EFFECT OF POTASSIUM AND INDOLE ACETIC ACID ON GROWTH AND YIELD OF TOMATO

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JUNE,2015

EFFECT OF POTASSIUM AND INDOLE ACETIC ACID ON GROWTH AND YIELD OF TOMATO

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Reg. No.:08-02997

A Thesis
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 (MS)
IN
HORTICULTURE

SEMESTER: JANUARY - JUNE,2015

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF POTASSIUM AND INDOLE ACETIC ACID ON GROWTH AND YIELD OF TOMATO"** 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 **MD. SHARIFUL ISLAM**, Registration No. **08-02997** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2015
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ACKNOWLEDGEMENT

The author deems it a much privilege to express his enormous sense of gratitude to the almighty creator for the ever ending blessings in successful completion of the research work.

The author feels proud to express his deep sense of gratitude, sincere appreciation and immense indebtedness to his supervisor **Professor Dr. Md. Nazrul Islam**, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his continuous guidance, cooperation, constructive criticism and helpful suggestions, valuable opinion in carrying out the research work and preparation of the thesis, without his intense co-operation this work would not have been possible.

The author feels proud to express his deepest respect, sincere appreciation and immense indebtedness to his co-supervisor **Prof. Md. Ruhul Amin**Department of Horticulture, SAU, Dhaka, for his scholastic and continuous guidance during the entire period of course, research work and preparation of the thesis.

The author expresses his sincere respect to **Prof.Dr. A. F. M. JamalUddin**, **Prof. Md. HasanuzzamanAkand**and**Prof. Dr. Md. IsmailHossain**, Department of Horticulture,SAU, Dhaka,for valuable suggestions and cooperation during the study period andalso expresses his heartfelt thanks to all the teachers of the Department of Horticulture, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.

The author extends his sincere appreciation to his father, Md.AbulShekh, beloved mother,Nargis Begum, brother Md. Tarikul Islam, well wishers and friends H. E. M. KhairulMazed and Molla Al Mamun.

The Author

EFFECT OF POTASSIUM AND INDOLE ACETIC ACID ON GROWTH AND YIELD OF TOMATO[1]

By

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ABSTRACT

An experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2014 to April 2015to study the effect of potassium and indole acetic acid on growth and yield of tomato. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and consisted of two factors, Factor A (4 Levels of potassium): K_0= Control, K_1= 110 kg/ha K_2O, K_2 = 140 kg/ha $K_2O$and K_3 = 170 kg/ha K_2O respectively andFactor B (3 Levels of indole acetic acid): I_0= Control, I_1= 25 ppm, I_2= 50 ppm IAA and.In case ofpotassium, K_2 produced the highest yield (64.17 t/ha) and K_0 produced the lowest yield (52.07 t/ha). In case of IAA, I_2treatment produced the highest yield (63.39 t/ha) and I_0produced the lowest yield (51.27 t/ha). The treatment combination of K_2I_2 produced the highest yield (70.78 t/ha) and K_0I_0produced the lowest yield (48.61 t/ha). The highest (3.80) benefit cost ratio was recorded from K_2I_2treatment combination. So, 140 kg/ha K_2O with 50 ppm IAA was found suitable for growth and yield of tomato.

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LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-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 Transplanting
et al.	and others
etc.	etcetera
FAO	Food and Agricultural Organization

GA_3	Gibberellic Acid
HRC	Horticulture Research Centre
Hort.	Horticulture
IAA	Indole-3-Acetic Acid
MOP	Muriate of Potash
ns	Non Significant
NAA	Naphthalene Acetic Acid
PGR	Plant Growth Regulator
ppm	Parts Per Million
Res.	Research

ABBREVIATIONS	**ELABORATIONS**
RH	Relative humidity
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource Development Institute
Sci.	Science 's
TSP	Triple Super Phosphate
UNDP	United Nations Development Program
Vol.	Volume

CHAPTER I

INTRODUCTION

Tomato (*Lycopersiconesculentum* Mill.) is a solanaceousself pollinated vegetable crop. It is one of the important, popular and nutritious vegetables grown in Bangladesh in both winter and summer season around all parts of the country. It is adapted to a wide range of climates. At present, tomato ranks third, next to potato and sweet potato, in terms of worlds vegetable production (FAO, 2013). The leading tomato producing countries of the world are China (50,000,000 tons), India (17,500,000 tons), United States (13,206,950 tons), Turkey (11,350,000 tons) Egypt (8,625,219 tons), Iran (6,000,000 tons), Italy (5,131,977 tons), Spain (4,007,000 tons), Brazil (3,873,985 tons) and Mexico (3,433,567 tons) (FAO, 2013).

Tomato fruit can be consumed either fresh, cooked or in the form of processed products such as jam, jelly, juice, ketchup, sauce etc. It is considered as 'poor man's apple' because of its attractive appearance and very high nutritive value, containing vitamin A, vitamin C and minerals like calcium, potassium etc. Apart from these, it also contains organic acids like citric, malic and aceitic acids which is found in fresh tomato fruit, promotes gastric secretion, acts as a blood purifier and works as intestinal antiseptic (Pruthi, 1993).Tomato is a rich source of lycopene and vitamins. Lycopene may help counteract the harmful effects of substances called free radicals, which are thought to contribute to age-related processes and a number of types of cancer, including, but not limited to, those of prostate, lung, stomach, pancreas, breast, cervex, colorectum, mouth and oesophagus. Masroor*et al.*, (1988).

Bangladesh produced 251000 tons of tomato in 23,827 hectares of land during the year 2012-2013 (BBS, 2013).The average yield of tomato in Bangladesh is quite low (10.54 t/ha)compare to that in China (48.1 t/ha), India (19.5 t/ha),Japan (52.817 t/ha), USA (81.0 t/ha),Turkey (33.1 t/ha),Egypt (34t/ha), Italy (50.7 t/ha), Spain (74.0t/ha), Brazil (60.7 t/ha), Mexico (30.5 t/ha) respectively (Anonymous, 2011). There are some high yielding varieties of tomato in Bangladesh today and the average yield of BARI Tomato-14 is 90-95 t/ha (Razzak*etal.*, 2011).

The growth behavior of many crop plants could be modified and controlled by applying small amount of growth regulators. But the time and method of application, the biological activity of growth regulators, its movement and persistence are important consideration when parent plant treatment investigated. The exogenous application of growth regulator IAAstimulate flowering, pollination, fertilization and seed setting to yield better quality seeds. The plant growth regulators have contributed a great deal to the progress of Olericulture. Hence, the manipulation of production techniques to achieve optimum sourcesink ratio that would augment high fruit and seed yield accompanied by seed quality attributes can be achieved by spraying suitable growth regulators at proper stage of crop growth. (Sanjeev, 2007).

Potassium is especially important in a multi nutrient fertilizer application (Brady, 1995). Potassium application increases the flower number, the peduncle length, the fruit set and the number of fruit (Besford and Maw, 1975). It has marked effect on the quality of tomato fruits particularly on color (Wall, 1940 and Ozbun*et al.*, (1967). Potassium also has an important role on balancing physiological activities.

IAA stimulates cell elongation by stimulating 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 (Zhao, 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 the 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, in accordance with recent agricultural policy to increase yield vertically and to get early yield and better quality fruit, an attempt was made to study the effects of different levels of potassium and different concentrations of Indole acetic acid on plant growth and yield of tomato with the following objectives:

- to find out the optimum level of potassium for the optimum growth and yield of tomato
- to study the effect of different concentrations of Indole acetic acid on growth and yield of tomato
- to find out the suitable combination of potassium and Indole acetic acid concentrations for higher yield of tomato

CHAPTER II
REVIEW OF LITERATURE

Tomato is an important vegetable crop and received much attention of the researchers throughout the world to develop its suitable production technique among various research works. Investigations have been made in various parts of the world to determine the different levels of potassium and Indole acetic acid for its successful cultivation. However, the combined effects of these production practices have not been defined clearly. In Bangladesh, there have not many studies on the influence of different levels of potassium and Indole acetic acid on the growth and yield of tomato. Relevant available information in this connection has been described in this chapter.

2.1 Effect of potassium on the growth and yield of tomato

Afzal*et al.* (2015) conducted an experiment to investigate the specific contribution of potassium to yield and quality of tomato, a field experiment was conducted on two tomato cultivars, Nagina and Roma. Foliar application with varying levels (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0%) of potassium solutions was applied to the plants and compared with control (without K). Exogenous application of 0.6% K significantly improved plant height, lycopene content, potassium, fruit weight and diameter. Exogenous application of 0.5, 0.6 and 0.7% K maximally improved ascorbic acid contents of both tomato cultivars whereas 0.4 and 0.8% did not improve ascorbic acid contents. Due to positive correlation between K nutrition and fruit quality attributes, exogenous application of an appropriate K level can contribute to higher yield and better quality of tomato fruits. Among all potassium levels, 0.5–0.7% K maximally improved performance of tomato plants of both cultivars.

Javaria*et al.* (2012) conducted a pot experiment which included six potassium fertilizer treatments (75, 150, 225, 300, 375, 450 Kg K_2O ha^{-1}) with basal doses of N and P (100 Kg and 80 Kg ha^{-1}, respectively). All potassium treatments significantly increased yield characteristics as well as post harvest quality of tomato fruit compared with untreated one (control). However, Treatment (NP+450 K_2O Kg ha^{-1}) surpassed all the other treatments in term of yield parameters. Potassium application significantly increased number of flowers $plant^{-1}$, fruit setting rate, number of truss $plant^{-1}$, fruits $plant^{-1}$ and yield ha^{-1}. Moreover, increased potassium levels also had positive effect on post harvest life attributes of tomato fruit. In addition, the Shelf life, quality of general appearance and taste were significantly influenced as potassium levels increased to 375 kg K_2O ha-1 but decreased at 450 Kg K_2O ha^{-1}. On the other hand, while increased potassium levels decreased all the undesired parameters, wilting and drying of calyx, physiological weight loss %, and % non marketable yield .Therefore, when potassium was applied @ 450 Kg K_2O ha^{-1} it increased the yield had decreased the adverse effect on marketable yield, wilting and drying of calyx and weight retention of tomato fruit. In conclusion 375-400 Kg K_2O ha^{-1} is recommended as it produced better quality tomatoes with longer postharvest life.

Iqbal*et al*. (2011) conducted an experiment to study the effect of N and K doses (60, 90 and 120kg ha^{-1} N and 90 kg, 110kg, 130kg of K) on growth, economical yield and yield components of tomato under the agro-climatic conditions of Swat. The parameters selected under study i.e plant height at flowering stage, days to flowering, days to maturity, number of primary branches per plant, fruit length, fruit width, number of fruits per plant and total yield were significantly affected by the applications of N and K. The maximum days to flowering (52) in 0kg N and 110kg of K, maximum days to maturity (85.67) were taken when was obtained with the application of 120kg N and 130kg ha^{-1} of K was applied. Maximum fruit length (5.96cm) was noted in 0kg of N and 130kg/N of K, while maximum fruit diameter (5.08cm) was noted when plants received 120kg N and 90kg K. in treatment 14 (120kg N and 90kg ha^{-1} of K), Economical yield (19 ton ha^{-1}) was obtained with 60kgN and 130kg ha^{-1} of potassium.

Ehsan*et al.* (2010) conducted a field experiment to evaluate comparative effects of sulphate and muriate of potash (SOP and MOP) application on yield, chemical composition and quality of tomato (*Lycopersiconesculentum* M. cultivar Roma) at National Agricultural Research Centre Islamabad, Pakistan. Potassium from two sources i.e., MOP and SOP was applied @ 0, 100 and 200 kg K ha^{-1} with constant dose of 200 kg N ha^{-1} and 65 kg P ha^{-1}. A significant increase in tomato yield with K application was observed. Potassium applied @ 100 kg K ha^{-1} as MOP produced significantly higher marketable tomatoes as compared to SOP and control. Vitamin C contents in tomato fruits increased with K application in the form of MOP. The K use as MOP significantly reduced incidence of leaf blight disease and insect pest attack in tomato plant as compared to SOP and control treatments.

Harneet*et al.,* (2004) conducted an experiment in Punjab, India during 2000-01 to study the effect of nitrogen and potassium application on the growth, yield and quality of spring crop of tomato cv. Punjab Upma. Treatments consisted of 16 combinations of 4 levels each of N (100, 140, 180, 220 kg/ha) and K (40, 60, 80, 100 kg/ha). Increasing the N level from 100 to 140 kg/ha and the K level from 40 to 60 kg/ha significantly increased marketable and total yields. Significant increase in juice content, ascorbic acid content, N and K concentrations in leaves was observed when the N level increased from 100 to 140 kg/ha. There was also a significant increase in the concentration of K in leaves when K level was increased from 40 to 60 kg/ha.

