INFLUENCE OF GIBBERALIC ACID ON GROWTH, YIELD AND QUALITY OF TOMATO CV. BIPUL PLUS

A THESIS

BY

MD. ABDUS SALAM

STUDENT ID: 1707109

SEMESTER: JANUARY-JUNE 2024

MASTERS OF SCIENCE (MS)

IN

AGRICULTURAL CHEMISTRY

DEPARTMENT OF AGRICULTURAL CHEMISTRY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJPUR-5200

JUNE 2024

INFLUENCE OF GIBBERALIC ACID ON GROWTH, YIELD AND QUALITY OF TOMATO CV. BIPUL PLUS

A THESIS

BY

MD. ABDUS SALAM

STUDENT ID: 1707109

SEMESTER: JANUARY-JUNE 2024

Submitted to the Department of Agricultural Chemistry
Hajee Mohammed Danesh Science and Technology University, Dinajpur
In partial fulfilment of the requirements for the degree of

MASTERS OF SCIENCE (MS)

IN

AGRICULTURAL CHEMISTRY

DEPARTMENT OF AGRICULTURAL CHEMISTRY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

JUNE 2024

INFLUENCE OF GIBBERALIC ACID ON GROWTH, YIELD AND QUALITY OF TOMATO CV. BIPUL PLUS

A THESIS

BY

MD. ABDUS SALAM

STUDENT ID: 1707109

SEMESTER: JANUARY-JUNE 2024

Approved as to the style and content by:

Professor Dr. Bikash Chandra Sarker
Supervisor

Professor Dr. Md. Abdul Hakim
Co-Supervisor

Professor Dr. Md. Jahidul Islam
Chairman of the Examination Committee &

Chairman

DEPARTMENT OF AGRICULTURAL CHEMISTRY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

JUNE 2024

ACKNOWLEDGEMENTS

The author deems it a much privilege to express his enormous sense of gratitude to the almighty Allah for there ever ending blessings for the successful completion of the research work for the degree of M.S in Agricultural Chemistry.

The author expresses his sincere appreciations, deepest gratitude and profound indebtedness to his reverend Supervisor ***Professor Dr. Bikash Chandra Sarker****, Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur for his valuable suggestions, scholastic guidance, constructive instructions, affectionate feelings and inspirations throughout the period of the research work and during the preparation of this thesis.*

From the core of his heart, the author humbly desires to express his deepest and profound gratitude and immense indebtedness to the Co-Supervisor ***Professor Dr. Md. Abdul Hakim****, Department of Agricultural Chemistry, for his critical advises and valuable comments as well as constructive criticisms during the research period and in the preparation of the dissertation.*

The author is happy to express sincere gratitude to his teacher ***Professor Dr. Md. Jahidul Islam, Chairman****, Department of Agricultural Chemistry, HSTU, for his co-operation and inspirations during the research work.*

The author has the pleasure to express his cordial appreciation to all of his well wishes to MS students of this Department of Agricultural Chemistry, HSTU, Dinajpur for their encouragement, inspirations and help during his M.S research work. The author likes to gratefully acknowledge to the authority of BADC, Dinajpur for supplying tomato samples for the study purpose.

The author is also indebted to all laboratory and office staff of the Department of Agricultural Chemistry, HSTU, Dinajpur, who directly or indirectly helped his to complete this work.

Last but not least the author expresses his heartfelt gratitude to his beloved parents, other family members, friends who always sacrificed and gave all sorts of support their causes of happiness for his higher study and constant inspirations throughout his academic careers.

The Author

ABSTRACT

An experiment was conducted at the experimental field of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from January 2024 to June 2024 to observe the effects of gibberellic acid (GA_3) on growth and quality of tomato cv bipul plus. The experiment consisted of five doses of GA_3 acid such as 10, 20, 30 and 40 ppm with control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 15 plots. Different doses of GA_3 showed significant influence on almost all the parameters studied concerned with growth and quality contributing characters of tomato. The hormone GA_3 (40 ppm) produced the tallest plant (72.94 cm) at 60 DAT, maximum number of leaves (96.00), maximum number of flowers (38.00), maximum number of fruits (20.00), maximum diameter of fruit (4.46 cm) and maximum fresh weight of fruit (53.33 g) in T_4 treatment. Maximum number of branches per plant (12.00) at 60 DAT produced by T_2 (20 ppm). On the other hand, minimum number of leaves (66.67) at 60 DAT, minimum number of branches (9.00), minimum number of flower (23.33), minimum length of leaf (37.39 cm), minimum diameter of fruit (3.89 cm), minimum fresh weight of fruit (42.01 g) were recorded from the treatment of 10 ppm GA_3 (T_1 treatment). The shortest plant height (72.94 cm) at 60 DAT, minimum number of fruit (14.33) produced by T_2 (20 ppm) treatment. The highest amount of total sugar (6.1 mg/100g), β carotene (14.48 mg/100g), vitamin C (29.0 mg/100g), sodium content (41.16 mg/100g), potassium content (108.92 mg/100g), calcium content (40.1 mg/100g) were recorded from 40 ppm (T_4 treatment). The lowest amount of total sugar (5.3 mg/100g), lowest ash content (0.48%), value of β carotene (5.26 mg/100g), value of vitamin C (16.43 mg/100g), sodium content (36.86 mg/100g), potassium content (98.3 mg/100g), calcium content (29.55 mg/100g) were recorded from 10 ppm GA_3 (T_1 treatment). The highest amount of moisture (95.49%) was obtained from T_1 (10 ppm) treatment. On the other hand, the lowest amount of moisture (94.23 %) was recorded from T_2 (20 ppm) treatment. From experiment, T_2 (20 ppm) treatment was given the highest amount of ash (0.64%), protein (1.65%) and ß-carotene (14.48 mg/100g). The highest amount of reducing sugar (5.5 mg/100g) was recorded from T_3 (30 ppm) treatment and the lowest amount of reducing sugar (3.85 mg/100g**)** was recorded from T_0 (control) treatment. So, it can fairly be concluded that the application of gibberellic acid at 40 ppm is quite effective to increase growth, yield and quality of tomato.

CONTENTS

CONTENTS (To be contd.)

CONTENTS (To be contd.)

LIST OF TABLES

LIST OF FIGURES

CHAPTER I
INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a solanaceous self-pollinated vegetable crop. It is one of the important, popular and nutritious vegetables grown in Bangladesh in both winter and summer season around all parts of the country (Haque *et al*., 2017). It was originated in tropical America, particularly in Peru, Ecuador and Bolivia. It is popular for its taste, nutritional status and various uses. Tomato is cultivated all over the country due to its adaptability to wide range of soil and climate (Ahmad, 2012). It ranks third, next to potato and sweet potato, in terms of world vegetable production (FAO, 2018) and tops the list of canned vegetables (Choudhury, 1979). The present leading tomato producing countries of the world are China, United States of America, India, Egypt, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (FAO, 2019).

Tomato fruit can be consumed either fresh, cooked or in the form of processed products such as jam, jelly, juice, ketchup, sauce etc. It is much popular for consumption as salad in the raw state and as processed soups, juice, ketchup, pickles, sauces, conserved puree, paste, powder and other products (Ahmad, 2010; Thompson and Kelly, 2000 and Bose and Som, 2005). It is considered as 'poor man's apple' because of its attractive appearance and very high nutritive value, containing vitamin A, vitamin C (Thompson and Kelly, 1957) and minerals like calcium, potassium etc. Nutritional value of red tomatoes (raw) per 100 g contains 18 kcal energy, 4.0 g carbohydrates, and 2.6 g sugars, 1.0 g dietary fiber, 0.2 g fat, 1.0 g protein, 95 g water, 13 mg vitamin C (Zhang *et al.,* 2009).

Tomato universally treated as ''Protective Food", is being extensively grown as annual plant. Tomato is also rich in medicinal value. It also contains organic acids like citric, malic and aceitic acids which is found in fresh tomato fruit, promotes gastric secretion, acts as a blood purifier and works as intestinal 2 anticeptic (Pruthi, 1993), Tomato is a rich source of lycopene and vitamins. Lycopene may help counteract the harmful effects of substances called free radicals, which are thought to contribute to age-related processes and a number of types of cancer, including, but not limited to, those of prostate, lung, stomach, pancreas, breast, carvex, colorectum, mouth and oesophagus (Masroor *et al.,* 1988). Today, tomatoes are one of the most important horticultural crops globally, with significant production in countries like China, India, and the United States. Their economic and culinary significance

continues to grow, driven by both traditional farming and advancements in agricultural technology.

In Bangladesh, tomato has great demand throughout the year, but its production is mainly concentrated during the winter season. Recent statistics showed that tomato covered 75602 acres of land and the total production was approximately 413610 metric tons (BBS, 2015). Thus, the average yield of 5471kg/acre which is quite low as compared to that of other tomato growing countries of the World (Aditya *et al*., 1997).

It is expected that improved management practices with modern technology would increase the yield considerably. The plant growth regulators have contributed a great deal to the progress of olericulture. The growth behavior of many crop plants could be modified and controlled by applying small amount of growth regulators. Plant growth regulators (PGRs) are used extensively in agriculture to enhance plant growth and improve yield by increasing fruit number, fruit set and size. Several research workers have studied the effect of plant growth substances on vegetable crops. Among them, gibberellins particularly GA_3 have been reported to show promising effect on tomato crop. Thus, it is Imperative to determine their concentration.

Gibberellic acid is one of the most important growth stimulating substances used in agriculture since long. It may promote cell elongation, cell division, flowering, pollination, fertilization, germination, breaking dormancy, leaf expansion, fruit setting, increasing fruit size, improving fruit quality and in many other aspects of plant growth and development and thereby increased crop production. Gibberellic acid when applied to flowers controlled fruit drop in tomato (Feofanova, 1960). So, to increase the yield and to avoid flower and fruit dropping, application of GA_3 at right concentration and right time is important.

The study of GA_3 hormone effects on tomato is justified for several key reasons:

Agricultural Productivity: Farmers can improve their farming operations by knowing how GA_3 hormone influence on tomato development.

Crop Improvement: Insights into the tolerance mechanisms of tomato to hormonal effects can guide breeding programs aimed at developing more resilient tomato varieties.

Food Security: One popular vegetable that has a lot of nutritional value is tomato. Improving its ability to withstand hormone might help stabilize food production and security.

Environmental Management: Studying the interaction between tomato and hormonal conditions can inform better management practices for soil and water resources.

Economic Impact: Reducing losses and boosting marketable output can result in significant financial benefits for farmers who can improve tomato yields under GA_3 hormone. By investigating the effects of GA_3 on tomato, researchers can provide valuable information to improve agricultural practices, enhance crop resilience, and support sustainable food production systems.

The research work of this topic is important for us to know which concentration are suitable for better quality of tomato.

An attempt was made to study the effects of different concentrations of gibberellic acid (GA_3) on the quality of tomato with the following objectives:

- To study the effect of application of gibberellic acid (GA_3) on growth and yield of tomato
- To evaluate the morphological and biochemical quality of tomato
- To investigate and compare the nutritional values and health benefit of tomato.

