GROWTH AND YIELD OF TOMATO AS INFLUENCED BY SEEDLING AGE AND IAA

UMME ZAHIDA AKHTAR

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA – 1207

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BY

UMME ZAHIDA AKHTAR

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Approved by:

Prof. Md. Hasanuzzaman Akand	**Prof. Dr. Md. Ismail Hossain**
Department of Horticulture	Department of Horticulture
SAU, Dhaka	SAU, Dhaka
Supervisor	**Co-Supervisor**

Tahmina Mostarin
Chairman
Examination Committee

DEDICATED

TO

"The Farmers working hard for the Development of Agriculture"

DEPARTMENT OF HORTICULTURE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka- 1207

CERTIFICATE

This is to certify that the thesis entitled "**Growth and Yield of Tomato as influenced by Seedling Age and Indole-3-acetic acid**" submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE**, embodies the result of a piece of ***bona fide*** research work carried out by **Umme Zahida Akhtar**, Reg. No. **14-06317** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June 2015
Dhaka, Bangladesh

Prof. Md. Hasanuzzaman Akand
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

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ABSTRACT

An experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2014 to April 2015 to study the growth and yield of tomato as influenced by seedling age and Indole-3-Acetic acid. The experiment was laid out in a Randomized Complete Block Design with three replications and consisted of two factors, Factor A(3 different age of seedling): S_1=25 , S_2= 30 , S_3= 35 days old seedling respectively and Factor B (4 levels of IAA): I_0 = 0 ppm, I_0 = 0 ppm, I_1 = 80 ppm I_2 = 100 ppm, I_3 = 120 ppm. The highest value in plant height (99.75 cm), weight of fruit (91.84 g), dry matter percentage of fruit (11.12%), length of root (37.83 cm), chlorophyll percentage of leaf (53.71%), carbon assimilation rate (11.32%) and yield of fruit (80.50 t/ha) were recorded from S_1 treatment and lowest value was found in S_3. In case of IAA, The highest value in plant height (88 cm), weight of fruit (91.12 g), dry matter percentage of fruit (11.72%), length of root (34.89 cm), chlorophyll percentage of leaf (56.04%), carbon assimilation rate (9.87 %) and yield of fruit (80.19 t/ha) were recorded from I_1 treatment and lowest value was found in I_0.. The treatment combination of S_1I_1 produced the highest value in plant height (108 cm), weight of fruit (110 g), dry matter percentage of fruit (12.17 %), length of root (43.01 cm), chlorophyll percentage of leaf (57.93%), carbon assimilation rate (12.55%) and yield of fruit (94.05 t/ha) and the S_3I_0 produced the lowest value in growth and yieldcharacteristics. So, 25 days old seedling and 80 ppm IAA combination was found suitable for growth and yield of tomato.

CONTENTS

CONTENTS

CONTENTS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

ABBREVIATION	ELABORATION
AEZ	Agr-Ecological Zone
Anon.	Anonymous]
ANOVA	Analysis of Variance
@	at the rate of
Adv.	Advanced
Agric.	Agricultural
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
CV	Coefficient of Variation
cv.	Cultivar
df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
DAT	Days after Transplantation
e.g.	example
et al.	and others
etc.	etcetera
FAO	Food and Agricultural Organization
GA_3	Gibberellic Acid

ABBREVIATION	ELABORATION
HRC	Horticultural Research Center
IAA	Indole-3-Acetic Acid
J.	Journal
MoP	Muriate of Potash
ns	Non Significant
NAA	Naphthalene Acetic Acid
PGR	Plant Growth Regulator
pH	Hydrogen ion concentration
ppm	Parts per million
%	Percentage
Res.	Research
RH	Relative Humidity
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources Development Institute
Sci.	Science
TSP	Triple Super Phosphate
UNDP	United Nations Development Program
µg	Microgram
Vol.	Volume

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) which belongs to the solanaceae family is a self pollinated vegetable crop. It gains importance for its wide range of use and nutritional values. In Bangladesh, tomato is cultivated all over the country due to its adaptability to wide range of soil and climate (Ahmed, 1995). At present, tomato ranks third, next to potato and sweet potato, in terms of worlds vegetable production (FAO, 2013). The leading tomato producing countries are China (50664255 ton), Egypt (8533803 ton), Italy (4932463 ton), Spain (3683600 ton), Brazil (4187646 ton), Mexico (3282583 ton) and USA (1257455 ton) [FAO, 2013].

Tomatoes are incredibly versatile food. Different stage of the fruit used for different purpose. It can be consumed either in fresh, cooked or as processed food like ketchup, sauce, juice, jam, jelly etc. Tomatoes are widely consumed either raw or after processing and can provide a significant proportion of the total antioxidants in the diet (Martinez-Valvercle *et al*., 2002).

Tomato contains various organic acids like citric, malic, acetic and folic acid. It is an excellent source of many nutrients and secondary metabolities that are important for human health; mineral matter, vitamins C and E, B-carotene, lycopene, flavonoids, organic acids, phenolics and chlorophyll (Giovanelli and Paradise, 2002). Tomatoes are a rich source of lycopene, lutein and beta-carotene, powerful antioxidants that have been shown to protect the eyes against light-induced damage associated with the development of cataracts and age-related macular degeneration (AMD). Tomato contains a number of nutritive elements almost double compared to fruit apple and shows superiority with regard to food values (Barman, 2007) that is why it is called “poor man’s apple” which can provide sufficient nutrient to the poor people in lower price.

Bangladesh produced 251000 tons of tomato in 23,827 hectres of land during the year 2012 -2013(BBS, 2012). The average yield of tomato in Bangladesh is quite low (10.54 t/ha) compare to that in China (48.1 t/ha), Egypt (34 t/ha), Italy (50.7 t/ha), Spain (74.0 t/ha), Brazil (60.7 t/ha), Mexico (30.5 t/ha) respectively (Anonymous, 2011).

Yield expression of a genotype largely dependent on environment and other management practices. Yield may vary with the variation of cultural practices. Seedling age may be the limiting factors of yield. The age of seedlings to be transplanted is very important for proper establishment in the field and production of good quality fruits as well as high yield. . The duration of transplants growth affect the vegetable development, vegetative mass, biochemical composition, output of standard transplants, growth after transplantation, resistance to unfavorable conditions, labor expenses of transplant cultivation [Vavrina 1998, Schrader 2000, Handley and Hutton 2003, Henare and Ravanloo 2008].

Application of modern technology during growth stage of plant may increase growth and yield. Gustafson (1936) was the first to demonstrate that the application of substances closely related to auxins onto the stigmas of tomato and several other species causes the ovary to develop into a parthenocarpic fruit. IAA stimulates cell elongation by stimulation wall-loosening factors, such as elastins, to loosen cell walls and the effect is stronger if gibberellins are also present (Bunger-Kibler and Bangerth, 1983). IAA also stimulates cell division if cytokinins are present (Zhoa, 2008). IAA induces the formation and organization of phloem and xylem. When the plant is wounded, the IAA may induce the cell differentiation and regeneration of the vascular tissues (Ulmasov *et al*., 1999). IAA promotes root initiation and induces both growth of pre-existing roots and adventitious root formation, i.e., branching of roots (Varga and Bruinsma, 1976). As more native auxin is transported down the stem to the roots, the overall development of the roots is stimulated. The longer and branched root can uptake more nutrients from the soil which are accumulated to the plant sink and increase the yield (Wang *et al*., 2005). If the source of IAA is removed, such as by trimming the tips of stems, the roots are less stimulated accordingly. IAA induces shoot apical dominance and the axillary buds are inhibited by IAA (Woodward and Bartel, 2005). IAA is required for fruit growth and development and delays fruit senescence and plays also a minor role in the initiation of flowering and development of reproductive organs (Asahira *et al*., 1967).

Therefore, as per requirement of recent agricultural policy to increase yield with better quality and less investment, an attempt was made to study the effects of different seedling age and different dose of Indole-3-Acetic Acid(IAA) on plant growth and yield of tomato with the following objectives:

i. To determine the effect of different seedling age on growth and yield of tomato.
ii. To investigate the effect of exogenous application of IAA(Indole-3-Acetic Acid) on growth and yield of tomato.
iii. To find out the suitable combination of seedling age and IAA for ensuring the maximum growth and yield of tomato.

CHAPTER II
REVIEW OF LITERATURE

Tomato is very important vegetable which can provide nutrition in relatively low price that has a great impact in developing countries like Bangladesh. This is why researchers are more concern about increasing yield in different parts of the worlds with different factors like seedling age and indole-3-acetic acid. But the combined effect of seedling age and indole-3-acetic acid has not clearly defined. Relevant available information in this connection has been described in this chapter:

2.1 Effect of Seedling age on growth and yield of tomato

Histamoni and Urabe (1973) reported that high soil temperature (15° C) use of the young tomato seedling supported vigorous vegetative growth, resulting in longer and thicker stems, more leaves and larger leaves. The proportion of large fruits increased with the use of young seedlings and additional nitrogen. Size of fruit showed an interaction between soil temperature and moisture. From the findings, it was possible to produce high yield of good quality fruit by controlling the nitrogen supply, plant density, high intensity, night temperature, soil temperature, soil moisture and seedling quality.

Tongova and Zhelev (1975) reported that both early sowing and early planting of tomato gave increased yield. The highest early and total yields were produced by plants sown on 20 September and transplanted at the 4-5 leaf stage.

Adelana (1976) reported that the earliest planting of tomato seedlings resulted in greater leaf area, higher yield and number of fruits per plant and greater average fruit weight than later planting. Souma *et al*. (1976) while investigating into the effect of the length of the seedling age on the growth, yield and quality of tomato reported that the seedling transplanted 40 days after sowing grow best and that abnormal fruits were produced by the plants transplanted 60 and

70 day after sowing. Dayan *et al*. (1978) have indicated that delayed planting reduced overall yield.

On the other hand, while investigating into the effect of different methods and time of sowing on yield and quality of tomato found that the number of fruits per plant and mean yield per plant decreased with delay in sowing date. Sowing date and transplant age have tremendous effect on growth and yield of tomato (Ravikumar and Shanmugavelu, 1983).

Adelana (1983) carried out an experiment to determine the right age to transplant tomato seedlings. Seedlings were transplanted at 3, 4, 5 and 6 weeks after sowing in the nursery. He found that the younger transplants grew faster and therefore produced greater dry matter than the older ones. Also, flowering and fruiting were earlier in the younger transplants. Fruit yield was highest in the 3-week old transplants but this was not significantly higher than those of 4-week old. It was therefore recommended that tomato seedlings should be transplanted when they are between 3 and 4 weeks old.

In Bangladesh, Rahman and Quasem (1986) carried out an experiment to observe proper age and yield contributing characters studied except days to first flower, days to 50% flower and seedling on yield of tomato. The age of seedling did not show any significant difference for all yield days to first fruit set where earliness was observed with the increased age of seedling. Yield increase of 8 tons per hectare was obtained from 40 days old seedling (64.53 t/ha) over 20 and 30 days of seedling.

In Thailand, Palamakumbura (1987) carried out an experiment to observe the effect of seedling age and spacing on growth and yield of tomato. Response of the tomato variety CL-143-0-10-3-0-1-10 to different seedling ages of 15, 20, 25 and 30 days as well as spacing of 50 × 100, 40 × 100, 30 × 100, 20 × 100 cm was studied during October 1st, 1986 to February 28th, 1987 at TOP/AVRDC experimental site, Kamphaeng Saen Campus of Kasetsart University, Thailand. He found that 20-day-old seedlings recorded the lowest mortality in the field after transplanting, compared to other seedling ages. The highest number of fruits/plant and the highest fruit weight were recorded with seedlings transplanted at 40 × 100 cm spacing. It is evident that the 25-day-old seedlings planted at 20 × 100 cm produced highest yield.

Vavrina and Orzolek (1993) conducted the research to determine the optimum age at which to transplant tomatoes. It was concluded that transplants ranging from 2 to 13 weeks old could produce similar yields, depending on many factors involved in commercial production.

Rahman *et al*. (1994) reported that in experiments of tomato cv. Manik, seedling age at transplanting had a significant effect on the number of days until flowering commenced the number of days until harvest, number of fruits/plant and yield. Plants grown from younger seedlings flowered and were ready to harvest earlier than those grown from older seedlings. The numbers of fruit/plant and average fruit weight were greatest when seedlings were 40 day old at transplanting.

Chui *et al*. (1997) conducted a greenhouse and field experiment with three tomato cultivars to study the influence of seedling age (4, 6, 8 or 10 weeks) on growth and early yield of fresh market tomatoes. Seedlings more than 6 weeks old showed slower growth and recovery after transplanting (RAT) and took longer time to flower in all 3 cultivars. Although older seedlings (> 8 weeks) had restricted roots, they produced higher early yields than younger seedlings. Three tomato cultivars were grown using the plug system or traditionally from seedlings sown in the field. They were then planted when 2 to 8 weeks old. There were no differences in performance of seedlings from the 2 different nursery systems when seedlings were less than 4 weeks old at planting. After 4 weeks, the growth rate of the field sown seedlings was greater than those raised as plugs

Sanjoy Saha (1999) studied the impact of seedling age (15 or 30 days old) and planting time (early: 16 November or late: 16 December) on the fruit yield performance of tomato (*Lycopersicon lycopersicum*) cultivars BT 18, BT 12, BT 10, BT 2 and MIXENT in upland rice (cv. Annada)- based cropping system. All cultivars performed well when planted early (with 15-day-old seedlings) and showed a declining trend in fruit yield and other yield-attributing characters when planted late with 30 days old seedlings. Among the tomato cultivars, remarkably good fruit yields of 60.7 and 47.0 t/ha were recorded from BT 18 during 1994-95 and 1995-96, respectively, when planted early with 15 days old seedlings. BT 12 gave fruit yields of 59.7 and 41.9 t/ha during 1994-95 and 1995-96, respectively. The economics of different tomato cultivars also showed the same trend. The gross return, net return and net return per rupee were highest in BT 18, followed by BT 12, respective of seedling age and planting time.