Liu *et al.,* (2004) conducted in a solar greenhouse using tomato cv. Zhongza 9 to investigate the light and temperature in the greenhouse, and the distribution of N, P and K in soil culture in winter-spring and autumn-winter crops. The distribution of total N, P and K was affected by light and temperature condition in the greenhouse. Both in winter-spring and autumn-winter crops, the distribution trend of total N, P and K was the same as that of dry material: mainly distributed in the stem and leaves before fruit formation stage, and in the fruits during fruit formation stage. In autumn-winter crop, because of the abominable light and temperature condition, the distributing proportion of N, P and K in early and middle stages of picking was higher than that in winter-spring crop. The total proportion changed with different elements and growth stages.

Clarke (2004) found little effect of potassium application on flower production, although the proportion of flowers that matured into marketable fruit and hence the yield, increased with potassium level.

Chandra *et al.*, (2003) conducted to the effects of N: P: K rate (200:100:150, 350:200:250 or 500:300:350 kg/ha) on the performance of 4 indeterminate tomato hybrids (Rakshita, Karnataka, Naveen and Sun 7611) were studied in a multi-span greenhouse during 2000-2001 and 2001-2002. In both years, Karnataka registered the greatest fruit diameter (6.97 and 6.98 cm), average fruit weight (83.28 and 83.88 g), fruit yield (2.85 and 3.07 kg/plant), calculated yield (8.55 and 9.21 kg/m^2), juice content (58.84 and 62.43%), gross income (94.05 and 101.31 rupees/m^2), net income (17.38 and 24.64 rupees/m2) and benefit: cost ratio (1.23 and 1.32), and the lowest cost of cultivation (76.67 rupees/m2 in each year). Rakshita exhibited the greatest pulp content (77.46 and 78.73%), total soluble solids (6.07 and 6.27%) and shelf life (6.40 and 6.50 days). Among the fertilizer levels, N: P: K at 350:200:250 kg/ha was superior in terms of fruit diameter, average fruit weight, yield, gross income and benefit: cost ratio.

A study was undertaken by Khalil *et al.,* (2001) in Peshawar, Pakistan in the summer of 1995-96 to determine the appropriate nitrogen fertilizer for maximum tomato (cv. Peshawar Local) yield and its effects on various agronomic characters of tomato. Treatments comprised: untreated control; 140 kg ammonium nitrate/ha; 140 kg ammonium nitrate/ha + 100 kg P/ha + 50 kg K/ha; 140 kg ammonium sulfate; 140 kg ammonium sulfate/ha + 100 kg P/ha + 50 kg K/ha; 140 kg urea/ha; 140 kg urea/ha + 100 kg P/ha + 50 kg K/ha. Generally, ammonium sulfate fertilizer was the most efficient source of nitrogen for tomato production, followed by urea and ammonium nitrate. The ammonium sulfate + P + K treatment was the best among all treatments with respect to days to flower initiation (57 days), days to first picking (94 days), weight of individual fruit (50.8 g), weight of total fruits per plant (1990 g) and yield (21865 kg/ha). The control resulted in the significantly lowest response with respect to different agronomic characters under study.

Sun-Hong Mei *et al.*, (2001) investigated the effect of K deficiency on the incidence of brown blotches in ripening fruits of tomatoes. K deficiency was associated with the occurrence of brown blotches, with more blotches observed in plants experiencing longer periods of K deficiency. Yield was reduced in K-deficient plants.

Pansare*et al.*, (1994) conducted a fertilizer trail to find out the effect of different N, P and K on yield and quality of tomato. They reported that the maximumyield of high quality tomatoes were obtained when straight fertilizers was added in the N, P, K ratio of 3:1:2 (140 kg N/ha, 50 kg P_2O_5/ha, 100 kg K_2O/ha).

Cerne and Briski (1993) conducted field trials on the fertilizer and irrigation requirement of tomato cv. Rutgers plants where 250 kg N and 72 kg P_2O_5/haplants 200 or 400 kg K_2O/ha in the first year, 0 or 140 kg K_20/ha in the second year, 0 or 40 t ; stable manure/ha were applied in all treatments. The combination of 400 kg K_2O/ha stable manure and irrigation gave the highest total yield in the 1st and 2nd years (1.03and 2.25 kg/plant respectively).

Silva and Vizzotto (1990) conducted field trail with the cultivar Angela Gigante 1-5, 100, the plants received N: P_2O_5: K_2O at 30-180: 75-450:30-170 kg/ha plus poultry manure at 0, 10 or 20 t/ha. The largest fruits and the highest yields (53 t/ha) were obtained by applying N: P_2O_5: K_2O at 104:259:140 kg/ha plus poultry manure at 20 t/ha.

Mehta and Saini (1986) conducted, two year fertilizer trails and found the plants received basal FYM (20 t/ha) and N at 75-125, P_2O_5 at 60-90 or K_2O at 30-60 kg/ha, significant yield increases were obtained with the highest N and K rates.

On a sandy loam soil Murphy (1964) found that applicationsof potassium increased plant height by up to 65%, but the responses are correspondingly smaller on soils with greater reserves of potassium. Increasing levels of potassium to improve all aspects of fruit quality eg.by reducing the incidence of hollow fruit, and of ripening disorders, by improving fruit shape and firmness.

2.2 Effect of IAA on growth and yield of Tomato

Khaled*et el.* (2015) included three concentrations of Indole Acetic Acid (0, 100 and 200 ppm) and three tomato varieties (BARI tomato 7, Manik and Ratan). Plant height, number of leaves and number of branches, days required for first flower initiation, days required for 50% flowering, days required for fruit setting, fruit cluster plant^{-1} , fruit plant^{-1}, weight tomato^{-1}, yield plant^{-1}, yield plot^{-1} and yield hectare^{-1} were significant influenced by the combined application of IAA and varieties of tomato. BARI Tomato-7 had the highest fruit yield with 100 ppm IAA and the lowest yield was observed in Ratan with 0 ppm IAA. IAA treated plots showed better performance for growth parameters and yield compared to control condition and 100 ppm IAA was more suitable that the 200 ppm IAA for higher yield of tomato cultivation. Among the treatment combinations, BARI Tomato-7 with 100 ppm IAA was superior, Ratan with 0 ppm IAA was inferior and BARI Tomato-7with 200 ppm IAA, Manik with 200 ppm IAA and Ratan with 200 ppm IAA treated plots showed the intermediate results for yield and yield components.

Singh *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 Pl (25 ppm IAA) x M2 (Humaur) interaction was better in increasing the plant growth at 75 DAT. The number of branches was signiticantly 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 P4 (75 ppm NAA) x M2 (Humaur). Application of 35 ppm IAA and 2000 ppm Humaur was significantly increased the tomato yield. P4 (75 ppm NAA) x M2 (2000 ppm Humaur) was also significantly increased the yield. It can be concluded that addition of PGR and micronutrient in tomato is useful for better production.

Djanaguiraman*et al*. (2004) conducted an experiment where the plants were with four different concentrations of Nitrophenols (ATONIK) at flowering and fruit setting stage. Observations 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 ppm and 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 micronutrient mixtures on fruit size, color and yield of tomato (*Lycopersiconesculentum*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 (DAT) and / or Micronutrient mixtures (2500 ppm Multiplex and 2000 ppm Humaur) at 25 and 50 DAT, respectively, on tomato cv. Krishna (F_1 hybrid). 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 [2- naphthoxyacetic acetic acid] and IAA (I, l0 or 100 ppm), applied as either as 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 I 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 an experiment to observed the effect of the plant growth regulators (PGRs) IAA and NAA (15 and 75 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 (DAT). 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 either PGR or micronutrient mixture. NAA at 75 ppm + Multiplex increased P content by l6.l2 % and iron content by 23.33%. The application of 75 ppm NAA + Humaur increased K content by 13.80% and Ca 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 (F_1 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 ppm + 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 clays alter 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 solid content (5.4%) in mature tomato fruits was recorded from treatments of- NAA and Humaur. The maximum lycopene and carotenoid contents were recorded from NAA and Multiplex. Reducing and non-reducing sugar contents were the highest (4 mg/l00 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 ($45CaCl_2$) in tomato leaves. All tomato (cv. Sunroad) leaves, except the 7th and 8th or 5th to 8th 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 GA_3 to either of these leaves resulted in the accumulation of $45Ca_2$ twice as high in the treated plants as in the plants which were sprayed distilled water (control plants). When 2-(3-chloroplrenoxy) propanoic acid (CPA) was applied onto the upper leaf, than $45Ca_2$ 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.

Sun *et al.* (2000) reported the role of growth regulators on cold water for 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 ^{0}C) on the reduction of stem elongation and of plung -grown tomato) seedlings was investigated. Paclobutrazol, ethephon and GA reduced the stem length but increase the stem diameter of the tomatoes at several water temperatures. 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 experiment 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 l0 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 l0 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 at100 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 increased flower induction and fruit set.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment.

3.1 Location of the experiment field

The experiment was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October 2014 to March 2015. The location of the experimental site was at 23.75^0N latitude and 90.34^0 E longitudes with an elevation of 8.45 meter from the sea level.

3.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of May to September (Anonymous, 1988) and scattered rainfall during rest of the year. Information regarding average monthly temperature as recorded by Bangladesh Meteorological Department (climate division) during the period of study has been presented 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 (Haider, 1991). The analytical data of the soil samples 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 experiments was "BARI Tomato-14". This is a high yielding and indeterminate type variety and the seeds were collected from theolericulture division of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI).

3.5 Raising of seedlings

Tomato seedlings were raised in two seedbeds of 2 m x 1m size. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed and 5 kg well rotten cow dung was mixed with the soil. 10 gram of seeds was sown on each seedbed on October 2014. After sowing, seeds were covered with light soil. The emergence of the seedlings took place within 5 to 6 days after sowing. Weeding, mulching and irrigation were done as and when required.

3.6 Treatments of the experiment

The experiment consisted of two factors in as follows:

Factor A: Four levels of potassium

K_0 = Control (no fertilizer)

K_1 = 110 kg K_20/ha

K_2 = 140 kg K_20/ha

K_3 = 170 kg K_20/ha

Factor B: Three levels of IAA (Indole acetic acid)

I_0 = Control

I_1 = 25 ppmIAA

I_2 = 50 ppmIAA

There were altogether 12 treatment combinations used in each block were as follows; K_0I_0, K_0I_1, K_0I_2, K_1I_0, K_1I_1, K_1I_2, K_2I_0, K_2I_1, K_2I_2, K_3I_0, K_3I_1, K_3I_2.

3.7 Design and layout of the experiment

The experiment was laid out in a 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 consisted 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 1.0 m and 0.5 m, respectively. A layout of the experiment has been shown in Figure 1.

