 cm) was obtained from the treatment combination S_0Z_0 (control) which was statistically similar to treatment combination S_0Z_1 and S_1Z_0.

4.5 Leaf breadth

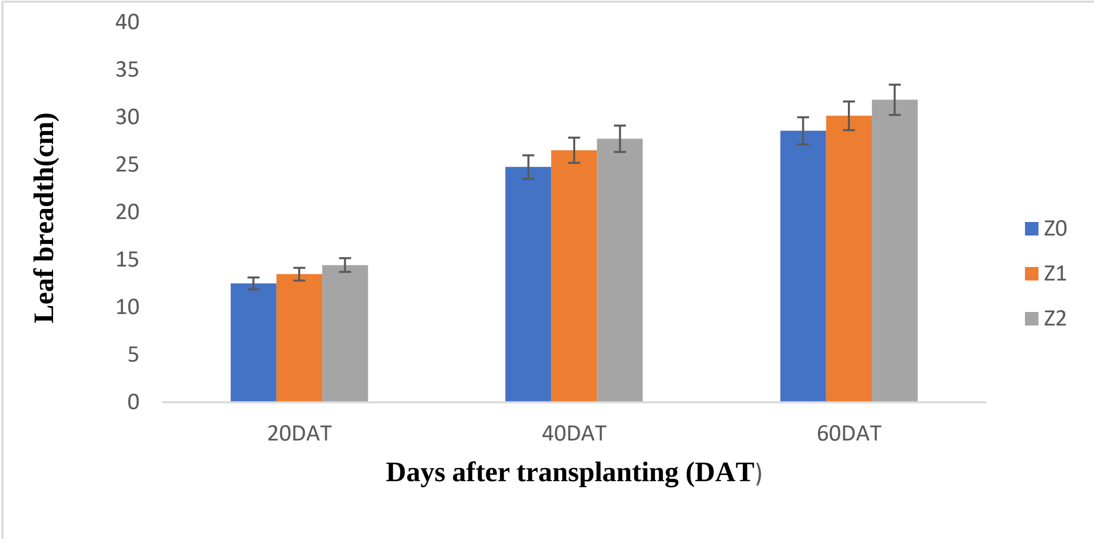
Leaf breadth of squash plant was also show variation by different levels of salicylic acid treatment at 20, 40 and 60 DAT. At 60 DAT (Fig 8 and Appendix XI). At 60DAT, the maximum leaf breadth (31.36 cm) was found from S_2 (90 ppm of salicylic acid) treatment which is statistically identical to S_1 treatment and lowest (28.56 cm) was found from the S_0 (control). Salicylic acid may cause the maximum of cell number and that's helps in enhanced leaf breadth stated by Kazemi (2013) and Khandaker *et al*. (2011).

Zinc sulphate had also a varied influence on leaf breadth of squash at 20, 40 and 60 DAT (Fig 9 and Appendix XI). At 60 DAT, the maximum leaf breadth (31.46 cm) was found from the Z_2 (50 ppm of zinc sulphate) which is statically similar with Z_1 treatment and the minimum leaf breadth (28.57cm) was recorded from the treatment Z_0 (control). Yadav *et al*. (2003) reported this kind of result also that micronutrients increase the leaf breadth.



Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid

Fig.8. Effect of salicylic acid on leaf breadth (cm) at different days after transplanting (DAT) of squash



Here, Z_0 = No zinc sulphate sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of

Fig.9. Effect of zinc sulphate on leaf breadth (cm) at different days after transplanting (DAT) of squash

Combined effect of different levels of salicylic acid and zinc sulphate showed variation on leaf breadth of squash at 20, 40 and 60 DAT (Table 6). At 60 DAT maximum leaf breadth (32.93cm) was observed in treatment combination Z_2S_2 (90 ppm of salicylic acid and 50 ppm of zinc sulphate) which was statistically similar with the treatment combinations S_2Z_1, S_2Z_0, S_1Z_2, S_1Z_1 and S_0Z_2 While the minimum leaf breadth (26.67cm) was found from the treatment combination Z_0S_0 (control) which was statistically similar with the treatment combination S_0Z_1.

Table 6. Combined effect of different levels of salicylic acid and zinc sulphate on leaf breadth (cm) at different days after transplanting (DAT) of squash

Treatment combinations	Leaf breadth (cm)		
	20DAT	40DAT	60DAT
S_0Z_0	11.44 d	21.97 e	26.67 d
S_0Z_1	11.96 cd	23.41 de	28.25 cd
S_0Z_2	12.73 bcd	24.96 cde	30.78 abc
S_1Z_0	11.55 cd	26.15 bcd	29.34 bcd
S_1Z_1	13.32 bcd	27.83 abc	30.78 abc
S_1Z_2	13.69 bcd	28.11 abc	31.82 ab
S_2Z_0	14.55 abc	26.17 bcd	29.72 abcd
S_2Z_1	15.16 ab	28.35 ab	31.44 abc
S_2Z_2	16.93 a	30.15 a	32.93 a
CV%	12.87	7.43	6.19
$LSD_{(0.05)}$	1.42	1.59	1.87

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

4.6 Days to 1st male flowering

Days to 1st male flowering of squash varied significantly in terms of different salicylic acid levels (Table 7). The lowest (11.22) days to 1st male flowering was found from S_2 (90 ppm of salicylic acid) treatment whereas the highest (12.91) days to 1st male flowering was recorded from S_0 (control) treatment.

Statistically significant variation was recorded in terms of days to 1st male flower initiation due to application of different levels Zinc sulphate (Table 7). The lowest (9.74) days to 1st male flowering was found from Z_1 (50ppm of zinc sulphate) treatment and highest (14.82) days to transplanting to 1st male flowering was found from Zo (control) treatment.

There had significant variation found among the treatment combination of different levels of salicylic acid and zinc sulphate in terms of days to 1st male flowering of squash (table 8 and Appendix). The highest (16.76) days to 1st male flowering was observed from S_0Z_0 (control) treatment combination which is statistically similar to S_1Z_0 treatment combination and the lowest (9.28) days to 1st male flowering was recorded from S_2Z_1 (90 ppm salicylic acid and 25 ppm zinc sulphate) treatment combination which is statistically similar to S_2Z_2, S_1Z_1 and S_0Z_1 treatment combinations.

Table 7. Effect of different levels of salicylic acid and zinc sulphate on days of 1st male and female flowering of squash.