Benedictos *et al*. (2000) reported that young (5 weeks old) transplants of tomato had highest fruit setting rate (81.69%), followed by medium-aged (7 weeks old) transplants (76.94%) and old (9 week old) transplants (76.04%).

Okano *et al*. (2000) reported the effects of seedling age at planting on the quality of nursery plants, on plant from after planting and on growth rate and fruit yield. The younger the seedling at planting, the faster the plant grew after planting. When seedlings were raised for >35 days, growth was considerably retarded. Dry weight of roots and stems at harvest were higher when tomatoes were planted at a younger age. However, leaf dry weight, total leaf area and fruit yield were highest in the 25 and 35 days old seedling plots. Total leaf area per plant was positively correlated with fruit yield.

Okano *et al*. (2000) observed the effect of seedling age at planting on plant form and fruit productivity in single-truss tomato (*Lycopersicon esculentum* Mill.) grown hydroponically. Light interception and photosynthetic activity of the leaves were also examined in plants with different plant forms. Growth after planting was retarded in proportion to the duration of rising of seedlings. 25-day to 35-day (4 to 7 leaf stages) plug seedlings was considered to be most suitable for single-truss cultivation of tomato. Fruit yield was positively correlated with total leaf area. Frequent emergence of lateral shoots could not be inhibited by the use of over mature seedlings. Interception of solar radiation which was highest for the uppermost leaf decreased for the leaves toward the lower part of the plant. Radiation interception by individual leaves varied depending on the plant form, which influenced the rate of field photosynthesis. Only upper three leaves contributed to photosynthesis in a shorter plant, while many more leaves in a taller plant.

Mercik & Skapski (1960) evaluated five self determined tomato varieties and reported that apart from Fire ball in which the youngest(4-week-old) transplants produced the highest early yields, the highest early yields were produced from the oldest(8-week-old) transplants. A delay of 2 weeks in planting out resulted in late maturity and reduction in yield of all five varieties.

Pena-Lomeli *et al.* (1991) used three cultivars of tomato transplants of 2, 3, 4, 5, and 6 weeks of age. They found the 3-week-old transplants had the highest yields across cultivars.

Salik *et al.* (2000) found that the medium aged seedlings (5 weeks) had the highest number of fruits per plant, marketable yield and fruit weight followed by 6 week and 4 weeks. Time taken to flowering was less in the case of 4 week seedlings than others. Number of branches was highest in 5 week old seedlings.

Weston and Zandstra (1989) used 4, 5, 6 and 7 week-old seedlings of tomato and found that 4 to 5 week-old transplants produced higher number and weight of fruits than younger or older transplants.

F. Agble (1988) conducted a research on four transplanting ages of tomato cultivar Lauranto seedlings, namely 20, 25,30 and 35 days, were compared during the major and minor rainy seasons for 2 years. Field survival of seedlings was least for 20-day-old transplants but high for the 25 and 30-day-old transplants. The 20-day-old transplants flowered before the 35-day old transplant. Both 25- and 30-day-old transplants matured early and gave higher yields than 20- and 35-day-old transplant

2.2 Effect of IAA on growth and yield of tomato

Sing *et al*. (2005) carried out an investigation to see the effects of different doses of PGRs (control, 25 or 75 ppm IAA, and 25 or 75 ppm NAA) and micronutrient(control, 2500 ppm Multiplex or 2000 ppm Humaur) mixtures and their interactions on plant growth, number of branches and yield of tomato at 35 and 70 days after transplanting(DAT). Plant growth was not affected significantly by any treatment and interaction, although the effect of P1(25 ppm IAA) x M2(Humaur) interaction was better in increasing the plant growth at 75 DAT. The number of branches was significantly and highly increased by the application of 75 ppm IAA and 25 ppm NAA. The initiation time of first flowering and first fruiting was significantly and highly increased by the interaction {4(75 ppm NAA) x M2(Humaur). Application of 35 ppm IAA and 2000 ppm Humaru was significantly increased the tomato yield. P4 (75 ppm NAA) x M2(2000ppm Humaur) was also significantly increased the yield.It can be concluded that addition of PGR and micronutrient in tomato is useful for better produciton.

Djanaguiraman *et al*. (2004) conducted an experiment where the plants were with four different concentrations of Nitrophenols(ATONIK)at flowering and fruit setting stage. Observatios were recorded in the flowers and developing fruits. Application of nitrophenols significantly increased the activity of antioxidant enzymes namely superoxide dismutase (SOD), catalase CAT), peroxidase (POX) and auxin content coupled with decreased activity of polyphenol oxidase [catechol oxidase] (PPO) and IAA oxidase (IAAO) enzymes over the control significantly. Among the concentrations, experimented, application of nitrophenols at 0.4% during fruit set stage was found to be the most effective in recording high antioxidant enzymes activity and auxin level which was reflected in an increased number of fruit clusters per plant, fertility coefficient and yield of tomato.

Gupta and Gupta (2004) studied the plants were sprayed with 25 or 75 ppm IAA and NAA, alone or in combination with the micronutrient mixtures Multiplex 2500 pp, amd 2000 ppm Humaur in a field experiment conducted in Allahahad, India to determine the effects of the treatments on the P content of tomato fruits and products. Application of 75 ppm NAA + multiplex resulted in the highest P content in tomato fruits , as well as in ketchup, and tomato puree and juice during both years.

Gupta *et al*. (2003) observed the response of plant growth regulators and micronutrients mixtures on fruit size, color and yield of tomato(Lycopersicon esculentum Mill.) An experiment was conducted by two years(1997-99) in Uttar Pradesh, India to determine the effect of growth regulators (25 ppm IAA and 45 ppm IAA) at 25 and 50 days after transplanting(DAY) and /or Micronutrient mixtures(2500 ppm Multiplex and 2000 ppm Humaur) at 25 and 50 DAT, respectively, on tomato cv. Krishna (F1 hyvrid). Among all Treatments, the largest fruit size (6.67 cm diameter), most attractive ripe fruit color(Phantom, 2L – 12) and the highest yield (63.61 t/ha) were observed with 45 ppm IAA + Multiplex micronutrient mixture at the maturity stage during 1998 – 99. The highest dry matter (12.7%) and ash content (1.0%) were obtained upon treatment with 45 ppm IAA + Humaur micronutrient mixture.

Singh *et al*. (2003) stated that the effects of 2,4-D. beta naphthoxyacetic acid 12-naphthoxyacetic acid] and IAA (1,10 or 100 ppm), applied as either seed Treatment or plant spray, on the growth and yield of tomato cv. Pusa Ruby were in Kanpur, Uttar Pradesh, India. Seed germination varied from 8.2 to 40.2% during the initial evaluation. Flowering was initially observed in treated plants at 77-87 days after sowing. 2,4-D at all concentrations resulted in earlier flowering, whereas 1 ppm BNOA and all concentrations of IAA delayed flowering, Plants treated with 100 ppm BNOA exhibited the greatest seed germination and fruit set, and the lowest number of days to flowering. BNOA applied at 100 ppm as seed treatment gave the earliest fruit ripening (earlier than the control by 15 days).

Gupta *et al*. (2002)a conducted an experiment on the effect of, IAA and NAA (35 and 75 ppm, respectively, at 25 and 50 days after transplanting) and the micro nutrients mixtures Multiplex and Humaur (2500 and 2000 ppm, respectively), on the tomato cultivar Krishna was evaluated in Karnataka, India during 1997 – 98 and 1998 – 99. The application of auxins and micronutrients significantly improved the fruit size (length 6.32 cm and diameter 6.78), dry matter, ash content, longest root length and yield of the greatest fruit size and yield were obtained with 75 ppm NAA + multiplex; while the highest dry matter and ash content were recorded for 75 ppm NAA + Humaur.

Gupta *et al*. (2002)b conducted and experiment to observed the effect of the plant growth regulators (PGRs) IAA and NAA(15 and 75 ppm), and micronutrient mixtures Multiplex (2500 ppm), and micronutrient mixtures Multiplex (2500 ppm)[Ca, Mg, S, Fe, Zn, Mo, Mn, B and NAA, } and Humaur (2000 ppm) on the nutritive value of tomato (cv. Krishna) fruits. PGRs were applied at 25 and 75 days after transplanting IDAT). Treatment with micronutrient mixtures was conducted at 25 and 75 DAT. Higher nutritive content was obtained with the application of both PGRs and micronutrient mixtures than treatment with wither PGR or micronutrient mixture. NAA at 75 ppm + Multiplex increased P content by 16.12 % and iron content by 23.33 %. The application of 75 ppm NAA + Humaur increased K content by 13.08% and Cs concentration by 52.38%. The Mg content increased by 43.84%due to the application of 25 ppm NAA + Humaur.

Singh *et al*. (2002) conducted a field experiment at Allahabad, Uttar Pradesh , India to determine the effect of plant growth regulators (PGRs) and commercially available micronutrient mixtures on growth, yield and quality of tomato cv. Gobi (F1 Hybrid). The treatments consisted of 2 concentrations (25 and 75 ppm) each of IAA and NAA, and micronutrients Humaur at 2000 ppm and multiplex at 2500 ppm. PGRs were applied in the form of foliar sprays at intervals of 26 and 29 days, respectively, and micronutrients were applied as a spray at 30 days after planting. Plant growth characters and fruit quality varied with the application of PGR and micronutrient mixture combinations.

Rai *et al.* (2002)conducted an experiment that application of IAA at 75 ppm along with Multiplex at 2500 ppm resulted in highest plant height and yield, and IAA at 75 ppm alone in the highest number of branches. Application of IAA at 25 ppm + Multiplex at 2500 ppm superior for ascorbic acid content. Maximum chlorophyll content and acidity were obtained with NAA at 75 ppm along with Humaur at 2000 ppm IAA at 75 pp + Humaur at 2000 ppm were the best for total soluble solids and carotenoid content. NAA at 75 ppm along with Multiplex at 2500 ppm gave the highest sugar content.

Gupta *et al.* (2001) studied with Tomato (cv. Krishna) plants were treated with IAA (25 ppm at 25 days after transplanting, DAT) and NAA (75 ppm at 75 DAT), and supplied with Multiplex (2500 ppm) and Humaur (2000 ppm), in a field experiment conducted during the rabi seasons. The physicochemical characteristics of fruits were analyzed. Maximum total soluble sold content (5.4%) in total mature fruits was recorded from treatments of NAA and Humaur. The maximum lycopene and carotenoid content were recorded from NAA and Multiplex. Reducing and non-reducing sugar contents were the highest (4 mg/100 g and 31.5 mg/100 g) when plants were treated with NAA and Humaur.

Chung and Chori (2001) stated the foliar application of plant growth regulators affects distribution and accumulation of calcium (45 CaCl2) in tomato leaves. All tomato(cv. Sunroad) leaves, except the 7^{th} and 8^{th} or 5^{th} to 8^{th} leaves from the cotyledons, stem apices and the inflorescence, were removed to investigate the effect of plant growth regulators (PGR) on the leaves. The application of GA3 to either of these leaves resulted in the accumulation of 45 Ca_2 twice as high in the treated plants as in the plants which were sprayed distilled water (control plants). When 2-(3-chloropllrenoxy) propanoic acid was applied onto the upper leaf, than 45 Ca_2 accumulation was higher than in the control plants, whereas there was no difference when CPA was applied onto the lower leaf. IAA or NAA treated leaves showed lower amount 45Ca_2 than the leaves of control plants, showing more inhibiting effect of NAA, in particular. The present study indicates that the application of various PGR does not interrupt the acropetal movement of calcium ion. But increase the stem diameter of the tomatoes at several water.

Sun *et al.* (2000) reported the role of growth regulators on cold water fir irrigation reduces stem elongation of plug grown tomato seedlings. The effect of growth regulators (abscisic acid, gibberellic acid(GA), paclobutrazol, ethephone, IAA and silver thiosulphate) and cold water irrigation at different treatments (5, 15, 25, 35, 45 and 55 C) on the reduction of stem elongation and of plung grown tomato) seedlings was investigated. Paclobutrazol, ethephone and GA reduced the stem length but it increase the stem diameter of the tomatoes at several water temperature. Cold water irrigation with the addition of 1.8 ppm GA or irrigation at room temperature could promote stem elongation. Irrigation at room temperature with the addition of 10 ppm paclobutrazol (Gas biosynthesis inhibitor) or cold water irrigation could inhibit stem elongation. The reduction in stem elongation in plung-grown tomato seedlings was due to the relationship of Gas metabolism and sensitivity.

El-Habbasha *et al.* (1999) studied the response of tomato plants to foliar spray with some growth regulators under late summer conditions. Field experiments were carried out with tomato (cv. Castelrock) over two growing seasons (1993 – 94) at Shalakan, Egypt. The effects of GA_3 IAA, TPA (tolylphthalamic acid) and 4-CPA) each at 2 different concentrations) 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, compare with controls.

Sumiati (1987) reported that tomato cultivars. Gondol, Meneymaker, Intan and Ratan sprayed with 1000 ppm chlorflurenol. 100 ppm IAA, 50 ppm NAA or 10 ppm, GA_3 or left untreated , compared with controls, fruit setting was hastened by 4-5 days in all cultivars following treatment with 100 ppm IAA or 10 ppm GA_3.

Perez and Ramirez(1980) carried out an experiment with the application of IAA at 25 and 35 ppm on tomato. They found increased fruit size quality with minimum seeds.

Younis and Tigani (1977) carried out an experiment with IAA application on tomato cv. John Moran plants. They observed that when IAA was applied to field grown tomato plants, 2 applications of IAA at 10 ppm increased the fruit set significantly.

