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Effect of Indole Acetic Acid and Boron on the Nutrient Contents of Summer Tomato Cultivar Bina Tomato-3

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Authors' contributions

This work was carried out in collaboration among all authors. Author MS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MAKC managed the analyses of the study. Author MAHC managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A pot experiment was carried out with tomato variety BINA Tomato-3 in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University (BAU), Mymensingh from March to August, 2010 to study the effect of Indole Acetic Acid(IAA) and Boron(B) on the nutrient contents of BINA Tomato-3. There were four doses of IAA viz. 0, 20, 40 and 60 ppm and B viz. 0, 1.5, 2.0 and 2.5 kg ha^{-1}. The experiment was laid out in a Completely Randomized Design (CRD) with 3 replications. The result revealed that nutrient contents of tomato fruits and plants such as N, P, Ca, Mg and B were significantly influenced by the application of IAA and B. The highest N (0.70%), Ca (0.69%), Mg (0.80%) in tomato fruits and highest N (0.40%), Ca (0.93%), Mg (0.90%) in tomato plants were obtained in 60 ppm IAA along with 2.0 kg B ha^{-1} and the lowest was obtained in the control treatment. In tomato fruits the highest P (0.41%) was found in $IAA_{40}B_{2.0}$ treatment,

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while the lowest P (0.18%) was recorded in $IAA_0B_{0.0}$. The lowest B (4.55μgg^{-1}) was recorded in control, while the highest B (15.72μgg^{-1}) was found in $IAA_{20}B_{2.0}$in tomato fruits. In tomato plants the highest P (0.34%) was recorded in $IAA_{60}B_{1.5}$ and the lowest P (0.20%) was found in control. The lowest B (4.15μgg^{-1}) was recorded in $IAA_0B_{0.0}$, while the highest B(13.33μgg^{-1}) was found in $IAA_{40}B_{2.0}$ in tomato plants. The overall results suggest that treatment $IAA_{60}B_{2.0}$ was the best from other treatments.

Keywords: Indole acetic acid; boron; nutrient; summer tomato.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum,* mill.), belongs to the family solanaceae. It is one of the most popular, nutritious, palatable and versatile cultivated vegetable all over the world including Bangladesh. It was originated in tropical America [1]. In Bangladesh, it ranks 2nd next to potato [2] and top of the list of canned vegetables. At present China, India, Egypt, Turkey, Iran, Italy, Mexico and Brazil are the leading tomato producing countries in the world [3]. The chemical composition of tomato includes total sugar 2.50-4.50%, vitamin C 15-20mg/100g, calcium 0.25-0.50 g/100g, magnesium 0.10-1.50 g/100g, phosphorus 0.20-0.80 g/100g, iron 40-500 ppm, zinc 10-50 ppm, lycopene 20-50 g/100g (dry fruit weight basis) [4].

In Bangladesh, it is widely cultivated due to its adaptability to wide range of soil and climate [5]. Soil and climatic conditions of all the districts of Bangladesh, especially Rajshahi, Natore, Chapainawabganj, Naogaon, Pabna, Bogra, Sirajgonj, Joypurhat, Rangpur and Gaibandha districts are very suitable for tomato cultivation. Tomato is a very nutritious vegetable containing considerable amounts of vitamins and minerals [6]. Tomato production during the summer season is restricted due to high temperature, high humidity, and rainfall. Adverse climatic condition during summer causes severe flower dropping in tomato. High temperature dries up stigmatic fluid and thus resulted in poor fruit setting and yield of tomato. However, scientists have been trying to develop heat tolerant varieties and Bangladesh Institute of Nuclear Agriculture (BINA) has developed some heat tolerant varieties like BINA Tomato-2, BINA Tomato-3 and BINA Tomato-5 [7]. Plant growth regulator has been reported to enhance fruit set under both normal and adverse weather conditions. The study on IAA for tomato production in Bangladesh is very rare and limited at the Research Institutes. IAA not only helps in fruit setting but also improves the biochemical and nutritional composition of tomato. This crop differs in their sensitivity to Boron (B) deficiency and the absorption of B varies with the types of soil. The reduced level of water in the soil also causes a proportionate to decrease the rate of B diffusion to root [8]. Visible symptoms of B deficiency (0.3 μm) initiated on young leaves as internal chlorosis later leading to necrosis [9]. Keeping these points in view the experiment was undertaken to determine the effect of IAA and B on the nutrient contents of BINATomato-3.