CHAPTER II
REVIEW OF LITERATURE

Tomato is an important vegetable crop and received much attention of the researchers throughout the world to develop its suitable production technique among various research works investigations have been made in various parts of the world to determine the different levels of gibberellic acid (GA_3) for its successful cultivation. In Bangladesh, there have not many studies on the influence of different levels of gibberellic acid (GA_3) on the growth and yield of tomato. Relevant available information in this connection has been described in this chapter.

Gibberellic acid (GA) is a plant's growth regulator widely used in the agriculture sector to increase crop productivity. It promotes elongation of stems, induces flowering, and influences various physiological processes. Applied in precise dosages per liter, GA contributes to improved yield and fruit development. Despite its benefits, the economic aspect, including the price per unit, influences its adoption. Gibberellic acid stands as a valuable tool in modern agriculture, offering targeted enhancements for optimal plant growth and yield. Utilizing gibberellic acid (GA) in agriculture revolutionizes plant growth enhancement. The role of the gibberellic acid plant in seeds is breaking seed dormancy, which further aids germination. Through precise dosage control, typically measured per liter, farmers can ne-tune its application to ensure optimal results. As one of the gibberellic acid plant uses, GA extends beyond mere growth, influencing key physiological processes and breaking seed dormancy, thereby promoting robust germination. This strategic integration of gibberellic acid into agricultural practices offers a valuable approach to bolster yield and fruit development. Despite its proven benefits, considerations of cost and price per unit remain crucial in determining the economic viability of implementing gibberellic acid plant growth in modern farming techniques.

The role of gibberellic acid in plants induces flowering, significantly impacting crop production. Employed as a plant growth regulator, GA application stimulates the synthesis of enzymes responsible for flower development, promoting early and uniform flowering across crops. Techniques involve precise dosage control, oven measured per liter, ensuring a targeted approach. The application of GA proves particularly beneficial for crops with inherent flowering challenges or those requiring synchronization for optimal yield. Excessive application may lead to unintended consequences, emphasizing the importance of dosage

precision. Farmers must consider the cost implications of GA usage, balancing its benefits against economic feasibility. By ne-tuning the dosage, farmers can harness the potential of gibberellic acid to achieve maximum agricultural yield, optimizing the delicate balance between plant growth stimulation and resource efficiency.

The use of GA proves particularly beneficial for fruit and ornamental crops, enhancing aesthetics and market value. Successful flower induction with GA leads to increased fruit set and improved overall crop yield. Continuous monitoring and adaptation of application methods further re ne the process. Despite its efficacy, horticulturists must consider cost implications and environmental factors in their decision-making. The application of the gibberellic acid plant growth regulator in agricultural crops significantly impacts yield by promoting favorable growth and development. Gibberellic Acid plant growth, as a plant growth regulator, plays a pivotal role in stimulating stem elongation, enhancing flower formation, and increasing fruit set. By breaking seed dormancy, GA facilitates uniform germination, ensuring a more synchronized and robust crop establishment.

2.1 Effect of gibberellic acid (GA_3) on growth and yield and quality of tomato

Mahmudul Hasan (2018) For the application of GA_3, the longest plant (88.88 cm at 60 DAT), the maximum dry matter of fruit (13.35%) and the highest yield (68.64 t ha^{-1}) and other yield contributing parameters were recorded from G_2 (75 ppm).

Ahmad *et al.*, (2017) evaluated the influence of different plant growth promoters on growth and yield of JP-27 summer cherry tomato line. Four different growth promoters including control viz. F0= Control (Water), F_1= Flora (Nitrobenzene 20% w/w) @ 2.5ml/L, F_2= 4-CPA @ 2.5 ml/L and F_3= GA_3 @ 200ppm was used in this experiment arranged in a Randomized 13 Completely Blocked Design (RCBD) with three replications. Maximum plant height, number of leaves, number of branches, days to first flower, number of flowers, number of fruits, fruit length, single fruit weight, yield/plant and yield/ha (194.5 cm, 28.7, 12.7, 18.0, 48.3, 34.7, 19.9 mm, 20.4 g, 458.7 g and 19.0 ton respectively) were found in F3 treatment,

Akand *et al.*, (2015) conducted an experiment on tomato crop at Sher-e- Bangla Agricultural University, Dhaka, Bangladesh. The experiment consisted three concentrations of GA_3 i.e. 75ppm, 100ppm and 125 ppm. Among the concentration of GA_3 they found highest yield (92.99 t/ha) with GA_3 @ 125 ppm whereas the G0 (no GA_3) gave lowest yield (60.46 t/ha).

Rahman *et al*., (2015) carried out an experiment to evaluate influence of different concentrations of GA_3 on biochemical parameters at different growth stages in order to maximize yield of summer tomato var. Binatomato-2. The concentrations of GA_3 were 0, 25, 50, 75 and 100 ppm. The application of 50 ppm GA_3 by root soaking had significantly increased the number of flowers, fruits and fruit yield per plant but similar results were achieved when only 25 ppm GA_3 was applied at the flowering stage. The fruit yield of tomato per plant increased linearly with the increased number of flowers and fruits per plant.

Mazed *et al*., (2014) observed that GA_3 had significant influence on growth and yield contributing characters of tomato. At 75 DAT, the highest plant height (117.30 cm), maximum number of leaves/plant (75.30) and highest yield (29.03 t/ha) were recorded from GA_3 spray at 120 ppm.

Kumar *et al*., (2014) conducted an experiment on tomato crop at SHIATS, Allahabad, UP. The experiment consisted of one tomato variety "Golden" and five levels of GA3 i.e. (10, 20, 30, 40 and 50 ppm). The highest plant height (38.17 cm) at 20 DAT, number of leaves (39.51) and fresh fruit weight was found 1.10 kg. Highest yield was estimated for GA_3 @ 50 ppm followed by GA_3 @ 40 ppm.

Kazemi *et al*., (2014) investigated the effect of 2 levels of GA_3 (10-4 and 10-8 mm) and 2 levels of potassium nitrate (6 and 8 mm) spray on growth, leaf NPK – content, University, karaj, Iran. With regard to fruit quality, the application of GA_3 at 10-8 mm and potassium nitate at 8mm increased fruit lycopene content and TSS. They concluded that GA_3 was suitable for increasing vegetative growth and reproductive characteristics of tomato.

Choudhury *et al.,* (2013) carried out a field experiment on tomato at Sher-e Bangla Agricultural University, Dhaka to assess the effect of different plant growth regulators on tomato during summer season. They confined that highest 15 yield (28.40 t ha^{-1}) were found in PGR (4-CPA + GA_3 @ 20 ppm of each), followed by PGR (4- CPA @ 20 ppm) and minimum yield (17.35 t ha^{-1}) obtained with control.

Gelmesa *et al*., (2010) conducted an experiment at Mekassa Agricultural Research center, Ethiopia on tomato. The experiment consisted of two tomato varieties one for processing (Roma VF) and one for fresh market (Fetan), three levels of 2,4-D (0, 5, 10 mg l^{-1}) and 4 levels of GA_3 (0, 10, 15 and 20 mg l^{-1}) were applied. They found increase in fruit length from 5.44 to 6.72 cm at 10 mg l-1 2, 4-D combined with 10 mg l^{-1} GA_3. The marketable fruit

yield of "Rome-VF was obtained 69.50 t ha^{-1} with 10 mg l^{-1} GA_3 followed by 67.92 t ha^{-1} with 15 mg l^{-1} GA_3.

Serrani *et al*., (2007) investigated the effect of applied gibberellin (GA_3) and auxin on fruit-set and growth in tomato (*Solanum lycopersicum* L.) cv. MicroTom. Unpollinated ovaries responded to GA_3 and to different auxins [indol-3- acetic acid, naphthaleneacetic acid, and 2,4-dichlorophenoxyacetic acid (2,4- D)], 2,4-D being the most efficient. Simultaneous application of GA_3 and 2,4-D produced parthenocarpic fruits similar to pollinated fruits, but for the absence of seeds, suggesting that both kinds of hormones are involved in the induction of fruit development upon pollination.

Rai *et al*., (2006) conducted an experiment during the 2003 winter season in Meghalaya, India, on tomato cv. Manileima to study the effect of plant growth regulators on yield. The treatments comprised 25 and 50 mg GA_3/litre, water spray. Data were recorded for growth, flowering and fruiting characteristics GA_3 significantly reduced the number of seeds per fruit but increased plant height, plant canopy size and number of branches per plant.

Khan *et al*., (2006) conducted an experiment to study the effect of 4 levels of gibberelic acid spray on the growth, leaf-NPK content, yield and quality parameters of 2 tomato cultivars (*Lycopersicon esculentum* Mill.), namely -3 and Hyb SC-3 and Himalata. They reported that irrespective of its 16 concentration, spray of gibberellic acid proved beneficial for most parameters, especially in the case of Hyb-SC-3.

Bhalekar *et al*., (2006) studied the effects of GA_3, NAA, 4-CPA and boron at 25 or 50 ppm on the growth and yield of tomato (cv. Dhanshree). Plant height was maximum with GA_3 at 25 and 50 ppm (74.21 and 75.33 cm, respectively), and 4- CPA at 50 ppm (72.22 cm). The number of primary branches per plant did not significantly vary among the treatments. GA_3 at 50 ppm resulted in the lowest number of primary branches per plant (69.55). The number of fruits per plant (38.86) was highest 50 ppm boron. The highest yields were recorded for boron at 25 and 50 ppm (254.2 and 264.4 quintal/ha).

Sasaki *et al*., (2005) studied the effect of plant growth regulators on fruit set of tomato (*Lycopersicon esculentum* cv. Momotaro) under high temperature and in a field (Japan) under rain shelter. Tomato plants exposed to high temperature ($34/20^0$C) had reduced fruit set. Treatments of plant growth regulators reduced the fruit set inhibition by high temperature to some extent, especially with mixtures of 4-chlorophenoxyacetic acid (4-CIIA) and

gibberellins (GAs). They also reported that tomatoes treated with a mixture of 4-CPA and GA_3 showed increased fruit set, dry matter content of fruit and the numbers of 17 normal fruits were more than the plants treated with 4-CPA alone during summer.

EI- Habbasha *et al*., (1999) carried out a field experiment with tomato cv. castel rock over two growing seasons (1993-94). The effects of GA_3 and 4-CPA on fruit yield and quality were investigated. Many of the treatments significantly increased fruit set percentage and total fruit yield, but also the percentages of puffy and parthenocarpic fruits compared to the controls.

Gulnaz *et al*., (1999) reported that seeds of tomato treated with to 10 ppm of GA_3 resulted in 36-43% increase in dry weight at 13.11 dSm^{-1}.

Gurdev and Saxena (1991) observed that the growth regulators (GA_3 at 10-5 M) increased total dry matter. Application of 10-5 M GA_3 on mustard at 40 or 60 days after sowing significantly increased total dry matter (Khan et al. 1998).

Shittu and Adeleke (1999) investigated the effects of foliar application of GA_3 (0, 10, 250 or 500 ppm) on growth and development of tomatoes cv 158-3 grown on pots. Plant height and number of leaves were significantly enhanced by GA_3 treatment. Plants treated with GA_3 with 250 ppm were the tallest plant the highest number of leaves.

