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Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Punjab 38040, Pakistan

Response of Exotic Tomato (cv. Pomodoro) to Soil and Foliar Applied Zinc and Boron

Elaf Anjum* and Aijaz Hussain Soomro
Institute of Food Sciences & Technology, Sindh Agriculture University, Tandojam
Emails: elaf496@gmail.com (E.A), elafarain@gmail.com (E.A)

Abstract

The exotic Tomato cultivar Pomodoro was evaluated against varying levels of soil applied Zinc(Zn) and Boron(B) at Sindh Agriculture University Tandojam in three replicated RCB design. Soil applied Zn and B @2 and 4 kg ha^{-1} and foliar application equally at 0.2% concentration were arranged in different combinations. Treatments were arranged as: T_1 =NPK @ 125-75-50 $kgha^{-1}$, T_2=T1+soil $ZnSO_4$ @4 $kgha^{-1}$, T_3=T1+soil applied Borax @2 $kgha^{-1}$, T_4=T1+soil applied $ZnSO_4$ and Borax @4 kg and 2 $kgha^{-1}$, T_5=T1+foliar $ZnSO_4$ @ 0.2%, T_6=T1+foliar boric acid @ 0.2%, T_7=T1+foliar $ZnSO_4$ and boric acid equally @0.2% concentrations. There was a significantly different response of exotic tomato to soil and foliar applied Zn and B levels. The exotic tomato responded more positively in terms of fruit yield (16835 kg ha^{-1}) under Zn+B soil application @4 kg+2kg ha^{-1} and 2 foliar sprays at 0.2% concentration, respectively in addition to NPK @125-75-50 kg ha^{-1}. It was concluded that NPK + foliar application of $ZnSO_4$ and boric acid each @ 0.2% equally at 15 days interval resulted highly positive impact on all the growth and yield contributing traits of tomato; where the tomato fruit yield was 16835 kg ha^{-1} as compared to 11711.67 kg fruit yield ha^{-1} without Zn and B.

INTRODUCTION

Micronutrients are essential for normal growth and development processes of plants because these work as mediators or activators of many enzyme systems. Iron is not constituent of chlorophyll but is essential for its formation. Manganese is related to oxidation reduction balance in plants, especially in connection with iron and nitrogen metabolism (Dursuna *et al.,* 2010). Zinc is needed by plants in some of their enzyme systems. Micronutrients disorder is known to be a widespread and serious problem in Pakistan soils. Further, under adverse conditions of water stress due to high temperature even with good irrigation system, crops may need additional supply of micronutrients to realize the yield potential (Khan *et al.,* 2002). The poor tomato harvest is mainly associated with micronutrient deficiency in soil, particularly in Zinc and Boron (Basavarajeshwari *et al.,* 2008). Zinc is well known is that one of important microelements in plant nutrition, which as a trace element is directly related with hormonal regulation as well as pigment synthesis. The problem of zinc up taking by the plants has been studied by many authors (Stojanova and Vasileva, 1993). Zinc deficiencies may occur on calcareous, high pH, sandy texture, high P, and eroded soils. Zinc deficiencies usually show up under cool wet conditions in early spring when root growth is slow. Poorly drained soils may be also deficient. Badly eroded soils and eroded knolls are likely to be low in Zn, soil test to be sure. Deficiency symptoms will most likely show up first in dry bean. Very high rates of P may induce Zn deficiency in flax. Zinc is involved in enzyme systems, metabolic reactions, and is necessary for production of chlorophyll and carbohydrates (Tavassoli *et al.,* 2008). Several approaches have been investigated to overcome the common problem of Zn deficiency. The Zn content of crops can be increased *via* Zn fertilization but the resource poor farmers are unable to bear the relatively high cost of Zn fertilizers (Gibbson, 2006).

Boron is non-metal micronutrient element obtained from tourmaline, a complex borosilicate is the main boron-containing mineral found in most soils. Release of boron from this mineral is quite slow (Singh *et al.,* 2002). Boron uptake by plants correlates extractable soil boron (Rashid, 1996). The studies showed that the application of Boron resulted in increased concentration and uptake of B and a decreased P concentration and uptake in all genotypes. The dry weight of all genotypes was decreased by application of B. However, applied P decreased B concentration and uptake (Gunes and Alpaslan, 2000). Boron deficiency in plant results in terminal bud growth stoppage young leaves die, impaired flowering and boll development, thickened, wilted, or curled leaves, thickened, cracked, or water-soaked condition of petioles and stems, discoloration, cracking, or rotting of fruit, tubers, or roots. Sugar transport in plants, pollen formation germination and development of nodules are also affected by Boron deficiency (Gunes and Alpaslan, 2000).