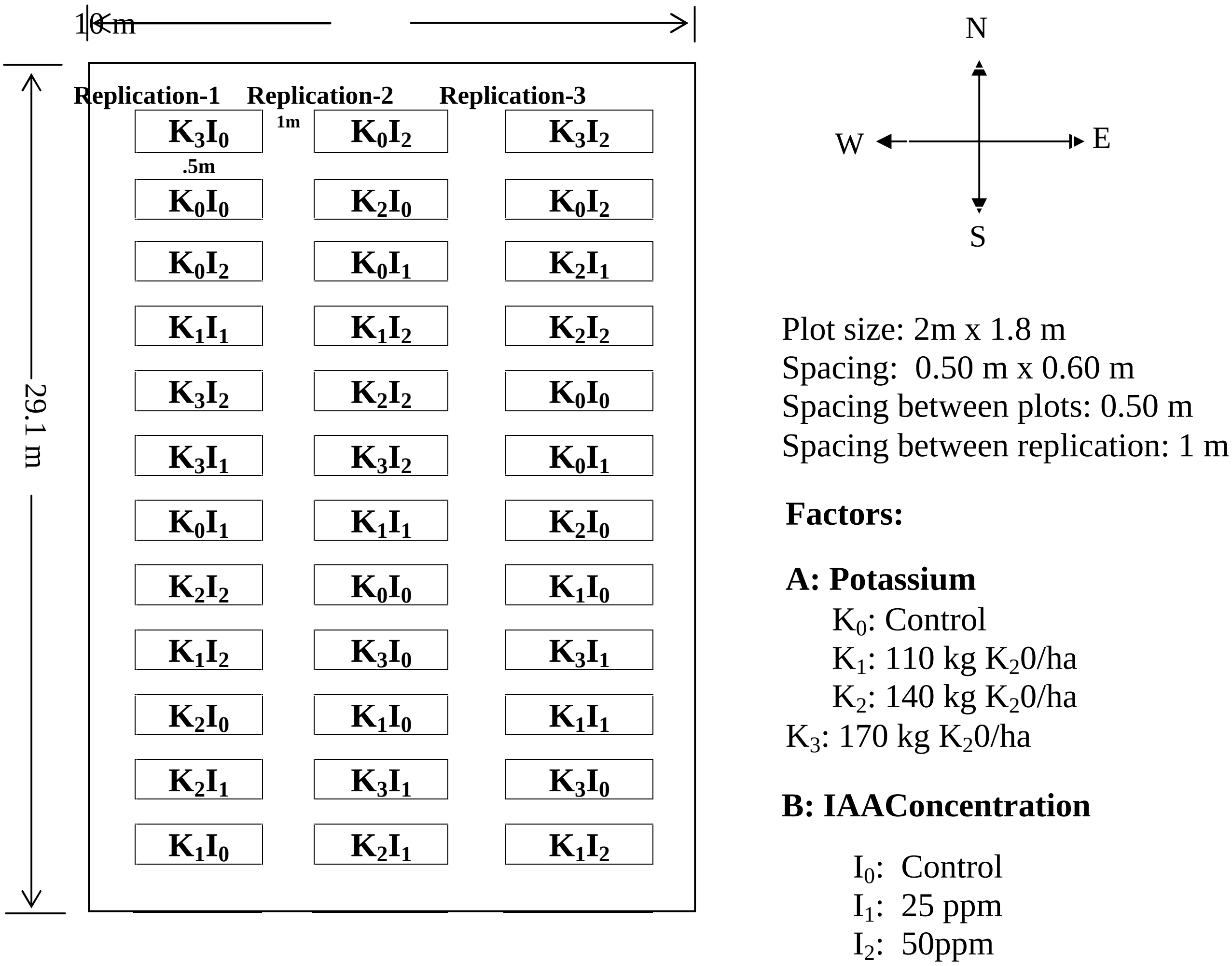


Fig. 1: Field layout of the experiment

3.8 Cultivation procedure

3.8.1Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The land of the experimental field was ploughed with a power tiller on 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 or the experiment was followed after land preparation.

3.8.2 Manure and fertilizers and its methods of application

Fertilizer	Quantity	Application method
Cow dung	15t/ha	Basel dose
Urea	400kg/ha	20,30 and 40 DAT, top dressing
TSP	300 kg/ha	Basel dose
MoP	As per treatment	20,30 and 40 DAT mixed with urea, top dressing

Rashid (1999).

According to Rashid (1999),the entire amount of cowdung and TSP were applied as basal dose during land preparation. Potassium was applied as per treatment and urea and TSP was applied at the rate of 400 kg/ha and 300 kg/harespectively. urea and MoP were used as top dressing in equal splits at 20, 30 and 40 days after transplanting.

3.8.3 Application and preparation of IAA

The stock solution of 1000 ppm of IAA was made by mixing of 1 g of IAAwith small amount of ethanol to dilute and then mixed in 1 litre of water. Then as per requirement of 25 ppm and 50 ppmsolution of IAA, 25 and 50 ml of stock solution were mixed with 1 litre of water respectively. Application of IAAwas done at 15 days interval that was at 20, 35, and 50 days after transplantation.

3.8.4 Transplanting of seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in November 2014 maintaining a spacing of 50 cm x 60 cm between the plants and rows,respectively. This allowed an accommodation of 12 plants in each plot. The seedbed was watered before uprooting the seedlings from the seedbed so as 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. 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:

3.8.5.1Gap filling

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

3.8.5.2Weeding

Numbers of Weeding were accomplished as and whenever required to keep the crop free from weeds.

3.8.5.3Staking

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

3.8.5.4Irrigation

Number of irrigation was given throughout the growing period by Garden pipe, watering cane. The first irrigation was given immediate after the transplantation, whereas others were applied when required depending upon the condition of the soil.

3.8.5.5 Plant protection

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

3.8.5.6 Insect pests

Denovarwas applied @ 6 ml/L against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was madefortnightly from a week after transplanting to a week before first harvesting.

3.9 Harvesting

Fruits were harvested at 4 to 5 days intervals during early ripe stage when they attained slightly red color. Harvesting was started from 1st March, 2015 and was continued up to end of March 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 10 days interval starting from 20 days of planting up to 60 days to observe the growth rate of plants. The average height was computed and expressed in centimeters.

3.10.2 Number of leaves per plant

The number of leaves per plant was manually counted at 20, 30, 40, 50 and 60 days after transplanting on tagged plants. The average of five plants were computed and expressed in average number of leaves per plant.

3.10.3 Number of branches per plant

The number of branch per plant was manually counted at 20, 30, 40, 50 and 60 days after transplanting from tagged plants. The average of five plants were computed and expressed in average number of branch per plant.

3.10.4Number of flower clusters per plant

The number of clusters was counted at 20, 30, 40, 50 and 60 days after transplantation from the 5 sample plants and the average number of flower cluster produced per plant was recorded.

3.10.5 Number of flowers per cluster

The number of flowers per cluster was counted at 50 and 60 days after transplanting from the 5 sample plants. From each plant randomly five clusters were selected and counted the number of flowers per cluster to make an average value for one plant. The final average value of number of flowers per cluster was calculated from 5 averages from five plants.

3.10.6 Number of fruits per cluster

The number of fruits per cluster was counted at 60 DAT and harvesting time from selected 5 plants. From each plant randomly five clusters were selected and counted the number of fruits per cluster to make an average value for one plant. The final average value of number of fruits per cluster was calculated from 5 averages from five plants.

3.10.7 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 determining 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.

3.10.8 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 determining 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.

3.10.9Fresh weight of leaves

Fresh weights of leaves were measured at the 60 days after transplantation from the 5 selected plants and there average was taken as the weight of fresh leaves per plant.

3.10.10 Dry matter content of leaves

After harvesting, randomly selected 100 gram of leaf sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 60^0c for 72 hrs. 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:

$$\text{Dry matter of leaf \%} = \frac{\text{Dry weight of leaf}}{\textbf{Fresh weight of leaf}} \times 100$$

3.10.11 Individual fruit weight

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 by dividing total weight of fruits by total number of fruits.

3.10.12Dry matter content of fruits

After harvesting, randomly selected 100 gram of fruit sample previously sliced in to very thin pieces. The fruits were then dried in the sun for one day and placed in oven maintained at 60^0c for 72 hrs. 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:

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

3.10.13Yield of fruits 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 during the harvest period and was expressed in kilogram (kg).

3.10.14Yield of fruits per hectare (ton)

It was measured by the following formula:

$$\text{Fruit yield (ton/h)} = \frac{\text{Fruit yield per plot (kg) x 10000}}{\textbf{Area of plot in square meter x 1000}}$$

3.11 Statistical analysis

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

3.12 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of potassium and IAA. All input cost including the cost for lease of land and interests on running capital was computed for the cost of production. The interests were calculated @ 13% in simple interest rate. The market price of tomato was considered for estimating the cost and return. Analyses were done according to the procedure determining by Alam*et al.*,(1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return}}{\textbf{Total cost of production}}$$

CHAPTER IV

RESULTS AND DISCUSSION

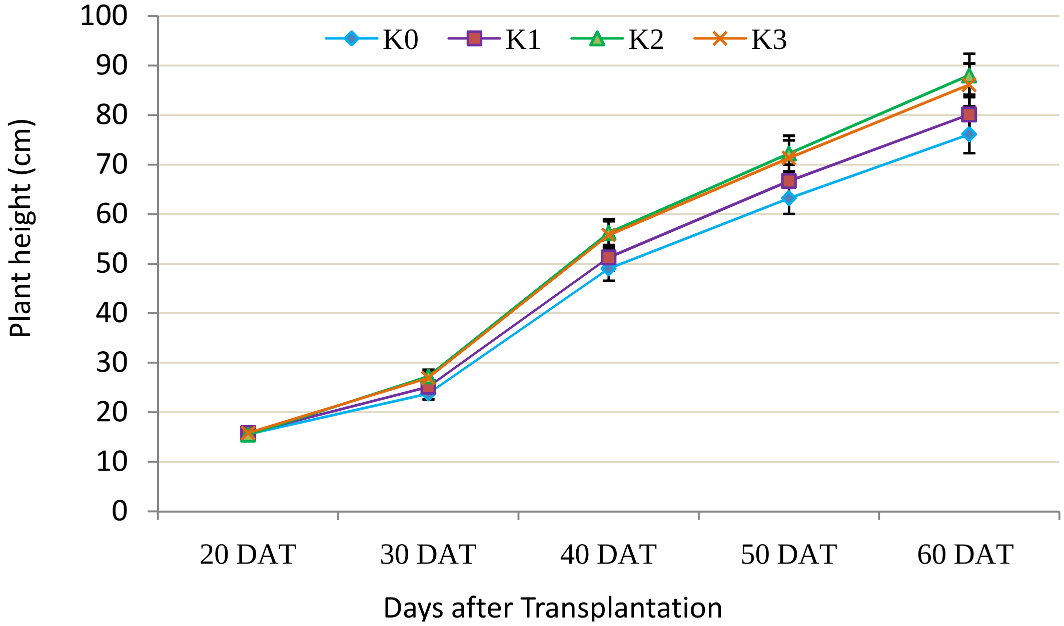
The present study was conducted to determine the effect of different levels of potassium and IAA on growth and yield of tomato. Data on different yield contributing characters and yield were recorded. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix III-VII. The results have been presented and discussed, and possible interpretations were given under the following headings.

4.1 Plant height

Significance difference was observed due to application of different levels of potassium on plant height at 30, 40, 50 and 60 DAT except 20 DAT (AppendixIII).At 30 DAT, the longest plant (27.22 cm) was found from K_2(140 kg/ha K_2O)which was statistically similar (26.89 cm) to K_3(170 kg/ha K_2O) while the shortest (23.78 cm) plant was recorded from K_0. At 40 DAT, the longest plant (56.22 cm) was recorded from K_2 which was statistically similar (55.78 cm) to K_3while the shortest (49.00 cm) plant was obtained from K_0 (control) which was statistically similar (51.22 cm) to K_1(110 kg/ha K_2O). The longest plant (72.22 cm) was found from K_2which was statistically similar (71.33 cm) to K_3 while the shortest (63.22 cm) plant was recorded from K_0 which was statistically similar to K_1 (66.67 cm) at 50 DAT. At 60 DAT, the highest plant height (88.00 cm) was recorded from K_2 which was statistically similar (86.11 cm) to K_3while the shortest plant height (76.11 cm) was found from K_0which was statistically similar (80.11 cm) to K_1 (Fig. 2). Mehrotra*et al.,* (1970) recorded the significant increase in the plant height (95 cm) with IAA spray at flower initiation stage in tomato. Spray of IAA significantly increased the plant height with increasing concentration. Harneet*et al.,* (2004) stated that K_2O increased plant height up to maximum doses with an increasing trend and Probably, K_2O ensured the availability of other essential nutrients as a result, maximum growth was occurred and the ultimate results are the maximum plant height.Chandra *et al.,* (2003) recorded the significant increase in the plant height (95 cm) with K_2Oapplication at flower initiation stage in tomato. Liu *et al.,* (2004) reported that spraying of K_2O at 100 kg/ha increased the plant height.