Treatments	Days of 1st male flower	Days of 1st female flower
Effect of Salicylic acid		
S_0	13.91 a	16.97 a
S_1	12.26 b	15.02 b
S_2	11.22 c	14.23 c
LSD value (0.05)	0.58	1.26
Effect of Zinc sulphate		
Z_0	14.82 a	18.79 a
Z_1	9.74 c	11.81 c
Z_2	11.83 b	14.83 b
LSD value (0.05)	1.23	1.26

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

4.7 Days to 1st female flowering

Application of different levels of salicylic acid showed variation in days to 1st female flowering (Table 7). The highest days to 1st female flowering (16.17) was recorded from S_0 (control) treatment and the lowest days to 1st female flowering (14.22) was recorded from S_2 (90ppm salicylic acid) treatment. The result of the experiment was in coincided with the findings of Mahadeen (2014)

In terms of days to 1st female flowering in relation with different levels of zinc sulphate displayed a statistically significant difference under the present trial (table 7). The maximum Days to 1st female flowering (18.79) was recorded from Z_0 (control) treatment and the minimum days to 1^{st} female flowering (11.80) was recorded from Z_1 (25 ppm of zinc sulphate) treatment. The results indicated that minimum days were required for transplanting to 1st female flower by the Z_1 treatment among the different levels of zinc sulphate treatment. From the results it is evident that zinc sulphate had significant influence on the time to first female flower. Similar result was found in pointed gourd by Shakirova *et al*. (2016).

Table 8. Combined effect of different levels of salicylic acid and zinc sulphate on days of 1^{st} male and female flowering of squash.

Treatment combinations	Days of 1^{st} male flower	Days of 1^{st} female flower
S_0Z_0	16.76 a	20.13 a
S_0Z_1	10.06 de	12.18 fg
S_0Z_2	11.93 cd	16.20 cd
S_1Z_0	14.70 ab	18.59 ab
S_1Z_1	9.88 de	11.93 fg
S_1Z_2	12.21c	14.56 de
S_2Z_0	13.02 bc	17.65 bc
S_2Z_1	9.28 e	11.31 g
S_2Z_2	11.36 cde	13.72 ef
CV%	10.13	8.33
$LSD_{(0.05)}$	2.13	2.18

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

It was observed that the combined effect of different levels of salicylic acid and zinc sulphate on days to 1st female flowering was statistically significant (Table 8). The highest number of days to 1st female flowering (20.13) was recorded from the treatment combination S_0Z_0 (control) which was statistically similar to S_1Z_0 and the lowest days to 1st female flowering (11.31) was recorded from the treatment combination of S_2Z_1 (90 ppm salicylic acid and 25 ppm zinc) which was similar to S_1Z_1, S_1Z_1 treatment combination which is consider as control in this study.

4.8 Number of male flowers per plant

A significant difference was obtained on number of male flowers per plant due to the effect of salicylic acid (Table 9 and Appendix VI). The highest number of male flowers (9.22) per plant was recorded in S_2 (90 ppm of salicylic acid) treatment and the lowest number of male flowers (6.53) per plant was recorded from S_0 (control) treatment. The results indicated that maximum male flowers in number were produced by the application of 90 ppm salicylic acid compared with the control. (Mahadeen, 2014) also reported similar findings from his experiment in case of cucumber.

Application of zinc sulphate showed variation on number of male flowers per plant of squash at different days after transplanting (DAT) (Table 9 and Appendix VI). Number of male flowers per plant ranged from 6.22 to 9.86. The highest number of male flowers (9.86) per plant was recorded in Z_1 (25 ppm of zinc sulphate) and the lowest number of male flowers (6.22) per plant in Z_0 (control). The fact that, adequate supply of zinc sulphate helped to get reproduction and development of squash plant. The present finding is agreed with the finding of Zhao *et al*. (2013), Tzerakis *et al*. (2013), Kazemi (2013), and Aydin *et al*. (2012).

Positive variation was observed in number of male flowers per plant due to combine effect of different levels of salicylic acid and zinc sulphate (Table 10 and Appendix VI). The highest number of male flowers (11.51) per plant was found in S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination which was statistically similar to S_1Z_1 treatment combination. While the lowest number of male flowers (5.62) per plant was recorded in S_0Z_0 (control) treatment combination which was statistically similar to S_0Z_2, S_1Z_0 and S_2Z_0 treatment combinations.

4.9 Number of female flowers per plant

A significant variation was found due to the effect of salicylic acid on number of female flowers per plant (Table 9 and Appendix VI). The highest number of female flowers (13.36) per plant was recorded in S_2 (90ppm of salicylic acid) treatment and the lowest number of female flowers (9.23) per plant was recorded from S_0 (control) treatment. The results indicated that maximum female flowers in number were produced by the application of 90 ppm salicylic acid compared with the control.

Table 9. Effect of different levels of salicylic acid and zinc sulphate on number of male and female flowers and number of fruits per plant of squash.

Treatments	Number of male flowers per plant	Number of female flowers per plant	Number of fruits per plant
Effect of Salicylic acid			
S_0	6.53 c	9.23 c	6.78 c
S_1	8.30 b	11.86 b	10.31 b
S_2	9.22 a	13.36 a	11.94 a
LSD (0.05)	1.21	1.42	1.56
Effect of Zinc sulphate			
Z_0	6.22 c	9.18 c	8.14 b
Z_1	9.87 a	13.53 a	11.32 a
Z_2	7.97 b	11.74 b	9.56 b
LSD (0.05)	1.21	1.42	1.56
CV%	15.15	12.27	7.22

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.

Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

Number of female flowers per plant was significantly influenced by zinc sulphate application in squash plant (Table 9 and Appendix VI). The highest number of female flowers (13.53) was recorded in Z_1 (25 ppm of zinc sulphate) treatment. The lowest values in number of female flowers (9.18) per plant were found in Z_0 (control) treatment. The fact that, adequate supply of zinc sulphate helps to get reproductive development of squash plant. The present finding is agreed with the finding of Moghaddasi *et al*. (2017), Tzerakis *et al*. (2013), Aydin *et al*. (2012), Dominy (2010).

Positive variation in number of female flowers per plant was recorded due to combined effect of different levels of salicylic acid and zinc sulphate application (Table 10 and Appendix VI). The highest number of female flowers (15.29) per plant was found in S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination which was similar to S_2Z_2 and S_1Z_1 treatment combinations. The lowest number of female flowers (7.44) per plant was observed in S_0Z_0 (control) treatment combination which is similar to S_0Z_2 and S_1Z_0 treatment combinations.

4.10 Number of fruits per plant

Number of fruits per plant was showed statistically significant variation for the application of salicylic acid (Table 9 and Applendix VI). The highest number of fruits (11.93) per plant was observed in S_2 (90 ppm of salicylic acid) treatment and the lowest number of fruits (6.78) was recorded from S_0 (control).That means application of 90 ppm salicylic acid help to increase fruits number per plant.

Application of zinc sulphate showed positive influences on total number of fruits per plant of squash (Table 9 and Appendix VI). The total number of fruits per plant ranged from 8.14-11.31. The highest value of total number of fruits (11.31) per plant was recorded for Z_1 (25 ppm of zinc sulphate) treatment and lowest number of fruits (8.14) per plant for Z_0 (control). The fact that, adequate supply of zinc helped to get reproductive development of squash. The present finding is agreed with the finding of Zhao *et al*. (2013), Tzerakis *et al*. (2013), Kazemi (2013), they observed Zn has appositive effect on cucumber fruit production.