Tomar and Ramgiry (1997) conducted an experiment and found that plants treated with GA_3 showed significantly greater plant height, number of branches/plant, number of fruits/plant, dry matter content of leaves, dry matter content of fruits and yield than untreated controls. GA_3 treatment at the seedling stage offered valuable scope for obtaining higher commercial tomato yields.

Bima *et al*., (1995) worked with Gibberellic acid and found that GA_3 (5-10 ppm) enhanced germination of seeds and induced flowering. NAA and 2,4-D (5-10 ppm) induced early flowering and promote fruit set.

El-Abd *et al*., (1995) studied the effect of plant growth regulators for improving fruit set of tomato. Two tomato cv. Alicante crops were produced in pots in the greenhouse. When the third flower of the second cluster reached antithesis, the cluster was sprayed with IAA, GA_3 or ABA at l0-4, 10-6 or 10-8 M each and ACC at l0-9, 10-10 or 10-11 M. All concentrations of IAA, GA_3 ACC and ABA induced early fruit set compared with controls sprayed with

distilled water. For the first of the two crops, the highest ABA concentration (l0-5 M) accelerated fruit set, but the other two concentrations delayed it. For the second crop, however all ABA treatments accelerated fruit set. ABA applions also retarded red fruit color formation, more so at increasing concentrations. IAA at l0-6 M resulted in the formation of double flowers of total fruits set from treated flowers, 40 % were double. GA_3 led to the formation of leafy clusters, with the number of leaves and dry matter content of leaves increasing with GA_3 concentration.

Saleh and Abdul (1980) conducted an experiment with GA_3 (25 or 50 ppm) which was applied 3 times in June or early July. They reported that GA_3 stimulated plant growth. It reduced the total number of flowers per plant, but increased the total yield compared to the control. GA_3 also improve fruit quality.

Singh and Lal (1995) reported the foliar spray of GA_3 (50 ppm) at 50 percent flowering increased the fruit set and seed yield of tomato. Total dry matter of a crop is the output of net photosynthesis Patel and Saxena (1994) reported that presoaking of seed of gram in varying concentrations of GA_3 showed the best results on dry weights.

Satti and Oebekar (1986) reported that an increase in fruit set of tomato due to application of GA_3 @ 45 ppm at various stages of inflorescence development.

Lilov and Donchev (1984) observed that by the application of GA_3 at 20, 40 or 100 mg/L the yields were reduced compared with the non-treated control.

Leonard *et al*., (1983) observed that inflorescence development in tomato plants (cv. King plus) grown under a low light regime was promoted by GA applied directly on the inflorescence.

Wu *et al.,* (1983) sprayed one-month old transplanted tomato plants with GA at 1, 10,100 ppm. They reported that GA_3 at 100 ppm increased plant height and leaf area.

Chern *et al*., (1983) presented that one-month old transplanted tomato plants were sprayed with 1, 10 or 100 ppm GA_3 and observed that GA_3 at 100 ppm increased leaf area, plant height and stem fresh and dry weight but 10 ppm inhibited growth.

Sawhney and Greyson (1972) reported that application of GA_3 non flowering plants of tomato induced multilocular, multicarpellary ovaries which were larger at antithesis than

control upon pollination produced fruits which were significantly larger with higher fresh weight.

Choudhury and Faruque (1972) reported that the percentage of seedless fruit increased with an increase in GA_3 concentration from 50 to 100 ppm and 120 ppm. However, the fruit weight was found to decrease by GA_3 effects.

Gain in dry matter per unit assimilatory area per unit time is the NAR. It was established that NAR become higher during vegetative stage and then decline rapidly as season progressed (Kollar *et al.,* 1970) possibly due to mutual leaf shading and increase of old leaves which could have lower photosynthetic efficiency (Pandey and Singh, 1978). The NAR was positively correlated with CGR (Majumder *et al.,* 1980).

Mehrotra *et al.,* (1970) recorded the significant increase in the plant height (95 cm) with 25 ppm GA_3 spray at flower initiation stage in tomato.

Jansen *et al.,* (1970) reported that tomato plants treated with GA_3 neither increased the yield nor accelerated fruit ripening. He also mentioned that increasing concentration of GA_3 reduced both the numbers and size of the fruits.

Bora and Selman *et al.,* (1969) working with tomato demonstrated that four foliar sprays of GA_3 (0, 5, 50 or 500 ppm) applied at 7, 17, 22, 27 or 370 increased the leaf area, weight and height of tomato plants. The best treatment was 5 ppm GA_3 at 22^0C.

Adlakha and Verma (1965) observed that when the first four clusters of tomato plants were sprayed three times at unspecified intervals with GA_3 at 50 and 100 ppm, the fruit setting, fruit weight and total yield increased by 5, 35 and 23%, respectively with the lower concentration than the higher.

Gustafson *et al.,* (1960) worked with different concentrations of GA_3 and observed that when 35 and 70 ppm GA_3 were sprayed to the flowers and flower buds of the first three clusters, percentage of fruits set increased but there was a decrease in the total weight. When only the first cluster was sprayed, the number of fruit set and the total weight per cluster was increased, but this response did not occured in subsequent clusters.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from January 2024 to April 2024 to study the effect of different levels of GA_3 on chemical composition of tomato cv Bipul plus. This chapter includes materials and methods that were used in conducting the experiment and presented below under the following headings:

3.1 Location of the experimental field

The experiment was conducted at Agricultural Chemistry field of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur. During the period from January to April, 2024. The location of the experimental site was at 25 39' N latitude and 88 4' E longitudes with an elevation of 37.50 meter from sea level.

3.2 Climate of the experimental area

Nature of the climate of the experimental area was subtropical. The monsoon, pre- monsoon, or hot season extends from March to April and winter season from November to February (Edris *et al.*, 1979). At the month of April to September heavy rainfall occurs. The winter season in Bangladesh is suitable for tomato cultivation.

3.3 Soil of the experimental field

The experimental site was a medium high land which remained fallow during the previous summer. The land was well-drained, sandy loam soil pH 6.20 and located in AEZ-1 (Old Himalayan Piedmont Plain.

3.4 Plant materials collection

The tomato cv. bipul plus tomato was used in the experiment. It was a high yielding, heat tolerant and indeterminate type variety. Seedling was collected from Bangladesh Agricultural Development Corporation (BADC), Dinajpur.

3.5 Raising of seedlings

Tomato seedlings were raised in two seedbeds of 3 m x 3m size. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed and 5 kg well rotten cow dung was mixed with the soil. After sowing, seeds were

covered with light soil. The emergence of the seedlings took place within 6 to 7 days after sowing. Weeding, mulching and irrigation were done as and when required.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:

Four levels of GA_3 (Gibberellic acid)

T_0 = Control (0 ppm of GA_3)
T_1 = 10 ppm of GA_3
T_2 = 20 ppm of GA_3
T_3 = 30 ppm of GA_3
T_4= 40 ppm of GA_3

3.7 Cultivation procedure

3.7.1 Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The land of the experimental field was ploughed with a power tiller on 20 December 2023. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After plouging and laddering, all the stubbles and uprooted weeds were removed and then the land was made ready. The field layout and design was followed after land preparation.

3.7.2 Manures and fertilizers and its methods of application

Fertilizer	**Quantity**	**Application method**
Cow dung	15 t/ha	Basal dose
Urea	400 kg/ha	25, 40 and 60 DAT
TSP	300 kg/ha	Basal dose
MOP	250 kg/ha	25, 40 and 60 DAT mixed with urea

According to Rashid (2012), the entire amount of cow dung and TSP were applied as basal dose during land preparation. Urea, TSP and MOP were applied at the rate of 400 kg/ha, 300 kg/ha and 250 kg/ha, respectively. Urea and MOP were used as top dressing in equal splits at 20, 30 and 40 days after transplanting.

3.7.3 Transplanting of seedlings

Healthy and uniform 40 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in 06 January, 2024 maintaining a spacing of 60 cm x 50 cm between the rows and plants, respectively. The seedlings were watered after transplanting. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.7.4 Application and preparation of GA_3

The stock solution of 1000 ppm of GA_3 was made by mixing of 1 g of GA_3 with small amount of ethanol to dilute and then mixed in 1 litre of distilled water. Then as per requirement of 10 ppm, 20 ppm, 30 ppm and 40 ppm solution of GA_3 10, 20, 30 and 40 ml of stock solution were mixed with 1 litre of distilled water respectively. Application of GA_3 was done at 15 days interval and was applied at 30, 45, and 60 days after transplanting.

3.7.5 Intercultural operations

After transplanting the seedlings, various kinds of intercultural operations were accomplished for better growth and development of the plants, which are as follows:

3.7.5.1 Gap filling

When the seedlings were well established, the soil around the base of each seedling was pulverized. A few gaps filling was done by healthy seedlings of the same stock where initial planted seedling failed to survive.

3.7.5.2 Weeding

Numbers of weeding were accomplished as and whenever necessary to keep the crop free from weeds.

3.7.5.3 Irrigation

Number of irrigation was given throughout the growing period by garden pipe and watering cane. The first irrigation was given immediate after the transplantation where as other were applied when and when required depending upon the condition of soil.

3.7.5.4 Plant protection

From seedling to harvesting stage i.e. any stage, tomato is very sensitive to diseases and pest. After getting a maturity stage protection measure was taken against diseases and pests. So that, any insect or fungal infection and insect infestation cannot appear in the plant.

3.8 Harvesting

Fruits of assigned GA_3 treated plants were harvested at 7 to 8 days intervals during early ripe stage when they attained slightly red color. Harvesting was started from 20 March, 2024 and was continued up to end of 20 April 2024.

3.9 Data collection

Six plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment.

3.9.1 Plant height

The plant height was measured in centimeters from the base of plant to the terminal growth point of main stem on tagged plants was recorded at 10 days interval starting from 20 days of planting up to 60 days to observe the plant height. The average height was computed and expressed in centimeter.

3.9.2 Number of branches plant

The number of branches per plant was manually counted at 50 and 60 days after transplanting from randomly selected tagged plants. The average of six plants were computed and expressed in average number of branch per plant.

3.9.3 Number of flowers

The number of flowers per cluster was counted at 50 and 60 days after transplanting from the six sample plants. From each plant randomly five clusters were selected and counted the number of flowers per cluster to make an average value for one plant. The final average value of number of flowers per cluster was calculated from six averages from six plants.

3.9.4 Number of fruits

The number of fruits per cluster was counted at 60 DAT and harvesting time from selected six plants. From each plant randomly five clusters were selected and counted the number of fruits per cluster to make an average value for one plant. The final average value of number of fruits per cluster was calculated from six plants.

3.9.6 Length of fruit

Among the total number of fruit harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for determine the length of fruit by slide calipers. The length of fruit was calculated by making the average of five fruits from each of the six plants.

3.9.7 Diameter of fruit

Among the total number of fruits harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for the diameter of fruit by slide calipers. The diameter of fruit was calculated by making the average of five fruits from each of the six plants.

3.9.8 Fresh weight of fruit

Among the total number of fruit harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for determine the individual fruit weight in gram. The weight was calculated from total weight of fruits was divided by total number of fruits of every harvest and finally making the average was made from four times harvesting data.