The confound effect of B in the rooting medium on the concentration of the other elements in the ear leaves and in the roots (Sayed, 1998). Boron application increased the stability of leaf membranes, chlorophyll, soluble sugars, soluble proteins, amino acid contents, leaf RWC and dry mass accumulation. Foliar boron application was more effective (Sakal *et al.,* 1999). Boron (soil or foliar applied) has effect on many functions of the plant such as hormone movement, active salt absorption, flowering and fruiting process, pollen germination, carbohydrates and nitrogen metabolism and water relations in the plants. Boron deficiency occurs in vegetable crops having high boron requirements when grown on alkaline soils with free lime and on sandy soils with low organic matter content. Boron deficiency causes reduced root growth, brittle leaves and necrosis of shoot apex (Singh and Gangwar, 1991). The present experiment was conducted to examine the response of exotic tomato (cv. pomodoro) to soil and foliar applied zinc and boron at Tando jam.

MATERIALS AND METHODS

The study was carried out during the year 2010-2011 at the experimental field at Horticulture Orchard, Sindh Agriculture University, Tandojam. The experiment was laid out in a three replicated Randomized Complete Block Design, having plot size of 3.5 m x 3.0 m (10.5 m^2).

The land was prepared as per the recommendations and raised beds were prepared to transplant the tomato nursery on both sides of the beds. The soil was initially plowed up by means of disc plow to remove the hard pan and disc harrow was operated. When the land was ploughed up, the clods were crushed, and leveling was done to eradicate the weeds and to make the soil surface leveled for uniform distribution of irrigation water. After soaking dose, when the soil came in condition, cultivator was operated and ridges were prepared keeping 60 cm distance between rows.

The seed of exotic variety "Pomodoro" was obtained from the local market and sown for raising nursery on 10th August 2010; when the seedlings were one and half month old, these were transplanted on both sides of the ridges on 26th September, 2010 keeping plant to plant distance of 30 cm. The irrigation was applied initially just before transplanting, and afterwards when felt necessary. The plots were prepared keeping in view the layout design. For fertilizer application, D.A.P. was given at the rate of 120 kg per hectare at the time of preparation of ridges (mixed in the soil). Besides, alongwith recommended rate of NPK fertilizers, zinc and boron were applied through soil as well as foliar application. The zinc was applied in the form of $ZnSO_4$ under soil and foliar treatment; and boron in the form of Borax in soil, whereas boric acid in foliar treatment. Three applications of foliar $ZnSO_4$ and boric acid were applied; first at flowering, and later at 15 days interval. The soil applied zinc and boron were applied at the time of sowing. For recording observations on various growth and fruit yield traits, five plants in each treatment were selected at random and labeled. The data were statistically analysed as suggested by Steel and Torrie (1984). All the statistical tests were performed by using Statistix (Version 8.1) Computer Software.

RESULTS

Days to Flowering

The flowering initiation of tomato variety "Pomodoro" was significantly ($P \leq 0.01$) affected by Zinc and Boron application methods. The results indicate that tomato plants fertilized with recommended NPK+foliar applied $ZnSO_4$ and boric acid equally @ 0.2% concentration (T7) took maximum number of days (58) to initiate flowering, closely followed by T6 (NPK+foliar applied boric acid @ 0.2%), T5 (NPK+foliar applied $ZnSO_4$ @ 0.2%) and T4 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1} and Borax @ 2 kg ha^{-1}) where the tomato plants initiate flowering in 55.33, 55.0 and 53.67 days, respectively. Similarly, tomato plants under T3 (NPK+soil applied Borax @ 2 kg ha^{-1}) and T2 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1}) initiate flowering in 51.67 and 51.33 days, respectively. Whereas, the tomato plants took minimum number of days (50.33) to initiate flowering when the crop was fertilized only with recommended NPK fertilizers and no Zinc or Boron.

Plant Height

The analysis of variance indicated that plant height of tomato variety "Pomodoro" was significantly ($P \leq 0.01$) affected by Zinc and Boron application methods. The results showed that tomato plants fertilized with recommended NPK+foliar applied $ZnSO_4$ and boric acid equally @ 0.2% concentration (T7) resulted in maximum plant height of 63.67 cm, followed by T5 (NPK+foliar applied $ZnSO_4$ @ 0.2%), T6 (NPK+foliar applied boric acid @ 0.2%), and T4 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1} and Borax @ 2 kg ha^{-1}) with the average plant height of 61.0, 59.67 and 57.0 cm, respectively. Similarly, the average plant height of tomato plants under T3 (NPK+soil applied Borax @ 2 kg ha^{-1}) and T2 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1}) was 53.67 and 51.67 cm, respectively; whereas, the minimum plant height of 50.0 cm was recorded in plots fertilized only with recommended NPK fertilizers and no Zinc or Boron.