Statistically significant variation was observed due to interaction of salicylic acid and zinc sulphate on fruits per plant of squash at different concentrations (Table 10 and Appendix VI). The highest number of fruits (13.37) per plant was observed from S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination which was similar to S_2Z_2 and S_1Z_1 treatment combinations. While the lowest number of fruits (5.44) per plant was recorded in S_0Z_0 (control) treatment combination which was statistically similar to S_0Z_1 and S_0Z_2 treatment combinations.

Table 10. Combined effect of different levels of salicylic acid and zinc sulphate on number of male and female flowers and number of fruits per plant of squash.

Treatment combinations	Number of male flowers per plant	Number of female flowers per plant	Number of fruits per plant
S_0Z_0	5.62 f	7.44 f	5.44 g
S_0Z_1	7.97 cde	11.45 cd	7.86 efg
S_0Z_2	6.01 ef	8.82 ef	7.05 fg
S_1Z_0	6.27 ef	9.65 def	8.38 def
S_1Z_1	10.12 ab	13.86 abc	12.71 ab
S_1Z_2	8.52 bcd	12.07 bcd	9.83 cde
S_2Z_0	6.77 def	10.46 de	10.62 bcd
S_2Z_1	11.51 a	15.29 a	13.37 a
S_2Z_2	9.38 bc	14.34 ab	11.81 abc
CV%	15.15	12.27	16.17
$LSD_{(0.05)}$	2.10	2.45	2.71

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

4.11 Fruit length

Different level of salicylic acid had a significant effect on fruit length of squash (Table 11). The lowest fruit length (21.71cm) was found in S_0 (control) and with the application of salicylic acid, the highest length of fruit 27.84 cm was found by the application of S_2 (90 ppm salicylic acid) treatment which was statistically identical to S_1 treatment.

Individual fruit length was significantly influenced by zinc sulphate application in squash (Table 11). With the application of zinc sulphate, the highest fruit length (27.38 cm) was recorded in Z_1 (25 ppm of zinc sulphate) which was similar to Z_2 treatment. The lowest value of the individual fruit length (23.15 cm) was found in Z_0 (control). The fact that, adequate supply of Zn help to get reproductive development of squash plant Reddy (2014).

Combined effect of salicylic acid and zinc sulphate application of different levels have a wide range of variation in case of individual fruit length (Table 12). The highest Individual fruit length (30.05cm) was found in S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination which was similar to S_2Z_2 and S_1Z_1 treatment combinations. The lowest individual fruit length (19.31 cm) was recorded in S_0Z_0 (control) treatment combination which was similar to S_0Z_2 treatment combination.

4.12 Fruit diameter

Fruit diameter of squash significantly influenced due to the application of different doses of salicylic acid (Table 11). The highest diameter of fruit (5.70cm) was recorded from S_2 (90 ppm of salicylic acid) treatment which was statistically similar to S_1 treatment. The lowest diameter of fruit (4.36cm) was recorded from S_0 (control) which was also similar to S_1 treatment.

Zinc sulphate application in squash exhibit significant influence on fruit diameter (Table 11). The diameter of fruit ranged from 3.71 cm to 6.23 cm. The highest fruit diameter (6.23cm) was produced in Z_1 (25 ppm of zinc sulphate) treatment and lowest diameter of fruit (3.71 cm) was recorded for Z_0 (control) treatment. The fact that, adequate supply of zinc sulphate helps to get reproductive development of squash plant. The present finding is similar to the finding of cucumber plant which was observed by Moghaddasi *et al*. (2017), Kucukyumuk *et al*. (2014), Deshmukh, (2014).

It was observed that the combined effect of different levels of salicylic acid and zinc sulphate on diameter of fruit was statistically significant (Table 12). The highest diameter of fruit (7.08 cm) was recorded from the treatment combination S_2Z_1 (90ppm salicylic acid and 25 ppm zinc) which was statistically similar to S_1Z_1 S_1Z_2 and S_2Z_1 treatment combination and the lowest diameter of fruit (3.12 cm) was recorded from the treatment combination of S_0Z_0 (control) which was statistically similar to S_1Z_0 and S_2Z_0 treatment combinations.

Table 11. Effect of different levels of salicylic acid and zinc sulphate on fruit length, fruit diameter and fruit dry weight (%) of squash.

Treatments	Fruit length (cm)	Fruit Diameter (cm)	Dry matter (%) of fruit
Effect of Salicylic acid			
S_0	21.71 b	4.37 b	5.29 b
S_1	26.33 a	5.38 ab	6.62 a
S_2	27.85 a	5.71 a	6.75 a
LSD value (0.05)	1.824	1.04	1.20
Effect of Zinc sulphate			
Z_0	23.15 c	3.72 b	5.01 b
Z_1	27.38 a	6.23 a	6.53 a
Z_2	25.34 b	5.51 ab	7.12 ab
LSD $_{(0.05)}$	1.8241	1.0432	1.2014

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

.4.13 Dry matter (%) of fruit

Dry matter (%) of fruit was influenced due to the application of different doses of salicylic acid (Table11). The highest dry matter (%) of fruit (6.75) was recorded from S_2 (90 ppm of salicylic acid) treatment which was statistically identical to S_1 (6.62) treatment. The lowest dry matter (%) of fruit (5.29) was recorded from S_0 (control) treatment.

Application of zinc sulphate exhibited a significant influence on the dry matter (%) of fruits of squash (Table 11). The highest dry matter (%) of fruit (7.12) was obtained from the Z_2 (50 ppm of zinc sulphate) treatment followed by the treatment Z_1 (25ppm of zinc sulphate) and lowest dry matter (%) of fruit (5.00) was found from the Z_0 (control) treatment. By increasing micronutrients (Zn) concentration help to increase the dry weight of fruit. Zinc application significantly increased plant and fruit dry weight reported by Feng *et al*. (2005). Significant difference was found during the combined application of different levels of salicylic acid and zinc sulphate application on dry matter (%) of fruit of squash (Table 12). The highest dry matter (%) of fruit (7.52) was obtained from S_1Z_2 (60 ppm salicylic acid and 50 ppm zinc sulphate) treatment combination which was similar to S_2Z_2, S_2Z_1 and S_1Z_1 treatment combinations while the lowest dry matter (%) (4.27) of fruit was recorded from the S_0Z_0 (control) treatment combination which was similar to treatment combinations S_0Z_1, S_0Z_2, S_1Z_0 and S_2Z_0.

Table 12. Combined effect of different levels of salicylic acid and zinc sulphate on fruit length, fruit diameter and dry matter (%) of squash.