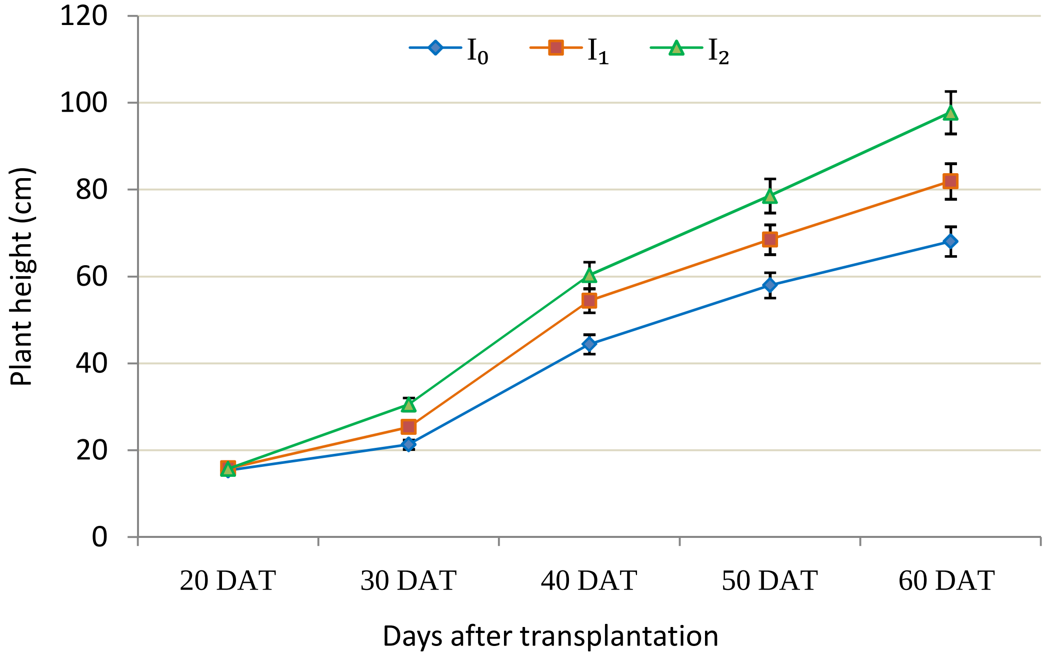
Significant difference was observed due to the application of different levels of IAA at 30, 40, 50 and 60 DAT except 20 DAT (AppendixIII).At 30 DAT, the highest plant height (30.58 cm) was recorded from I_2 (50 ppm IAA) and the shortest plant (21.33 cm) was found from I_0 (control). At 40 DAT, the longest plant (60.33 cm) was found from $I_2$and the shortest plant (44.42 cm) was obtained from I_0. The longest plant (78.58 cm) was recorded from I_2 and the shortest plant (58.00 cm) was found from I_0 at 50 DAT.At 60 DAT, the longest plant (97.75 cm) was obtained from I_2while the shortest plant (68.08 cm) was found from I_0 (control) treatment (Fig. 3). Murphy (1964) found that applicationof IAAincreased plant height up to 65%.Rai*et al.* (2002) observed that the application of 75 ppm IAA increased the plant height significantly.

Combined effects of potassium and IAA showed significant difference on plant height at all observation except 20 DAT (AppendixIII). However at 30 DAT the longest plant (31.33 cm) was recorded from K_2I_2 (140 kg/ha of K_2O + 50 ppm IAA) and the shortest (19.33 cm) plant was found from K_0I_0 (no K_2O +no IAA). The longest plant (62.00 cm) was recorded from K_2I_2which was similar to K_3I_0, K_3I_2 and the shortest plant (35.33 cm) was obtained fromK_0I_0(no K_2O + no IAA) which was statistically identical to (40.67 cm) K_0I_1at 40 DAT. At 50 DAT, the longest plant (81.00 cm) was obtained from K_2I_2which was statistically similar to K_3I_2 and the shortest plant (49.67 cm) was found from K_0I_0which was similar to K_0I_1. Finally at 60 DAT the longest plant (101.00 cm) was recorded from K_2I_2 similar to K_3I_2 while the shortest (57.33 cm) was observed in K_0I_0which was statistically similar to K_0I_1treatment combination (Table 1).



K_0: control, K_1: 110 kg/ha K_2O, K_2:140 kg/ha K_2O, K_3:170 kg/ha K_2O

Fig. 2 Effect of potassium on plant height of tomato



I_0 : control, I_1: 25 ppm IAA, I_2:50 ppm IAA

Fig. 3 Effect of IAA on plant height of tomato

Table1.Combined effects of potassiumand IAAon plant height of tomato

Treatments	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
K_0I_0	13.00	**19.33 h**	**35.33 f**	**49.67 g**	**57.33 g**
K_0I_1	13.33	19.33gh	40.67 f	54.33 fg	65.00 fg
K_0I_2	13.00	20.00 g	46.67 e	58.00 ef	68.33 ef
K_1I_0	14.00	20.67 fg	47.00 e	58.00 ef	69.67 ef
K_1I_1	13.67	21.33 fg	49.67 de	60.00 ef	72.33 ef
K_1I_2	14.00	22.33 ef	50.33 c-e	63.33 de	74.67 de
K_2I_0	13.67	24.33 de	54.00 b-d	68.67 cd	83.67 cd
K_2I_1	14.00	25.33 cd	55.67 bc	70.00 b-d	85.00 c
K_2I_2	13.67	**31.33 a**	**62.00 a**	**81.00 a**	**101.00 a**
K_3I_0	14.00	27.67 b	56.67 ab	73.00 bc	91.67 bc
K_3I_1	14.00	26.67 bc	56.00 bc	71.00 bc	89.67 bc
K_3I_2	13.33	28.67 b	58.67 ab	77.00 ab	94.67 ab
LSD $_{(0.05)}$	**1.01**	**2.25**	**5.83**	**7.22**	**9.16**
CV%	**5.07**	**5.21**	**6.59**	**6.34**	**6.51**

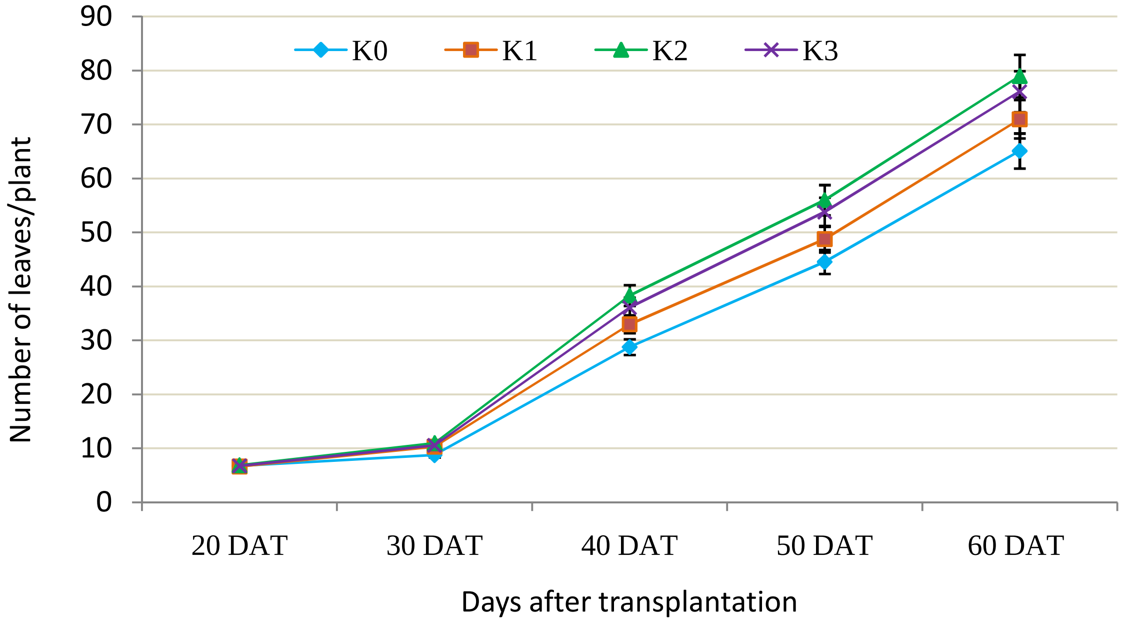
K_0 : control (No K_2O) K_1 :110 kg K_2O I_0: control (No IAA)I_2: 50 ppmIAA
K_2 :140 kg K_2O K_3 :170 kg K_2O I_1: 25 ppm IAA

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.

4.2 Number of leaves per plant

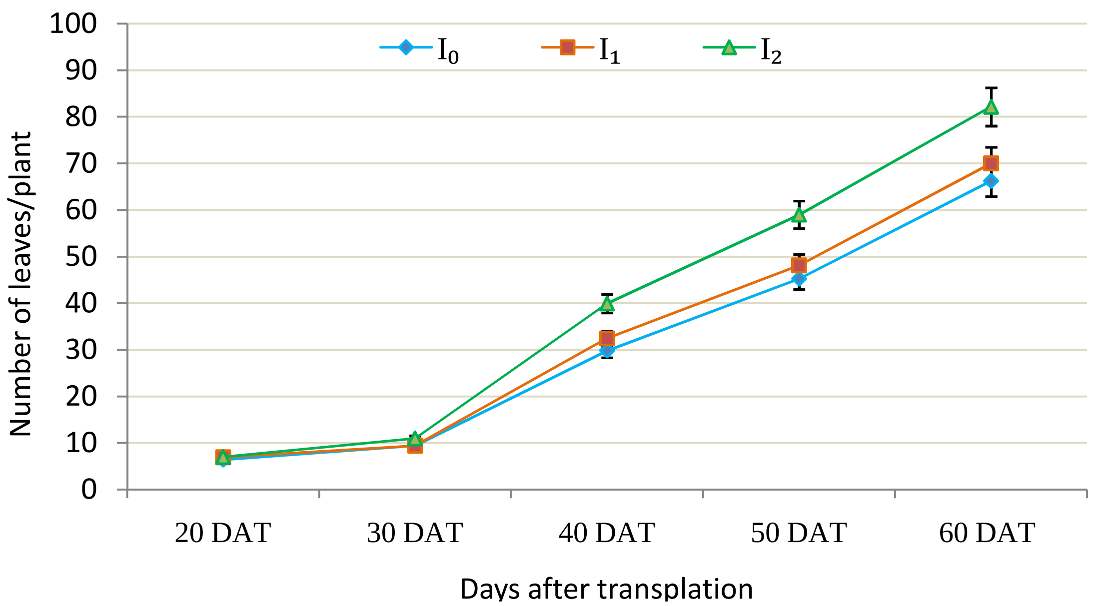
The significant variation was found at 30, 40, 50, and 60 DAT due to the application of different levels of potassium except 20 DAT (Appendix IV). At 30 DAT, the highest number of leaves per plant (11.00) was found from K_2(140 kg/ha K_2O) which was statistically similar to K_3 (10.56) while the lowest number of leaves per plant (8.77) was observed from K_0.At 40 DAT, the maximum number of leaves per plant (38.33) was recorded from K_2while the lowest number of leaves per plant (28.78) was obtained from K_0 (control). The highest number of leaves per plant (56.00) was found from K_2 which was statistically similar to K_3(53.78) while the lowest number of leaves per plant (44.56) was recorded from K_0 at 50 DAT. Finally at 60 DAT, the maximum numberof leaves per plant (79.00) was recorded from K_2which was statistically similar to K_3(76.11)while the minimum numberof leaves per plant (65.11) was obtained from K_0treatment (Fig. 4). Chandra *et al.*, (2003) studied the effect of potassium for improving the tomato cv. Alicante and reported that application of K_2O increased the number of leaves per plant and K_2O increased the number of leaves per plant up to optimum level.Cerne and Briski (1993) reported the enhanced effect of K_2O on vegetative growth in tomato.

Due to the application of different concentration of IAA showed significant differences on number of leaves per plant at all observation except 20 DAT (Appendix IV). The maximum numberof leaves per plant (11.67) was counted from I_2 (50 ppm IAA) and the minimum number of leaves per plant (9.41) was found from I_0 which was statistically similar (9.40) to I_1 at 30 DAT. At 40 DAT, the maximum number of leaves per plant (39.92) was recorded from I_2followed by (32.42) I_1 and the minimum number of leaves per plant (29.83) was obtained from I_0 (control).



K_0: control, K_1: 110 kg/ha K_2O, K_2:140 kg/ha K_2O, K_3:170 kg/ha K_2O

Fig. 4 Effect of potassium on number of leaves per plant



I_0: control, I_1: 25 ppm IAA, I_2:50 ppm IAA

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

Table 2. Combined effects of potassium and IAA on number of leaves per plant

Treatments	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
K_0I_0	5.33	**9.33 f**	**22.00 f**	**39.33 d**	**54.67 e**
K_0I_1	5.33	11.33 cd	29.67 de	46.00 cd	64.67 d
K_0I_2	5.66	10.66 de	29.00 de	49.00 c	68.33 d
K_1I_0	5.33	10.33 d-f	29.67 c-e	50.67 c	69.33 d
K_1I_1	6.00	10.33 d-f	29.00 de	49.00 c	66.12 d
K_1I_2	5.66	10.34 d-f	27.00 ef	45.00 cd	63.00 de
K_2I_0	6.00	10.33 d-f	34.33 b-d	51.33 c	70.00 d
K_2I_1	6.00	10.66 de	31.33 c-e	51.00 c	71.00 cd
K_2I_2	5.33	**15.00 a**	**45.67 a**	**70.67 a**	**92.67 a**
K_3I_0	6.00	12.33 c	36.33 bc	58.33 b	79.33 bc
K_3I_1	5.33	9.66 ef	29.33 de	48.33 c	68.67 d
K_3I_2	6.00	13.67 b	40.33 ab	62.67 b	82.01 b
LSD $_{(0.05)}$	**0.76**	**1.15**	**6.35**	**6.81**	**8.51**
CV%	**5.71**	**7.74**	**10.08**	**7.97**	**7.21**

K_0 : control (No K_2O) K_1 :110 kg K_2O I_0: control (No IAA)I_2: 50 ppmIAA
K_2 :140 kg K_2O K_3 :170 kg K_2O I_1: 25 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.