3.10 Physio-chemical analysis of tomato fruit

3.10.1 Determination of moisture content

The moisture content was determined using the Standard Official Methods of Analysis of the AOAC, specifically procedure 14:004. This process entailed subjecting the rice samples to a temperature of 100^0C until they reached a consistent weight, and then determining the moisture content by measuring the weight loss of the dried samples. Afterward, they were allowed to cool and weighed at the same temperature for a period of 30 minutes until consistent weights were achieved, yielding the value of W_3.

Then, the moisture content of the rice sample was calculated from the equation:

$$\% \text{ moisture} = \frac{W2 - W3}{W2 - W1} \times 100$$

3.10.2 Determination of ash content

AOAC (2000) method was used to determine the total ash content. 5 mL sample was taken in a dry, clean porcelain dish and weighted accurately. Hot air oven method was applied to remove the moisture. Then the sample was burned using an electric heater. This was done to avoid the loss of sample in the muffle furnace at higher temperature of 550°C and ignited until light gray ash was appeared. The sample was then cooled in desiccators and weighed. The ash content is expressed

$$\%\text{Ash} = \frac{Wt.of\ ash}{Wt.of\ sample} \times 100$$

3.10.3 Determination of fiber

The determination of crude fibre was conducted using the AOAC, 1970 method (method 14:020). A rice sample weighing approximately 2.0 g was subjected to hydrolysis in a beaker using petroleum ether. Subsequently, it was heated under reflux for a duration of 30 minutes with a solution consisting of 1.25% H_2SO_4 per 100 mL of solution, totaling 200 mL Gooch filter crucible, subjected to drying at a temperature of 100^0C for a duration of 2 hours in an oven, subsequently chilled, and finally washed.

The percentage crude fiber in the rice sample was calculated as per the formula

$$\% \text{ Crude fiber} = \frac{\text{Wt. after drying}}{\text{Wt. of sample}} \times 100$$

3.10.4 Estimation of protein

The modified kjeldahl method is used to determine the total nitrogen consisting of organic and ammonium forms. It is a wet oxidation procedure; whose complex form of nitrogen in plant protein is converted to nitrogen. 1g previously oven dried sample was taken in a digestion flask. 10g potassium sulphate (K_2SO_4), 0.1g copper sulphate ($CuSO_4$), 1g selenium powder and 25 ml conc. H_2SO_4 was added to it and heated until the solution became clear.

Then the flask was cooled. The micro burette was filled with 0.01N HCL until the blue color disappears. The blank distillation was carried out and titrated.

Calculation:

$$\% \text{ Nitrogen } = \frac{\text{Titrate value } \times \text{N } \times 0.014 \times 100}{\text{Weight of sample}}$$

$$\% \text{ Protein } = \% \text{ Nitrogen } \times 6.25$$

3.10.5 Determination of vitamin C or L ascorbic acid

Standardization of dye solution:

5 ml of standard vitamin C solution was taken in a 100 ml conical flask and titrated with dye solution from burette.

$$\text{Dye factor } = \frac{0.5}{\text{Titrated value}}$$

10 g of eggplant sample blended with about 50 ml metaphosphoric acid solution then it was filtered with white thin cloth then it was transferred in a 100 ml volumetric flask and then volume made up to the mark with metaphosphoric acid solution. Then 10 ml of eggplant sample was taken in a conical flask and titrated with dye solution from burette.

$$\% \text{ vitamin C } = \frac{\text{Titrate value } \times \text{ Dye factor } \times \text{ Volume of sample made up } \times 100}{\text{Volume of sample used } \times \text{ Weight of sample } \times 1000}$$

3.10.6 Determination of total sugar

Fehling A: 69.28 g copper sulphate was dissolved in distilled water. Diluted to 1000 mL filter and stored in amber colored bottle.

Fehling B: 346 g Rochelle salt (potassium sodium tartarate) and 100 g NaOH was dissolved in distilled water. Diluted to 1000 mL filtered and stored in amber colored bottle.

3.10.7 Estimation of reducing sugars

It was determined according to the method described by Haq and Rab (2012) and Santini *et al* (2014) with slight modification. 20 g of the eggplant pulp was crushed in a mortar and pestle

then transferred in a 200 mL volumetric flask. The volume was adjusted to 150 mL by adding purified water. Reducing sugar was calculated using the following equation:

$$\% \text{ Reducing sugar } = \frac{\text{Fehling factor} \times \text{ Dilution } \times 100}{\text{Titre } \times \text{Weight or volume of sample}}$$

3.10.8 Determination of Sodium (Na) content

Preparation of a series of sodium standard solutions containing 5, 10, 15, 20, 25, 30, 40, 50 and 60 ppm Na by pipetting 5, 10,15, 20, 25, 30, 40, 50 and 60 ml of 100 ppm Na solution were taken in 9 (nine) different 100 ml volumetric flasks, respectively. The volume up to the mark was made with distilled water in each flask and the flask was shaked thoroughly. Thus, a series of potassium standard solution was prepared. The readings of flame emission spectrophotometer (% emission) for the sodium standard series solutions was taken along with the unknown plant extract sample.

3.10.9 Determination of Potassium (K) content

Preparation of a series of potassium standard solutions containing 5, 10, 15, 20, 25, 30, 40, 50 and 60 ppm K by pipetting 5, 10, 15, 20, 25, 30, 40, 50 and 60 ml of 100 ppm K solution was taken in 9 (nine) different 100 ml volumetric flasks, respectively. The volume up to the mark was made with distilled water in each flask and the flask was shaked thoroughly. Thus, a series of potassium standard solution was prepared.

3.10.10 Determination of Sulfur (S) content

About 0.3 g Barium chloride was added to 20 ml of unknown test solution and it was mixed until barium chloride dissolves completely. Then it was allowed to stand it for 30 minutes before reading. After that spectrophotometer reading was taken at 425 nm wavelength putting the cuvette in the cuvette chamber against the blank one. Finally the concentration of sulfate was fined out from the standard curve. A standard curve was prepared using X-axis for S concentration (ppm) and Y-axis for absorbance.

3.10.11 Determination of Calcium (Ca) content

Calcium was estimated by complex metric method of titration using Na2-EDTA as Complexing Agent.5 mL of plant extract solution was taken in a 250 mL conical flask. 20 mL distilled water was added into the conical flask and shaken thoroughly.10 drop of each masking agent data and calculated the amount of calcium by the following formula:

1 mL 1M EDTA ≡ 1mL 1M Ca = 40.08 mg Ca

3.10.12 Estimation of Magnesium (Mg) content

5 ml of plant extract solution was taken in a 250 ml conical flask. 20 ml distilled water was added into the conical flask and was shaken thoroughly. 10 drops of each masking agent was added to it. 5 ml of Ammonia ammonium buffer solution was added and shaken thoroughly. 5-6 drops of EBT indicator should be added into the conical flask (depending on the concentration of the indicator solution) and the flask should be shaken thoroughly.

Formula of Calculation:

1 ml 1M EDTA ≡ 1ml 1M Mg = 24.305 mg Mg

3.10.13 Determination of Phosphorus (P) content

Phosphorus was determined by placing 5 g of the dried sample in a crucible and then in a Muffle furnace at 450°C until it was grey in colour (Pavlista et al., 2008). The ash was extracted with hot concentrated HNO_3, washed and then made up to a volume of 100 ml. The mixture, 10 ml of concentrated HNO_3 and 30 ml of molybdate solution was gently stirred and was allowed to stay overnight. Conversion Factor: 1 ml of 0.1 N NaOH = 0.0001351 g of P

1 ml of 0.1 N NaOH = 0.000309 g of P_20_5

$$\%P = \frac{\text{ml of 0.1 N NaOH used} \times 0.000135 \times \text{aliquot} \times 100 \text{ factor}}{\text{Weight of substance used}}$$

3.11 Statistical analysis

The recorded data on various parameters were statistically analyzed using MSTAT-C statistical package program. The mean for all the treatments was calculated and analysis of variance for all the characters were performed by F- Difference between treatment means were determined by LSD according to Gomez and Gomez, (1984) at 5% level of significance.

CHAPTER IV
RESULTS AND DISCUSSION

The present study was conducted to find the effect of GA_3 on growth and yield of tomato. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are given in. The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following headings:

4.1 Morphological properties of tomato

Table 4.1.1 Effect of GA_3 on plant height, number of brunch, number of leaf and number of flower and number of fruit of tomato

Variety	Parameters				
	Plant height (cm)	Number of Branch	Number of Leaves	Number of Flower	Number of Fruit
T_0	80.26 ab	10.67 ab	85.00 a	29.67 ns	18.67 ns
T_1	76.42 ab	9.00 b	66.67 b	23.33 ns	14.33 ns
T_2	90.47 a	13.00 a	92.00 a	28.00 ns	14.00 ns
T_3	72.94 b	11.33 a	95.67 a	34.33 ns	19.00 ns
T_4	84.72 ab	12.33 a	95.33 a	37.33 ns	20.00 ns
CV	8.51	17.15	13.93	17.91	16.37
LSD	15.02	6.02	11.15	18.58	9.38

Note: T_0= 0 ppm (Control), T_1= 10 ppm, T_2= 20 ppm, T_3= 30 ppm, T_4= 40 ppm

The significant difference was recorded due to the application of GA_3 on plant height, number of branches and number of leaves. The maximum plant height (90.47cm) was recorded from T_2 (20 ppm) treatment and the minimum plant height (72.94 cm) was recorded from T_3 (30 ppm) treatment. The maximum number of branches (12.33) was found from T_4 (40 ppm) treatment on the other hand the minimum number of branches (9.00) was found from T_1 (10 ppm) treatment. Rai *et al.,* (2006) conducted an experiment GA_3 significantly reduced the number of seeds per fruit but increased plant height, plant canopy size and number of branches per plant. The maximum number of leaves (95.67) was recorded from T_4 (40 ppm) and the minimum number of leaves (66.67) was recorded from T_1 (10 ppm)

treatment. Akhtar *et al*., (2007) conducted an experiment to study the effect of different rates of GA_3 and agreed with the results.

There was no significant effect among the GA_3 treatment on number of flower and number of fruit. The maximum number of flower (37.33) was recorded from T_4 (40 ppm) and the minimum number of flower (23.33) was found from T_1 (10 ppm) treatment. Singh and Lal (2011) reported the foliar spray of GA_3 (50 ppm) at 50 percent flowering increased the fruit set and seed yield of tomato. The maximum number of fruit 20 was recorded from T_4 (40 ppm) on the other hand the minimum number of fruit (14.33) was recorded from T_1 (10 ppm) treatment. Deb *et al*., (2009) found significant response of GA_3 with respect to number of fruits/plant.