Treatment combinations	Fruit length (cm)	Fruit Diameter (cm)	Dry matter (%) of fruits
S_0Z_0	19.31 e	3.12 e	4.27 d
S_0Z_1	23.73 cd	5.05 bcd	6.11 bcd
S_0Z_2	22.10 de	4.94 bcd	5.50 bcd
S_1Z_0	23.71 cd	3.86 de	4.92 cd
S_1Z_1	28.38 ab	6.57 ab	6.58 abc
S_1Z_2	26.89 b	5.72 abc	8.35 a
S_2Z_0	26.44 bc	4.17 cde	5.83 bcd
S_2Z_1	30.05 a	7.08 a	6.90 abc
S_2Z_2	27.050 ab	5.8700 abc	7.5200 ab
CV%	7.22	20.25	19.32
$LSD_{(0.05)}$	3.16	1.81	2.08

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

4.14 Fruit yield per plant

Statistically significant variation was recorded in yield per plant of squash for the application of different levels of salicylic acid (Table 13 and Appendix VII). The maximum fruit yield per plant (2.42 Kg) was found in S_2 (90ppm of salicylic acid) treatment and the minimum fruit yield per plant (1.50 Kg) was obtained from S_0 (control) treatment. At 90 ppm concentration salicylic acid helps to increase the yield of squash plant by mitigating different stress.

Significant influence was found due to application of zinc sulphate on fruit yield per plant (Table 13 and Appendix VII). The fruit yield per plant widely ranged from1.46 to 2.59 Kg. The highest fruit yield per plant (2.59 Kg) was recorded in Z_1 (25 ppm of zinc sulphate) treatment and the lowest fruit yield per plant (1.46 Kg) was found in Z_0 (control). The fact that, adequate supply of zinc sulphate helped to get reproductive development of squash.

Combined effect of salicylic acid and zinc sulphate showed significant differences on fruit yield per plant of squash (Table 13 and Appendix VII). The treatment combination S_2Z_1 (90 ppm of salicylic acid and 25 ppm zinc sulphate) gave the maximum fruit yield per plant (3.04 Kg) which was similar to S_1Z_1 (60 ppm of salicylic acid and 25 ppm zinc sulphate) treatment combination whereas the minimum fruit yield per plant (1.15 Kg) was observed in S_0Z_0 (control) treatment combination which was statistically similar to S_0Z_2 treatment combination.

4.15 Fruit yield per plot

Application of salicylic acid exhibited a significant influence on the fruit yield per plot of squash plant (Table 13 and Appendix VII). The highest fruit yield per plot (9.68 kg) was found from the S_2 (90ppm of salicylic acid) treatment and the lowest fruit yield per plot (6.02 kg) from the S_0 (control) treatment. Parvin and Haque (2017), Kareem *et al*. (2017) and Yildirim *et al*. (2007) reported that increasing all the vegetative characteristics salicylic acid increase the yield of the plant.

Significant variation was found among the fruit yield per plot of squash due to the application of different levels of zinc sulphate treatment in squash plant (Table 13 and Appendix VII). The highest fruit yield per plot (10.38 kg) was obtained from the Z_2 (25ppm of zinc sulphate) treatment and the lowest fruit yield per plot (5.86 kg) from the Z_0 (control) treatment. Quratul *et al*. (2016) and Yadav *et al*. (2015) reported that as zinc helps in the vegetative growth which causes highest yield of the crop.

Combined application of different levels of salicylic acid and zinc sulphate significantly increased the fruit yield of squash in per plot (Table 14 and Appendix VII). The highest fruit yield per plant (12.18 kg) was obtained from the S_1Z_2 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination which is statistically similar to S_1Z_1 (60ppm salicylic acid and 25 ppm of zinc sulphate treatment combination and the lowest fruit yield per plot (4.63 kg) was obtained from the Z_0S_0 (control) treatment combination which was statistically similar to S_0Z_2 treatment combination.

Table: 13. Effect of different levels of salicylic acid and zinc sulphate on fruit yield per plant (g), fruit yield per plot (kg) and fruit yield ha (t) of squash

Treatments	Fruit yield per plant (Kg)	Fruit yield per plot (Kg)	Fruit yield per ha (t)
Effect of Salicylic acid			
S_0	1.50 c	6.02 c	23.51 c
S_1	2.16 b	8.67 b	33.88 b
S_2	2.42 a	9.68 a	37.83 a
LSD value (0.05)	0.16	0.79	3.120
Effect of Zinc sulphate			
Z_0	1.46 c	5.86 c	22.91 c
Z_1	2.59 a	10.38 a	40.57 a
Z_2	2.03 b	8.13 b	31.74 b
LSD value (0.05)	0.16	0.79	3.12

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.

Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

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Table 14. Combined effect of different levels of salicylic acid and zinc sulphate sulphate on fruit yield per plant, fruit yield per plot and fruit yield ha of squash

Treatment combinations	Fruit yield per plant (Kg)	Fruit yield per plot (Kg)	Fruit yield per ha (t)
S_0Z_0	1.15 g	4.63 g	18.09 g
S_0Z_1	1.96 de	7.85 de	30.66 de
S_0Z_2	1.39 fg	5.57 fg	21.78 fg
S_1Z_0	1.51 f	6.04 f	23.60 f
S_1Z_1	2.78 ab	11.13 ab	43.47 ab
S_1Z_2	2.21 cd	8.85 cd	34.56 cd
S_2Z_0	1.73 ef	6.92 ef	27.03 ef
S_2Z_1	3.04 a	12.18 a	47.57 a
S_2Z_2	2.49 bc	9.96 bc	38.90 bc
CV%	9.86	9.84	9.84
LSD $_{(0.05)}$	0.68	1.38	1.47

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid.
Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

4.16 Fruit yield per ha

Application of salicylic acid also exhibited a significant influence on the fruit yield per hectare (Figure 13 and (Table 13 and Appendix VII). The highest fruit yield per hectare (37.83 t) was found from the treatment S_2 (90ppm of salicylic acid) and the lowest fruit yield per hectare (23.5 t) from the S_0 (control) treatment. These results are in agreement with that obtained by Parvin and Haque (2017), Kareem *et al*. (2017), Yildirim *et al*. (2007) and Kazemi (2013).

The fruit yield per hectare was significantly influenced by application of zinc sulphate in squash (Table 13 and Appendix VII). The highest fruit yield per hectare (31.74t) was recorded in Z_1 (25 ppm of zinc sulphate) treatment. The lowest value of fruit yield per hector (22.91 t) was found in Z_0 (control).

Combined application of salicylic acid and zinc sulphate significantly influenced on the fruit yield per hectare of squash production (Table 14 and Appendix VII). The highest fruit yield per hectare (47.57 t) was obtained from the S_2Z_1 (90ppm salicylic acid and 25 ppm of zinc sulphate) treatment combinations which was statistically similar to S_1Z_1 (60ppm salicylic acid and 25 ppm of zinc sulphate) treatment combination and the lowest fruit yield per hectare (18.09 t) was observed from the Z_0S_0 (control) treatment combination which was statistically similar to S_0Z_2 treatment combination.

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4.17 SPAD value (%)

Salicylic acid has a positive influence on SPAD value (%) of squash plant at different concentrations of vegetative and reproductive stages (table 15). The highest SPAD value (%) (41.01) was found from S_1 (60 ppm of salicylic acid) treatment and lowest SPAD value (%) (34.60) was recorded from S_0 (control) treatment.