2. MATERIALS AND METHODS

A pot experiment was conducted at the net house of the department of Agricultural Chemistry, Bangladesh Agricultural University (BAU), Mymensingh. The research work was accomplished in earthen pot and the different nutrients of the fruit and plant samples were analyzed in the laboratory of the Department of Agricultural Chemistry, BAU, Mymensingh.

The climate of the experiment area was under the sub-tropical climatic zone, which is characterized by moderate to high temperature, heavy rainfall, high humidity and relatively long day during Kharif season (March to August). Before starting the experiment initial soil sample of the experimental plots was analyzed in the laboratory for determination of its physical and chemical properties. The treatments included in the experiment were as follows:

Factor A : Four levels of IAA viz.

1. No IAA (IAA_0)
2. 20 ppm IAA (IAA_{20})
3. 40 ppm IAA (IAA_{40})
4. 60 ppm IAA (IAA_{60})

Factor B: Four levels of Boron viz.

1. No B ($B_{0.0}$)
2. 1.5 kg B ha^{-1} ($B_{1.5}$)
3. 2.0 kg B ha^{-1} ($B_{2.0}$)
4. 2.5 kg B ha^{-1} ($B_{2.5}$)

2.1 Chemical Analysis of Fruit

2.1.1 Total nitrogen determination

Total N was estimated by semi-micro kjeldahl method [10] and [11]. In this method, exactly 0.5 g oven dried and the ground sample was digested with 3 mL of H_2O_2 and 6 mL concentration H_2SO_4 in presence of 1 g catalyst mixture in the digestion tube. After the completion of digestion, the flask was cooled at room temperature and about 25 mL of distilled water was added. For performing distillation, 10 mL of the digested solution was taken in a distillation unit with 10 mL of 40% NaOH. The distillate was collected in 10 mL 2% boric acid containing a mixed indicator. The collected distillate in boric acid was titrated with standardized 0.1N H_2SO_4. The N percentage was calculated by the following formula-

$$\% \text{ N} = \frac{(\text{T-B}) \times \text{N} \times 1.4}{\text{S}}$$

where,

T = Sample titration (mL) value
B = Blank titration (mL) value
N = Strength of H_2SO_4 (N)
S = Sample weight (g)

2.1.2 Preparation of fruit extract for the determination of different nutrient contents

Exactly 1g of dried and finely ground fruit material was taken into a 250 mL conical flask and 10mL of di-acid mixture (HNO_3: $HClO_4$ = 2:1) was added to it. Then it was placed on an electric hot plate for heating at 180-200°C until the solid particles disappeared and white fumes were evolved from the flask. Then, it was cooled at room temperature, washed with distilled water and filtered through filter paper (Whatman No. 42) making the volume up to the mark with distilled water following wet oxidation methods as described by [12]. The solution was used for the analysis of P, Ca, Mg and B.

2.1.3 Phosphorus determination

The phosphorus content of the fruit extract was determined by developing blue colour with stannous chloride ($SnCl_2.2H_2O$) reduction of phosphomolybdate complex and measuring the colour with the help of a spectrophotometer (Model-LT-31) at 660 nm wavelengths [12]. Stannous chloride was used as a reducing agent to form molybdophosphoric blue complex with sulphomolybdate. Exactly 2 mL aliquot was taken in a 100 mL volumetric flask followed by the addition of 4 mL of sulphomolybdic acid and 6 drops of stannous chloride solution. The volume was made up to the mark with distilled water and was shaken thoroughly. Finally, the absorbance of light at 660 nm wave length was measured with the help of a spectrophotometer.