Table 4.1.2 Effect of GA_3 on length of fruit, diameter of fruit, total weight of fruit, edible and non-edible part weight of tomato

Variety	Parameters				
	Length of fruit (cm)	Diameter of fruit (cm)	Total weight of fruit (g)	Edible part weight (g)	Non-edible part weight (g)
T_0	4.74 c	3.97 bc	45.87 c	41.00 bc	4.76 ab
T_1	5.16 ab	3.89 c	42.01 d	37.53 d	4.43 b
T_2	4.93 bc	4.08 bc	45.44 c	40.13 c	4.88 ab
T_3	5.07 bc	4.16 b	48.70 b	42.77 b	5.57 ab
T_4	5.44 a	4.46 a	53.33 a	47.66 a	6.15 a
CV	5.16	5.35	8.98	9.02	13.43
LSD	0.35	0.21	2.04	2.37	1.40

Note: T_0= 0 ppm (Control), T_1= 10 ppm, T_2= 20 ppm, T_3= 30 ppm, T_4= 40 ppm

The significant difference was recorded due to the application of GA_3 on length of fruit, diameter of fruit, total weight of fruit, edible part weight, non-edible part weight. The maximum length of fruit (5.44 cm) was recorded from T_4 (40 ppm) treatment, on the other hand the minimum length of fruit (4.74 cm) was recorded from T_0 (control) treatment. Desai *et al*., (2012) conducted an experiment on tomato variety GT-3 (Gujarat tomato-3) at JAU, Junagarh, India and found maximum fruit length (7.57 cm) with GA_3 @ 75 ppm. The maximum diameter of fruit (4.46 cm) was found from T_4 (40 ppm) and the minimum diameter of fruit (3.97 cm) was found from T_0 (control) treatment. Desai *et al*., (2012)

conducted an experiment on tomato and recorded maximum fruit girth (6.47 cm) and pulp seed ratio with GA_3 application.

The maximum total weight of fruit (53.33 g) was recorded from T_4 (40 ppm), on the other hand the minimum total weight of fruit (42.01g) was recorded from T_1 (10 ppm) treatment. The maximum edible part weight (47.66 g) was recorded from T_4 (40 ppm) and the minimum edible part weight (37.53 g) was recorded from T_1 (10 ppm) treatment. The maximum non edible part weight (6.15 g) was recorded from T_4 (40 ppm) treatment. On the other hand the minimum non edible part weight (4.43 g) was recorded from T_1 (10 ppm) treatment. Sanyal *et al*., (2012) studied that the effects of plant growth regulators and reported that plant growth regulators had profound effects on fruit length and weight.

4.2 Nutrients present in tomato

Tomato is one of the most important vegetable crops in al over the world including Bangladesh, because of its high nutritive value. It is an excellent source of micronutrients, minerals (notably potassium), carboxylic acids, antioxidants such as lycopene, ß-carotene, lutein, phytoene, phytouene, phenolic compounds vitamins, and trace elements, but low in fat and calories, as we l as being cholesterol free (Caputo *et al.*, 2004; Hernández-Suárez *et al.*, 2007, Luthria *et al*., 2010; Molla *et al*., 2012; Nour *et al.*, (2013).

4.3 Effect of GA_3 on biochemical constituents of tomato

4.3.1 Moisture content

There is no significant difference was recorded due to the application of GA_3 (Table 4.3). The highest amount of moisture (95.49%) was recorded from T_1 (10 ppm) treatment. On the other hand, the lowest amount of moisture (94.23%) was recorded from T_2 (20 ppm) treatment. Kher *et al*., (2017) demonstrates that GA_3 application at 50 ppm concentration effectively increased the moisture content of tomato fruits.

4.3.2 Fiber content

The significant difference observed due to the application of GA_3 (Table 4.3). The highest value of fiber content (1.14%) was recorded in T_2 (20 ppm) treatment. and the lowest value of fiber content (0.91%) recorded in T_1 (10 ppm) treatment. Kaur *et al*., (2011) showed that moderate doses (20-40 ppm) significantly increased the levels of pectin and cellulose, thereby enhancing the fiber content.

4.3.3 Ash content

The highest value (0.64 %) was recorded in T_2 (20 ppm) treatment and the lowest value (0.48%) was recorded in T_1 (10 ppm) treatment. Nahar *et al.,* (2011) demonstrated that lower doses of GA_3 promote balanced growth in tomatoes. While the study didn't focus on ash content, it suggests that moderate growth may not excessively dilute the mineral content, potentially maintaining or slightly increasing the ash content in the fruit. The significant difference was observed due to the application of GA_3 (Table 4.3).

4.3.4 Protein content

The significant differences were recorded due to the application of GA_3 (Table 4.3). The highest value (1.65%) was recorded in T_2 (20 ppm) treatment and the lowest value (1.11%) was found in T_0 (control) treatment. Nahar *et al.,* (2011) found that low to moderate doses of GA_3 can enhance overall metabolic activity, including the biosynthesis of macromolecules such as proteins.

Table 4.3: Effect of GA_3 on moisture, ash and protein contents of tomato plants

Treatment	Moisture %	Ash%	Protein%	Fiber%
T_0	95.03 ns	0.58 c	1.11 d	1.06 bc
T_1	95.49 ns	0.48 d	1.27 c	0.91 d
T_2	94.23 ns	0.64 a	1.65 a	1.14 a
T_3	94.71 ns	0.61 b	1.47 b	1.02 b
T_4	95.11 ns	0.62 b	1.61 a	1.12 a
CV	0.50	10.77	16.12	8.73
LSD	2.32	0.02	0.07	0.07

Note: T_0= 0 ppm (Control), T_1= 10 ppm, T_2= 20 ppm, T_3= 30 ppm, T_4= 40 ppm

4.3.5 Reducing sugar

The highest amount of reducing sugar (5.5 mg/100g) was recorded from T_3 (30 ppm) treatment. On the other hand, the lowest amount of reducing sugar (3.85 mg/100g**)** was recorded from T_0 (control) treatment. Nahar *et al.,* (2011) showed that low doses of GA_3 stimulated moderate growth in tomatoes without significantly altering their reducing sugar content.

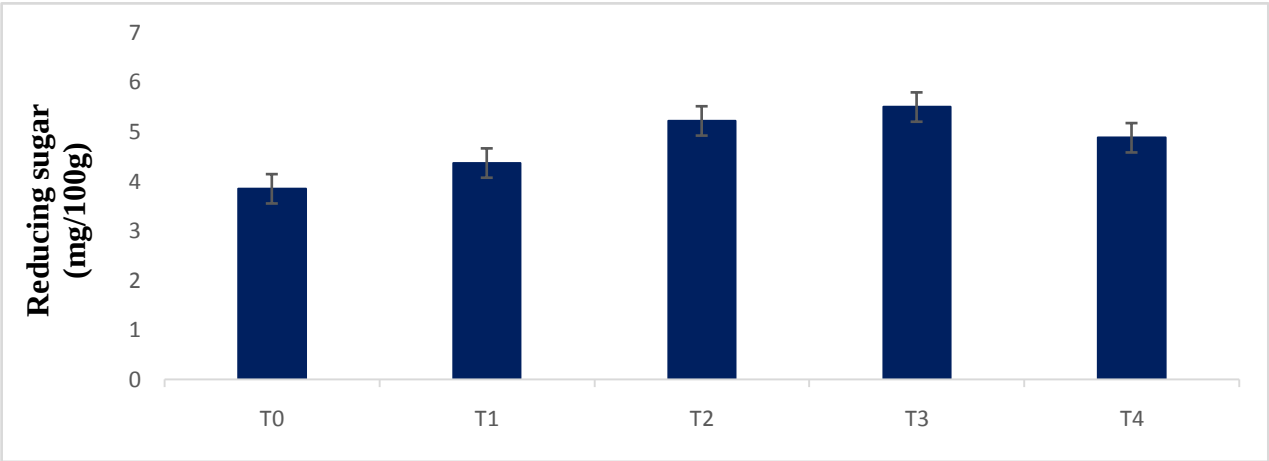

Figure 4.1: Reducing sugar of different treatments of tomato

4.3.6 Total sugar

The significant difference was observed due to the application of GA_3. The highest amount of total sugar (6.1 mg/100g) was recorded from T_4 (40 ppm) treatment. On the other hand, the lowest amount of total sugar (5.3 mg/100g) was recorded from T_0 (control) treatment. Kinet and Peet (2007) found that moderate doses of GA_3 (around 50 ppm) effectively increased the total sugar content in tomato.

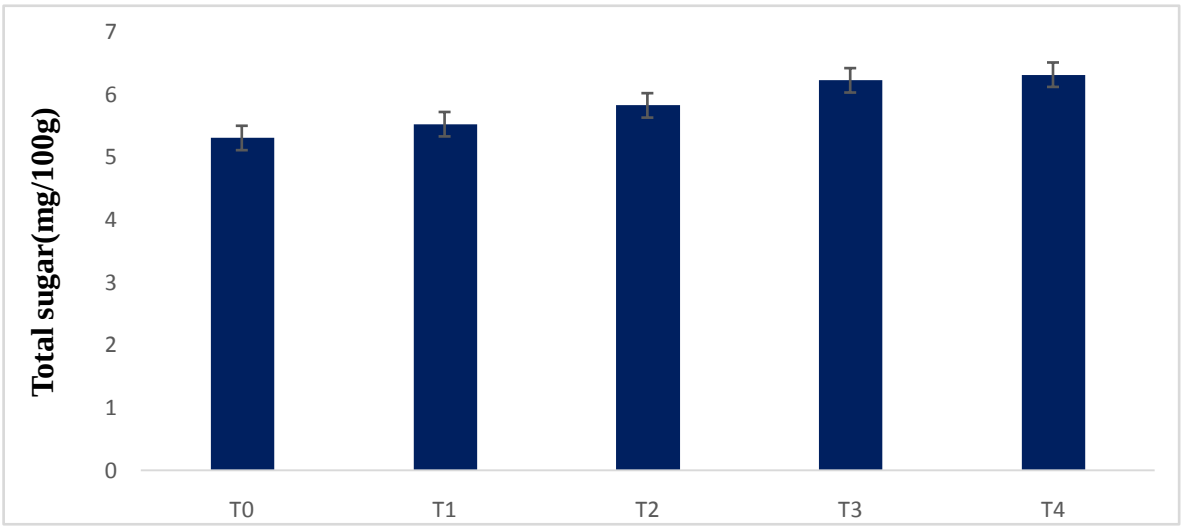

Figure 4.2: Total sugar of different treatments of tomato

4.3.7 ß carotene content

The significant difference was observed due to the application of GA_3. The highest value (14.48 mg/100g) was recorded in T_2 (20 ppm) treatment and the lowest value of β carotene (5.26 mg/100g) was recorded in T_0 (control) treatment. Rahman *et al.*, (2019) stated that the

highest β carotene (0.34 mg/100g) was recorded from G2 (75 ppm GA_3) and the lowest β-carotene was (0.30 mg/100g) from G0 (control) treatment.