Kaushik *et al*. (1974) reported that 10 ppm of IAA increased the number and weight of fruits per plant significantly. The application of IAA at 100 ppm markedly reduced fruit number and yield.

Singh and Upadhayaya (1967) studied the effect of IAA and NAA on tomato and reported that the regulators activated growth, increased the fruit set, size and yield of fruit and induced parthenocarpic fruit. The chemicals could be applied on seeds, roots, whole plants or flowers, but foliar application was very effective for increasing the size of fruit and the yield.

Mukharji and Roy (1966) found that application of IAA had protected the flower and premature fruit drop and increased length of size fruit in tomato plant.

Leopold (1964) observed that with the increase in concentration of auxin there was a comparable increase in percentage of flower cluster.

Chhonkar and Singh (1959) recorded increasing yield of tomato by seedling treatment with growth substances. They reported that high concentration of IAA reduced plant height but increased yield through induction and fruit set.

CHAPTER III

MATERIAL AND METHOD

3.1 Location of the field

The experiment was conducted at Horticultural farm of the Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2014 to April 2015 The location of the experimental site was at 23^0 $46^/$ N latitude and 90^0 $22^/$ E longitude with an elevation of 8.24 meter from sea level.

3.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of May to September and scattered rainfall during the rest of the year. Information regarding average monthly temperature as recorded by Meteorogical Department (climate division) during the period of study is available in Appendix I.

3.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro- Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8 – 6.5, ECE – 25.28. The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.4 Plant materials collection:

The tomato variety used in the experiment was “BARI Tomato 14”, a high yielding indeterminate type variety. The seeds were collected from Olericulture division of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur.

3.5 Raising of seedlings

Tomato seedlings were raised in three see beds of 2 m X 1 m size with the interval of 5 days. The soil was well prepared and made into loose friable and dried by spading. Before raising seedling the seed bed was cured by fungicide. All weeds and stubbles were removed. The soil of seed bed was mixed with 5 kg rotten cow dung. Five gram of seeds were sown in first seed bed on 01 November 2014, then five gram in second seed bed on 05 November 2014 and another five gram seed in the third seed bed on 10 November. 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 they required.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:

Factor A: Three ages of seedlings

S_1 = 25 days

S_2 = 30 days

S_3 = 35 days

Factor B: Four levels of IAA (Indole-3-Acetic Acid)

I_0 = Control (No IAA)

I_1 = 80 ppm

I_2 = 100 ppm

I_3 = 120 ppm

There were altogether 12 treatment combination used in each block were as follows: S_1I_0, S_1I_1, S_1I_2, S_1I_3, S_2I_0, S_2I_1, S_2I_2, S_2I_3, S_3I_0, S_3I_1, S_3I_2, S_3I_3,

3.7 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 29.1 m X 10 m was divided into three equal blocks. Each block was consists of 12 plots where 12 treatments were allotted randomly. There were 36 unit plots in the experiment . The size of each plot was 1.8 m X 2 m. The distance between two blocks and two plots were kept 1 m and 0.5 respectively. A layout of the experiment has been shown in Figure 1.

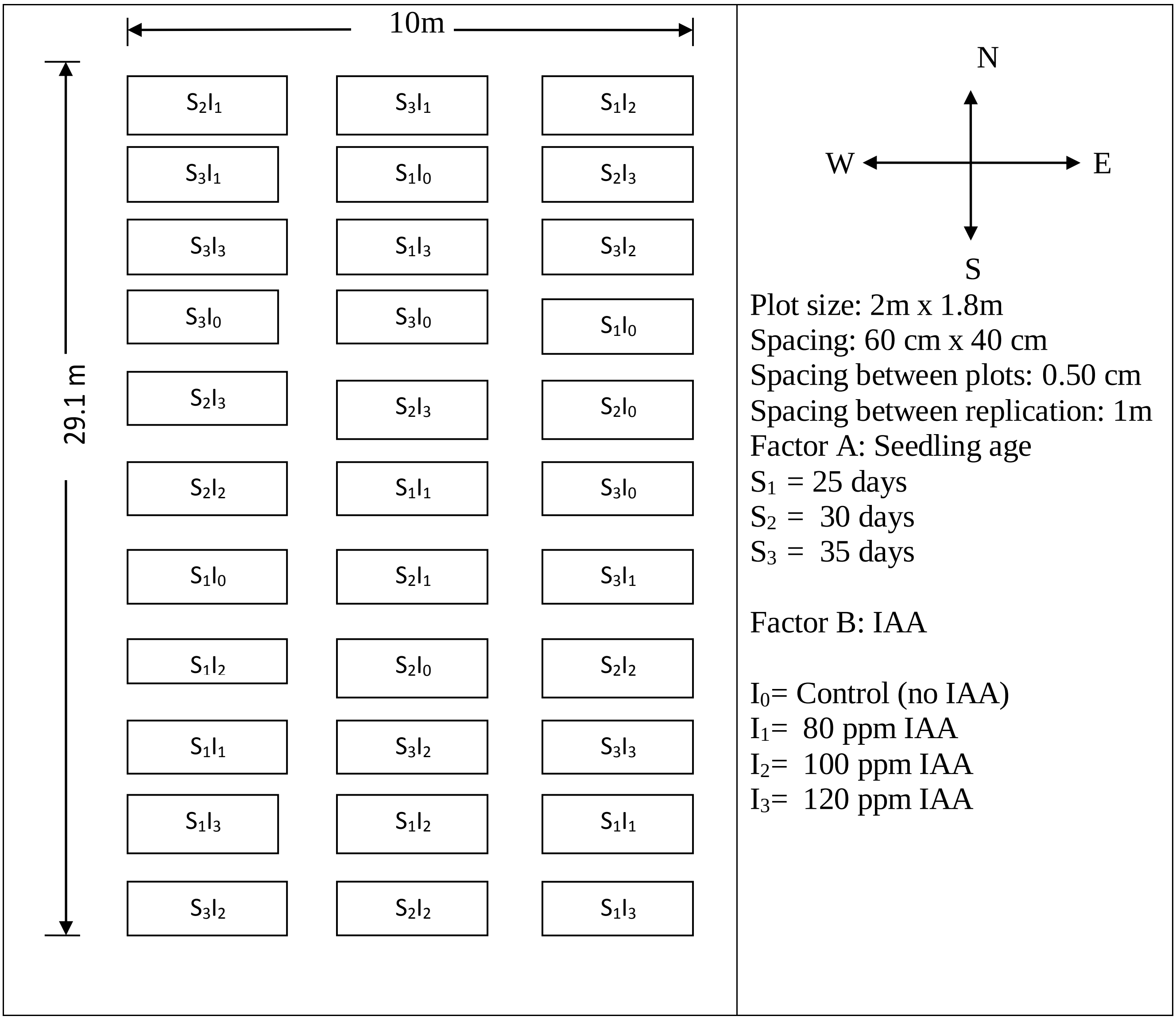


Fig. 1 : Field layout of the experiment plot

3.8 Cultivation procedure

3.8.1 Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The land of the experiment field was ploughed with a power tiller on November 2014. 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 ploughing 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.

3.8.2 Manures and Fertilizers and it's methods of application:

Fertilizer	Quantity	Application of method
Cow dung	15 ton/ha	Basal dose
Urea	400 kg/ha	20, 30 and 40 DAT
TSP	300 kg/ha	Basal dose
MOP	250 kg/ha	20, 30 and 40 DAT mixed with urea

Rashid (1999)

Manure and fertilizers were applied according to Rashid (1999). The 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.

3.8.3 Preparation of seedling:

The seedlings were raised in different seed bed with the interval of 5 days. The seedlings were transplanted in the main field after completion of different age as 25 days, 30 days and 35 days.

3.8.4 Transplanting of seedlings

Healthy and uniform seedling with different age like 25 days, 30 days and 35 days were uprooted separately from the seed bed and were transplanted in the experimental plots in 05 December, 2014 maintaining a spacing of 60 cm X 40 cm between the rows and plants respectively. This allowed an accommodation of 15 plants in each plot. The seedbed was watered before uprooting the seedlings from the seedbed to minimize damage to the roots. The seedlings were watered after transplanting. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.8.5. Preparation and application of IAA

The stock solution of 1000 ppm of IAA was made by mixing of 1 g of IAA with small amount of ethanol to dilute and then mixed in 1 litre of distilled water. Then as per requirement of 80 ppm, 100 ppm and 120 ppm solution of IAA, 80, 100 and 120 ml of stock solution were mixed with 1 litre of distilled water respectively. Application of IAA was done at 15 days interval and was applied at 25, 40 and 55 days after transplanting.

3.8.6 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:

3.8.6.1 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.

3.8.6.2 Weeding

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

3.8.6.3 Staking

When the plants were well established, staking was given to each plant by rope and bamboo stick to keep them erect. Within a few days of staking, as the plants grew up, other cultural operations were carried out.

3.8.6.4 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 as and when required depending upon the condition of soil.

3.8.6.5 Plant protection

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

3.8.6.6 Insect pests

Bavistin 50 WP and Ripcord 10 EC were applied @ 10 ml/L against the fungal disease, leaf curl disease and insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly for a week after transplanting to two weeks before first harvesting.

3.9 Harvesting

Fruits were harvested at 7 to 8 days intervals during early ripe stage when they attained slightly red color. Harvesting was started from 8 March, 2015 and was continued up to end of 20 April 2015.

3.10 Data collection

Five 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.

3.10.1 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 15 days interval starting from 15 days of planting up to 75 days to observe the plant height. The average height was computed and expressed in centimeter.

3.10.2 Number of leaves per plant

The number of leaves per plant was manually counted at 15, 30, 45, 60 and 75 days after transplanting from randomly selected tagged plants. The average of five plants were computed and expressed in average of leaves per plant.

3.10.3 Number of branches per plant

The number of branches per plant was manually counted at 15, 30, 45, 60 and 75 days after transplanting from randomly selected tagged plants. The average of five plants were computed and expressed in average number of branch per plant.

3.10.4 Number of flowers per cluster

The number of flowers per cluster was counted at 45 days after transplanting from the five 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 flower per cluster was calculated from five averages from five plants.

3.10.5 Number of cluster per plant

The number of clusters was counted at 60 days after transplanting from the five sample plants and the average number of clusters produced per plant was recorded.

3.10.5 Number of fruits per cluster

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

3.10.6 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 five plants.

3.10.7 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 determine the diameter of fruit by slide calipers. The diameter of fruit was calculated by making the average of five fruits from each of the five plants.

3.10.8 Fresh weight of individual 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 fruits of every harvest and finally making the average was made from four times harvesting data.

3.10.9 Dry matter content of fruit (%)

After harvesting, randomly selected 100 gm of fruit sample previously sliced in to very thin pieces. The fruits were then dried in the sun for seven days and placed in oven maintained at 60^0 for 72 hours. The sample was then transferred into desiccators and allowed to cool down to the room temperature. The final weight of the sample was taken. The dry matter was calculation by the following formula:

Dry matter of fruit (%) = $\frac{Dry\ weight\ of\ fruit}{\text{Fresh weight of fruit}}$X100

3.10.10 Length of root

The length of root was manually measured at the time of harvest from randomly selected five plants. The averages_root length of five sample plants were considered as root length of plant.

3.10.11 Chlorophyll percentage of leaf

The Chlorophyll percentage of leaf of the plant was measure by a SPAD meter, a product of Konica Minolta Sensing Ltd. Singapore, at 60 days after transplanting from randomly selected five tagged plants. This machine gives the direct calculated value of the chlorophyll percentage of leaf of the plant. The Chlorophyll percentage of five tagged leaves of each plant was measured and calculated the average Chlorophyll percentage of leaf of each plant of five sample plants.

3.10.11 Dry matter content of leaf (%)

After harvesting, randomly selected 100 gram of leaf sample previously dried in the sun for seven days and were put into envelop and placed in oven maintained at 60^0 for 72 hours. The sample was then transferred into desiccators and allowed to cool down to the room temperature. The final weight of the sample was taken. The dry matter was calculated by the following formula: Dry matter of leaf (%): $\frac{\text{Dry weight of leaf}}{\text{Fresh weight of leaf}}$X 100

3.10.12 Carbon assimilation rate

The carbon assimilation rate of the plant was measured by an automatic "LCpro$^+$ (advanced photosynthesis measurement system) meter" which is a product of ADC Ltd. Hertfordshire EN 11 ONT, United Kingdom at 60 days after transplanting from five tagged plants of each plot. This machine gives the direct calculated result of carbon assimilation rate of the plant. The Carbon assimilation rate of five tagged leaves of each plant was measured and calculated the average Carbon assimilation rate of one plant.

3.10.13 Yield per plot (Kg)

An electric balance was used to measure the weight of fruits per plot. The total fruit yield of each unit plot measured separately from each sample plant during the harvesting period and was expressed in kilogram (kg).