Number of Branches

The number of branches plant^{-1} of tomato (cv. Pomodoro) was significantly ($P \leq 0.01$) influenced by Zinc and Boron application methods. The data indicated that maximum number of branches (13.27) plant^{-1} of tomato was recorded in plants receiving NPK+foliar applied $ZnSO_4$ and boric acid @ 0.2% equally (T7), followed by T6 (NPK+foliar applied boric acid @ 0.2%), T5 (NPK+foliar applied $ZnSO_4$ @ 0.2%) and T4 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1} and Borax @ 2 kg ha^{-1}) with 11.30, 11.07 and 9.74 branches plant^{-1}, respectively. The average branches plant^{-1} in tomato plants under T3 (NPK+soil applied Borax @ 2 kg ha^{-1}) and T2 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1}) was 9.28 and 9.05, respectively; whereas, the lowest number of branches 8.44 plant^{-1} was recorded in plots fertilized only with recommended NPK fertilizers and no Zinc or Boron.

Number of Fruits

The analysis of variance demonstrates that the number of fruits plant^{-1} of tomato (cv. Pomodoro) was significantly ($P \leq 0.01$) influenced by Zinc and Boron application methods. The results showed that maximum number of tomato fruits (36.67) plant^{-1} was recorded in plants receiving NPK+foliar applied $ZnSO_4$ and boric acid @ 0.2% equally (T7), followed by T6 (NPK+foliar applied boric acid @ 0.2%), T5 (NPK+foliar applied $ZnSO_4$ @ 0.2%) and T4 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1} and Borax @ 2 kg ha^{-1}) with 31.33, 30.67 and 28.33 fruits plant^{-1}, respectively. The fruits plant^{-1} under T3 (NPK+soil applied Borax @ 2 kg ha^{-1}) and T2 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1}) was 26.67 and 26.0, respectively; whereas, the lowest number of fruits 23.0 plant^{-1} was recorded in plots fertilized only with recommended NPK fertilizers and no Zinc or Boron.

Fruits Weight

The analysis of variance shows that the weight of fruits plant^{-1} of tomato was significantly ($P \leq 0.01$) affected by Zinc and Boron application methods. The results indicated that maximum weight of tomato fruits (1168.33 g) plant^{-1} was achieved in plants receiving NPK+foliar applied $ZnSO_4$ and boric acid @ 0.2% equally (T7), followed by T6 (NPK+foliar applied boric acid @ 0.2%), T5 (NPK+foliar applied $ZnSO_4$ @ 0.2%) and T4 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1} and Borax @ 2 kg ha^{-1}) with 919.33, 899 and 867.67 g weight of fruits plant^{-1}, respectively. The fruits plant^{-1} under T3 (NPK+soil applied Borax @ 2 kg ha^{-1}) and T2 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1}) was 805 and 799.33 g, respectively; whereas, the minimum weight of fruits 711.67 g plant^{-1} was recorded in plots fertilized only with recommended NPK fertilizers and no Zinc or Boron.

Fruit Yield

The analysis of variance suggested that the fruit yield ha^{-1} was significantly ($P \leq 0.01$) affected by Zinc and Boron application methods. The data showed that the highest fruit yield of 16835 kg ha^{-1} was obtained when the crop fertilized with NPK+foliar applied $ZnSO_4$ and boric acid @ 0.2% equally (T_7), followed by T6 (NPK+foliar applied boric acid @ 0.2%), T5 (NPK+foliar applied $ZnSO_4$ @ 0.2%) and T4 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1} and Borax @ 2 kg ha^{-1}) with 14919.33, 14899.0 and 13867.67 kg fruit yield ha^{-1}, respectively. The fruits yield ha^{-1} under T3 (NPK+soil applied Borax @ 2 kg ha^{-1}) and T2 (NPK+soil applied $ZnSO_4$ @ 4 kg ha^{-1}) was 12805.0 and 12799.33 kg, respectively; whereas, the minimum fruit yield of 11711.67 kg ha^{-1} was recorded in plots fertilized only with recommended NPK fertilizers in absence of Zinc or Boron.