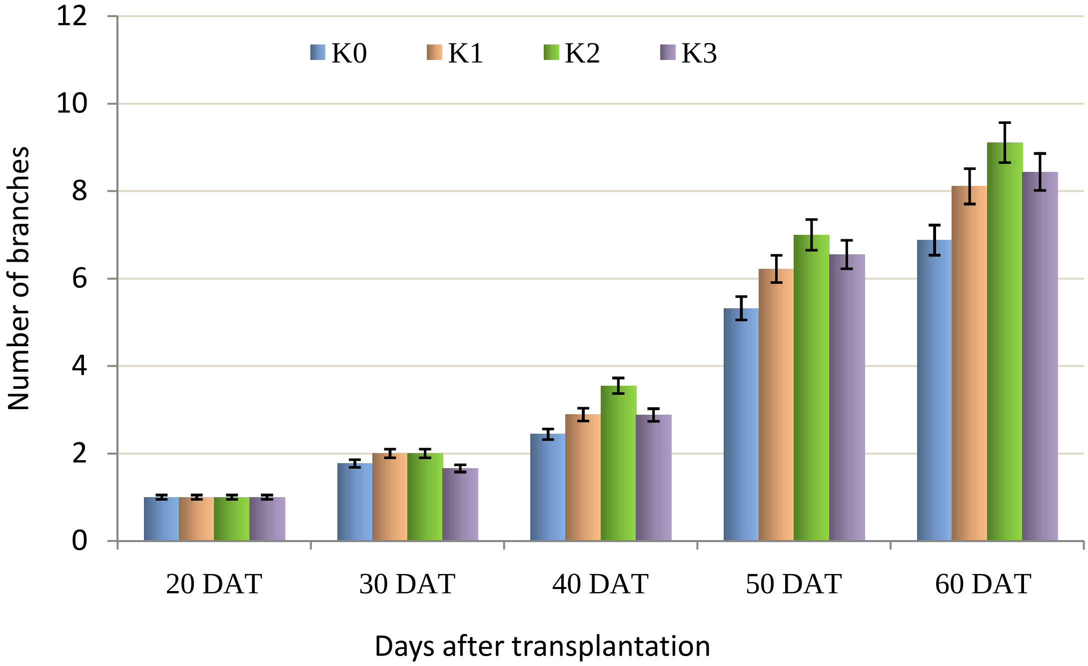
The maximum number of leaves per plant (59.00) was found from $I_2$and the minimum number of leaves per plant (45.25) was observed from I_0 which was statistically similar (48.08) to I_1 at 50 DAT.At 60 DAT, the maximum number of leaves per plant (82.17) was counted from I_2followed by (70.00) $I_1$and the minimum number of leaves per plant (66.25) was obtained 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 effects of potassium and indole-3-acetic acid (IAA) showed statistically significantdifferences on number of leaves per plant at 30, 40, 50 and 60 DAT except 20 DAT (Appendix IV). At 30 DAT the maximum number of leaves per plant (15.00) was counted from K_2I_2 (140 kg/ha of K_2O + 50 ppm IAA) and the minimum number of leaves per plant (9.33) was found from K_0I_0 (no K_2O +no IAA) which was similar to K_1I_0,K_1I_1,K_1I_2,K_2I_0. The maximum number of leaves per plant (45.67) was recorded from K_2I_2 which was similar to K_3I_2 and the minimum number of leaves per plant (22.00) was obtained from K_0I_0similar to K_1I_2at 40 DAT. At 50 DAT, the maximum number of leaves per plant (70.67) was obtained from K_2I_2 and the minimum number of leaves per plant (39.33) was found from K_0I_0 similar to K_0I_1, K_1I_2. Finally at 60 DAT, the maximum number of leaves per plant (92.67) was counted from K_2I_2 while the minimum number of leaves per plant (54.67) was observed in K_0I_0Statistically similar to K_1I_2treatment combination (Table 2).

4.3 Number of branches per plant

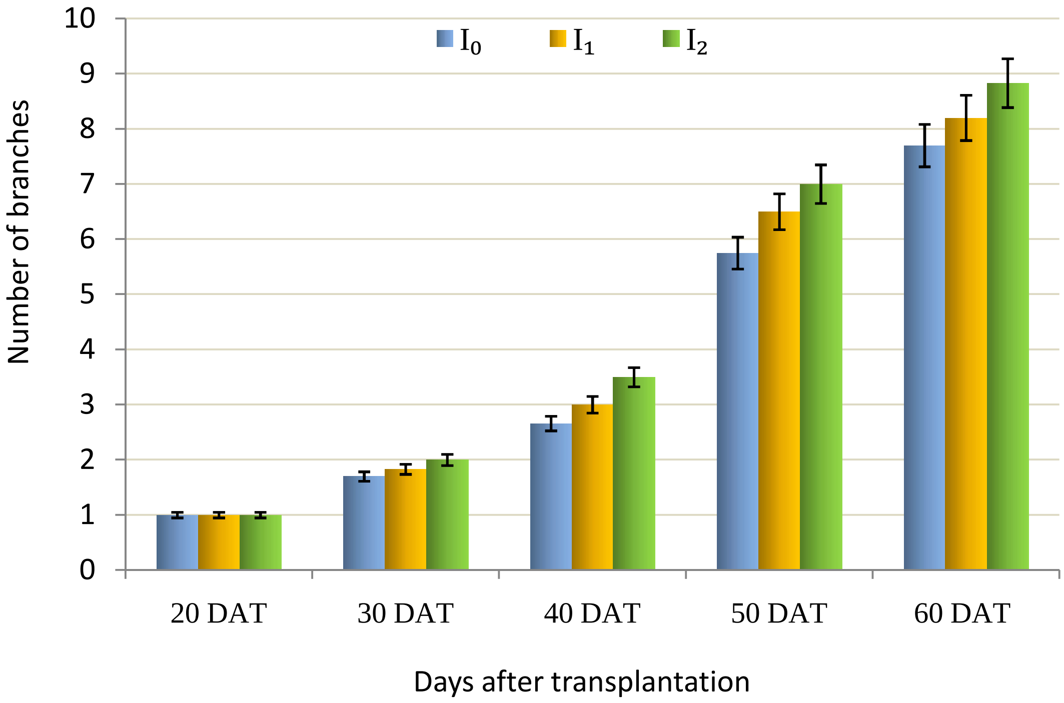
There was significant variation observed in number of branches per plant at 30, 40, 50, and 60 DAT due to the application of different levels of potassium except 20 DAT (Appendix V). At 30 DAT, the maximum number of branches per plant (2.00) was recorded from K_2 (140 kg/ha K_2O), which was similar to K_1 (110 kg/ha K_2O), while treatment K_0 (0 kg/ha K_2O) showed the minimum number of branches per plant (1.77). At 40 DAT, maximum number of branches per plant (3.55) was recorded from K_2, followed by K_3(2.88) while from treatment K_0 obtained minimum number of branches per plant (2.44). At 50 DAT, the maximum number of branches per plant (6.66) was recorded from K_2(140 kg/ha K_2O),while treatment K_0 showed the minimum number of branches per plant (4.77). The maximum number of branches per plant (9.11) was recorded from K_2(140 kg/ha K_2O) while treatment K_0 (no K_2O) showed the minimum number of branches per plant (6.88) at 60 DAT (Fig. 6). Mehta and Saini (1986) observed that the application of K_2O increased the number of branches against untreated plant. Murphy (1964) found that plants treated with K_2O showed significantly greater branch number per plant than untreated control. Liu *et al.*, (2004) reported that 145 kg/ha K_2O application resulted the highest number of primary branches per plant. Clarke (2004)reported the increased number of branches per plant due to the application of 150 kg/ha K_2O.

The significant variation was found in 30, 40, 50, and 60 DAT due to the application of different levels of IAA except 20 DAT (Appendix V). The maximum number of branches per plant (2.25) was counted from I_2 (50 ppm IAA), while the minimum number of branches per plant (1.50) was obtained from I_0 (no IAA) at 30 DAT. At 40 DAT,the maximum number of branches per plant (3.16) was recorded from I_2 (50 ppm IAA), while the minimum number of branches per plant (2.66) was obtained from I_0 (no IAA).



K_0: control, K_1: 110 kg/ha K_2O, K_2:140 kg/ha K_2O, K_3:170 kg/ha K_2O

Fig. 6 Effect of potassium on number of branches per plant



I_0: control, I_1: 25 ppm IAA, I_2:50 ppm IAA

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

Table 3. Combined effects of potassiumand IAA on number of branches per plant

Treatments	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
K_0I_0	1.00	**1.00 d**	**2.00 d**	**5.00 c**	**7.00 e**
K_0I_1	1.00	2.00 b	3.00 b	7.33 b	9.66 a-c
K_0I_2	1.00	2.00 b	3.00 b	7.00 b	9.66 a-c
K_1I_0	1.00	2.00 b	2.66 bc	7.66 ab	9.33 bc
K_1I_1	1.00	1.30 c	2.33 cd	5.33 c	7.66 de
K_1I_2	1.00	2.00 b	3.00 b	6.66 b	8.33 c-e
K_2I_0	1.00	2.00 b	3.66 ab	7.33 b	9.66 a-c
K_2I_1	1.00	2.00 b	3.00 b	7.33 b	9.00 b-d
K_2I_2	1.00	**3.00 a**	**4.00 a**	**8.66 a**	**11.00 a**
K_3I_0	1.00	2.00 b	2.66 bc	7.66 ab	9.33 bc
K_3I_1	1.00	2.00 b	3.00 b	7.00 b	9.00 b-d
K_3I_2	1.00	2.00 b	3.00 b	7.66 ab	10.00 ab
LSD $_{(0.05)}$	**0.00**	**0.28**	**0.56**	**1.08**	**1.48**
CV%	**0.00**	**9.93**	**10.52**	**10.45**	**10.53**

K_0 : control (No K_2O) K_1 : 110 kg K_2O I_0 : control (No IAA) I_2 : 50 ppm IAA
K_2 : 140 kg K_2O K_3 : 170 kg K_2O I_1 : 25 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.

The maximum number of branches per plant (6.75) was recorded from I_2 (50 ppm IAA) while the minimum number of branches per plant (5.57) was obtained from I_0 (no IAA) at 50 DAT. At 60 DAT the maximum number of branches per plant (8.83) was recorded from I_2 while the minimum number of branches per plant (7.91) was obtained from I_0 treatment (Fig. 7). Singh *et al*. (2005) found that number of branches significantly increased by the application of IAA at 75 ppm.Rai*et al*. (2002) found the highest number of branches due to the application of 75 ppm IAA.

Significant differences were observed due to the combined effects of potassiumand IAA on number of branches per plant at 30, 40, 50 and 60 DAT except 20 DAT (Appendix V). At 30 DAT, the maximumnumber of branches per plant (3.00) was recorded from K_2I_2 (140 kg/haK_2O + 50 ppm IAA) and the minimum (1.00) number of branches per plant was observed from the treatment combination of K_0I_0(no K_2O +no IAA). At 40 DAT the maximumnumber of branches per plant (4.00) was counted from K_2I_2 (140 kg/haK_2O +50 ppm IAA) which isstatistically similar to K_2I_0 and the minimum number of branches per plant (2.00) was recorded from the treatment combination of K_0I_0 (no K_2O +no IAA) which was statistically similar to K_1I_1. The maximum number of branches per plant (8.66) was recorded from K_2I_2 (140 kg/haK_2O +50 ppm IAA) which is statistically similar to K_1I_0, K_3I_0,K_3I_2 and the minimum number of branches per plant (5.00) was observed from the treatment combination of K_0I_0 (no K_2O +no IAA) at 50 DAT. At 60 DAT the maximum number of branches per plant (11.00) was recorded from K_2I_2 (140 kg/haK_2O +50 ppm IAA) which was statistically similar to K_0I_1, K_0I_2, K_3I_2 treatment combination and the minimum number of branches per plant (7.00) was recorded from the treatment combination of K_0I_0which was statistically similar to K_1I_1 and K_1I_2treatment combination (Table 3).