3.10.13 Yield per hectre (Ton)

It was measured by the following formula;

$$\text{Yield of tomato (t/ha)} = \frac{\text{Fruit yield per unit plot(kg) X1000}}{\text{Area of unit plot in square meter}} \text{ X 1000}$$

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 determine by Duncan's Multiple Range Test (DMRT) according to Gomez an Gomez, (1984) at 5% level of significance

CHAPTER – IV

RESULTS AND DISCUSSION

The present study was conducted to find out the growth and yield of tomato influenced by seedling age and IAA. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameter are given in Appendix III-IX. 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 Plant height

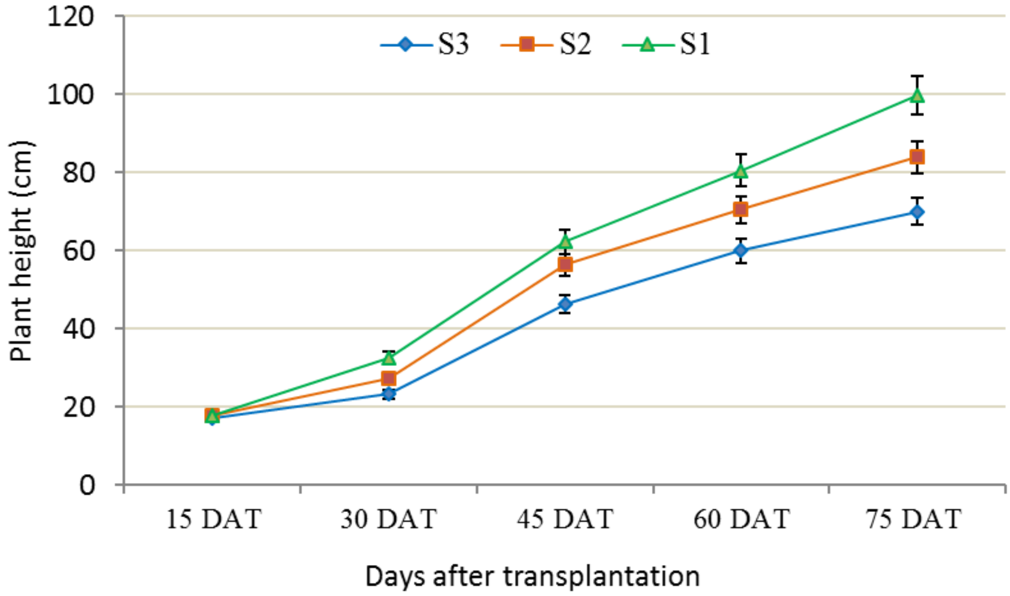
Significant difference was observed on plant height due to use of different age of seedling at 30, 45, 60 and 75 DAT except 15 days (Appendix III). At 30 DAT, the longest plant (32.58 cm) was recorded from S_1(25 days) and the shortest plant (23.33 cm) was found in S_3(35 days). At 45 DAT the longest plant (62.33 cm) was recorded in S_1(25 days) and shortest (46.42 cm) plant was found in S_3(35 days).The plant height was highest at S_1(25 days) as 80.58 cm as followed by shortest of 60 cm in S_3(35 days) at 60 DAT. The longest plant (99.75 cm) was found at 75 DAT in S_1 as followed by shortest (70.08 cm) in S_3. (Fig.2)

Significance difference was observed due to application of different levels of IAA at 30, 45, 60 and 75 DAT except 15 DAT (Appendix III). At 30 DAT, the longest plant (27.22 cm) was recorded from I_1(80 ppm) and the shortest plant (23.78 cm) was found at I_0 (control). At 45 DAT, the longest plant 56.22 cm found from I_1 and the shortest plant (49 cm) obtained from I_0. At 60 DAT, the longest plant (72.22 cm) was found from I_1 and the shortest plant (63.22 cm) obtained from I_0 (control) treatment (Fig. 3). Murphy (1964) found that application of IAA increased plant height up to 65%. Rai *et al*. (2002) observed that the application of 75 ppm increased the plant height significantly.

Combined effects of seedling age and IAA showed significant difference on plant height at all observation except 15 DAT (Appendix III). However at 30 DAT the longest plant (31.33 cm) was recorded from S_1I_1(25 days seedling + 80 ppm IAA) and the shortest (17.33 cm) at S_3I_0 (35 days seedling + no IAA). At 45 DAT the longest plant (62 cm) was found at S_1I_1 which was statistically similar to S_1I_2 (61.67 cm) and S_1I_3 (56.67 cm) and the shortest plant (35.33 cm) was found at S_3I_0 (35 days seedling + no IAA) which was statistically identical to S_3I_3 (40.67 cm). At 60 DAT, the longest plant (82 cm) was found from S_1I_1 that was statistically similar to S_1I_2 (78.00 cm) and the shortest plant (50.67 cm) found from S_3I_0 combination. At 75 DAT, the longest plant (108 cm) was recorded as at S_1I_1 which was statistically similar to S_1I_2 (99.67 cm) combination and the shortest plant (62.33 cm) was found at S_3I_0 combination (Table 1).

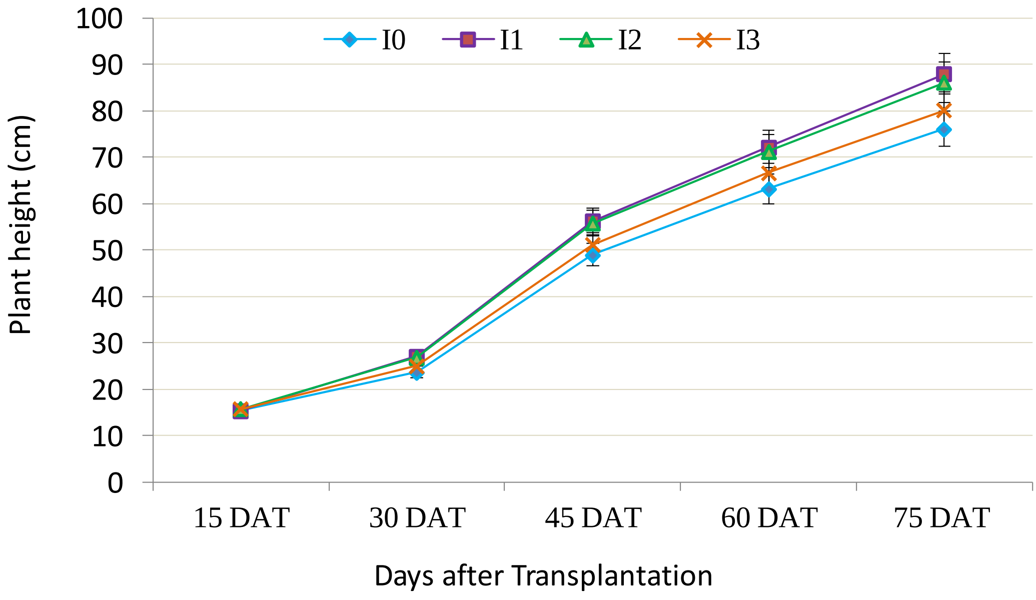
4.2 Number of leaves per plant

Due to use of different age of seedling showed significant difference on number of leaves per plant at all observation except 15 DAT (Appendix IV). At 30 DAT, the maximum number of leaves per plant (12) was counted from S_1 (25 days) and minimum number of leaves per plant(10.14) was obtained from S_3(35 days). At 45 DAT, maximum number of leaves per plant (40.93) was counted from S_1 and the minimum number of leaves per plant (30.85) was counted from S_3. At 60 DAT, the maximum number of leaves per plant (61.01) obtained from S_1 and the minimum number of leaves (47.27) was counted from S_3. At 75 DAT, maximum number of leaves per plant (84) was counted from S_1 and the minimum number of leaves per plant (68.02) was obtained from S_3 (Fig. 4). Histamoni and Urabe (1973) reported that high soil temperature (15º C) use of the young tomato seedling supported vigorous vegetative growth, resulting in longer and thicker stems, more leaves and larger leaves.



S_1 : 25 days old seedling; S_2 : 30 days old seedling; S_3 : 35 days old seedling.

Fig. 2. Effect of seedling age on plant height of tomato



I_0 : control (No IAA); I_1 : 80 ppm IAA; I_2 : 100 ppm IAA; I_3 : 120 ppm IAA.

Fig. 3. Effect of IAA on plant height of tomato

Table1. Combined effect of seedling age and IAA on plant height of tomato

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
S_1I_0	18.02	26.67 bc	56.00 bc	72.00 bc	94.67 bc
S_1I_1	17.69	31.33 **a**	62.00 **a**	82.00 **a**	108.00 **a**
S_1I_2	17.35	28.67 b	61.67 ab	78.00 ab	99.67 ab
S_1I_3	18.02	27.67 b	56.67 ab	74.00 bc	96.67 bc
S_2I_0	17.69	21.33 fg	49.67 de	61.00 ef	77.33 ef
S_2I_1	17.69	24.33 de	54.00 bcd	69.67 cd	88.67 cd
S_2I_2	18.02	25.33 cd	55.67 bc	71.00 bcd	90.00 c
S_2I_3	18.02	22.33 ef	50.33 cde	64.33 de	79.67 de
S_3I_0	17.02	17.33 h	35.33 f	50.67 g	62.33 g
S_3I_1	17.02	20.00 g	46.67 e	59.00 ef	73.33 ef
S_3I_2	18.02	20.67 fg	47.00 e	59.00 ef	74.67 ef
S_3I_3	17.35	19.33gh	40.67 f	55.33 fg	70.00 fg
$LSD_{0.05}$	**1.01**	**2.25**	**5.83**	**7.22**	**9.16**
CV%	**6.03**	**5.19**	**6.71**	**6.29**	**6.85**

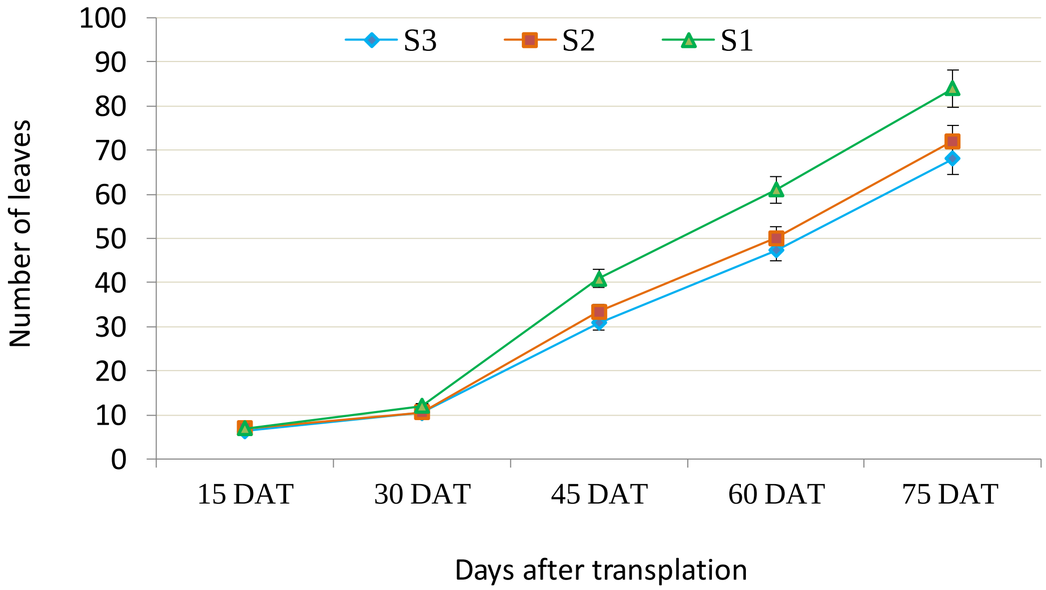
S_1:25 days old seedling S_2: 30days old seedling S_3:35 days old seedling

I_0 : control (No IAA) I_1 : 80 ppm IAA I_2 : 100 ppm IAA I_3: 120 ppm IAA

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

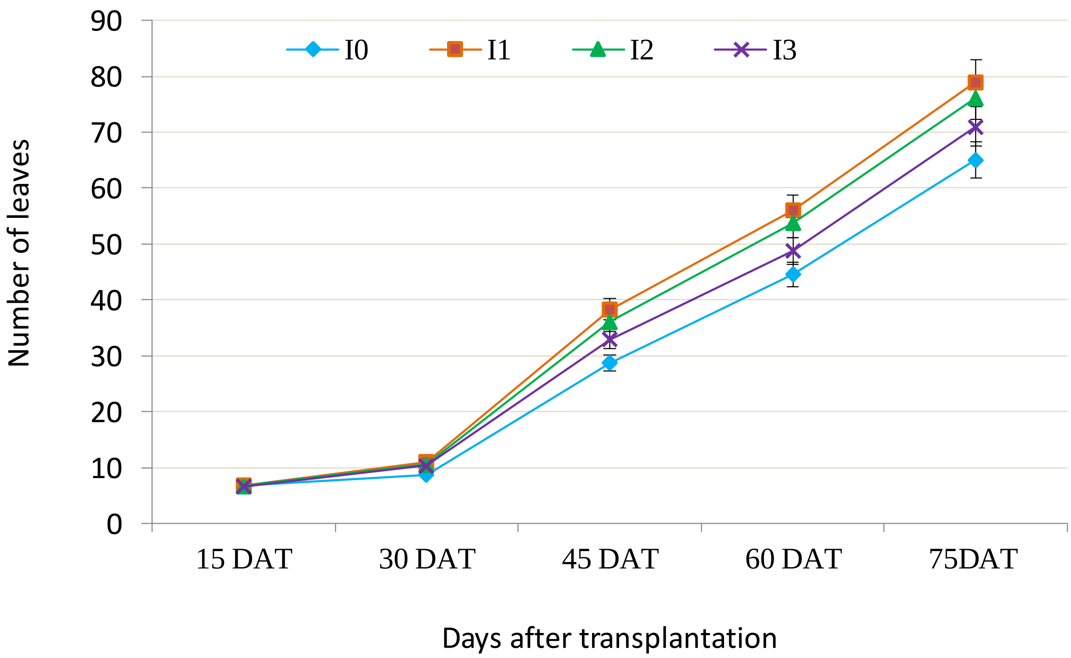
Different application of IAA showed different significant effect on number of leaves per plant at all observation except 15 DAT (Appendix IV). At 30 DAT, the maximum number of leaves per plant (11) was counted from I_1 (80 ppm) and the minimum number of leaves per plant (8.77) was counted from I_0 (no IAA). At 45 DAT, the maximum number of leaves per plant (38.33) was obtained from I_1 and the minimum number of leaves per plant (28.78) was counted from I_0. At 60 DAT, the maximum number of leaves per plant (56) was counted from I_1 and the minimum number of leaves per plant (44.56) was obtained from I_0. At 75 DAT, the maximum number of leaves per plant (79) was counted from I_1 and the minimum number of leaves per plant (65.11) was counted from I_0 (Fig 5). Harneet *et al.*, (2004) had found the effect of nitrogen and IAA application on the growth, yield and quality of tomato is better than non-treated. He recorded that there was also a significant increase in number of leaves when IAA level was increased.