The effect of zinc sulphate on SPAD value (%) of squash plant was significantly varied (Table 15). The highest SPAD value (%) of squash (43.378) was recorded from Z_2 (50ppm of zinc sulphate) treatment, the minimum SPAD value (%) (34.40) was recorded from Z_0 (control) treatment.

Statistically significant effect of different levels of salicylic acid and zinc sulphate on SPAD value (%) of squash plant at different concentrations (Table 16). The highest leaf SPAD value (%) (46.93) was found from S_1Z_2 (60 ppm of salicylic acid and 50ppm of zinc sulphate) treatment combination which was similar to S_2Z_2 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination. The lowest SPAD value (%) (31.50) was found from S_0Z_0 (control) which was statistically similar to S_0Z_1 and S_1Z_0 treatment combinations.

4.18 Beta carotene content

Different levels of salicylic acid influenced significantly on beta carotene content of squash (Table 15). The highest value of beta carotene content (135.74g) was found from S_2 (90 ppm of salicylic acid) which was identical to S_1 and lowest value of beta carotene content (132.13) was recorded from S_0 (control) treatment. IT means that salicylic acid has effect on beta carotene content of squash.

The effect of zinc sulphate on beta carotene content of squash plant was significantly varied (Table 15). The highest beta carotene content of squash (136.72g) was recorded from Z_1 (25ppm of zinc sulphate) treatment, the minimum value (132.24g) was recorded from Z_0 (control) treatment.

Combined effect of different levels of salicylic acid and zinc sulphate showed significant variation on beta carotene content of squash (Table 16). The highest beta carotene content (138.47 g) was found from S_1Z_1 (60 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination which was statistically similar to S_2Z_2 and S_2Z_1 treatment combinations. The lowest value (130.43) was found from S_0Z_0 (control) treatment combination which was similar to S_0Z_2 and S_1Z_0 treatment combinations.

Table 15. Effect of different levels of salicylic acid and zinc sulphate SPAD value (%) and beta carotene content of squash

Treatments	SPAD value (%)	Beta carotene content (mg/100 g)
Effect of Salicylic acid		
S_0	34.60 b	132.13 b
S_1	41.01a	135.46 a
S_2	40.96 a	135.74 a
LSD value (0.05)	2.25	1.74
Effect of Zinc sulphate		
Z_0	34.40 c	132.24 c
Z_1	38.78 b	136.72 a
Z_2	43.37 a	134.37 b
LSD value (0.05)	2.25	1.74

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.

Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid. Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

Table 16. Combined effect of different levels of salicylic acid and zinc sulphate SPAD value (%) and beta carotene content (mg/100g) of squash

Treatment combinations	SPAD value (%)	Beta carotene content (mg/100 g)
S_0Z_0	31.50 f	130.43 f
S_0Z_1	33.70 ef	134.50 bcd
S_0Z_2	38.60 cd	131.47 ef
S_1Z_0	35.13 def	132.70 def
S_1Z_1	40.83 bc	138.47 a
S_1Z_2	46.93 a	135.20 bcd
S_2Z_0	36.56 de	133.60 cde
S_2Z_1	41.83 bc	137.20 ab
S_2Z_2	44.60 ab	136.43 abc
CV%	5.81	1.30
$LSD_{(0.05)}$	3.90	3.04

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid.
Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate.

4.19 Economic analysis

All the material and non-material input cost like land preparation, squash seed cost, manure and fertilizer cost, irrigation and manpower required for all the operation, interest on fixed capital of land (Leased land by bank loan basis) and miscellaneous cost were considered for calculating the total cost of production from planting seed to harvesting of squash were recorded for unit plot and converted into cost per hectare. Price of squash was considered at market rate @ Tk. 25.

4.19.1 Gross return

The combination of salicylic acid and zinc sulphate fertilizer showed different gross return. Gross income was calculated on the basis of sale of fruit. The highest gross return

(1189425Tk) obtained from S_2Z_1 (90ppm of salicylic acid and 25ppm of zinc sulphate) treatment combination and lowest gross return (452325Tk) obtained from S_0Z_0 (control) treatment combination. All data are presented in (Table 17).

4.19.2 Net return

The combination of different levels of salicylic and zinc sulphate exhibited different net return. The highest net return obtained (881669 Tk) from S_2Z_1 (90ppm of salicylic acid and 25ppm of zinc sulphate) treatment combination treatment combination and second highest net return obtained S_1Z_1 treatment combination from and lowest net return 145649 Tk obtained from S_0Z_0 (control) treatment combination was showed in (Table 17).

4.19.3 Benefit Cost Ratio (BCR)

In the combination of different levels of salicylic acid and zinc sulphate highest benefit cost ratio (3.86) was noted from S_2Z_1 (90ppm of salicylic acid and 25ppm of zinc sulphate) treatment combination and the second highest benefit cost ratio (3.53) was estimated from S_1Z_1 treatment combination. The lowest benefit cost ratio (1.47) was obtained from S_0Z_0 (control) treatment combination. From economic point of view, it was apparent from the above results that the combination of S_2Z_1 treatment combination was more profitable than rest of the combination (Table 17).

Table 17. Cost and return analysis considering different levels of salicylic acid and zinc sulphate of squash.

Treatment combinations	Yield (t/ha)	Gross return (Tk/ha)	Total cost of production (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio (BCR)
S_0Z_0	18.09	452325	306676	145649	1.47
S_0Z_1	30.66	766500	306796	459704	2.50
S_0Z_2	21.78	544500	306916	237584	1.77
S_1Z_0	23.60	590075	307336	282739	1.92
S_1Z_1	43.47	1086825	307456	779369	3.53
S_1Z_2	34.56	864175	307576	556599	2.81
S_2Z_0	27.03	675925	307636	368289	2.20
S_2Z_1	47.57	1189425	307756	881669	3.86
S_2Z_2	38.90	972500	307876	664624	3.16

Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid, And Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University Dhaka 1207, November 2020 to February 2021, to foliar application of salicylic acid and zinc sulphate levels on the growth and yield of squash under net house condition. Three levels of Salicylic acid viz. S_1= no salicylic acid (control), S_2 = 60 ppm of salicylic acid, S_2= 90 ppm of salicylic acid. Three concentrations of zinc sulphate viz. Z_0 = no zinc sulphate (control), Z_1 = 25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate. The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. The crop was harvested from 30 January 2021 to 2 March 2021. Data on growth and yield contributing parameters were recorded for each treatment combination and replication and the collected data were statistically analyzed to evaluate the treatment effects on squash plant. The summary of the results has been presented in this chapter.