4.4 Number of flower clusters per plant

Significant variation was found on number of flower clusters per plant due to the application of different levels of potassium(Appendix VI). The highest number of flower clusters per plant (18.86) was recorded from K_2(140 kg/ha K_2O) treatment, which is statistically identical (18.65) to K_3(170 kg/ha K_2O),while the lowest (12.08) number of flower clusters per plant was obtained from K_0 (control) treatment (Table 4). Cerne and Briski (1993) recorded the significant increase in number of flowercluster per plant tomato cv. Money maker with application of 130 kg/ha K_2O against untreated.Chandra *et al.,* (2003) observed that irrespective of its levels of potassium (K_2O) proved the beneficial for increased number of flower cluster of tomato plant.

The number offlower clusters per plant varied significantlydue to the application of different concentrations of IAA (Appendix VI). The maximum number of flower clusters per plant (22.09) was counted from I_2 (50 ppm IAA) treatment, while the minimum number of flower clusters per plant (10.31) was found from I_0 (control) treatment (Table 4). Leopold (1964) observed that with the increase in contrationof auxin (IAA). There was a comparable increase in percentage of flower cluster.

Combined effect of different levels of K_2O and IAA showed significant differences on number offlower clusters per plant (Appendix VI). The treatment combination of K_2I_2 (140 kg/ha K_2O +50 ppm IAA) performed the maximum number offlower clusters per plant (27.33) and the treatment combination of K_0I_0 (control) performed the minimum number offlower clusters per plant (8.66) which is statistically identical (9.33) to K_0I_1treatment and similar to K_1I_1 (Table 5).

4.5 Number of flowers per cluster

Number of flowers per cluster varied significantly due to the application of different levels of potassium(Appendix VI). The highest number of flowers per cluster (6.73) was counted from K_2 (140 kg/ha K_2O) treatment, which wasstatistically similar (6.52) to K_3 (170 kg/ha K_2O),while the lowest (6.12) number of flowers per cluster was obtained from K_0 (control) treatment which is statistically similar to K_1 treatment (Table 4). Silva and Vizzotto (1990) reported the application of K_2O (150 kg/ha K_2O) at 50 percent flowering increased the fruit set and seed yield of tomato.Chandra *et al.,* (2003) reported that K_2O and IAA were indispensable for the development of the fertile flowers at the medium and the lower concentration respectively.Liu *et al.,* (2004) observed that the effect of 150 kg/haK_2O and auxin (IAA) at 45 ppm increased the number of flower per cluster of Dhananshree tomato cultivar.

Significant variation was found on the number of flowers per cluster due to application of different concentrations of IAA (Appendix VI). The maximum number of flowers per cluster (6.86) was found from I_2 (50 ppm IAA) treatment,while the minimum number of flowers per cluster (5.73) was found from I_0(control) treatment (Table 4). Chhonkar and Singh (1959) reported that high concentration IAA increased yield through increased flower induction and fruit set.

Significant variation was found on number of flowers per cluster due to the combined effects of different levels of potassiumand IAA (Appendix VI). The treatment combination of K_2I_2 (140 kg/ha K_2O +50 ppm IAA) performed the maximum number of flowers per cluster (8.23) which was statistically similar to K_3I_0 andK_3I_1while the minimum (4.77) number of flowers per cluster was obtained from the treatment combination of K_0I_0 (Table 5).

4.6 Number of fruits per cluster

Significant variation was found on number of fruits per cluster due to the application of different levels of potassuim(Appendix VI). Treatment K_2 (140 kg/ha K_2O) performed the maximum number of fruits per cluster (6.37), whichwas statistically identical (6.26) to K_3 (170 kg/ha K_2O), while the minimum (5.45) number of fruits per cluster was obtained from K_0 (0 kg/ha K_2O) treatment (Table 4).Harneet*et al.,* (2004) reported an increase in fruit set of tomato due to application of K_2O @ 125 kg/ha at various stages of inflorescence development.Chandra *et al.,* (2003) found that plants treated with K_2O showed significantly greater number of fruits per cluster than untreated controls.

Number of fruits per cluster varied significantly due to application of different concentrations of IAA (Appendix VI). The maximum number of fruits per cluster(6.43) was recorded from I_2 (50 ppm IAA) treatment, while the minimum number of fruits per cluster (4.35) was found from I_0 treatment (Table 4). Chandra *et al.,*(2003) found that the number of fruits per cluster increased with the increase in the rate of indole-3-acetic acid. Younis and Tigani (1977) observed that when IAA applied to the field grown tomato plants. 2 application of IAA 10 kg/haincrease the fruit set significantly.Kaushik*et al*. (1974) reported that 10 kg/haof IAA increased the number and weight of fruits per plant significantly.

Due to combined effect of different levels of IAA and potassium showed significant differences on number of fruits per cluster (Appendix VI). The treatment combination of K_2I_2 (140 kg/ha K_2O + 50 ppm IAA) performed the maximum number of fruits per cluster (8.00) while the treatment combination of K_0I_0 (control) performed the minimum number of fruits per cluster(3.33) per plant which is statistically identical to K_0I_1, K_0I_2 andK_1I_0 treatment combination (Table 5). El-Habbasha*et al*. (1999) found that the number of fruit per cluster increased due to the application K_2O and IAA on tomato (cv. Castelrock). Sasaki *et al*. (2005) reported that tomatoes treated with a mixture application of IAA and K_2O showed increased fruit set per cluster and number of normal fruits were more than plants treated with IAA alone during summer.

4.7 Length of fruit

The length of fruit varied significantly due to the application of different levels of potassium(Appendix VI). The highest length of fruit (5.97 cm) was recorded from K_2 (140 kg/ha K_2O) treatment which is statistically identical (5.77 cm) to K_3 (170 kg/ha K_2O) and (5.46cm) to K_1 (110 kg/ha K_2O) while the lowest length of fruit (4.88 cm) was obtained from K_0 treatment (Table 4).Chandra *et al.,* (2003) recorded significantly increased fruit length (5.15 cm) width application of K_2O(120kg/ha) at pre-bloomed stage in tomato.

In case of length of fruit, significant variation was found due to the application of different concentrations of IAA (Appendix VI). The highest length of fruit (5.95 cm) was obtained from I_2 (50 ppm IAA) treatment,while the lowest length of fruit (5.14 cm) was found from I_0 (control) treatment, which is statistically identical to I_1(5.43 cm) treatment (Table 4). Gupta *et al.* (2002)[a] observed that the application of 50 ppm IAA and micronutrients significantly improved the fruit size (length 6.32 cm).Mukharji and Ray (1966) found that the application of IAA increased the length of fruit in tomato plant.

Significant variation was found on length of fruitdue to the combined effects of different levels of potassiom and IAA and(Appendix VI). The treatment combination of I_2K_2 (140 kg/ha K_2O + 50 ppm IAA) performed the highest length of fruit (5.98 cm) which is statistically similar to K_0I_2, K_1I_0, K_2I_0, K_2I_1, K_3I_0, K_3I_1, K_3I_2, while the minimum length of fruit (3.52 cm) was obtained from the treatment combination of K_0I_0treatment combination (Table 5).

4.8 Diameter of fruit

Significant variation was found on diameter of fruit due to the application of different levels of potassiom(Appendix VI). The highest diameter of fruit (6.48 cm) was recorded from K_2 (140 kg/ha K_2O) treatment, which was statistically identical to K_3 (6.34 cm) and similar to K_1 (6.15 cm) treatment, while the minimum diameter of fruit (5.73 cm) was obtained from K_0 (control) treatment, which is statistically similar to K_1 treatment (Table 4). Chandra *et al.*, (2003) reported that the significant increase of fruit size (diameter) of tomato due to the application of potassium.

The diameter of fruit varied significantly due to the application of different concentrations of IAA (Appendix VI). The maximum diameter of fruit

(6.51cm) was recorded from I_2 treatment which was statistically similar to I_1 treatment, while the minimum diameter of fruit (5.80 cm) was found from I_0 (control) treatment (Table 4). Gupta *et al*. (2003) reported that the largest fruit size (6.67 cm diameter) was observed with application of 45 ppm and IAA and multiple micro nutrient mixtures at maturity stage.Gupta *et al*. (2002)[a] observed that the application of 50 ppm IAA and micronutrients significantly improved the fruit size (diameter 6.78 cm).

Combined effects of different levels of potassiomand IAA showed significant differences on diameter of fruit(Appendix VI). The treatment combination of K_2I_2 (140 kg/ha K_2O + 50 ppm IAA) performed the maximum diameter of fruit (6.98 cm) which was statistically similar to K_0I_2, K_1I_0, K_1I_2, K_2I_1, K_3I_1, K_3I_2, while the minimum diameter of fruit (4.98 cm) was obtained from the treatment combination of I_0K_0 which statistically similar to K_0I_1 and K_1I_1 treatment combination (Table 5).

4.9 Fresh weight of leaves

Fresh weight of leaves varied significantly due to the application of different levels of potassium. The maximum (159.8 g) of fresh leaves was recorded from K_3 (170 kg K_2O ha^{-1}) while the minimum (149.4 g) fresh weight of leaves were recorded from K_0 (control) treatment (Table 6).

Fresh weight of leaves varied significantly due to the application of different concentration of IAA.The maximum (279.4 g) of fresh leaves was recorded from I_1 (25 ppm IAA) while the minimum (154.4 g) fresh leaves were recorded from I_0 (control) treatment (Table 6).

Combined effect of potassium and IAA showed statistically significant differences on fresh weight of leaves. The maximum (263.5 g) of fresh leaves was recorded from the treatment combination of K_3I_1 (170 kg K_2O + 25 ppm IAA) which was statistically similar to K_1I_1, K_1I_2, K_2I_1, K_2I_2, K_3I_0, and K_3I_2. The minimum (149.9 g) of fresh leaves was obtained from K_0I_0 (no potassium + no IAA) treatment (Table 7).

Table 4. Single effect of potassium and IAA at different levels on yield characteristics of tomato plant

Treatments	Number of flower clusters/plant	Number of flowers/cluster	Number of fruits/cluster	Length of fruit (cm)	Diameter of fruit (cm)
K_0	12.08 c	6.12 c	5.45 c	4.88 b	5.73 b
K_1	15.19 b	6.31 bc	5.87 b	5.46 a	6.15ab
K_2	**18.86 a**	**6.73 a**	**6.37 a**	**5.97 a**	**6.48 a**
K_3	18.65 a	6.52 ab	6.26 a	5.77 a	6.34 a
$LSD_{(0.05)}$	1.35	0.40	0.39	0.52	0.45
I_0	10.31 c	5.73 c	4.35 c	5.14 b	5.80 b
I_1	15.36 b	6.43 b	5.85 b	5.43 b	6.15ab
I_2	**22.09 a**	**6.86 a**	**6.43 a**	**5.95 a**	**6.51 a**
$LSD_{(0.05)}$	1.17	0.34	0.34	0.45	0.39
CV%	7.69	7.24	6.84	8.94	8.26

K_0 : control (No K_2O) K_1 : 110 kg K_2O I_0 : control (No IAA) I_2 : 50 ppm IAA
K_2 : 140 kg K_2O K_3 : 170 kg K_2O I_1 : 25 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.Yield characteristics of tomato at different levels of potassium and indole acetic acid concentration

Treatments	Number of flower clusters/plant	Number of flowers/cluster	Number of fruits/cluster	Length of fruit	Diameter of fruit
K_0I_0	**8.66 h**	**4.77 f**	**3.33 de**	**3.52 d**	**4.98 e**
K_0I_1	9.33 h	6.53 e	4.00 d	4.70bc	5.41 de
K_0I_2	12.00 fg	6.80 de	4.00 d	5.24 a-c	6.41 a-c
K_1I_0	12.33 fg	6.61 de	4.00 d	5.26 a-c	6.34 a-c
K_1I_1	10.00 gh	7.08 c-e	6.00 c	4.51 c	5.73 c-e
K_1I_2	14.33 f	6.94 c-e	6.00 c	4.85bc	6.55ab
K_2I_0	17.00 e	7.27 b-d	6.00 c	5.33 a-c	5.98 b-d
K_2I_1	20.00 cd	7.22 b-e	6.00 c	5.18 a-c	6.25 a-c
K_2I_2	**27.33 a**	**8.23 a**	**8.00 a**	**5.98 a**	**6.98 a**
K_3I_0	22.00 bc	7.57 a-c	7.00 b	5.45ab	6.17 b-d
K_3I_1	18.67 de	7.61 a-c	7.00 b	5.24 a-c	6.42 a-c
K_3I_2	24.33 b	7.85 b	7.00 b	5.49ab	6.39 a-c
LSD $_{(0.05)}$	2.34	0.32	0.68	0.91	0.79
CV%	7.61	6.73	6.65	9.85	7.72

K_0 : control (No K_2O) K_1 : 110 kg K_2O I_0 : control (No IAA) I_2 : 50 ppm IAA
K_2 : 140 kg K_2O K_3 : 170 kg K_2O I_1 : 25 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.