Combined effect of seedling age and indole-3-acetic acid showed statistically significant differences on number of leaves per plant at 30, 45, 60 and 75 DAT except 15 DAT (Appendix IV). At 30 DAT, the maximum number of leaves per plant (16) was counted from S_1I_1 (25 days old seedling + 80 ppm) and the minimum number of leaves per plant (10.33) was counted from S_3I_0 (35 days old seedlings + no IAA). At 45 DAT, the maximum number of leaves per plant (50.67) was obtained from S_1I_1 which was statistically similar to S_1I_2 (45.33) and the minimum number of leaves per plant (27) was counted from S_3I_0. At 60 DAT, the maximum number of leaves per plant (71.67) was obtained from S_1I_1 and the minimum number of leaves per plant (40.33) was counted from S_3I_0. At 75 DAT, the maximum number of leaves per plant (97.67) was counted from S_1I_1 and minimum number of leaves per plant (59.67) was obtained from S_3I_0 (Table 2).



S_1 : 25 days old seedling; S_2 : 30 days old seedling; S_3 : 35 days old seedling.

Fig. 4. Effect of seedling age on number of leaves per tomato plant



I_0 : control (No IAA); I_1 : 80 ppm IAA; I_2 : 100 ppm IAA; I_3 : 120 ppm IAA.

Fig. 5. Effect of IAA on number of leaves per tomato plant

Table 2.Combined effects of seedling age and IAA on number of leaves per tomato plant

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
S_1I_0	5.67	10.66 ef	34.33 de	49.33 c	71.67 d
S_1I_1	6.00	16.00 a	50.67 a	71.67 a	97.67 **a**
S_1I_2	6.00	14.67 b	45.33 ab	63.67 b	87.01 b
S_1I_3	6.00	13.33 c	41.33 bc	60.33 b	84.33 bc
S_2I_0	6.00	11.33 def	34.00 de	51.00 c	73.00 d
S_2I_1	6.00	11.33 def	39.33 bcd	52.33 c	75.00 d
S_2I_2	6.00	11.67 de	37.33 cde	52.00 c	76.00 cd
S_2I_3	5.67	11.33def	33.00 ef	46.00 cd	68.00 de
S_3I_0	5.33	10.33 f	27.00 f	40.33 d	59.67 e
S_3I_1	5.67	11.66 de	34.00 de	50.00 c	73.33 d
S_3I_2	5.33	11.33 def	35.67 cde	51.67 c	74.33 d
S_3I_3	5.33	12.33 cd	34.67 de	47.00 cd	69.67 d
LSD $_{0.05}$	**0.76**	**1.15**	**6.35**	**6.81**	**8.51**
CV%	**6.56**	**6.63**	**10.52**	**7.48**	**6.57**

S_1: 25 days old seedling S_2: 30 days old seedling S_3: 35 days old seedling

I_0 : control (No IAA) I_1 : 80 ppm IAA I_2 : 100 ppm IAA I_3: 120 ppm IAA

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

4.3 **Number of branches per plant**

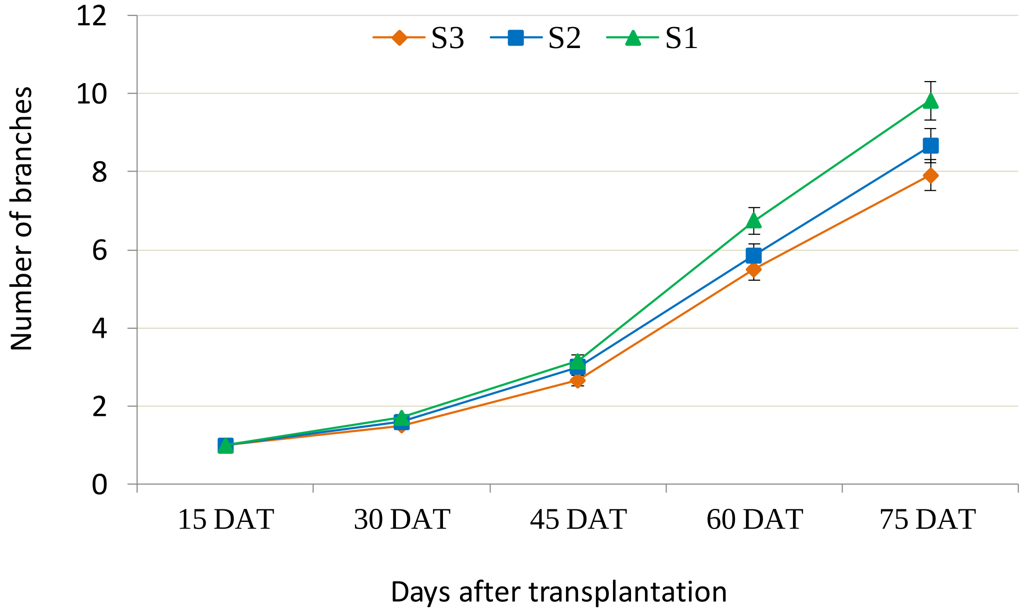
A significant variation was found in 30, 45, 60 and 75 DAT due to use of different seedling age except 15 DAT (Appendix V). At 30 DAT, the maximum number of branches per plant (1.7) was found in S_1(25 days) and the minimum number of branches per plant (1.5) was found from S_3(35 days). At 45 DAT, the maximum number of branches per plant (3.16) was found in S_1 and the minimum number of branches per plant (2.66) was found from S_3. At 60 DAT, the maximum number of branches per plant (6.75) was found in S_1 and the minimum branches per plant (5.5) were found from S_3. At 75 DAT, the maximum number of branches per plant (9.83) was found in S_1 and the minimum branches per plant (7.91) was found from S_3 (Fig. 6).

Due to different dose of IAA significant variation was found in 30, 45, 60 and 75 DAT except 15 DAT (Appendix V). At 30 DAT, the maximum number of branches per plant (2.00) was found in I_1 (80 ppm) and the minimum number of branches per plant (1.77) was found from I_0 (0 ppm). At 45 DAT, the maximum number of branches per plant (3.55) was found in I_1 and the minimum number of branches per plant (2.44) was found from I_0. At 60 DAT, the maximum number of branches per plant was found in I_1(6.66) and the minimum number of branches per plant (5.77) was found from I_0. At 75 DAT, the maximum number of branches per plant (10.11) was found in I_1 and the minimum number of branches per plant (7.88) was found from I_0 (Fig 7). Sing *et al*. (2005) found that the number of branches was significantly and highly increased by the application of 75 ppm IAA and 25 ppm NAA.

Combined effect of seedling age and indole-3-acetic acid showed statistically significant differences on number of branches per plant at 30, 45, 60 and 75 DAT except 15 DAT (Appendix V). At 30 DAT, the maximum number of branches per plant (3.00) was counted from S_1I_1 (25 days old seedling + 80 ppm) which was statistically identical to S_1I_0 (2.00) followed by S_1I_2 (2.00), S_1I_3 (2.00) and the minimum number of branches per plant(1.00) was counted from S_3I_1(35 days old seedlings + 80 ppm IAA) which was statistically identical to S_3I_2 (1.00). At 45 DAT, the maximum number of branches per plant (5.00) was obtained from S_1I_1 and the minimum number of branches per plant (3.00) was counted from S_3I_0 (35 days old seedlings + 0 ppm IAA). At 60 DAT, the maximum number of branches per plant (8.66) was obtained from S_1I_1 which was statistically similar to S_1I_2 & S_1I_3 (7.66) and the minimum number of branches per plant(5.00) was counted from S_3I_0. At 75 DAT, the maximum number of branches per plant (11.00) was counted from S_1I_1 which was statistically similar to S_1I_2 (10.00) followed by S_2I_1, S_3I_1 and S_3I_3 (9.66) and the minimum number of branches per plant (7.00) was obtained from S_3I_0 (Table 3).

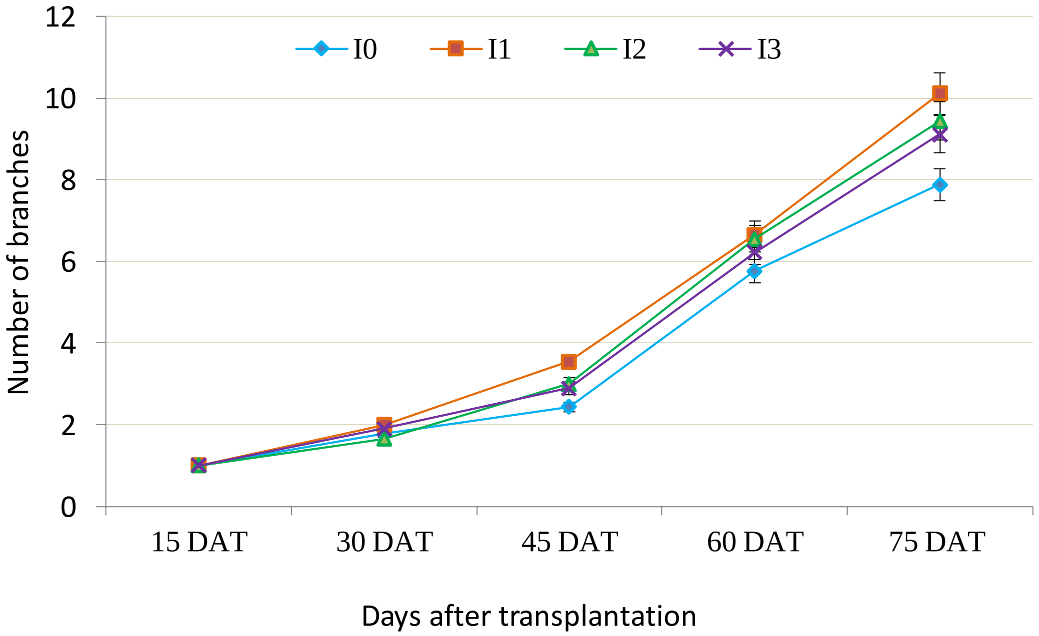
4.4 Stem diameter of plant

The significant variation was found in 30, 45, 60 and 75 DAT due to different seedling age except 15 DAT (Appendix VI). At 30 DAT, the maximum stem diameter (0.93 cm) was found in S_1 (25 days) and the minimum stem diameter (0.82cm) was found from S_3 (35 days old seedling). At 45 DAT, the maximum stem diameter (1.58 cm) was found in S_1 and the minimum stem diameter was found from S_3 (1.39 cm) which was statistically identical to S_2(1.43 cm). At 60 DAT, the maximum stem diameter was found in S_1(2.15 cm) which was statistically similar to S_2 (2.05 cm) and the minimum stem diameter was found from S_3 (1.92 cm).



S_1 : 25 days old seedling; S_2 : 30 days old seedling; S_3 : 35 days old seedling.

Fig. 6. Effect of seedling age on number of branches per tomato plant



I_0 : control (No IAA); I_1 : 80 ppm IAA; I_2 : 100 ppm IAA; I_3 : 120 ppm IAA.

Fig. 7. Effect of IAA on number of branches per tomato plant

Table3. Combined effect of seedling age and IAA on number of branches of tomato plant

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
S_1I_0	1.00	2.00 b	4.00 b	7.00 b	9.00 bcd
S_1I_1	1.00	3.00 a	5.00 a	8.66 a	11.00 a
S_1I_2	1.00	2.00 b	4.00 b	7.66 ab	10.00 ab
S_1I_3	1.00	2.00 b	3.66 bc	7.66 ab	9.33 bc
S_2I_0	1.00	1.30 c	3.33 cd	5.33 c	7.66 de
S_2I_1	1.00	2.00 b	4.66 a	7.33 b	9.66 abc
S_2I_2	1.00	2.00 b	4.00 b	7.33 b	9.00 bcd
S_2I_3	1.00	2.00 b	4.00 b	6.66 b	8.33 cde
S_3I_0	1.00	2.00 b	3.00 d	5.00 c	7.00 e
S_3I_1	1.00	1.00 d	4.00 b	7.00 b	9.66 abc
S_3I_2	1.00	1.00 d	3.66 bc	7.66 ab	9.33 bc
S_3I_3	1.00	2.00 b	4.00 b	7.33 b	9.66 abc
$LSD_{0.05}$	**0.005**	**0.28**	**0.56**	**1.08**	**1.48**
CV%	**0.00**	**8.62**	**10.45**	**10.74**	**10.37**

S_1: 25 days old seedling S_2: 30 days old seedling S_3: 35 days old seedling

I_0 : control (No IAA) I_1 : 80 ppm IAA I_2 : 100 ppm IAA I_3: 120 ppm IAA

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

At 75 DAT, the maximum stem diameter was found in S_1 (2.66 cm) and the minimum stem diameter (2.30 cm) was found from S_3 which was statistically identical to S_2 (2.37 cm) (Table 4). Histamoni and Urabe (1973) reported that high soil temperature (15° C) use of the young tomato seedling supported vigorous vegetative growth, resulting in longer and thicker stems.