Squash plant expresses variation at different level of salicylic acid in case of almost all the parameters. At 60 DAT, the highest plant height was (58.20 cm) and the maximum (18.7) number of leaves per were found in S_2 (90 ppm of salicylic acid) treatment. Whereas the shortest plant height (49.43 cm) and minimum number of leaves per plant (14.09) were recorded from S_0 (control). At 60 DAT, the highest leaf length was (32.91cm) and the highest leaf breadth (31.36cm) were found in S_2 (90 ppm of salicylic acid) treatment. Whereas the lowest leaf length (28.73 cm) and lowest leaf breadth per plant (28.56 cm) were recorded from S_0 (control). At 60 DAT highest stem diameter (2.56 cm) was observed in S_2 (90 ppm of salicylic acid) treatment and the lowest stem diameter (2.31cm) was recorded in S_0 (control) treatment. It was revealed that maximum days to first male (12.91) and female (16.17) flowering were recorded in S_0 (control). While minimum days first male (11.22) and female (14.22) flower opening were found in S_2 (90 ppm of salicylic acid). Highest number of female and male flowers (13.36) and (9.22) and maximum number fruit per plant (11.93) were found in S_2 (90 ppm of salicylic acid) treated plants and the lowest number of male (6.53) and female (9.23) flowers and minimum number of fruits (6.78) per plant was found in S_0 (control) treatment. Results revealed that the highest value of fruit length, fruit diameter, dry matter (%) of fruits, beta carotene content and SPAD value

(%) was found in S_2 (90 ppm of salicylic acid) and the lowest value was found in S_0 (control). The highest yield per plant (2.42 Kg), highest yield per plot (9.68 kg) and height yield per ha (37.83 t) was observed in S_2 (90 ppm of salicylic acid) and the lowest yield per plant (1.50 Kg), lowest yield per plot (6.02 kg) and lowest yield per ha (23.5t) were achieved in S_0 (control) treatment.

At 60 DAT, the highest plant height (58.34 cm) and the maximum number of leaves (18.08) per plant were found in Z_2 (50 ppm of zinc sulphate) treatment. Whereas the shortest plant height (50.69 cm) and minimum number of leaves per plant (14.47) were recorded from Z_0 (control) treatment. At 60 DAT, the highest leaf length (33.64 cm) and the highest leaf breadth (31.46 cm) was found in Z_2 (50 ppm of zinc sulphate) treatment. Whereas the lowest leaf length (28.73 cm) and lowest leaf breadth (28.57 cm) per plant were recorded from Z_0 (control). At 60 DAT highest stem diameter (2.64 cm) was observed in Z_2 (50 ppm of zinc sulphate) treatment and the lowest stem diameter (2.27 cm) was recorded in Z_0 (control) treatment. It was revealed that maximum days to 1st male (14.82) and female (18.79) flowering were recorded in Z_0 (control). While minimum days to 1st male (9.74) and female (11.80) flower opening were found in Z_1 (25 ppm of zinc sulphate). Highest number of female (13.53) and male (9.86) flowers and maximum number fruits per plant (11.31) were found in Z_1 (25 ppm of zinc sulphate) treated plants and the lowest number of male (6.22) and female flower (9.18) and minimum number of fruit (8.14) per plant was found in Z_0 (control) treatment. Results revealed that the highest value of fruit length (27.38 cm), fruit diameter (6.23 cm) was found in Z_1 (25 ppm of zinc sulphate) and the lowest value was found in Z_0 (control). In case of fruit dry weight percentage application of zinc sulphate also showed significant variance. Results revealed that SPAD value (%) and beta carotene content was maximum at Z_1 (25 ppm zinc sulphate) and Z_2 (50 ppm zinc sulphate) respectively. The highest yield per plant (2.59 Kg), highest yield per plot (10.38 kg) and height yield per ha (31.74 t) was observed in Z_1 (25 ppm of zinc sulphate) treatment and the lowest yield per plant (1.46 Kg), lowest yield per plot (5.86 kg) and lowest yield per ha (22.91 t) were achieved in Z_0 (control) treatment.

At 60 DAT, the longest plant height (63.75 cm) and the maximum number of leaves (21.11) per plant were found from the S_2Z_2 (90 ppm of salicylic acid and 50 ppm of zinc sulphate) treatment combination while the shortest plant height (46.20 cm) and minimum number of leaves (11.63) were recorded in S_0Z_0 (control) treatment combination. At 60 DAT, highest leaf length (35.78 cm) and highest leaf breadth (32.93 cm) were observed in the S_2Z_2 (90 ppm of salicylic acid and 50 ppm of zinc sulphate) treatment combination while the lowest leaf length (26.36 cm) and lowest leaf breadth (26.67 cm) were recorded in S_0Z_0 (control) treatment combination. Highest stem diameter (2.82 cm) was recorded in S_2Z_2 (90 ppm of salicylic acid and 50 ppm of zinc sulphate) treatment combination while the lowest stem diameter (2.17 cm) was recorded in S_0Z_0 (control) treatment combination. Maximum days to 1st male (16.76) and female (20.13) flower opening was observed in observed in S_0Z_0 (control) treatment combination while minimum days to 1st male (9.28) and female (11.31) flower opening were obtained in S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination. Results also expressed that, highest number of male (11.51) and female (15.29) flowers and highest number of fruits (13.37) were found in S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination and lowest number of male (5.62) and female (7.44) flowers and lowest number of fruits (5.44) per plant were found in S_0Z_0 (control) treatment combination. It was also observed in this study that height fruit length (30.05 cm) and highest fruit diameter (7.08 cm) were found in S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) whereas, lowest fruit length (19.31 cm) and lowest fruit diameter (3.12 cm) was exhibited in S_0Z_0 (control) treatment combination. Highest dry matter (%) of fruit (8.35) was found in S_1Z_2 (60 ppm of salicylic acid and 50 ppm of zinc sulphate) while lowest dry matter (%) of fruit (4.27) was found in S_0Z_0 (control) treatment combination. The maximum yield per plant (3.04 Kg), highest yield per plot (12.18 kg) and highest yield per ha (47.58 t) was observed in S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) and the minimum yield per plant (1.15 Kg), lowest yield per plot (4.63 kg) and lowest yield per ha (18.09 t) was observed in S_0Z_0 (control) treatment combination. High beta carotene content (138.47 mg) and high SPAD value (46.93%) was observed in S_1Z_1 and S_1Z_2 respectively. And the lowest value of beta carotene (130.43 mg) and SPAD (31.50%) was recorded in S_0Z_0 (control) treatment combination. The highest gross return (1189425 tk) was obtained from S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) while the lowest gross return (452325 tk) was obtained from S_0Z_0 (control) treatment combination. The highest net return (881669 tk) was obtained from S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) while the lowest net return (145649 tk) was obtained from S_0Z_0 (control) treatment combination. The highest benefit cost ratio (3.86) was obtained from S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) while the lowest benefit cost ratio (1.47) was obtained from S_0Z_0 (control) treatment combination.