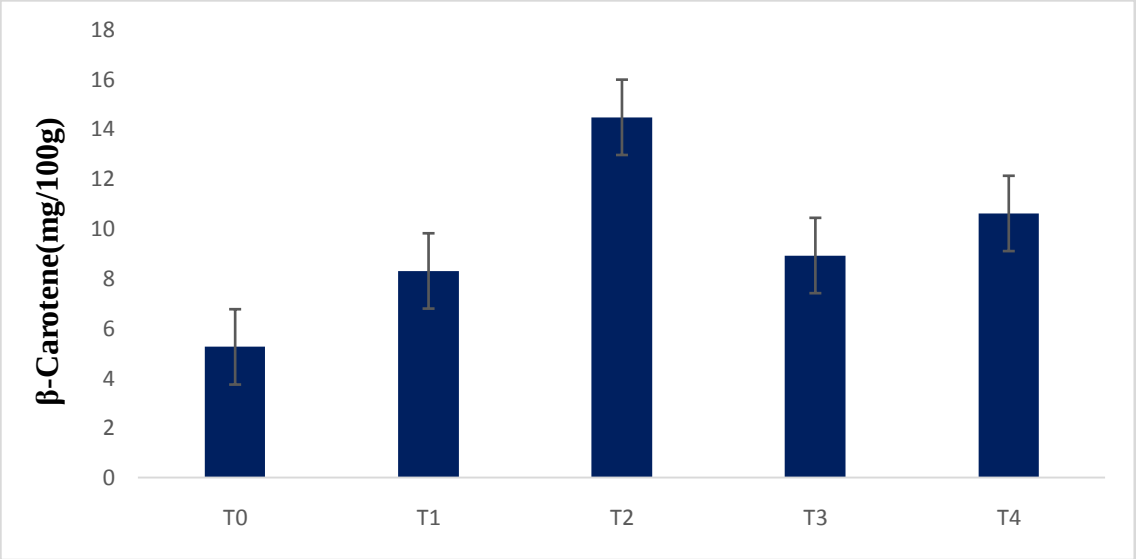

Figure 4.3: ß-carotene of different treatments of tomato

4.3.8 Vitamin A

The significant difference was recorded due to the application of GA_3. The highest value (24.14 mg/100g) was found in T_2 (20 ppm) treatment and the lowest value (8.77 mg/100g) was recorded in T_0 (control) treatment. Ahmed *et al.*, (2017) observed the highest increase in beta-carotene content was at 100 ppm GA_3.

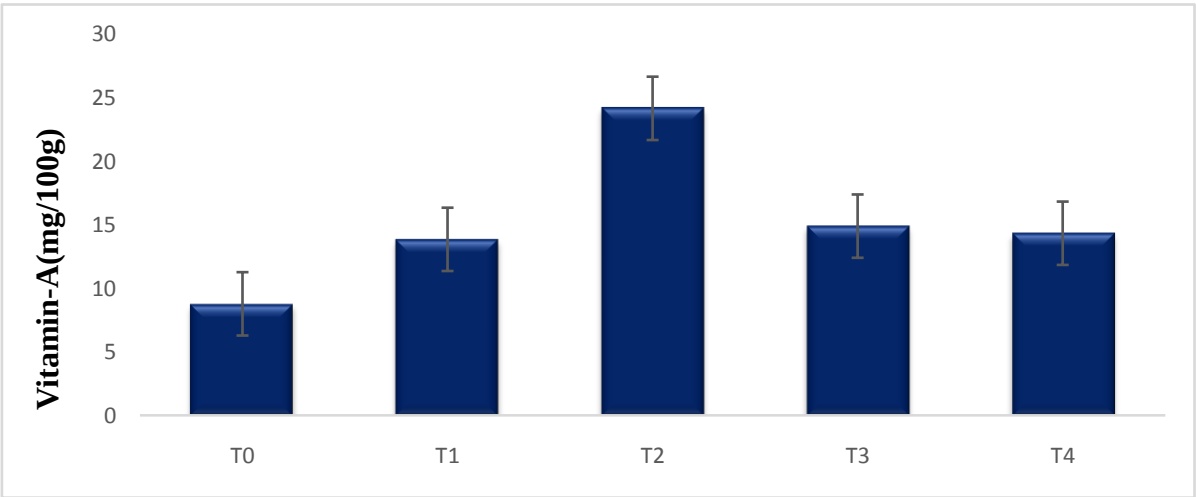

Figure 4.4: Vitamin A of different treatments of tomato

4.3.9 Vitamin C

The significant difference was observed due to the application of GA_3. The highest value (29.0 mg/100g) was recorded in T_4 (40 ppm) treatment and the lowest value (16.43 mg/100g) was recorded in T_0 (control) treatment. Rahman *et al*., (2019) observed that the higher amount of Vitamin C (104.8 mg/100 g) was found from Z1 (0.5 kg Zn ha^{-1}) treatment and lower amount Vitamin C (86.86 mg/100 g) was found from Z0 (control) treatment.

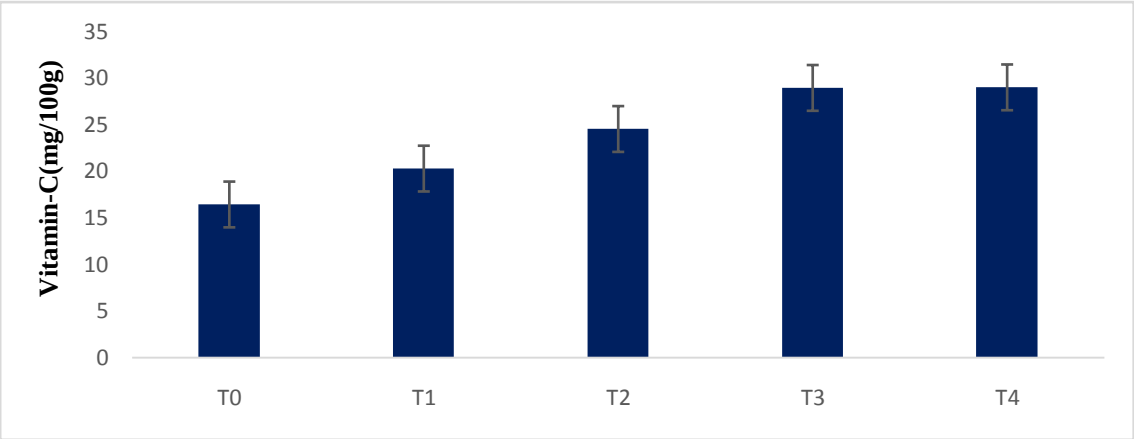

Figure 4.5: Vitamin C of different treatments of tomato

4.4 Mineral contents of tomato

Tomatoes are rich sources of biologically essential minerals such as Na, K, Ca, Mg, S and P for which contents are similar to those reported in eggplants and higher than those found in carrots, potatoes or onions

Table 4.4: Effect of GA_3 on sodium, magnesium and calcium contents of tomato plants

Treatment	Na mg/100g	Mg mg/100g	Ca mg/100g
T_0	36.86 b	47.78 a	29.55 b
T_1	37.18 b	48.2 a	39.74 a
T_2	40.43 a	48.38 a	29.92 b
T_3	40.35 a	42.25 b	39.81 a
T_4	41.16 a	42.51 b	40.1 a
CV	5.14	6.88	15.52
LSD	0.91	1.2	1.08

Note: T_0= 0 ppm (Control), T_1= 10 ppm, T_2= 20 ppm, T_3= 30 ppm, T_4= 40 ppm

4.4.1 Sodium content

The significant difference was observed due to the application of GA_3 (Table 4.4). The Na content available in various treatments of tomato ranged from 36.86 to 41.16 mg/100g. The highest Na content (41.16 mg/100g) was found in T_4 (40 ppm) treatment. On the other hand, the lowest Na content (36.86 mg/100g) was obtained from T_0 (control) treatment. Gupta and Kaur (2013) reported that the highest reduction in sodium content was observed at 100 ppm GA_3.

4.4.2 Magnesium content

The significant difference was observed due to the application of GA_3 (Table 4.4). The highest amount of Mg (48.38 mg/100g) was found in T_2 (20 ppm) treatment. On the other hand, the lowest amount of Mg (42.25 mg/100g) was obtained from T_3 (30 ppm) treatment. A study by Khan *et al*., (2014) who found that applying GA_3 at 20 ppm significantly increased the Mg content in tomato leaves compared to untreated controls. The increased Mg content was attributed to enhanced root development and nutrient uptake.

4.4.3 Calcium content

The significant difference was recorded due to the application of GA_3 (Table 4.4). The highest amount of Ca (40.1 mg/100g) was recorded in T_4 (40 ppm) treatment. On the other hand, the lowest amount of Ca (29.5 mg/100g) was recorded from T_0 (control) treatment. El-Tohamy and El-Greadly (2007) reported that the highest calcium content was observed at 100 ppm GA_3, suggesting an optimal concentration for calcium uptake.

4.4.4 Potassium content

The significant difference was observed due to the application of GA_3. The highest amount of K content (108.92 mg/100g) was found in T_4 (40 ppm) treatment. On the other hand, the lowest amount of K content (98.3 mg/100g) was obtained from the T_0 (control) treatment. El-Tantawy and El-Beik (2009) observed that the highest potassium content was at 100 ppm GA_3, indicating an optimal concentration for potassium uptake.

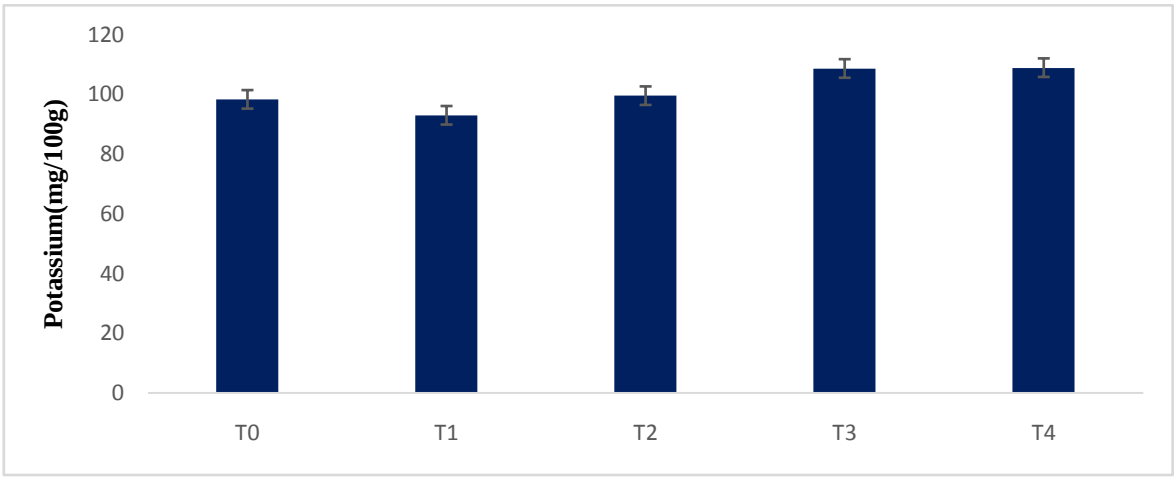

Figure 4.6: Potassium content of different treatments of tomato

4.4.5 Phosphorus content

The significant difference was observed due to the application of GA_3. The highest amount of P content (14.88 mg/100g) was found in T_2 (20 ppm) treatment. On the other hand, the lowest amount of P content (13.17 mg/100g) was obtained from T_1 (10 ppm) treatment. Ali *et al.*, (2015) observed that the highest phosphorus content was at 100 ppm GA_3, suggesting an optimal concentration for maximizing P uptake.