Due to different dose of IAA, variation was found in 30, 45, 60 and 75 DAT except 15 DAT (Appendix VI). At 30 DAT, the maximum stem diameter (0.92 cm) was measured in I_1 (80 ppm) which was statistically similar to I_2 (0.90 cm) and the minimum stem diameter (0.80 cm) was measured from I_0. At 45 DAT, the maximum stem diameter (1.45 cm) was found in I_1 which was statistically similar to I_2 (1.39 cm) and the minimum stem diameter (1.25 cm) was found from I_0. At 60 DAT, the maximum stem diameter (2.10 cm) was found in I_1 which was statistically identical to I_2 (2.06 cm) and statistically similar to I_3 (1.97) and the minimum stem diameter (1.82 cm) was found from I_0. At 75 DAT, the maximum stem diameter (2.57 cm) was found in I_1 which was statistically identical to I_2 (2.55 cm) and statistically similar to I_3 (2.41) and the minimum stem diameter (2.20 cm) was found from I_0 (Table 4). Sun et al. (2000) reported that the application of IAA mixed with the water of 45^0 c temperature on tomato plant at lower concentration increased the stem diameter.

Combined effect of seedling age and indole-3-acetic acid showed statistically significant differences on stem diameter at 30, 45, 60 and 75 DAT except 15 DAT (Appendix VI). At 30 DAT, the maximum stem diameter (1.02 cm) was measured from S_1I_1 (25 days old seedling + 80 ppm) which was statistically similar to S_1I_2 (0.95 cm) and the minimum stem diameter (0.71 cm) was measured from S_3I_0 (35 days old seedlings + 0 ppm IAA). At 45 DAT, the maximum stem diameter (1.77 cm) was measured from S_1I_1 (25 days old seedling + 80 ppm) and the minimum stem diameter (1.22 cm) was obtained from S_3I_0 (35 days old seedlings + 0 ppm IAA). At 60 DAT, the maximum stem diameter (2.31 cm) was measured from S_1I_1 (25 days old seedling + 80 ppm) that is statistically similar to S_1I_2 (2.24 cm) and the minimum stem diameter (1.67 cm) was measured from S_3I_0 (35 days old seedlings + 0 ppm IAA). At 75 DAT, the maximum stem diameter (3.13 cm) was obtained from S_1I_1 (25 days old seedling + 80 ppm) which was statistically similar to S_1I_2 (2.81 cm) and the minimum stem diameter (2.20 cm) was measured from S_3I_0 (35 days old seedlings + 0 ppm IAA) (Table 5).

4.5 Number of fruit per cluster

Significant variation was observed on number of fruit per cluster due to application of different age of seedling (Appendix VII). The maximum number of fruit per cluster (8.65) was found in S_1 (25 days) and the minimum number of fruit per cluster (4.57) was found in S_3 (35 days).(Table 6). Weston and Zandstra (1989) found that 4 to 5 week-old transplants produced higher number fruits than younger or older transplants.

Significant variation was found on number of fruit per cluster due to application of different doses of IAA (Appendix VII). The maximum number of fruit per cluster (7.00) was counted from I_1 (80 ppm) which was statistically identical to I_2 (6.89) and the minimum number of fruit per cluster (5.45) was found in I_0 (0 ppm) (Table 6). El-Habbasha *et al*(1999) reported that, many of the treatment with IAA significantly increase fruit set percentage.

Combined effect of different seedling age and different level of IAA showed significant differences on number of fruit per cluster (Appendix VII). The maximum number of fruit per cluster (8.30) was found in S_1I_1 (25 days old seedling + 80 ppm IAA) and the minimum number of fruit per cluster (2.97) counted in S_3I_0 (35 days old seedling + 0 ppm) which was statistical identical to S_3I_1 (2.97) (Table 7).

Table 4.Effects of seedling age and different level of IAA concentration on stem diameter of tomato plant

Treatments	15 DAT (cm)	30 DAT (cm)	45 DAT (cm)	60 DAT (cm)	75 DAT (cm)
S_1	0.63	0.93 a	1.58a	2.15a	2.66 a
S_2	0.60	0.87 b	1.43b	2.05ab	2.37 b
S_3	0.56	0.82c	1.39b	1.92b	2.30 b
LSD $_{0.05}$	**0.12**	**0.04**	**0.09**	**0.18**	**0.13**
I_0	0.60	0.80c	1.25c	1.82b	2.20b
I_1	0.63	0.92a	1.45a	2.10a	2.57a
I_2	0.65	0.90 a	1.39ab	2.06a	2.55 a
I_3	0.49	0.86b	1.34b	1.97ab	2.41ab
LSD $_{0.05}$	**0.08**	**0.03**	**0.09**	**0.15**	**0.17**
CV%	**4.47**	**7.69**	**7.18**	**9.89**	**9.05**

S_1: 25 days old seedling S_2: 30 days old seedling S_3: 35 days old seedling

I_0 : control (No IAA) I_1 : 80 ppm IAA I_2 : 100 ppm IAA I_3: 120 ppm IAA

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

Table 5.Combined effects of seedling age and IAA on stem diameter of tomato plant

Treatments	15 DAT (cm)	30 DAT (cm)	45 DAT (cm)	60 DAT (cm)	75 DAT (cm)
S_1I_0	0.64	0.79 d	1.42 cd	1.91 cd	2.50bcdef
S_1I_1	0.65	1.02**a**	1.77**a**	2.31**a**	3.13**a**
S_1I_2	0.64	0.95ab	1.56 b	2.24ab	2.81ab
S_1I_3	0.65	0.90bc	1.51bc	2.08abc	2.68bcd
S_2I_0	0.60	0.82 d	1.38 cd	1.99bc	2.35ef
S_2I_1	0.65	0.85 cd	1.42bcd	2.01abc	2.39def
S_2I_2	0.66	0.85 cd	1.42bcd	2.14abc	2.74bc
S_2I_3	0.62	0.80 d	1.37 d	1.97bc	2.45cdef
S_3I_0	0.59	0.71 e	1.22 e	1.67 d	2.20 f
S_3I_1	0.59	0.81 d	1.41 cd	1.98bc	2.51bcdef
S_3I_2	0.61	0.84 cd	1.42bcd	2.02abc	2.54bcde
S_3I_3	0.56	0.79 d	1.38cd	1.94 cd	2.47cdef
LSD $_{0.05}$	**0.18**	**0.07**	**0.14**	**0.29**	**0.33**
CV%	**4.17**	**7.69**	**7.18**	**9.89**	**9.05**

S_1: 25 days old seedling S_2: 30 days old seedling S_3: 35 days old seedling

I_0 : control(No IAA) I_1: 80 ppm IAA I2 : 100 ppm IAAI3: 120 ppm IAA

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

4.6 Length of fruit

Significant variation was found in length of fruit due to use of different age of seedling (Appendix VII). The maximum length of fruit (6.12 cm) was found in S_1 (25 Days) and the minimum length of fruit (5.26 cm) was found in S_3 (35 Days) which was statistically identical to S_2 (5.55 cm) (Table 6).

Significant variation was found in length of fruit due to application of different level of IAA (Appendix VII). The maximum length of fruit (6.09 cm) was found in I_1 (80 ppm) which was statistically identical to I_2 (5.89 cm) followed by I_3 (5.58 cm) and the minimum length of fruit (5.00 cm) was found in I_0 (0 ppm) (Table 6). Gupta *et al* (2002)a conducted an experiment and found that, the application of auxins and micronutrients significantly improved the fruit size (length 6.32 cm) with 75 ppm NAA + multiplex;

Combined effect of different seedling age and different level of IAA showed significant differences on length of fruit (Appendix VII). The maximum length of fruit (7.39 cm) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) which was statistically similar to S_1I_2 (6.90 cm) & S_1I_3 (6.86), S_21_1 (6.74 cm), S_21_2 (6.59 cm) and the lowest length of fruit (4.93 cm) measured in S_3I_0 (35 days old seedling + 0 ppm).

4.7 Diameter of fruit

Significant variation was found in diameter of fruit due to use of different age of seedling (Appendix VII). The maximum diameter of fruit (7.66 cm) was found in S_1 (25 Days) which was statistically similar to S_2 (7.29 cm) and the minimum diameter of fruit (6.95 cm) was found in S_3 (35 Days) (Table 6).

Significant variation was found in diameter of fruit due to application of different level of IAA (Appendix VII). The maximum diameter of fruit (7.63 cm) was found in I_1 (80 ppm) which was statistically identical to I_2 (7.48 cm) and the minimum diameter of fruit (6.88 cm) was found in I_0 (0 ppm) (Table 6). Gupta *et al* (2002)a conducted an experiment and found that, The application of auxins and micronutrients significantly improved the fruit size (diameter 6.78) were obtained with 75 ppm NAA + multiplex;

Combined effect of different seedling age and different level of IAA showed significant differences on diameter of fruit (Appendix VII). The maximum diameter of fruit (8.97 cm) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) which was statistically similar to S_2I_3 (8.53 cm) and the lowest diameter of fruit (5.96 cm) measured from S_3I_0 (35 days old seedling + 0 ppm)(Table 7).

4.8 Fresh weight of individual fruit

Significant variation found in fresh weight of individual fruit due to use of different age of seedling (Appendix VII). The maximum fresh weight of fruit (91.84 g) was found from S_1 (25 days) and the minimum fresh weight of fruit (70.34 g) was found in S_3 (35 days) which was statistically identical to S_2 (75.18 gm) (Table 6). Weston and Zandstra (1989) found that 4 to 5 week-old transplants produced higher weight of fruits than younger or older transplants.

Significant variation was found in fresh weight of individual fruit due to application of different level of IAA (Appendix VII). The maximum fresh weight of individual fruit (91.12 g) was found in I_1 (80 ppm) which was statistically identical to I_2 (85.79 g) and the minimum fresh weight of individual fruit (69.34 g) was found in I_0 (0 ppm) which was statistically identical to I_3 (70.23 g) (Table 6). El-Habbasha *et al* (1999) reported that, many of the treatment with IAA significantly increase fruit set percentage.

Table 6.Effects of different levels of IAA and seedling age on yield characteristics of tomato plant

Treatments	Number of fruit/cluster	Length of fruit (cm)	Diameter of fruit (cm)	Fresh weight of individual fruit(g)	Dry mater content of fruit (%)
S_1	8.65 a	6.12 a	7.66 a	91.84 a	11.12 a
S_2	6.07b	5.55 b	7.29ab	75.18b	10.02 b
S_3	4.57c	5.26 b	6.95b	70.34b	9.88 b
$LSD_{0.05}$	**0.29**	**0.36**	**0.48**	**6.45**	**1.03**
I_0	5.45 c	5.00 b	6.88 b	69.34 b	8.90 c
I_1	7.00 a	6.09 a	7.63 a	91.12 a	11.72a
I_2	6.89 a	5.89 a	7.48 a	85.79 a	10.40 b
I_3	6.00 b	5.58 a	7.20 ab	70.23 b	10.29 b
$LSD_{0.05}$	**0.35**	**0.57**	**0.49**	**7.45**	**1.40**
CV%	**7.95**	**10.02**	**8.42**	**10.02**	**9.77**

S_1: 25 days old seedling S_2: 30 days old seedling S_3: 35 days old seedling

I_0 : control (No IAA) I_1 : 80 ppm IAA I_2 : 100 ppm IAA I_3: 120 ppm IAA

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

Table 7. Combined effects of seedling age and IAA on yield characteristics of tomato of plant

Treatments	Number of fruit/cluster	Length of fruit (cm)	Diameter of fruit (cm)	Fresh weight of individual fruit(g)	Dry mater % of fruit
S_1I_0	6.97b	6.65abc	8.40abc	69.33 efg	10.04 bcd
S_1I_1	8.30 a	7.39 a	8.97 a	110.0 a	12.17 a
S_1I_2	6.97b	6.90ab	8.37abc	96.33 b	11.08 abcd
S_1I_3	6.96b	6.86 ab	8.16bcd	87.67bc	11.27 abc
S_2I_0	2.97e	5.93 c	7.70cde	82.67 cd	9.56 cd
S_2I_1	5.97 c	6.74abc	7.96bcd	84.00bcd	9.97 cd
S_2I_2	5.96 c	6.59abc	8.23abc	73.00 def	11.23 abcd
S_2I_3	3.97d	6.26bc	8.53 ab	57.00 gh	9.35 d
S_3I_0	2.97 e	4.93d	5.96 e	53.00 h	7.14e
S_3I_1	3.63 e	6.64abc	8.39abc	76.33cde	10.20 abcd
S_3I_2	3.97d	6.67abc	8.32abc	85.00 bcd	11.88 ab
S_3I_3	3.30de	6.11bc	7.39de	63.00 fgh	10.29 abcd
$LSD_{0.05}$	**0.68**	**0.91**	**0.79**	**12.91**	**1.91**
CV%	**7.95**	**10.02**	**8.42**	**10.45**	**9.77**

S_1: 25 days old seedling S_2: 30 days old seedling S_3: 35 days old seedling

I_0 : control (No IAA) I_1 : 80 ppm IAA I_2 : 100 ppm IAA I_3: 120 ppm IAA

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

Combined effect of different seedling age and different level of IAA showed significant differences on fresh weight of individual fruit (Appendix VII). The maximum fresh weight of individual fruit (110.0 g) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) and the lowest fresh weight of individual fruit (53.0 g) was found in S_3I_0 (35 days old seedling + 0 ppm) (Table 7).

4.9 Dry matter content of fruit

Due to use of different age of seedling significant variation was found in dry matter content of fruit (Appendix VII). The maximum dry matter content of fruit (11.12%) was found from S_1 (25 days) and the minimum dry matter content of fruit (9.88%) was found in S_3 (35 days) which was statistically identical to S_2 (10.02%). (Table 6). Adelana (1983) found that the younger transplants grew faster and therefore produced greater dry matter than the older ones.

Significant variation was found in dry matter content of fruit due to application of different level of IAA (Appendix VII) . The maximum dry matter content of fruit (11.72%) was found in I_1 (80 ppm) and the minimum dry matter content of fruit (8.90%) was found in I_0 (0 ppm) (Table 6). Gupta *et al* (2002a) conducted an experiment and recorded the highest dry matter and ash content from 75 ppm NAA + Humaur.