Conclusion

The overall results obtained from this study facilitated to draw the following conclusions:

- This experiment indicated that foliar application of different levels of salicylic acid and zinc sulphate have a positive influence on growth and yield of squash.
- In case of yield of squash, the combination of S_2 (90 ppm of salicylic acid) along with Z_1 (25 ppm of zinc sulphate) were provided the better performance of all yield contributing parameters than the other treatment combinations.
- In the consideration value for money concept, S_2Z_1 (90 ppm of salicylic acid and 25 ppm of zinc sulphate) treatment combination was more suitable as the highest benefit cost ratio (3.86) than the other treatment combinations. So, it can be repeated in different agro ecological zones of Bangladesh for better yield and consideration value for money concept. It is obligatory that similar experiment should be carried out with more variables to reconfirm the recommendation

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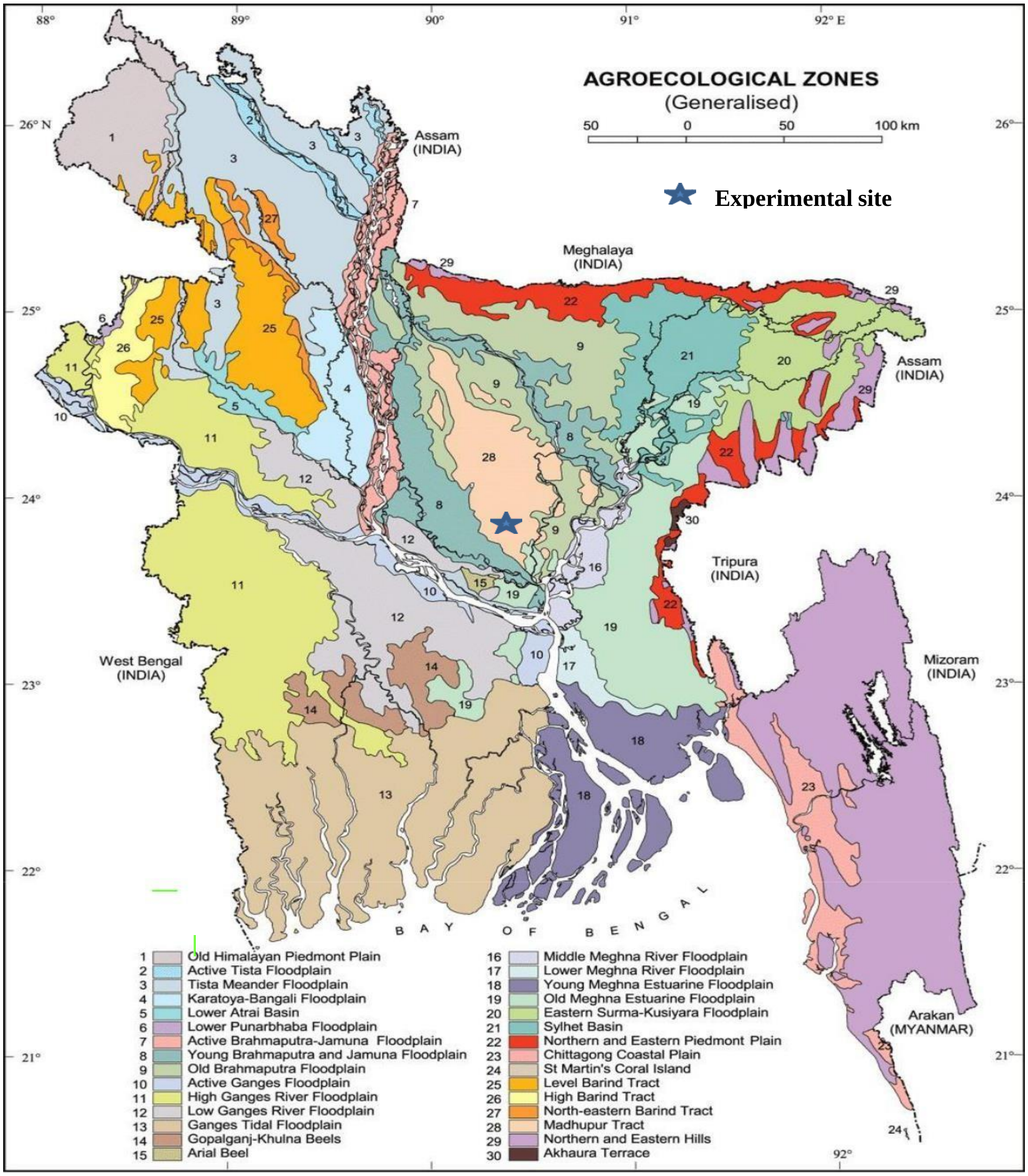
APPENDICES

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



Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2020 to March 2021

Month and year	RH (%)	Air temperature (°C)			Rain fall (mm)
		Max.	*Min.*	*Mean*	
November, 2020	56.25	28.70	8.62	18.66	14.5
December, 2020	51.75	26.50	9.25	17.87	12.0
January, 2021	46.20	23.70	11.55	17.62	0.0
February, 2021	37.95	22.85	14.15	18.50	0.0
March, 2021	35.75	21.55	15.25	18.40	0.0

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	Sher-e-Bangla Agricultural University, 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
pH	6.2
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: Analysis of variance of data on plant height at different days after transplanting (DAT) as influenced by different level of salicylic acid and zinc sulphate of squash

Source of variation	Degree of freedom (df)	Mean square of plant height (cm) at different days after transplanting		
		20 DAT	40 DAT	60 DAT
Replication	2	5.1339	2.306	11.368
Factor A (Salicylic acid)	2	23.8767**	88.129	186.114*
Factor B (Zinc sulphate)	2	52.0530*	131.966*	131.566*
A×B	4	0.2545	0.182*	6.136*

*Significant at 0.05 level of probability **significant at 0.01 level of probability and ^{ns} non-significant

Appendix V: Analysis of variance of data on number of leaves at different days after transplanting (DAT) as influenced by different level of salicylic acid and zinc sulphate of squash

Source of variation	Degree of freedom (df)	Mean square of number of leaves at different days after transplanting		
		20 DAT	40 DAT	60 DAT
Replication	2	0.22114	0.1959	0.4371
Factor A (Salicylic acid)	2	4.81463**	38.9544**	48.2466*
Factor B (Zinc sulphate)	2	5.16563*	27.9045*	29.8117*
A×B	4	0.07258^{ns}	0.8598*	1.7581*

*Significant at 0.05 level of probability; **significant at 0.01 level of probability and ^{ns} non- significant

Appendix VI: Analysis of variance of data on number of male flowers per plant, number of female flower per plant, number of fruits per plant as influenced by different level of salicylic acid and zinc sulphate of squash

Source of variation	Degree of freedom (df)	Mean square		
		Number of male flowers per plant	Number of female flowers per plant	Number of fruits per plant
Replication	2	2.7205	0.4823	2.2968
Factor A (Salicylic acid)	2	16.7870**	36.6443*	62.4188*
Factor B (Zinc sulphate)	2	29.9370*	42.9696**	22.6786*
A×B	4	1.4759*	1.0561*	1.0907*

*Significant at 0.05 level of probability **significant at 0.01 level of probability and ^{ns} non- significant

Appendix VII: Analysis of variance of data on fruit yield per plant, fruit yield per plot, fruit yield per ha as influenced by different level of salicylic acid and zinc sulphate of squash