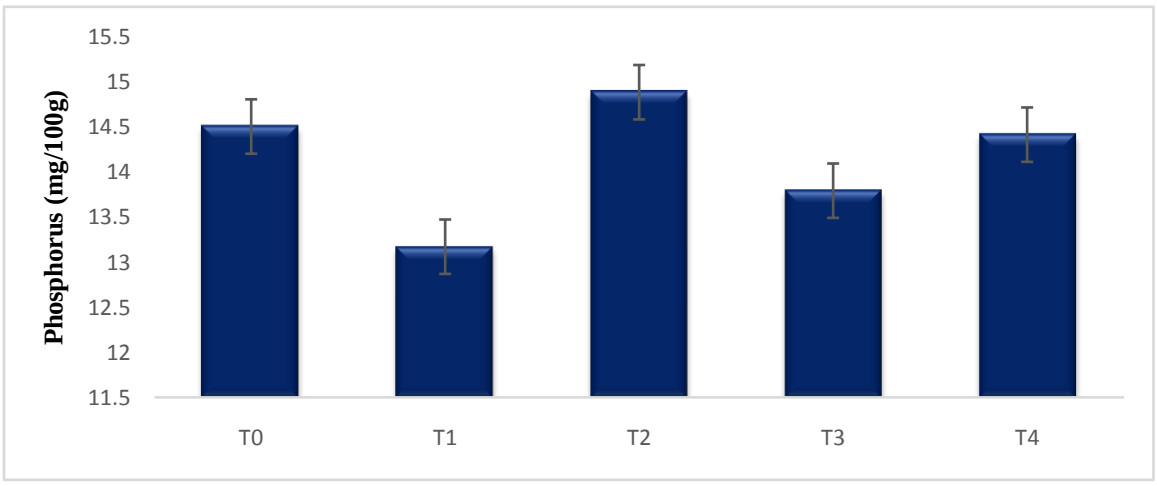

Figure 4.7: Phosphorus content of different treatments of tomato

4.4.6 Sulphur content

The significant difference was observed due to the application of GA_3. The highest amount of S content (10.04%) was found in T_4 (40 ppm) treatment. On the other hand, the lowest amount of S content (7.72%) was obtained from T_2 (20 ppm) treatment. Youssef and Awad (2008) found the optimal concentration for maximizing sulfur content was at 100 ppm GA_3.

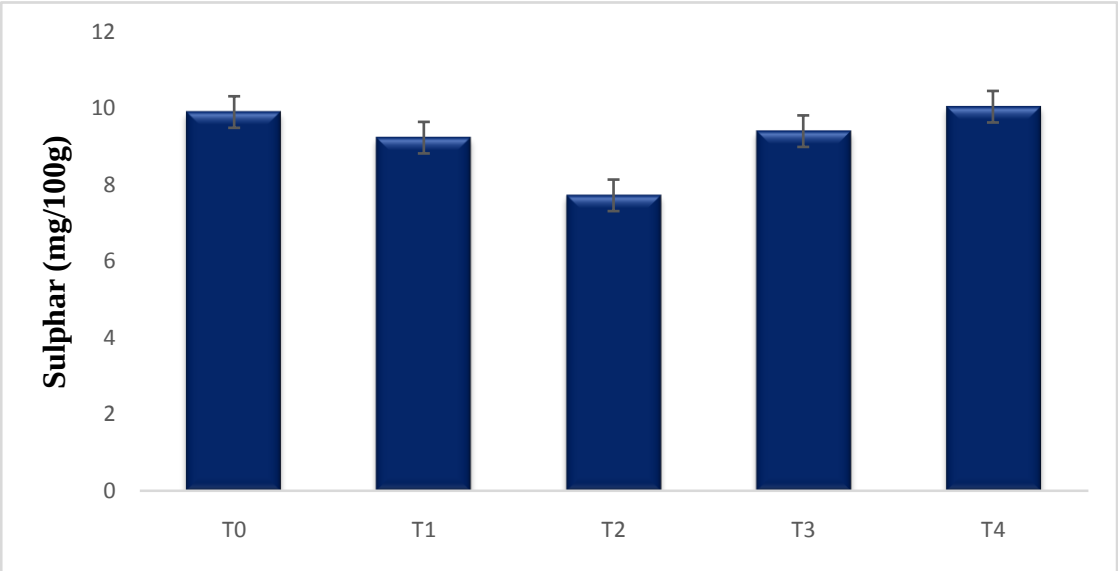

Figure 4.8: Sulphur content of different treatments of tomato

CHAPTER V
SUMMARY AND CONCLUSION

Tomato is agronomically and economically important plant, a member of Solanaceae family with a significant foundation source of various vital vitamin C and nutra-ceuticals compounds. A restricted sum of research was performed to explore health maintain compounds present in tomato besides antioxidant and phenolic activities. Additionally, primary metabolites, like amino acids and carbohydrates, mainly overlooked. Tomato is rich source of various valuable bioactive components which must be recognized and more research would be carried out to recognize the nutritive and pharmacological worth of tomato in real words.

Due the application of GA_3, the tallest plant (72.94 cm) at 60 DAT, maximum number of leaves (96.00), maximum number of flowers (38.00), maximum number of fruits (20.00), the maximum length of fruit (5.44 cm), maximum diameter of fruit (4.46 cm) and maximum fresh weight of fruit (53.33 g) were recorded from 40 ppm GA_3 (T_4 treatment). Maximum number of branches per plant (12.00) at 60 DAT produced by T_2 (20 ppm) treatment. On the other hand, minimum number of leaves (66.67) at 60 DAT, minimum number of branches (9.00), minimum number of flower (23.33),minimum length of leaf (37.39 cm), minimum diameter of fruit (3.89 cm) and minimum fresh weight of fruit (42.01 g) were recorded from the treatment of 10 ppm GA_3 (T_1 treatment). The shortest plant height (72.94 cm) at 60 DAT, minimum number of fruit (14.33), minimum length of fruit (4.74 cm) were produced by T_2 (20 ppm) treatment.

The highest amounts of total sugar (6.1 mg/100g), β carotene (14.48 mg/100g), vitamin C (29.0 mg/100g), sodium content (41.16 mg/100g), potassium content (108.92 mg/100g), calcium content (40.1 mg/100g) were recorded from 40 ppm GA_3 (T_4 treatment). The lowest amounts of total sugar (5.3 mg/100g), fiber content (0.91%), ash content (0.48%), value β carotene (5.26 mg/100g), value of vitamin C (16.43 mg/100g), sodium content (36.86 mg/100g), magnesium content (42.25 mg/100g), potassium content (98.3 mg/100g), lowest calcium content (29.55 mg/100g) were recorded from 10 ppm GA_3 (T_1 treatment). The highest amount of moisture (95.49%) was recorded from T_1 (10 ppm). On the other hand, the lowest amount of moisture (94.23 %) was recorded from T_2 (20 ppm) treatment.

From experiment T_2 (20 ppm) was given the highest amounts of ash (0.64%), protein (1.65%), ß-carotene (14.48 mg/100g) and magnesium (48.38 mg/100g). The highest amounts of reducing sugar (5.5 mg/100g) was obtained from T_3 (30 ppm) treatment and the lowest amount of reducing sugar (3.85 mg/100g**)** was obtained from T_0 (0 ppm) treatment. Based on the conducted experiment, it has been determined that gibberellic acid had a significant impact on the growth and fruit yield of tomato. Among the various treatments of gibberellic acid, the usage of GA_3 at 40 ppm resulted in an increased plant height, number of flower clusters, number of flowers, number of fruits and early flowering in tomato. High concentration of gibberellic acid enhances stem elongation leading to taller plants, number of flower and fruit per plant, fruit size and weight, improving water and nutrient uptake, increase the levels of certain vitamins, minerals, growth, yield and quality of tomato.

Future Research Recommendations

Future studies should be

- Investigate the impact of varying GA_3 concentrations and application frequencies at different growth stages to optimize growth and yield.
- Conducted by setting more treatments of GA_3 to study the maximum growth and yield of tomato at different places of Bangladesh.
- Focus on broader applications and long-term impacts on agro-ecosystems and consumer health.

REFERENCES

Aditya TL, Rahman, Alam MS and Akhtar *et al*. (2007). Correlation and path co-efficient analysis in tomato. Bangladesh Journal of Agriculture Science 26(1):119-122.

Adlakha PA and Verma SK. 1965. Effect of gibberellic acid on fruiting and yield of tomato. Science and Culture 31: pp. 301-303.

Ahmad H, Hassan MR, Laila B, Mahbuba S and Uddin AFMJ. 2017. Plant growth promoters on growth and yield of summer cherry tomato line (JP-27). Journal of Bioscience and Agriculture Research.12 (02): 1041-1047.

Ahmed S, Ahammed GJ and Yu JQ. 2017. Influence of gibberellic acid on Growth, Yield, and Antioxidant Content of tomato (*Solanum lycopersicum*). Journal of Plant Physiology, 215, 29-35.

Akand MH, Mazed HEM, Pulok AI, Chowdhury SN and Moonmoon JF. 2015. Growth and yield of tomato (*Lycopersicon esculentum* Mill.) as influenced by different different level of gibberellic acid application. International Journal of Applied Research 1(3):71-74.

Akhtar N, Bhuian AH, Quadir A and Mondal F. 1997. Effect of NAA on yield and quality of summer tomato. Annals Bangladesh Agriculture 6(1): 67-70. BBS. 2015. Year Book of Agricultural Statistics of Bangladesh, Statistics Division, Ministry of Planning, Govt. of the People's Republic of Bangladesh. p. 297.

Akter A, Ali E, Islam, MMZ, Karim R. and Razzaque, AHM. 2007. Effect of GA_3 on Growth and Yield of Mustard. Int. J. Sustain. Crop Prod. 2(2):16-20

Ali A and Anjum MA. 2015. Influence of gibberellic acid on Growth, Yield, and Nutrient Uptake of tomato (*Solanum lycopersicum* L.). Journal of Plant Nutrition, 38(4), 610-617.

Bhalekar, NB, Gupta, MN and Deshpande NSA. 2006. Effect of growth regulators on growth and yield of tomato in summer. Journal of Maharashtra Agricultural Universities. 31(1):6465.

Bhosle AB, Khorbhade SB, Sanap PB and Gorad MJ. 2002. Effect of plant hormones on growth and yield of summer tomato. (*Lycopersicon esculentum* Mill.). Orissa Journal of Horticulture. 30(2): 63-65.

Bima P, Surati FM, Soressi GP, Terzi M, Cella R and Falavigna A. 1995. Effect of gibberellic acid and micropropagation on auxiliary shoot induction in monostem

genotype of tomato (*Lycopersicon esculentan* Mill.). Advanced Horticulture Forest. 4: 73-84.

Bose, TK and Som, MG. 1990. Vegetable Crops in India. Published by B. Mitra and Naya Prokash, 206 Bidlran Sarani, Kolkata, India. p. 241 and 249.

Chern JK, Wu CW Lin JK and Tarng SF. 1983. Effect of plant growth regulators on the growth and development of tomato Journal Agronomic Association China. 124: 31-42.

Choudhury B. 1979. Vegetables (6th Revised Edn.) national Book Trust, New Delhi, India. p. 46.