Combined effect of different seedling age and different level of IAA showed significant differences on dry matter content of fruit (Appendix VII). The maximum dry matter content of fruit (12.17%) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) and the lowest dry matter content of fruit (7.14%) measured in S_3I_0 (35 days old seedling + 0 ppm) (Table 7).

4.10 Length of root:

Significant difference was found in length of root due to difference in seedling age (Appendix VIII). The maximum length of root (37.83 cm) was found from S_1(25 days) and the minimum length of root (29.75 cm) was found in S_3(35 days) which was statistically identical to S_2 (32.42 cm) (Table 8).

Significant variation was found in length of root due to application of different level of IAA (Appendix VIII) . The maximum length of root (34.89 cm) was found in I_1 (80 ppm) which was statistically identical to I_2 (34.22 cm)and statistically similar to I_3 (33.44 cm) and the minimum length of root (30.78 cm) was found in I_0 (0 ppm) (Table 8). Gupta *et al* (2002)a conducted an experiment and found that, the application of auxins and micronutrients significantly produce longest root length with 75 ppm NAA + multiplex.

Combined effect of different seedling age and different level of IAA showed significant differences on length of root (Appendix VIII). The maximum length of root (43.01cm) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) which was statistically similar to S_1I_2 (41.34 cm), and the lowest length of root (29.68 cm) recorded from S_3I_0 (35 days old seedling + 0 ppm) (Table 9).

4.11 Chlorophyll percentage

Significant difference was found in chlorophyll percentage due to difference in seedling age (Appendix VIII). The maximum chlorophyll percentage (53.71%) was found from S_1(25 days) which was statistically similar to S_2 (53.47%) and the minimum chlorophyll percentage (49.35%) was found in S_3 (35 days) (Table 8).

Significant variation was found in chlorophyll percentage due to application of different level of IAA (Appendix VIII). The maximum chlorophyll percentage (56.04%) was found in I_1(80 ppm) which was statistically similar to I_2 (53.66%) and the minimum chlorophyll percentage (49.87%) was found in I_0 (0 ppm) which was statistically identical to I_3 (51.12%) (Table 8). Rai *et al.* (2002)

found that, maximum chlorophyll content and acidity were obtained with NAA at 75 ppm along with Humaur at 2000 ppm.

Combined effect of different seedling age and different level of IAA showed significant differences on chlorophyll percentage. The maximum chlorophyll percentage (57.93%) was obtained from S_1I_1 (25 days old seedling + 80 ppm IAA) and the lowest chlorophyll percentage (39.83%) recorded from S_3I_0 (35 days old seedling + 0 ppm) (Table 9).

4.12 Dry matter content of leaf

Due to different age of seedling significant variation was found in dry matter content of leaf (Appendix VIII). The maximum dry matter percent of leaf (13.09%) was found from S_1 (25 days) and the minimum dry matter percent of leaf (11.50%) was found in S_2 (30 days) that is statistically similar to S_3 (11.74%) (Table 8). Okano *et al*. (2000) reported that, leaf dry weight highest in the 25 and 35 days old seedling plots.

Significant variation was found in dry matter content of leaf due to application of different level of IAA (Appendix VIII). The maximum dry matter content of leaf (12.40%) was found in I_1(80 ppm) which was statistically similar to I_2 (12.28%) followed by I_3 (11.94%) and the minimum dry matter percent of leaf (10.82%) was found in I_0 (0 ppm) (Table 8). Gupta *et al*(2002a) conducted an experiment and recorded the highest dry matter and ash content from 75 ppm NAA + Humaur.

Combined effect of different seedling age and different level of IAA showed significant differences on dry matter percent of leaf. (Appendix VIII). The maximum dry matter percent of leaf (13.60%) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) which was statistically similar to S_1I_2 (11.58%) and S_1I_3 (11.50%) and the lowest dry matter percent of leaf(8.02%) measured in S_3I_0(35 days old seedling + 0 ppm) (Table 9).

Table 8.Yield characteristics of tomato at different level of IAA concentration and seedling age

Treatments	Length of root (cm)	Chlorophyll percentage	Dry mater % of leaf	Number of cluster /plant	Number of flower/cluster
S_1	37.83 a	53.71 a	13.09 a	25.10 a	6.83 a
S_2	32.42 b	53.47 ab	11.50b	17.35 b	6.14b
S_3	29.75 b	49.35 b	11.74ab	12.35 c	5.45c
LSD $_{0.05}$	**2.88**	**4.13**	**1.35**	**1.17**	**0.34**
I_0	30.78 b	49.87 b	10.82 b	14.13c	5.84c
I_1	34.89 a	56.04 a	12.40 a	20.91 a	6.45 a
I_2	34.22 a	53.66 ab	12.28ab	20.80a	6.24ab
I_3	33.44 ab	51.12 b	11.94ab	17.24b	6.03bc
LSD $_{0.05}$	**3.33**	**4.76**	**1.56**	**1.35**	**0.40**
CV%	**10.28**	**9.47**	**10.56**	**7.36**	**6.95**

S1: 25 days old seedling S2: 30 days old seedling S3: 35 days old seedling

I0 : control (No IAA) I1 : 80 ppm IAA I2 : 100 ppm IAA I3: 120 ppm IAA

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

Table 9.Combined effects of seedling age and IAAon yield characteristics of tomato of plant

Treatments	Length of root (cm)	Chlorophyll percentage	Dry mater % of leaf	Number of cluster /plant	Number of flower/cluster
S_1I_0	34.68cde	51.71 abc	10.63 ab	21.67 de	6.64abc
S_1I_1	43.01 a	57.93 a	13.60 a	30.33 a	7.26 a
S_1I_2	41.34ab	44.98cd	11.58 ab	27.33 b	6.88b
S_1I_3	40.34abc	48.24 bc	11.50 ab	25.00 bc	6.60abc
S_2I_0	34.01 de	55.11ab	10.79 bc	13.00 gh	6.11cde
S_2I_1	35.01 cde	47.21bcd	10.13 ab	20.00 e	6.30bcd
S_2I_2	35.68 bcd	49.04 bc	11.46 ab	23.00 cd	6.25bcde
S_2I_3	33.01de	50.55 abc	9.58 bc	17.33 f	5.97cde
S_3I_0	29.68e	39.83d	8.02 c	10.66h	4.80f
S_3I_1	32.68de	48.01 bcd	11.10 ab	15.00 fg	5.83de
S_3I_2	31.68de	45.98cd	12.12 ab	15.33 fg	5.64de
S_3I_3	33.01de	51.61abc	11.69ab	12.33 h	5.56e
$LSD_{0.05}$	**5.77**	**8.25**	**2.71**	**2.34**	**0.69**
CV%	**10.28**	**9.47**	**10.56**	**7.36**	**6.95**

S1: 25 days old seedling S2: 30 days old seedling S3: 35 days old seedling

I0 : control (No IAA) I1 : 80 ppm IAA I2 : 100 ppm IAA I3: 120 ppm IAA

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

4.13 Number of cluster per plant

Due to use of different age of seedling significant variation was found in cluster per plant (Appendix VII). The maximum cluster per plant (25.10) was counted from S_1 (25 days) and the minimum cluster per plant (12.35) was found in S_3(35 days) (Table 8). Adelana (1976) reported that the earliest planting of tomato seedlings resulted higher number of fruits per plant than later planting.

Significant variation was found in cluster per plant due to application of different level of IAA (Appendix VII). The maximum cluster per plant (20.91) was found in I_1 (80 ppm) which was statistically identical to I_2 (20.80) and the minimum cluster per plant (14.13) was found in I_0 (0 ppm) (Table 8). Djanaguiraman *et al*. (2004) studied on application of nitrophenols at 0.4%, that significantly increased the activity of antioxidant enzymes namely superoxide dismutase (SOD), catalase CAT), peroxidase (POX) and auxin content which reflected as increase in fruit cluster per plant, fertility coefficient and yield of tomato.

Combined effect of different seedling age and different level of IAA showed significant differences on cluster per plant (Appendix VII). The maximum cluster per plant (30.33) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) and the lowest cluster per plant per plant (10.66) counted in S_3I_0 (35 days old seedling + 0 ppm) (Table 9).

4.14 Number of flower per cluster

Due to use of different age of seedling significant variation was found in number of flower per cluster (Appendix VIII) . The maximum number of flower per cluster (6.83) was counted from S_1 (25 days) and the minimum number of flower per cluster (5.45) was found in S_3 (35 days) (Table 8)

Significant variation was found in number of flower per cluster due to application of different level of IAA Appendix VIII). The maximum number of flower per cluster (6.45) was found in I_1 (80 ppm) which was statistically similar to I_2 (6.24) and the minimum number of flower per cluster (5.84) was found in I_0 (0 ppm) (Table 8). Leopold (1964) observed that with the increase in concentration of auxin there was a comparable increase in percentage of flower cluster.

Combined effect of different seedling age and different level of IAA showed significant differences on number of flower per cluster (Appendix VIII). The maximum number of flower per cluster (7.26) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) and the lowest number of flower per cluster (4.80) counted in S_3I_0 (35 days old seedling + 0 ppm) (Table 9).

4.15 Carbon assimilation rate

Significant difference was found in carbon assimilation rate due to different use of seedling age (Appendix IX). The maximum carbon assimilation rate (11.32%) was found in S_1 (25 days) while the minimum carbon assimilation rate (6.50%) recorded from S_3 (35 days) (Table 10).

Significant difference was found on carbon assimilation rate due to the application of different levels of IAA (Appendix IX). The maximum carbon assimilation rate (9.87%) was found in I_1 (80 ppm) which was statistically identical to I_2 (9.58%) while the minimum carbon assimilation rate (7.42%) was recorded from I_0 (0 ppm) (Table 10).

Combined effect of different seedling age and different level of IAA showed significant differences on carbon assimilation rate (Appendix IX). The maximum carbon assimilation rate (12.55%) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) which was statistically similar to S_1I_2 (11.13%) and the lowest carbon assimilation rate (5.14%) measured in S_3I_0 (35 days old seedling + 0 ppm) (Table 11).

4.16 Yield per plot

The yield per plot varied significantly due to variation in seedling age (Appendix IX). The maximum yield per plot (28.98 kg) was recorded from S_1 (25 days) while the minimum yield per plot (23.20 kg) was recorded from S_3 (35 days) which was statistically identical to S_2 (24.37 kg) (Table 10). Adelana (1983) found that fruit yield was highest in the 3-week old transplants.

Significant variation was found in yield per plot due to application of different level of IAA (Appendix IX). The maximum yield per plot (28.87 kg) was recorded from I_1 (80 ppm) which was statistically identical to I_2 (27.89 kg) while the minimum yield per plot (21.26 kg) was recorded from I_0 (0 ppm) (Table 10).

Combined effect of different seedling age and different level of IAA showed significant differences on yield per plot (Appendix IX). The maximum yield per plot (33.86 kg) was found from S_1I_1 (25 days old seedling + 80 ppm IAA) which was statistically similar to S_1I_2 (31.65 kg) and the lowest yield per plot (20.12 kg) measured from S_3I_0 (35 days old seedling + 0 ppm) (Table 11).

4.16 Yield per hectare

The yield per hectare varied significantly due to variation in seedling age (Appendix IX). The maximum yield (80.50 t/ha) was recorded from S_1(25 days) while the minimum yield (64.44 t/ha) was recorded from S_3 (35 days) which was statistically identical to S_2 (67.69 t/ha) (Table 10). Palamakumbura (1987) found that 25-day-old seedlings planted at 20 × 100 cm produced highest yield.

Significant variation was found in yield due to application of different level of IAA (Appendix IX). The maximum yield (80.19 t/ha) was recorded from I_1 (80 ppm) which was statistically identical to I_2 (77.47 t/ha) while the minimum yield (59.05 t/ha) was recorded from I_0 (0 ppm) (Table 10). El-Habbasha *et al.* (1999) studied response of tomato plants to foliar spray of GA3, IAA and found that many of the treatments significantly increased total fruit yield and percentage of puffy and parthenocarpic fruits, compared with controls.

Combined effect of different seedling age and different level of IAA showed significant differences on yield (Appendix IX). The maximum yield (94.05 t/ha) found from S_1I_1 (25 days old seedling + 80 ppm IAA) which was statistically similar to S_1I_2 (87.91 t/ha) and the lowest yield (55.88 t/ha) measured in S_3I_0 (35 days old seedling + 0 ppm) (Table 11).