4.10 Dry matter content of leaves

Dry matter content of leaves varied significantly due to the application of different levels of potassium. The maximum (9.90%) dry matter content of leaves was recorded from K_3 (170 kg K_2O ha^{-1}) which was statistically identical (9.85%) to K_2 (140 kg K_2O ha^{-1}) while the minimum (7.99%) dry matter content of leaves was recorded from K_0 (control) treatment (Table 6).

Dry matter content of leaves varied significantly due to the application of different concentration of IAA. The maximum (10.68%) dry matter content of leaves was recorded from I_1 (25 ppmIAA) which was statistically identical (9.98%) to I_2 (50 ppmIAA), while the minimum (8.21%) dry matter content on leaves was found from I_0 (control) treatment (Table 6).

Combined effect of potassium and IAA showed statistically significant differences on dry matter content of leaves. The maximum (10.96%) dry matter content of leaves was recorded from the treatment combination of K_3I_1 (170 kg K_2O + 25 ppmIAA) which is statistically identical to K_3I_2 (10.60 %) and the minimum (7.74%) dry matter content of leaves was obtained from K_0I_0 (control) treatmentcombination (Table 7).

4.11 Average individual fruit weight

Weight of individual fruit differed significantly due to the application of different level of potassium(Appendix VII). The maximum (135.9g) weight of individual fruit was recorded from K_2 (140 kg K_2O ha^{-1}) while the minimum (107.8 g) weight of individual fruit was recorded from K_0 (control)treatment (Table 6).

Weight of individual fruit showed significant differences due to application of different concentrations of IAA (Appendix VII). The maximum (122.31 g) weight of individual fruit was recorded from I_2 (50 ppmIAA) while the minimum (102.93 g) weight of individual fruit was found from I_0 (control)treatment (Table 6). Singh and Upadhayaya (1967) founded that the application of IAA and NAA increased the fruit size and individual fruit weight of tomato.

Combined effect of potassium and IAA showed statistically significant differences for weight of individual fruit (Appendix VII). The maximum (162.53 g) weight of individual fruit was recorded from K_2I_2 (140 kg K_2O + 50 ppmIAA) which was statistically similar to K_1I_2 (154.03 g) and the treatment combination of K_0I_0 (control) performed the minimum (86.74 g) weight of individual fruit(Table 7).

4.12 Dry matter content of fruits

Dry matter content of fruits differed significantly due to the application of different levels of potassium(Appendix VII). The maximum (10.04%) dry matter content of fruits was recorded from K_3 (170 kg K_2O ha^{-1}) which was statistically identical (9.91%) to K_2 (140 kg K_2O ha^{-1}) while the minimum (7.81%) dry matter content of fruits was found from K_0 (control) treatment (Table 6).

Dry matter content offruits varied significantly due to the application of different concentrations of IAA(Appendix VII). The maximum (10.86 %) dry matter content of fruits was recorded from I_2 (50 ppmIAA) which was statistically similar (10.54%) to I_1 (25 ppmIAA), while the minimum (8.73%) dry matter content of fruits was obtained from I_0 treatment(Table 6).

Due to combined effect of potassium and IAAshowed statistically significant variation on dry matter content of fruits(Appendix VII). The maximum (11.83%) dry matter content of fruits was recorded from K_2I_2 (140 kg K_2O + 50 ppmIAA)which was statistically similar to K_3I_0, K_3I_1, K_3I_2 andK_2I_2. The minimum (7.91%) dry matter content of fruits was found from K_0I_0 (control) treatment (Table 7).

4.13 Yield of fruits per plot (kg)

Yield per plot was differed significantly due to the application of different levels of potassium (Appendix VII). The maximum (23.10 kg) fruits per plot was recorded from K_2 (140 kg K_2O ha^{-1}), while the minimum (19.89 kg) fruits per plot was found from K_0 (control) treatment (Table 6). Mehta and Saini (1986) conducted, two years fertilizer trails and found the plants received basal FYM (20 t/ha) and N at 75-125, P_2O_5 at 60-90 or K_2O at 30-60 kg/ha, significant yield increases were obtained with the highest K rates.

Significant differences were recorded on yield of fruit per plot due to application of different concentrations of IAA in tomato(Appendix VII). The maximum (22.82 kg) yield per plot was recorded from I_2 (50 ppmIAA) while the minimum (18.46 kg) yield per plot was obtained from I_0 (control) treatment (Table 6).

Significant difference on yield per plot was recorded due to the combined effect of potassium and IAA (Appendix VII). The maximum (25.48 kg) yield per plot was recorded from K_2I_2 (140 kg K_2O + 50 ppmIAA)and the minimum (17.50kg) yield per plot was obtained from the treatment combination of K_0I_0(control) treatment (Table 7).

4.14 Yieldof fruits per hectare

Different level of potassium showed significant variation for yield per hectare of tomato (Appendix VII). The highest (64.17 t/ha) yield was recorded from K_2 (140 kg K_2O ha^{-1}) which was statistically higher (56.92t/ha and 55.25 t/ha) to K_3 (170 kg K_2O ha^{-1}) and K_1(110 kg K_2O ha^{-1}), while the lowest (55.25 t/ha) yield was found from K_0 (control)treatment (Table 6).Pansare*et al.*, (2004) reported that the maximumyield tomato was obtained when straight fertilizers were added in the 130 kg K_2O/ha.Harneet*et al.,* (2004) reported that appropriate amount of potassium increased the yield of tomato.

Yield per hectare showed significant differences due to the application of different levels of IAA to tomato plant(Appendix VII). The highest (63.39 t/ha) yield was recorded from I_2 (50 ppmIAA) while the lowest (51.27 t/ha) yield was recorded from I_0 (control)treatment (Table 6).Singh *et al*. (2005) investigated that the application of 35 ppm IAA significantly increased the tomato yield. Gupta *et al*. (2003) observed that the highest yield (63.61 t/ha) obtained by the application of 45 ppm IAA and multiple nutrient mixture on "Krishna" tomato variety. Rai*et al*. (2002) recorded the highest yield of tomato due to the application of 75 ppm IAA.Singh and Upadhayaya (1967) reported that the application of IAA increased the total yield and induced parthenocarpic fruit.

Potassium and Indole acetic acid showed significant combined effect on yield per hectare(Appendix VII). The highest (70.78 t/ha) yield was obtained from K_2I_2 (140 kg K_2O + 50 ppmIAA) and the lowest (48.61 t/ha) was recorded from K_0I_0 (control)treatment (Table 7).

4.15 Economic analysis

Input costs for land preparation, seed cost, fertilizer, irrigation and man power required for all the operations from sowing to harvesting of tomato were recorded for unit plot and converted into cost per hectare (Appendix VIII & IX). Prices of tomato were considered in market of Agargaon, Dhaka (7 tk./kg hole sale) rate basis. The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings:

4.15.1 Gross return

In the combination of potassium fertilizer and IAA showed different gross return under the trial (Table 8). The highest gross return (Tk. 4,95,460/ha) was recorded from K_2I_2 (110 kg K_2O/ha + 50 ppmIAA) and the second highest gross return (Tk. 4,45,270) was recorded from K_1I_2 (110 kg K_2O/ha + 50 ppmIAA). The lowest gross return (Tk. 3,40,270) was recorded from K_0I_0 (control).

Table 6. Yield characteristics of tomato at different levels of potassium and indole acetic acid concentration

Treatment(s)	Fresh weight of leaves (g)	Dry matter content of leaves (%)	Average Individual fruit weight (g)	Dry mater content of fruits(%)	Yield/Plot (kg)	Yield/hectare (t/ha)
K_0	149.4 c	7.99 c	107.8c	7.81 c	19.89 b	55.25 b
K_1	154.3 b	9.51 b	115.2 b	9.02 b	20.18 b	56.06 b
K_2	155.4 b	9.85 a	**135.9 a**	9.91 a	**23.10 a**	**64.17 a**
K_3	**159.8 a**	**9.90 a**	111.6 b	**10.04 a**	20.49 b	56.92 b
LSD 0.05	3.8	0.35	6.870	0.98	2.51	2.556
I_0	154.4 c	8.21 b	102.93 c	8.73 b	18.46 c	51.27 c
I_1	**279.4 a**	**10.68 a**	115.12 b	10.54 a	21.47 b	59.64 b
I_2	267.9 b	9.98 a	**122.31 a**	**10.86 a**	**22.82 a**	**63.39 a**
LSD 0.05	3.3	2.2	5.949	2.05	0.815	2.231
CV (%)	5.3	10.5	6.27	11.3	5.69	5.69

K_0 : control (No K_2O) I_0: control (No IAA)
K_1 :110 kg K_2O I_1: 25 ppm IAA
K_2 :140 kg K_2O I_2: 50 ppmIAA
K_3 :170 kg K_2O

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 effect of potassium fertilizer and IAA on yield characteristics of tomato

Treatment(s)	Fresh weight of leaves (g)	Dry matter content of leaves (%)	Average individual fruit weight (g)	Dry mater content of fruits (%)	Yield/Plot (kg)	Yield/hectare (t/ha)
K_0I_0	149.9 e	7.74 e	86.74ef	7.91 f	17.50ef	48.61 ef
K_0I_1	190.6 cd	7.90 de	114.33 cd	8.35 e	18.40ef	51.11 ef
K_0I_2	215.6 b-d	7.94 de	113.04 cd	9.20 c-f	18.70ef	51.94 ef
K_1I_0	149.3 bc	7.86 e	110.03 cd	8.31 e	19.23 de	53.42 de
K_1I_1	241.6 ab	8.11 c-e	103.73 de	9.21 b-d	20.44 cd	56.78 cd
K_1I_2	236.7 a-c	8.30 cd	154.03 a	9.85 a-c	22.90 b	63.61 b
K_2I_0	150.8 d	8.10 c-e	88.53ef	8.45ef	21.13 c	58.69 c
K_2I_1	226.3 a-c	9.24 b-e	119.73bc	10.73 a-d	21.63bc	60.08 bc
K_2I_2	235.5 a-c	10.19 a-d	**162.53 a**	**11.83 a**	**25.48 a**	**70.78 a**
K_3I_0	151.4 ab	9.14 b-e	94.54ef	9.81 a-c	20.83 cd	57.86 cd
K_3I_1	**263.5 a**	**10.96 a**	103.83 de	11.55 a	21.41bc	59.47 bc
K_3I_2	251.6 ab	10.60ab	130.73 b	10.85 a-d	21.63bc	60.08 bc
LSD 0.05	6.6	6.3	11.90	1.22	1.64	4.547
CV (%)	5.3	10.5	6.27	20.3	5.69	5.69

K_0 : control (No K_2O) K_1 : 110 kg K_2O I_0 : control (No IAA) I_2 : 50 ppm IAA
K_2 : 140 kg K_2O K_3 : 170 kg K_2O I_1 : 25 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

4.15.2 Net return

In case of net return different treatment combination showed different amount of net return. The highest net return (Tk.3,38,011/ha) was recorded from K_2I_2 and the second highest net return (Tk. 2,90,194/ha) was recorded from K_1I_2. The lowest net return (Tk. 2,02,992/ha) was recorded from K_0I_0(Table 8).

4.15.3 Benefit cost ratio (BCR)

The benefit cost ratio (BCR) was different from each other among all the treatment combinations of potassium and IAA. The highest (3.15) benefit cost ratio was obtained from K_2I_2 and the lowest benefit cost ratio (2.48) was recorded from K_0I_0 (control) treatment (Table 8). From the economic point of view, it was apparent from the above results treatment combination of K_2I_2that is 140 kg K_2O per hectare (234 kg MOP/ha) and 50 ppm IAA was more profitable compare to others treatment combinations.