Choudhury S, Islam N, Sarkar MD and Ali MA. 2013. Growth and Yield of Summer tomato as Influenced by Plant Growth Regulators. International Journal of Sustainable Agriculture. 5 (1): 25-28.

Chung HD and Chori YZ. 2001. Foliar application of plant growth regulators affects distribution and accumulation of calcium (45CaCl2) in tomato leaves. Korean Journal of Horticulture Science 42(6):656-660.

Deb P, Suresh CP, Saha P and Das N. 2009. Effect of NAA and GA_3 on yield and quality of tomato *(Lycopersicon esculentum* Mill.). Environment and Ecology. 27(3):1048-1050.

Davies *et al.* (2003). Influence of auxins and micronutrient formulations on phosphorus content in tomato (*Lycopersicon Esculentum* Mill.) fruits and its products. Advanced Plant Science. l7(1): 129-132.

Desai SS, Chovatia RS and Virendra S. 2012. Effect of different plant growth regulators and micronutrients on fruit characters and yield of tomato cv. Gujarat tomato-3 (GT-3). Asian Journal of Horticulture. 7(2): 546-549.

Edris KM, Islam ATMT, Chowdhury MS and Haque AKMM.1979. Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. 1979; 118.

EI-Habbasha KM, Gomaa HM, EI-Gizawy AM and Mohamed SS. 1999. Response of tomato plants to foliar spray with some growth regulators under later summer conditions. Egyptian Journal of Horticulture. 26: 35-46.

El-Abd SO, Singer SA, Ilelmy YI and Beltagv MSE. 1995. Plant growth regulators for improving fruit set of tomato. Egypt Journal of Horticulture., 22 (2): pp. 163-173.

El-Tanahy EM and El-Beik KH. 2017. Physiological Responses of Tomato Plants to gibberellic acid (GA_3) and Indole Acetic Acid (IAA). Journal of Plant Nutrition, 32(7), 1191-1203.

El-Tohamy WA and El-Greadly NH. 2007. Physiological Responses, Growth, Yield and Quality of Snap Beans in Response to Foliar Application of Nutritional Compounds. Research Journal of Agriculture and Biological Sciences, 3(3), 168-175.

FAO. 2012. FAO Production Year Book. Food and Agricultural Organization of the United Nations, Rome 00100, Italy.

Gad N. and Atta Ali, MA. 2006. Effect of NAA and IBA on root formation of tomato. Journal of Applied Science Research. 2(7):423-429.

Gelmesa D, Abebie B and Desalegn L. 2010. Effects of gibberellic acid and 2,4-dichlorophenoxyacetic acid spray on fruit yield and quality of tomato (*Lycopersicon esculentum* Mill.). Journal of Plant Breeding and Crop Science. 2(10): 316-324.

Gomez KA and Gomez AA. 1984. Statistical Procedures for Agricultural Research (2nd Edn.). John Willey and Sons, Singapore. pp. 28-92.

Groot SPC, Bruibsma J and Karssen CM. 1987. The role of endogenous gibberellic in seed and fruit development of tomato *(Lyropersicon esculentum* Mill.). Studies with a gibberellic deficient mutant. Physiologia Planetarium. 71 (2): 184-190.

Gulnaz A, Iqbal J and Awn F. 1999. Seed treatment with growth regulators and crop productivity. II. Response of critical growth stages of tomato under salinity stress. Cereal Research Communications. 27 (4):419-426.

Gupta PK and Gupta AK. 2000. Efficacy of plant growth regulators (IAA and NAA) and micronutrient mixture on growth, flowering, fruiting and shelf life of tomato. (*Lycopersicon esculentum* Mill.). Bioved. 11:25-29.

Gupta PK, Gupta AK and Reddy S.2002. Efficacy of PGR (IAA and NAA) and micronutrient (Multiplex and Humaur) on mineral. Bionotes. 5 (l): pp. l8-20.72

Gupta PK, Gupta AK and Varshney ML. 2001. Effect of auxins (IAA & NAA) and micronutrient mixtures (Multiplex and Humaur) on biochemical parameters of tomato fruits. Bionotes., 3 (2): p. 38.

Gupta R and Kaur N. 2013. Effect of Gibberellic Acid on Sodium Exclusion and Growth of tomato (*Lycopersicon esculentum* Mill.) under Salt Stress. Journal of Plant Growth Regulation,32(3), 617-624.

Haider EA. 1991. Agro Ecological Region of Bangladesh. Land Resources Appraisal of Bangladesh Agricultural Development. Plant Physiology. 31: pp. 312-323.

Haque MS, Islam MT and Rahman M. 1999. Studies on the presentation of semi-concentrated tomato juice. Bangladesh Journal of Agricultural. Science. 26(1): 37-43.

Hossain MAE. 1974. Studies on the effect of parachlorophenoxy acetic acid and gibberellic acid on the production of tomato. An M. Sc. Thesis Dept. of Hort., BAU, Mymensingh. pp. 25.

Gurpinder Kaur and Amarjeet Kaur 2011. Plant growth and fruit yield attributes of cape gooseberry cv. Aligarh asaffected by the use of different growth regulators. AGRICULTURAL RESEARCH COMMUNICATION CENTRE Agric. Sci. Digest., 36 (2) 2016: 138-14.

Kanwar JS, Saimvhi MS, Saimbhi MS and Nandapuri KS. 1976. Effect of GA on Increasing fruit set and yield in tomatoes. The Punjab Vegetables Grower. 11: 41-43.

Kar PL, Longkumar M and Sanyal D. 1993. Effect of plant growth regulators and their methods of application on growth, flowering and yield in tomato (*Lycopersicon esculentum* Mill) cv. Pusa Early Dwarf. Horticultural Journal. 6(1):45-49.73

Kataoka K, Uernachi A, Nonaka I and Yazawa S. 2004. Effects of endogenous gibberellins in the early stages of fruit growth and development of the 'Severianian' tomato. Journal of Horticultural Science Biotechnology. 79 (1): 54-58.

Kaushik MP, Sharma JK and Singh I. 1974. Effect of alpha naphthalene acetic acid, gibberellic acid, kinetin and norphactin on yield of tomato. Plant Science 6: 51-53.

Kazemi M. 2014. Effect of gibberellic acid and potassium Nitrate spray on vegetative growth and reproductive characteristics of tomato. Journal of Biology and Environmental Science. 8(22):1-9.

Mehta AK and Mathi DJ. 1975. Effects of growth regulators on summer tomato (*Lycopersicon esculentum* Mill.) Haryana Horticultural Science. 4 (2): 167-176.

Nahar, N, Hasanuzzaman, M, & Rahman, ML. (2011). "Effect of GA_3 on growth and yield of tomato." Bangladesh Research Publications Journal.30(1):11-16.75.

Nibhavanti B, Bhalekar MN, Gupta NS and Anjali D. 2006. Effect of growth regulators on growth and yield of tomato in summer. Maharastra Journal of Agriculture.31 (1): 64-65.

Olaiya CO, Soetan KO and Ogunkolade NS. 2010. Evaluation of the biochemical effects of auxins on nutritional quality of tomato (*Solanum lycopersicon*),

Onofeghara FA. 1981. The effects of growth substance on flowering and fruiting of tomato *(Lycopersicon esculentum* Mill.). Phyton Argentina. 40 (1): pp.107-116.

Pandy VK and Singh VB. 1983. Vegetative growth. dry matter production and seed yield of field pea (*Pisum sativum* L.). legume Res. 3:1-6.

Pargi SC, Lal EP, Singh N and Biswas TK. 2014. Effect of Naphthalene Acetic acid on biochemical parameters, growth and yield of tomato (*Lycopersicon esculentus* L. Mill). IOSR Journal of Agriculture and Veterinary Science. 7(7):16-18.

Patel JS, Sitapara HH and Patel KA. 2012. Influence of plant growth regulators on growth, yield and quality of tomato and brinjal, International Journal of Forestry & Crop Improvement 3 (2): 116-118.

Pruthi JS. 1993. Major spices of India. Crop management and post-harvest technology. Indian journal of Agricultural Research. New Delhi.

Pundir JPS and Yadav PK. 2001. On effect of GA_3, NAA and 2, 4-D on growth, yield and quality of tomato var. Punjab Chhuhara. Current Agriculture. 25 (1/2): 137-15.

Rodríguez-Concepción M and Stange C. 2013. Biosynthesis of carotenoids in tomato fruits. Molecular Plant, 6(2), 345-358.

Singh DK and Lal G. 2001. Effect of plant bio-regulators on the growth and yield of tomato (*Lycopersicon esculentum* Mill.). Progressive Horticulture. 33(1):61-64.

Singh J, Singh KP and Kalloo G. 2002. Effect of some plant growth regulators on fruit set and development under cold climatic conditions in tomato (*Lycopersicon esculentum* Mill.) Prog. Horticulture 34 (2): 211-214.

Singh R, Sant AK and Singh L. 2005. Effect of plant growth and micro-nutrient mixture on growth and yield of tomato (*Lycopersicon esculentum* Mill.). Bioved. 16 (1/2): pp.101105

Singh Y and Singh SS. 2011. Effect of different concentration of plant growth regulators on the yield and quality attributes of tomato (*Lycopersicon esculentum* Mill.). Vegetable Science. 38(2):228-230.

Sumiati E. (1987). Effect of plant growth regulators on flowering and yield of tomatoes in the Lembang Highlands. Bull. Pene. Horticulture 15 (1): 134-143.

Thompson HC and Kelly WC. 1957. Vegetable Crops. 5th Edn. McGraw Hill Book Co., New York, p.392.

Thompson HC and Kelly WC. 1983. Vegetable Crops. 5th Edn. Tata McGraw Hill Publishing Co. Ltd. New Delhi. p. 611.79

Tiwari AK and Singh DK. 2014. Use of Plant Growth Regulators in tomato (*Solanum lycopersicum* L.) under Tarai Conditions of Uttarkhand. Indian Journal of Hill Farming. 27 (2).

Tomar IS and Ramgiry SR. 1997. Effect of growth reguletor on yield and yield attributes n tomato (*Lycopersicon esculentum* Mill). Advanced plant Sciences., 10 (2): 29-31.

Verma PPS, Meena M and Meena SK. 2014. Influence of Plant Growth Regulators on Growth, Flowering and Quality of tomato (*Lycopersicon Esculentum* Mill). Indian Journal of Hill Farming. 27(2):19-22.

Zhang CX, Chen YM, Fu JH, Cheng SZ and Lin FY. 2009. Greater vegetable and fruit intake is associated with a lower risk of breast cancer among Chinese woman. International Journal of Cancer. 125(1):8-181

Youssef AM and Awad ME. 2008. Physiological Response of tomato Plants to Some Bioregulators. Research Journal of Agriculture and Biological Sciences, 4(5), 422-430.

Wu CW, Lin JY, Tarug S and Cheru JL. 1983. Effect of plants growth regulators on the growth and development of tomato. II. Effects of plant growth regulators on vegetative growth of tomato. Journal of Agriculture in China. 124: pp. 31-42

Yadav PK and Pundir JPS. 2001. Effect of GA_3, NAA and 2,4-D on growth, yield and quality of tomato var. Punjab Chhuhara. Current Agriculture. 25(1/2):137-138.