2.1.4 Calcium determination

Calcium content of the fruit extract was determined by complexometric method of titration using Na_2EDTA as a complexing agent at pH 12 where calcon was taken followed by 40 mL water, 3 mL 10% NaOH solution, 10 drops each of the hydroxylamine hydrochloride ($NH_2OH.HCl$), potassium ferrocyanide [$K_4Fe(CN)_6.3H_2O$] and TEA (triethanol amine; $C_6H_{15}NO_3$), as masking agent, After the addition of calcon indicator solution, the test sample was titrated against Na_2-EDTA (0.01M) solution from a burette until the pink colour of the solution turned into pure blue.

2.1.5 Magnesium determination

Magnesium content of the fruit extract was determined by the complexometric method of titration using Na_2EDTA as a complexing agent at pH 10 where EBT (Eriochrome Black T) was used as an indicator [12]. Exactly 5 mL of the aliquot was taken following the addition of 40 mL distilled water, 5 mL NH_3-NH_4 buffer solution, 10 drops each of the hydroxyl amine hydrochloride ($NH_2OH.HCl$), potassium ferrocyanide [$K_4Fe(CN)_6.3H_2O$], sodium tungstate ($Na_2WO_4.2H_2O$) and TEA.

2.1.6 Boron determination

The content of boron in fruit extract was determined by a spectrophotemetric method using azomethine-H reagent. Exactly 5mL of extract was taken in a 250 mL volumetric flask. Then 4mL buffer musking solution and 4mL azomethine-H was added. Then the volume was made upto the mark. After one hour, absorbence was measured at 420 nm wavelength with help of a spetrophotometer following the analytical technique outlined by [13]. (Triethanol amine; $C_6H_{15}NO_3$), as a masking agent, after the addition of EBT indicator solution, the aliquot was titrated against Na_2EDTA (0.01M) solution from a burette until the pink colour of the solution turned into pure blue.

2.1.7 Plant analysis after harvesting

For the determination of N, Ca, Mg, P and B in plant, 1g dry ground plant sample was taken. Preparation of the stock solution and analyses of the elements were the same as the previous methods of fruit analysis.

2.2 Experimental Design and Statistical Analysis

The experiment was laid out in Completely Randomized Design (CRD) with three replications. The recorded data were subjected to statistical analysis. All the data were analyzed for ANOVA with the help of a computer package program of MSTAT-C (Mathematical and Statistical calculation) [14].

3. RESULTS AND DISCUSSION

3.1 The Effect of IAA on Different Nutrients Content in Fruits of BINA Tomato-3

The nutrient contents of tomato fruits were found highest for N (0.64%), P (0.37%), Ca (0.64%), Mg (0.73%) and B (12.63 μgg^{-1}) in treatment IAA_{60} and all these fine nutrient elements were lowest in the treatment where no IAA was used (Table 1). The contents of N, P, Ca, Mg and B in tomato fruits significantly increased due to IAA application.

3.2 The Effect of B on Different Nutrients Content in Fruits of BINA Tomato-3

BINA tomato-3 fruits contained the highest amount of nutrients viz. N (0.64%), P (0.36%), Mg (0.71%) and B 14.13μgg^{-1} at $B_{2.0}$ but the content of Ca (0.52%) was highest in $B_{1.5}$ treatments. All these nutrients were lowest in control ($B_{0.0}$) treatment (Table 2). A significant variation in N, P, Mg and B contents of tomato fruits were observed due to different levels of B fertilizer. Boron did not show a significant effect on Ca content in tomato fruits.