Source of variation	Degree of freedom (df)	Mean square		
		Fruit yield per plant (gm)	Fruit yield per plot (kg)	Fruit yield per ha (t)
Replication	2	2.9269	0.4573	6.973
Factor A (Salicylic acid)	2	2.019879*	32.2883*	492.668*
Factor B (Zinc sulphate)	2	2.876193*	45.9684*	701.632*
A×B	4	8.1003*	1.3001*	19.840*

*Significant at 0.05 level of probability **significant at 0.01 level of probability and ^{ns} non- significant

Appendix VIII: Effect of different levels of salicylic acid and zinc sulphate plant height at different days after transplanting (DAT) of squash

Treatments	Plant height(cm)		
	20DAT	**40DAT**	**60DAT**
Effect of Salicylic acid			
S_0	20.625 c	45.988 c	49.430 c
S_1	22.750 b	49.933 b	53.887 b
S_2	24.944 a	53.168 a	58.206 a
LSD value (0.05)	2.1243	2.5238	3.2439
Effect of Zinc sulphate			
Z_0	20.518 c	45.961 c	50.698 c
Z_1	23.106 b	48.618 b	54.480 b
Z_2	25.230 a	53.510 a	58.344 a
LSD value (0.05)	2.1243	2.5238	3.2439

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid, And Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate

Appendix IX: Effect of different levels of salicylic acid and zinc sulphate number of leaves per plant at different days after transplanting (DAT) of squash

Treatments	Number of leaves per plant		
	20DAT	**40DAT**	**60DAT**
Effect of Salicylic acid			
S_0	4.53 b	11.28 c	14.09 c
S_1	5.95 a	12.91 b	16.01 b
S_2	6.23 a	15.41 a	18.70 a
LSD value (0.05)	1.02	1.341	1.759
Effect of Zinc sulphate			
Z_0	4.53 b	11.47 c	14.44 c
Z_1	5.64 a	13.14 b	16.27 b
Z_2	6.54 a	14.99 a	18.08 a
LSD value (0.05)	1.02	1.341	1.75

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid, And Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate

Appendix X: Effect of different levels of salicylic acid and zinc sulphate leaf length at different days after transplanting (DAT) of squash

Treatments	Leaf length (cm)		
	20DAT	**40DAT**	**60DAT**
Effect of Salicylic acid			
S_0	13.16 c	24.19 b	28.72 c
S_1	14.47 b	28.16 a	31.82 b
S_2	16.43 a	29.13 a	33.91 a
LSD value (0.05)	1.161	1.432	1.85
Effect of Zinc sulphate			
Z_0	13.14 c	24.79 c	28.73 c
Z_1	14.53 b	26.65 b	31.07 b
Z_2	16.40 a	29.04 a	33.64 a
LSD value (0.05)	1.161	1.43	1.85

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.
Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid, And Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate

Appendix XI: Effect of different levels of salicylic acid and zinc sulphate leaf beadth at different days after transplanting (DAT) of squash

Treatments	Leaf breadth (cm)		
	20DAT	40DAT	60DAT
Effect of Salicylic acid			
S_0	12.04 b	23.44 b	28.56 b
S_1	12.85 b	28.36 a	30.64 a
S_2	15.54 a	28.22 a	31.36 a
LSD value (0.05)	1.73	1.95	1.86
Effect of Zinc sulphate			
Z_0	13.14 c	24.76 c	28.57 b
Z_1	14.53 b	26.53 b	30.15 ab
Z_2	16.40 a	27.74 a	31.84 a
LSD value (0.05)	1.73	1.95	1.86

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.

Here, S_0 = No salicylic acid (control), S_1 = 60 ppm of salicylic acid, S_2 = 90 ppm of salicylic acid, And Z_0 = No zinc sulphate (control), Z_1 =25 ppm of zinc sulphate, Z_2 = 50 ppm of zinc sulphate

Appendix XII. Production cost of squash per hectare

A) **Material cost (Tk./ha)**

Treatment combinations	Seed cost	Urea	TSP	MoP	Cowdung cost	Zinc sulphate	Salicylic acid	Sub Total 1(A)
S_0Z_0	2500	3740	3740	2250	60000	-	-	72230
S_0Z_1	2500	3740	3740	2250	60000	100		72330
S_0Z_2	2500	3740	3740	2250	60000	200		72430
S_1Z_0	2500	3740	3740	2250	60000	-	550	72780
S_1Z_1	2500	3740	3740	2250	60000	100	550	72880
S_1Z_2	2500	3740	3740	2250	60000	200	550	72980
S_2Z_0	2500	3740	3740	2250	60000	-	800	73030
S_2Z_1	2500	3740	3740	2250	60000	100	800	73130
S_2Z_2	2500	3740	3740	2250	60000	200	800	73230

Labor cost: 300 Tk. per person
Squash seed @ Tk. 2500
Urea @ Tk. 22 kg^{-1}
TSP @ Tk. 22 kg^{-1}
MoP @ Tk. 15 kg^{-1}
$ZnSO_4$ @ Tk. 300 kg^{-1}
Cowdung @ Tk. 10000 t^{-1}

B) **Non-material cost (Tk. /ha)**

Treatment combinations	Land preparation	Net cost	Seed sowing and transplanting	Intercultural operation	Harvesting	Sub total 1B	Total input cost (1A+1B)
S_0Z_0	50000	30000	15000	35000	20000	150000	222230
S_0Z_1	50000	30000	15000	35000	20000	150000	222330
S_0Z_2	50000	30000	15000	35000	20000	150000	222430
S_1Z_0	50000	30000	15000	35000	20000	150000	222780
S_1Z_1	50000	30000	15000	35000	20000	150000	222880
S_1Z_2	50000	30000	15000	35000	20000	150000	222980
S_2Z_0	50000	30000	15000	35000	20000	150000	223030
S_2Z_1	50000	30000	15000	35000	20000	150000	223130
S_2Z_2	50000	30000	15000	35000	20000	150000	223230

C. Overhead cost and total cost of production (Tk./ha)

Treatment combinations	Cost of lease of lands for 6 months (8% of value of land Tk. 10,00,000/-	Miscellaneous cost (5% of input cost)	Interest of running capital for 6 months (15% of the total input cost)	Total	Total cost of production (Input cost + Interest of running capital, Tk/ha)
S_0Z_0	40000	11111.5	33334.5	84446	306676
S_0Z_1	40000	11116.5	33349.5	84466	306796
S_0Z_2	40000	11121.5	33364.5	84486	306916
S_1Z_0	40000	11139	33417	84556	307336
S_1Z_1	40000	11144	33432	84576	307456
S_1Z_2	40000	11149	33447	84596	307576
S_2Z_0	40000	11151.5	33454.5	84606	307636
S_2Z_1	40000	11156.5	33469.5	84626	307756
S_2Z_2	40000	11161.5	33484.5	84646	307876

SOME PICTORIAL VIEW DURING EXPERIMENTATION

Plate no 1: Photograph of squash seedling in seedbed

Plate no 2: Photograph of experimental plot

Plate no 3: Photograph of squash plant

Plate no 4: Photograph of harvested fruits (Showing the comperes between S_0Z_0 and S_2Z_1)