Table 10.Yield characteristics of tomato at different level of IAA concentration and seedling age

Treatments	Carbon assimilation rate	Yield per plot (kg)	Yield per hectare (ton)
S_1	11.32 a	28.98 a	80.50 a
S_2	8.85 b	24.37 b	67.69 b
S_3	6.50 c	23.20 b	64.44b
LSD $_{0.05}$	**0.71**	**1.34**	**3.72**
I_0	7.42c	21.26 c	59.05 c
I_1	9.87 a	28.87 a	80.19a
I_2	9.58a	27.89 a	77.47a
I_3	8.70b	24.05 b	66.80 b
LSD $_{0.05}$	**0.82**	**1.54**	**4.30**
CV%	**10.25**	**6.47**	**6.84**

S1: 25 days old seedling S2: 30 days old seedling S3: 35 days old seedling

I0 : control (No IAA) I1 : 80 ppm IAA I2 : 100 ppm IAA I3: 120 ppm IAA

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

Table 11. Combined effects of seedling age and IAA on yield of tomato plant

Treatments	Carbon assimilation rate	Yield per plot (kg)	Yield per hectare (ton)
S_1I_0	9.81 cd	23.48 ef	65.22ef
S_1I_1	12.55 **a**	33.86 **a**	94.05**a**
S_1I_2	11.13 ab	31.65 ab	87.91 ab
S_1I_3	10.79bc	30.10 bc	83.61bc
S_2I_0	8.01ef	22.29fg	61.91fg
S_2I_1	10.10cd	26.62de	73.94 de
S_2I_2	9.12de	29.47bc	81.86bc
S_2I_3	8.16ef	23.25f	64.58f
S_3I_0	5.14 g	20.12g	55.88 g
S_3I_1	6.97f	26.31de	73.08de
S_3I_2	7.45f	28.61cd	79.47cd
S_3I_3	7.16 f	22.91fg	63.63fg
LSD $_{0.05}$	**1.43**	**2.68**	**7.44**
CV%	**10.25**	**6.47**	**6.84**

S_1: 25 days old seedling S_2: 30 days old seedling S_3: 35 days old seedling)

I_0 : control (No IAA) I_1 : 80 ppm IAA I_2 : 100 ppm IAA I_3: 120 ppm IAA

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

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2014 to April 2015 to find out the effect of different age of seedling and different concentration of IAA on growth and yield of tomato. The experiment consisted of two factors: Factor A: Three age of seedling. The treatments are S_1: 25 days old seedling, S_2: 30 days old seedling, S_3: 35 days. Factor B ; Four level of IAA. The treatments are: I_0: 0 ppm IAA(control), I_1:80 ppm IAA, I_2: 100 ppm IAA, I_3: 120 ppm IAA. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the optimum level of seedling age and IAA on tomato.

At 30, 45, 60, 75 DAT and at harvest the highest plant height (32.58, 62.33, 80.58, 99.75 cm), the maximum number of leaves per plant (12, 40.93, 61.01, 84.03), the maximum number of branches per plant (1.7, 3.16, 6.75, 9.83), the maximum size of stem diameter (0.93, 1.58, 2.15, 2.66 cm), the maximum number of cluster per plant (25.10), the highest number of flower per cluster(6.83),the highest number of fruit per cluster (8.65), the highest length of fruit (6.12 cm), the highest diameter of fruit (7.66 cm), the maximum fresh weight of fruit (91.84 g), the highest dry matter percentage of fruit (11.12%), highest dry matter percentage of leaf (13.09%),the highest length of root (37.83 cm), the maximum chlorophyll percentage of leaf (53.71%), the highest carbon assimilation rate (11.32%), the maximum yield of fruit per plot (28.98 kg) and the highest yield of fruit (80.50 t/ha) were recorded from the treatment of 25 days old seedling that is S_1 treatment. On the other hand, the shortest plant height (23.33, 46.42, 60, 70.08 cm), the minimum number of leaves per plant

(10.41, 30.85, 47.27, 68.02), the minimum number of branches per plant (1.5, 2.66, 5.5, 7.91), the minimum size of stem diameter (0.77, 1.32, 1.85, 2.36 cm), the minimum number of cluster per plant (12.35), the minimum number of flower per cluster (5.45),the minimum number of fruit per cluster (4.57), the shortest length of fruit (5.26 cm), the minimum diameter of fruit (6.95 cm), the minimum fresh weight of fruit (70.34 g), the minimum dry matter percentage of fruit (9.88%), the minimum dry matter percentage of leaf (11.74%),the shortest length of root (29.75 cm), the minimum chlorophyll percentage of leaf (49.35%), the minimum carbon assimilation rate (6.50%), the minimum yield of fruit per plot (23.20 kg) and the lowest yield of fruit (64.44 t/ha) were recorded from the treatment of 35 days old seedling that is S_3 treatment.

At 30, 45, 60, 75 DAT and at harvest the highest plant height (27.22, 56.22, 72.22, 88 cm), the maximum number of leaves per plant (11, 38.33, 56, 79), the maximum number of branches per plant (2, 3.55, 6.66, 10.11), maximum size of stem diameter(0.92, 1.45, 2.10, 2.57 cm), the maximum number of cluster per plant (20.91), the highest number of flower per cluster (6.45), the highest number of fruit per cluster (7.00), the highest length of fruit (6.09), the maximum diameter of fruit (7.63 cm), the maximum fresh weight of fruit (91.12 g), the highest dry matter percentage of fruit (11.72%), the highest dry matter percentage of leaf (12.40%), the highest length of root (34.89 cm), the maximum chlorophyll percentage of leaf (56.04%), the highest carbon assimilation rate (9.87%), the maximum yield of fruit per plot (28.87 kg) and the highest yield of fruit (80.19 t/ha) were recorded from the treatment of 80 ppm IAA that is I_1 treatment. On the other hand, the shortest plant height (23.78, 49, 63.22, 76.11 cm), the minimum number of leaves per plant (8.77, 28.78, 44.56, 65.11), the minimum number of branches per plant (1.77, 2.44,5.77,7.88), the minimum size of stem diameter (0.75, 1.29, 1.80, 2.26 cm), the minimum number of cluster per plant (14.13), the minimum number of flower per cluster (5.84),the minimum number of fruit per cluster (5.45), the shortest length of fruit (5.00 cm), the minimum diameter of fruit (6.88 cm), the minimum fresh weight of fruit (69.34 g), the minimum dry matter percentage of fruit (8.90%), the minimum dry matter percentage of leaf (10.82%), the shortest length of root (30.78 cm), the minimum chlorophyll percentage of leaf (49.87%), the minimum carbon assimilation rate (7.42%), the minimum yield of fruit per plot (21.26 kg) and the lowest yield of fruit (59.05 t/ha) were recorded from the treatment of I_0 that is 0 ppm Indole-3-acetic acid .

At 30, 45, 60, 75 DAT and at harvest the highest plant height (31.33,62.00, 82.00, 108.00 cm), the maximum number of leaves per plant (16.00,50.67, 71.67,97.67), the maximum number of branches per plant (3.00,5.00,8.66 ,11.00), the maximum size of stem diameter (1.02, 1.77, 2.31, 3.13 cm), the maximum number of cluster per plant (30.33), the highest number of flower per cluster (7.26), the highest number of fruit per cluster (8.30), the highest length of fruit (7.39 cm), the maximum diameter of fruit (8.97 cm), the maximum fresh weight of fruit (110.00 g), the highest dry matter percentage of fruit (12.17%), the highest dry matter percentage of leaf (13.60%),the highest length of root (43.01 cm), the maximum chlorophyll percentage of leaf (57.93%), the highest carbon assimilation rate (12.55%), the maximum yield of fruit per plo (33.86 kg) and the highest yield of fruit (94.05 t/ha) were recorded from the treatment combination of S_1I_1 (25 days old seedling + 80 ppm IAA). On the other hand, the shortest plant height (17.02,17.33,35.33,50.67 cm), the minimum number of leaves per plant(10.33, 27.00 , 40.33, 59.67), the minimum number of branches per plant (2,3,5,7), the minimum size of stem diameter (0.68, 1.18, 1.61, 2.12 cm), the minimum number of cluster per plant (10.66), the minimum number of flower per cluster (4.80),the minimum number of fruit per cluster (2.97), the minimum length of fruit (4.93 cm), the minimum diameter of fruit (5.96 cm), the minimum fresh weight of fruit (53.00 g), the minimum dry matter percentage of fruit (7.14%), the minimum dry matter percentage of leaf (8.02%),the shortest length of root (29.68 cm), the minimum chlorophyll percentage of leaf (39.83%), the lowest carbon assimilation rate (5.14%), the minimum yield of fruit per plot (20.12 kg) and the lowest yield of fruit (55.88 t/ha) were recorded from the treatment combination of S_3I_0 35 days old seedling + 0 ppm IAA).

Conclusion:

Based on the result of the present study it was found that application of 25 days old seedling and 80 ppm IAA treatment combination performed the highest yield (94.05 t/ha) for tomato production.

Considering the findings of the experiment, it can be concluded that –

- The combination of 25 days old seedling and 80 ppm IAA that is S_1I_1 treatment combination was found the appropriate practice for tomato production.

Recommendation:

The cumulative effect of age seedling and IAA was positive up 25 days and 80 ppm respectively. On the other hand the cumulative effect of 35 days old seedling and 120 ppm IAA was antagonistic. Due to some limitations it was unable to find out the effect of further increasing the age of seedling and concentration of IAA. So the recommendation is –

- Further research should be conducted by setting different age of seedling and more treatment of IAA to find out the most suitable stage of seedling that could be more effective for the highest positive cumulative effect.

CHAPTER VI

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APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2014 to April 2015

Month	Air temperature (^0C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
October , 2014	29.18	18.26	81	39
November, 2014	25.82	16.04	78	0
December, 2014	22.4	13.5	74	0
January, 2015	24.5	12.4	68	0
February , 2015	27.1	16.7	67	3
March , 2015	31.4	19.6	54	11
April , 2015	35.3	22.4	51	15

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix II. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percentage (%)
Sand	27
Silt	43
Clay	30

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.45
Total nitrogen (%)	0.03
Available P (ppm)	20
Exchangeable K (%)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix-III. Analysis of variance of data on plant height at different DAT of tomato plant

Source of variation	Degrees of freedom (df)	Mean square of plant height at				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Replication	2	2.694^{NS}	9.250	46.861	114.528	235.083
Factor A (Seedling age)	2	0.861^{NS}	258.250 **	776.694 **	1271.194 **	2644.333 **
Factor B (Indole-3-acetic acid)	3	0.250^{NS}	23.287 **	111.741 **	159.065 **	269.361**
Interaction (A X B)	6	0.417^{NS}	2.509 *	13.657 *	5.231 **	23.333 *
Error	22	0.361^{NS}	1.765	11.891	18.194	29.265

NS : Non significant ; ** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-IV. Analysis of variance of data on number of leaves at different DAT of tomato plant

Source of variation	Degrees of freedom (df)	Mean square of number of leaves at				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Replication	2	0.444 NS	1.583	0.694	13.361	6.361
Factor A (Seedling age)	2	1.194 NS	20.250 **	329.194 **	632.528 **	830.861 **
Factor B (Indole-3-acetic acid)	3	0.074 NS	8.407 **	154.481**	236.963 **	335.287 **
Interaction (A X B)	6	0.046 NS	4.657 **	32.120 *	61.02 **	89.898 *
Error	22	0.202 NS	0.462	14.088	16.179	25.270

NS: Non significant; ** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-V. Analysis of variance of data on number of branches per plant at different DAT of tomato plant

Source of variation	Degrees of freedom (df)	Mean square of number of branches at				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Replication	2	0.0^{NS}	0.028	0.111	2.528	5.861
Factor A (Seedling age)	2	0.0^{NS}	1.694 **	0.778 **	4.361 **	4.528 **
Factor B (Indole-3-acetic acid)	3	0.0^{NS}	0.250 **	1.889 **	6.852 **	7.806 **
Interaction (A X B)	6	0.0^{NS}	0.917 *	0.333 *	0.769 *	0.861 *
Error	22	0.0^{NS}	0.028	0.111	0.407	0.770

NS : Non significant ; ** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix-VI. Analysis of variance of data on stem diameter of tomato plant at different DAT

Source of variation	Degrees of freedom (df)	Mean square of stem diameter of plant at				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Replication	2	0.001^{NS}	0.002	0.004	0.017	0.047
Factor A (Seedling age)	2	0.009^{NS}	0.050 **	0.134 **	0.169 *	0.428 **
Factor B (Indole-3-acetic acid)	3	0.001^{NS}	0.026 **	0.067 **	0.145 *	0.237 **
Interaction (A X B)	6	0.001^{NS}	0.006 *	0.020 *	0.025 *	0.070 **
Error	22	0.000^{NS}	0.002	0.007	0.031	0.039

NS: Non significant ** : Significant at 1% level of probability; * : Significant at 5% level of probabilit

Appendix-VII. Analysis of variance of data on yield Characteristics of tomato plant

Source of variation	Degrees of freedom (df)	Mean square of				
		Number of fruit/ cluster	Length of fruit	Diameter of fruit	Fresh weight of individual fruit	Dry matter content of fruit (%)
Replication	2	1.444	1.742	0.021	58.528	3.726
Factor A (Seedling age)	2	99.361 **	2.303 **	1.499 **	1526.778 **	5.568 *
Factor B (Indole-3-acetic acid)	3	31.657 **	2.035 **	0.995 *	1089.185 **	11.979 **
Interaction (A X B)	6	5.657 *	0.321 **	0.622 *	423.519 *	2.039 **
Error	22	0.535	0.290	0.221	58.104	1.278

Appendix-VIII. Analysis of variance of data on yield Characteristics of tomato plant

Source of variation	Degrees of freedom (df)	Mean square of				
		Length of root	Chlorophyll percentage of leaf	Dry matter content of leaf (%)	Number of clusters/plant	Number of flowers/cluster
Replication	2	13.583	32.594	4.133	9.194	0.644
Factor A (Seedling age)	2	203.583 **	72.122 *	8.783 *	51.194 **	5.769 **
Factor B (Indole-3-acetic acid)	3	29.259 *	32.469 *	10.163 *	4.963 *	0.630 *
Interaction (A X B)	6	10.398 *	83.489 *	2.969 *	2.046 *	0.159 *
Error	22	11.614	23.792	2.572	0.164	0.169

** : Significant at 1% level of probability;   * : Significant at 5% level of probability

Appendix-IX. Analysis of variance of data on yield Characteristics of tomato plant

Source of variation	Degrees of freedom (df)	Mean square of		
		Carbon assimilation rate	Yield per plot (kg)	Yield per hectare (ton)
Replication	2	11.677	1.075	8.286
Factor A (Seedling age)	2	69.542 *	112.244 **	865.613 **
Factor B (Indole-3-acetic acid)	3	10.889 **	111.504 **	860.656 **
Interaction (A X B)	6	1.225 **	7.341 **	56.659 **
Error	22	0.713	2.510	19.347

** : Significant at 1% level of probability; * : Significant at 5% level of probability