3.3 Interaction Effect of Different Levels of IAA and B on Different Nutrients Content in Fruits of BINA Tomato-3

Effect of interaction on different nutrients content in fruits of BINA tomato-3 is presented in Table 3. The effects of IAA with different doses of boron on N, P, Ca, Mg and B contents in tomato fruits were statistically significant. The nutrients contents of tomato fruits were found highest for N (0.70%) in treatment $IAA_{60}B_{2.0}$and lowest value (0.49%) was obtained in treatment $IAA_0B_{0.0}$. The P content of tomato fruits was highest (0.41%) in treatment $IAA_{40}B_{2.0}$and it was lowest (0.18%) in treatment $IAA_0B_{0.0}$. The Ca content of tomato fruits was highest (0.69%) in treatment $IAA_{60}B_{2.0}$and its lowest value (0.32%) was found in $IAA_{20}B_{2.0}$ and $IAA_{20}B_{2.5}$ treatments. The Mg content of tomato fruits was highest (0.80%) in treatment $IAA_{60}B_{2.0}$ and its lowest value (0.30%) was obtained in control. The B content of tomato fruits was highest (15.72 μgg^{-1}) in treatment $IAA_{20}B_{2.0}$ and its lowest value (4.55 μgg^{-1}) was found in treatment control. The results clearly indicated that N, P, Ca, Mg and B contents increased in tomato fruits due to the application of IAA and B.

3.4 The Effect of IAA on Different Nutrients Content in Plant of BINA Tomato-3

The highest P (0.32%), Ca (0.89%), Mg (0.84%) and B (11.13μgg^{-1}) was found in IAA_{60} treatment but N (0.37%) was found in IAA_{40} treatment. The lowest nutrients viz. N, P, Ca, Mg and B was found in IAA_0 (control) treatment. The results in Table 4 showed that the application of IAA significantly increased the N, P, Ca, Mg and B contents of tomato plants.

Table 1. The effect of different levels of IAA on nutrients content in fruits of BINA tomato-3

Treatments	N (%)	P (%)	Ca (%)	Mg (%)	B (μgg^{-1})
IAA_0	0.54c	0.24c	0.43	0.56b	9.44b
IAA_{20}	0.56bc	0.33b	0.36	0.67a	11.13ab
IAA_{40}	0.62ab	0.34ab	0.53	0.56b	12.13a
IAA_{60}	0.64a	0.37a	0.64	0.73a	12.63a
Level of significance	**	**	**	**	**
LSD	0.01	0.00	0.02	0.01	0.46

*NS = Not significant, **indicates significant at 1% level of probability. Figures in a column having same or no letter(s) do not differ significantly*

Table 2. The effect of different levels of B on nutrients content in fruits of BINA tomato-3

Treatments	N (%)	P (%)	Ca (%)	Mg (%)	B (μgg^{-1})
$B_{0.0}$	0.54c	0.28c	0.47	0.56b	7.84c
$B_{1.5}$	0.61a	0.31bc	0.52	0.57b	10.73b
$B_{2.0}$	0.64a	0.36a	0.49	0.71a	14.13a
$B_{2.5}$	0.57ab	0.33ab	0.49	0.68a	12.63a
Level of significance	**	**	NS	**	**
LSD	0.01	0.00	0.02	0.01	0.46

*NS = Not significant, **indicates significant at 1% level of probability. Figures in a column having same or no letter(s) do not differ significantly*

Table 3. Interaction effect of IAA and B on nutrients content in fruits of BINA tomato-3