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

Calculation:

$$\text{BCR of } I_2G_2 \text{ treatment combination} = \frac{\text{4,95,460Tk.}}{\textbf{1,57,449Tk.}}$$

= 3.15

Table 8. Cost and return of tomato production influenced by potassium and IAA

Treatment combination	Total Cost of Production (Tk. /ha)	Yield of Tomato (t/ha)	Gross return (Tk. /ha)	Net Return (Tk. /ha)	BCR
K_0I_0	137278	48.61	340270	202992	2.48
K_0I_1	142024	51.11	357770	215746	2.52
K_0I_2	143211	51.94	363580	220369	2.54
K_1I_0	149143	53.42	373940	224797	2.51
K_1I_1	153889	56.78	397460	243571	2.58
K_1I_2	155076	63.61	445270	290194	2.87
K_2I_0	151516	58.69	410830	259314	2.71
K_2I_1	156262	60.08	420560	264298	2.69
K_2I_2	**157449**	**70.78**	**495460**	**338011**	**3.15**
K_3I_0	153889	57.86	405020	251131	2.63
K_3I_1	158635	59.47	416290	257655	2.62
K_3I_2	159822	60.08	420560	260738	2.63

K_0 : control (No K_2O) I_0: control (No IAA)
K_1 :110 kg K_2O/haI_1: 25 ppm IAA
K_2 :140 kg K_2O/haI_2: 50 ppmIAA
K_3 :170 kg K_2O/ha

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 October 2014 to March 2015 to determine the effect of different levels of potassium and different concentration of IAA on the growth and yield of tomato. The experiment consisted of two factors: Factor A: four levels of potassium K_0: 0 kg K_2O/ha, K_1: 110 kg K_2O/ha, K_2: 140 kg K_2O/ha, K_3: 170 kg K_2O/ha and Factor B: I_0: No IAA; I_1: 25 ppmIAA; I_2: 50 ppmIAA. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different yield contributing characters and yield were recorded to find out the optimum level of potassium and IAA on tomato.

At 60 days after transplanting the longest plant height (88.0 cm), maximum number of leaves per plant (79.0), maximum number of branches per plant (9.11), maximum number of flower clusters per plant (18.86), maximum number of flowers per cluster (6.73), maximum number of fruits per cluster (6.37), the highest length of fruit (5.97 cm), the highest diameter of fruit (6.48 cm), maximum fresh weight of individual fruit (135.9 g),maximum yield of fruit per plot (23.10 kg), and the highest yield of fruit per hectare (64.17 t/ha) were recorded from the treatment of 140 kg/ha K_2O that is K_2treatment.The maximum fresh weight of leaf (159.8 g), maximum dry matter percentage of leaf (9.90 %), highest dry matter percentage of fruit (10.04 %) were recorded from 170 kg/ha K_2O that is K_3 treatment. On the other hand the shortest plant height (76.11 cm), minimum number of leaves per plant (65.11), minimum number of branches per plant (6.88), minimum number of flower clusters per plant (12.08), minimum number of flowers per cluster (6.12), minimum number of fruits per cluster (5.45), the lowest length of fruit (4.88 cm), the lowest diameter of fruit (5.73 cm), minimum fresh weight of leaf (149.4 g), minimum average individual weight of fruit (107.8 g), the lowest dry matterpercentage of fruit (7.81 %), minimum dry matter percentage of leaf (7.99 %), minimum yield of fruit per plot (19.89 kg), andthe lowest yield of fruit per hectare (55.52 t/ha) were recorded from K_0(control) treatment.

At 60 days after transplanting the longest plant height (97.75 cm), maximum number of leaves per plant (82.17), maximum number of branches per plant (8.83), maximum number of flower clusters per plant (22.09), the highest number of flowers per cluster (6.86), maximum number of fruits per cluster (6.43), the highest length of fruit (5.95 cm), the highest diameter of fruit (6.51 cm),maximum fresh weight of fruit (122.31 g),maximum yield of fruit per plot (22.82 kg), and the highest yield of fruit per hectare (63.39 t/ha) were recorded from the treatment of 50 ppm Indole-3-acetic acid (IAA) that is I_2treatment.The maximum fresh weight of leaf (279.4 g), maximum dry matter percentage of leaf (10.68 %), maximum dry matter percentage of fruit (10.86 %) were recorded from I_1 treatment. On the other hand the shortest plant height (68.08 cm), minimum number of leaves per plant (66.25), minimum number of branches per plant (7.66), minimum number of flower clusters per plant (10.31), minimum number of flowers per cluster (5.73), minimum number of fruits per cluster (4.35), lowest length of fruit (5.14 cm), lowest diameter of fruit (5.80 cm), minimum fresh weight of individual fruit (102.93 g), minimum fresh weight of leaves (154.4 g)the lowest dry matter percentage of fruit (8.73%), minimum dry matter percentage of leaf (8.21%), minimum yield of fruit per plot (18.46 kg), and the lowest yield of fruit per hectare (51.27 t/ha) were recorded from I_0 (control) treatment.

At 60 days after transplanting the longest plant height (101.0 cm), maximum number of leaves per plant (92.67), maximum number of branch per plant (11.00), maximum number of flower clusters per plant (27.33), maximum number of flowers per cluster (8.23), maximum number of fruits per cluster (8.00), the highest length of fruit (5.98 cm), the highest diameter of fruit (6.98

cm), maximum fresh weight of fruit (162.53 g), the highest dry matter percentage of fruit (11.83 %),maximum yield of fruit per plot (25.48 kg), and the highest yield of fruit per hectare (70.78 t/ha) were recorded from the treatment combination of 50 ppm Indole-3-acetic acid (IAA) and 140 kg/ha K_2O that is K_2I_2treatment. Maximum fresh weight of leaf (263.5 g) and maximum dry matter percentage of leaf (10.96 %) were recorded from K_3I_1treatment combination. On the other handthe shortest plant height (57.33 cm), minimum number of leaves per plant (54.67), minimum number of branch per plant (7.00), minimum number of flower clusters per plant (8.66), minimum number of flowers per cluster (4.77), minimum number of fruits per cluster (3.33), the shortest length of fruit (3.52 cm), shortest diameter of fruit (4.98 cm), minimum fresh weight of fruit (86.74 g), lowest dry matter percentage of fruit (7.91 %), minimum fresh weight of leaf (149.9 g), minimum dry matter percentage of leaf (7.74 %), minimum yield of fruit per plot (17.50 kg), and the lowest yield of fruit per hectare (48.61 t/ha) were recorded from the treatment combination of 0 kg/ha K_2O and 0 ppm Indole-3-acetic acid (IAA) that is K_0I_0 (control)treatment combination.

The highest gross return (Tk. 4,95,460/ha),net return (Tk. 3,38,011/ha), benefit cost ratio (3.15), was recorded from the treatment combination of 50 ppm Indole-3-acetic acid (IAA) and 140 kg/ha K_2O that is K_2I_2treatment.Whereas the lowest gross return (Tk. 3,40,270/ha), net return (Tk. 2,02,992/ha) and benefit cost ratio (2.48) was recorded from the treatmentcombination of 0 ppm Indole-3-acetic acid (IAA) and 0 kg/ha K_2O that is K_0I_0 (control) treatment combination.

Conclusion

Based on the result of the present study it was found that application of 140 kg/ha $K_2O$and 50 ppm Indole-3-acetic acid (IAA) that is K_2I_2treatment combinationperformed the highest yield (70.78 t/ha) and highest (BCR) benefit cost ratio (3.15) for tomato production. Considering the findings of the experiment, it can be concluded that -

- ✓ The combination of 234 kg/ha MOP fertilizer and 50 ppm IAA (Indole-3-Acetic Acid) that is K_2I_2 treatment combination will be the appropriate practice for tomato production and also for highest economic return.

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 June 2015

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
October ,14	32.18	21.26	76	134
November,14	31.82	14.04	81	24
December,14	26.40	13.50	87	5
January,15	28.51	11.40	74	8
February ,15	28.10	12.70	79	32
March ,15	34.40	17.60	70	61
April , 15	37.30	21.40	66	137
May, 15	36.20	23.25	72	245
June, 15	36.42	25.50	81	315

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				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	2.694	9.250	46.861	114.528	235.083
Factor A (Potassium)	3	0.250	23.287 **	111.741 **	159.065 **	269.361**
Factor B (Indole-3-acetic acid)	2	0.861	258.250 **	776.694 **	1271.194 **	2644.333 **
Interaction (A X B)	6	0.417	2.509 *	13.657 *	5.231 **	23.333 *
Error	22	0.361	1.765	11.891	18.194	29.265
** : 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				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	0.444	1.583	0.694	13.361	6.361
Factor A (Potassium)	3	0.074	8.407 **	154.481**	236.963 **	335.287 **
Factor B (Indole-3-acetic acid)	2	1.194	20.250 **	329.194 **	632.528 **	830.861 **
Interaction (A X B)	6	0.046	4.657 **	32.120 *	61.602 **	89.898 *
Error	22	0.202	0.462	14.088	16.179	25.270
** : 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				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	0.0	0.028	0.111	2.528	5.861
Factor A (Potassium)	3	0.0	0.250 **	1.889 **	6.852 **	7.806 **
Factor B (Indole-3-acetic acid)	2	0.0	1.694 **	0.778 **	4.361 **	4.528 **
Interaction (A X B)	6	0.0	0.917 **	0.333 *	0.769 *	0.861 *
Error	22	0.0	0.028	0.111	0.407	0.770
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

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

Source of variation	Degrees of freedom (df)	Mean square of				
		Number of clusters/ plant	Number of flowers/cluster	Number of fruits/cluster	Length of fruit	Diameter of fruit
Replication	2	1.444	0.644	9.194	1.742	0.021
Factor A (Potassium)	3	31.657 **	0.630 *	4.963 **	2.035 **	0.995 *
Factor B (Indole-3-acetic acid)	2	99.361 **	5.769 **	51.194 **	2.303 **	1.499 **
Interaction (A X B)	6	5.657 **	0.159 *	2.046 **	0.321 **	0.622 *
Error	22	0.535	0.169	0.164	0.290	0.221
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

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

Source of variation	Degrees of freedom (df)	Mean square of					
		Fresh weight of leaf (g)	Dry mater content of leaf (%)	Average weight of individual fruit (g)	Dry mater content of fruit (%)	Yield/Plot (kg)	Yield/hectare(t/ha)
Replication	2	21.075	8.286	2986.309 **	11.677	19.687 **	151.858 **
Factor A (Potassium)	3	111.504 **	860.656 **	410.572 **	10.889 **	5.438 **	41.964 **
Factor B (Indole-3-acetic acid)	2	112.244 **	865.613 **	3666.516 **	69.542 **	59.776 **	461.111**
Interaction (A X B)	6	7.341 **	56.659 **	49.376	1.225 **	0.886	6.836
Error	22	2.510	19.347	1.278	11.614	23.792	2.572

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

Appendix-VIII. Input cost

Treatments Combination	Labour Cost (TK.)	Ploughing Cost (TK.)	Seedling cost (TK.)	Irrigation Cost (TK.)	Pesticides cost (TK.)	IAA cost (TK.)	Manure and fertilizers cost (TK.)				Sub Total (A)
							Cowdung	Urea	TSP	MP	
K_0I_0	12000	15000	2500	9000	2000	0	15000	8000	13200	0	76700
K_0I_1	14000	15000	2500	9000	2000	2000	15000	8000	13200	0	80700
K_0I_2	14000	15000	2500	9000	2000	3000	15000	8000	13200	0	81700
K_1I_0	14000	15000	2500	9000	2000	0	15000	8000	13200	8000	86700
K_1I_1	16000	15000	2500	9000	2000	2000	15000	8000	13200	8000	90700
K_1I_2	16000	15000	2500	9000	2000	3000	15000	8000	13200	8000	91700
K_2I_0	14000	15000	2500	9000	2000	0	15000	8000	13200	10000	88700
K_2I_1	16000	15000	2500	9000	2000	2000	15000	8000	13200	10000	92700
K_2I_2	16000	15000	2500	9000	2000	3000	15000	8000	13200	10000	93700
K_3I_0	14000	15000	2500	9000	2000	0	15000	8000	13200	12000	90700
K_3I_1	16000	15000	2500	9000	2000	2000	15000	8000	13200	12000	94700
K_3I_2	16000	15000	2500	9000	2000	3000	15000	8000	13200	12000	95700

Appendix- IX. Grand total cost of production

Treatments Combination	Cost of lease of land for 6 months (13% of value of land Tk.6,00000/year (B)	Sub Total Cost of production (A+B)	Interest on running capital for 6 months(Tk. 13% of cost/year (C)	Total (A+B+C) (TK.)	Miscellaneous cost(Tk. 5% of the input cost)	Grand Total Cost of Production (TK.)
K_0I_0	39000	115700	15041	130741	6537	137278
K_0I_1	39000	119700	15561	135261	6763	142024
K_0I_2	39000	120700	15691	136391	6820	143211
K_1I_0	39000	125700	16341	142041	7102	149143
K_1I_1	39000	129700	16861	146561	7328	153889
K_1I_2	39000	130700	16991	147691	7385	155076
K_2I_0	39000	127700	16601	144301	7215	151516
K_2I_1	39000	131700	17121	148821	7441	156262
K_2I_2	39000	132700	17251	149951	7498	157449
K_3I_0	39000	129700	16861	146561	7328	153889
K_3I_1	39000	133700	17381	151081	7554	158635
K_3I_2	39000	134700	17511	152211	7611	159822