Treatments	N (%)	P (%)	Ca (%)	Mg (%)	B (μgg^{-1})
$IAA_0B_{0.0}$	0.49c	0.18h	0.40 cde	0.30f	4.55f
$IAA_0B_{1.5}$	0.57abc	0.23gh	0.45 b-d	0.55de	9.34de
IAA_0 $B_{2.0}$	0.59abc	0.28fg	0.43 b-d	0.71ab	11.73bcd
IAA_0 $B_{2.5}$	0.50bc	0.26g	0.45 b-d	0.66bcd	12.13a-d
IAA_{20} $B_{0.0}$	0.51bc	0.29efg	0.43 b-d	0.75ab	7.34ef
IAA_{20} $B_{1.5}$	0.62abc	0.30def	0.37de	0.50e	10.14cde
IAA_{20} $B_{2.0}$	0.63abc	0.37abc	0.32e	0.68abc	15.72a
IAA_{20} $B_{2.5}$	0.49c	0.34cd	0.32e	0.76ab	11.33bcd
IAA_{40} $B_{0.0}$	0.56abc	0.29efg	0.45b-d	0.56cde	8.54de
IAA_{40} $B_{1.5}$	0.66a	0.33bcd	0.61abc	0.48e	12.13a-d
IAA_{40} $B_{2.0}$	0.64ab	0.41a	0.51a-d	0.66bcd	14.53ab
IAA_{40} $B_{2.5}$	0.60abc	0.35bc	0.56a-d	0.55de	13.33abc
IAA_{60} $B_{0.0}$	0.59abc	0.34bc	0.61abc	0.63bcd	10.93cde
IAA_{60} $B_{1.5}$	0.60abc	0.37abc	0.64ab	0.74ab	11.33bcd
IAA_{60} $B_{2.0}$	0.70a	0.39ab	0.69a	0.80a	14.52ab
IAA_{60} $B_{2.5}$	0.68a	0.36bc	0.61abc	0.76ab	13.73abc
Level of significance	*	**	**	**	**
LSD	0.07	0.03	0.10	0.06	1.84

*NS = Not significant, **indicates significant at 1% level of probability. Figures in a column having same or no letter(s) do not differ significantly*

Table 4. The effect of different levels of IAA on plant nutrients content of BINA tomato-3

Treatments	N (%)	P (%)	Ca (%)	Mg (%)	B (μgg^{-1})
IAA_0	0.22b	0.25c	0.59c	0.37d	7.24b
IAA_{20}	0.33a	0.28b	0.72b	0.57c	10.73a
IAA_{40}	0.37a	0.31a	0.82a	0.69b	10.73a
IAA_{60}	0.36a	0.32a	0.89a	0.84a	11.13a
Level of significance	**	**	**	**	**
LSD	0.01	0.00	0.02	0.02	0.50

*NS = Not significant, **indicates significant at 1% level of probability. Figures in a column having same or no letter(s) do not differ significantly*

Table 5. The effect of different levels of B on plant nutrients content of BINA tomato-3

Treatments	N (%)	P (%)	Ca (%)	Mg (%)	B (μgg^{-1})
$B_{0.0}$	0.30	0.26b	0.67	0.53	7.44b
$B_{1.5}$	0.32	0.30a	0.77	0.61	10.24a
$B_{2.0}$	0.33	0.31a	0.79	0.68	11.63a
$B_{2.5}$	0.33	0.30a	0.80	0.64	10.53a
Level of significance	NS	**	NS	NS	**
LSD	0.01	0.00	0.02	0.02	0.50

*NS = Not significant, **indicates significant at 1% level of probability. Figures in a column having same or no letter(s) do not differ significantly*

Table 6. Interaction effect of different levels of IAA and B on plant nutrients content of BINA tomato-3

Treatments	N (%)	P (%)	Ca (%)	Mg (%)	B (μgg^{-1})
$IAA_0B_{0.0}$	0.17f	0.20g	0.51d	0.36f	4.15e
$IAA_0B_{1.5}$	0.22ef	0.26ef	0.59cd	0.36f	6.94de
IAA_0 $B_{2.0}$	0.26de	0.28cde	0.64bc	0.39f	8.54bcd
IAA_0 $B_{2.5}$	0.23def	0.26ef	0.61cd	0.39f	9.34a-d
IAA_{20} $B_{0.0}$	0.35ab	0.25f	0.61cd	0.42f	8.54bcd
IAA_{20} $B_{1.5}$	0.30bcd	0.28cde	0.69bc	0.56de	11.33abc
IAA_{20} $B_{2.0}$	0.31bc	0.29cd	0.75abc	0.68bcd	12.13ab
IAA_{20} $B_{2.5}$	0.35ab	0.31bc	0.83ab	0.60cd	10.93a-d
IAA_{40} $B_{0.0}$	0.35ab	0.28cde	0.72bc	0.56de	7.34cde
IAA_{40} $B_{1.5}$	0.38ab	0.30bc	0.85ab	0.68bcd	11.33abc
IAA_{40} $B_{2.0}$	0.35ab	0.33ab	0.83ab	0.76abc	13.33a
IAA_{40} $B_{2.5}$	0.37ab	0.31bc	0.88ab	0.74a-d	10.93a-d
IAA_{60} $B_{0.0}$	0.32bc	0.29cd	0.83ab	0.76abc	9.74a-d
IAA_{60} $B_{1.5}$	0.38ab	0.34a	0.93a	0.86ab	11.33abc
IAA_{60} $B_{2.0}$	0.40a	0.33ab	0.93a	0.90a	12.53ab
IAA_{60} $B_{2.5}$	0.36ab	0.30	0.88ab	0.83ab	10.93a-d
Level of significance	**	**	**	**	**
LSD	0.04	0.01	0.09	0.09	2.00

*NS = Not significant, **indicates significant at 1% level of probability. Figures in a column having same or no letter(s) do not differ significantly*

3.5 The Effect of Boron on Different Nutrients Content in a Plant of BINA Tomato-3

The nutrients N, P, Mg and B content of BINA tomato-3 was highest 0.33%, 0.31%, 0.68% and 11.63μgg^{-1} respectively in treatment $B_{2.0}$ and Ca was 0.80% in treatment $B_{2.5}$. All these nutrients were lowest in control treatment (Table 5). The application of boron had significantly increased the P and B contents of tomato plants whereas, in boron had no significant effects on N, Ca and Mg contents of tomato plants.

3.6 The Interaction Effect of Different Levels of IAA and B on Different Nutrients Content in a Plant of BINA Tomato-3

Effect of interaction on different nutrients content in a plant of BINA tomato-3 is presented in Table 6. All the treatments significantly increased N, P, Ca, Mg and B contents in tomato plants as compared to the control treatment ($IAA_0B_{0.0}$). The interaction effect of different levels of IAA and B on nutrients composition of tomato plants was found highest for N (0.40%) in treatment $IAA_{60}B_{2.0}$. P (0.34%) was found highest in treatment IAA_{60} $B_{1.5}$ and Ca was highest (0.93%) in treatments $IAA_{60}B_{1.5}$ and IAA_{60} $B_{2.0}$. Mg was found highest (0.90%) in treatment $IAA_{60}B_{2.0}$. The maximum B content (13.33μgg^{-1}) in treatment IAA_{40} $B_{2.0}$ and all these nutrients were lowest in treatment IAA_0 $B_{0.0}$ in control. The results showed that N, P, Ca, Mg and B contents increased in tomato plants due to the application of IAA and B.

It was further observed that the nutrients content in both tomato fruits and plants increased with the increasing level of IAA and a minimum level of B but better nutrients content in tomato fruits and plants were possible by using 60 ppm IAA and 2 kg B ha^{-1}. Applying of both natural and synthetic auxin helps the farmer in cultivating tomato in an adverse climatic condition which can give good fruit yield by increasing vegetative and reproductive growth and reducing the flower and fruit drop [15, 16].

4. CONCLUSION

When IAA and B were applied together, it gave a remarkably higher response in terms of nutrient contents of a summer tomato. The highest Nitrogen, Calcium and Magnesium of BINA Tomato-3 in both cases of fruits and plants were obtained from the application of IAA at the rate of 60 ppm along with B at the rate of 2.0 kg ha^{-1}.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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