DISCUSSION

Days to Flowering

Plants fertilized with recommended NPK+foliar applied $ZnSO_4$ and boric acid equally @ 0.2% concentration (T7) took maximum number of days (58) to initiate flowering and with decrease in the rates of soil or foliar applied Zn and B, the days to flower were considerably reduced. This indicates that the soil under experiment was deficient of available Zinc and Boron and application of these micronutrients resulted in prolonged growth period. However, foliar application of micronutrients stimulated the growth more than their soil application. Alizai (2008) found prolonged period from sowing to flowering due to foliar and soil application of Zn and boron. They reported that soil deficiency in Zn and B was corrected by their synthetic application and hence growth period was increased. Bhutto (2003) suggested 2.0% B and Zn equally for foliar application to get proper plant growth in tomato and Bhatt and Srivastava (2006) reported foliar application of micronutrients for optimizing the duration from transplanting to flowering in tomato.

Plant Height

Tomato plants fertilized with recommended NPK+foliar applied $ZnSO_4$ and boric acid equally @ 0.2% concentration resulted in maximum plant height of 63.67 cm, while the minimum plant height of 50.0 cm was recorded in plots fertilized only with recommended NPK fertilizers and no Zinc or Boron. This suggested that the soil under experiment was Zinc and Boron deficient; and with their application, the tomato plants grew taller as compared to those receiving only NPK fertilizers. However, foliar application of micronutrients stimulated the growth more than their soil application. Similar results have also been reported by Bose and Tripathi (1996) who found that foliar application of Zn and B resulted in plant height of 81.56 cm. However, the difference in the plant height might be due to varieties they used. Haque *et al.* (2011) reported plant height upto 72.2 cm when 6 kg Zn was applied; while Bhutto (2003) recommended foliar application of 2.0% Zn and B for achieving optimum plant growth in tomato.

Number of Branches

The maximum number of branches (13.27) plant^{-1} of tomato was recorded in plants receiving NPK+foliar applied $ZnSO_4$ and boric acid @ 0.2% equally, which decreased to minimum (8.44) in plots fertilized only with recommended NPK fertilizers and no Zinc or Boron. This indicated that combined foliar application of Zinc or Boron was more effective which resulted in higher number of branches plant^{-1} as compared to rest of the treatments. Bose and Tripathi (1996) reported 19 branches plant^{-1} and Haque *et al.* (2011) concluded that for achieving optimum branching in tomato B @ 6 kg ha^{-1} would be adequate to correct the soil for proper growth and branches development upto 16.33 branches plant^{-1}. Bhutto (2003) suggested 2.0% B and Zn as foliar application on tomato; while Patil *et al.* (2008) reported that boric acid resulted in maximum number of primary branches (18.30) in tomato.

Number of Fruits

The maximum number of tomato fruits (36.67) plant^{-1} was recorded in plants receiving NPK+foliar applied $ZnSO_4$ and boric acid @ 0.2% equally which decreased with decrease in the level of soil and foliar applied micronutrients reaching to least fruits (23.0 plant^{-1}) in plots fertilized only with recommended NPK fertilizers and no Zinc or Boron.

It was noted that combined foliar application of Zinc or Boron was more effective as compared to soil applied Zn or B which resulted in higher weight of fruits plant^{-1} as compared to rest of the treatments. Bose and Tripathi (1996) who found that foliar application of Zn and B resulted in highest number of fruits/plant (31.9), Haque *et al.* (2011) achieved 67.33 fruits plant^{-1}; while Bhutto (2003) reported more fruits in tomato when foliar application of micronutrients was done as compared to maintaining the crop only on recommended rate of macronutrients. The differences in the number of fruits might be associated with genetic makeup of the varieties they used.

Weight of Fruits

The weight of fruits plant^{-1} was significantly ($P \leq 0.01$) affected by Zinc and Boron levels and their application methods and maximum weight of tomato fruits (1,168.33 g) plant^{-1} was achieved in plants receiving NPK+foliar applied $ZnSO_4$ and boric acid @ 0.2% equally but decreased under lower levels of micronutrients reaching lowest weight of fruits (711.67 g plant^{-1}) when fertilized only with recommended NPK fertilizers and no Zinc or Boron. Bose and Tripathi (1996) reported 1.407 kg/plant fruit weight in tomato when Zn and B were applied as foliar application. Khan and Khan (1996) reported positive effect on fruit yield of tomato when Zn and B were applied as foliar application. Haque *et al.* (2011) reported 2.07kg/plant and fruit yield of 30.50 t ha^{-1} in tomato.

Yield Per Ha

The fruit yield ha^{-1} was significantly ($P \leq 0.01$) affected by Zinc and Boron application methods and the highest fruit yield of 16835 kg ha^{-1} was obtained when the crop fertilized with NPK+foliar applied $ZnSO_4$ and boric acid @ 0.2% equally but decreased under rest of the treatments reaching to the lowest level (11,711.67 kg ha^{-1}) when fertilized only with recommended NPK fertilizers in absence of Zinc or Boron. The results suggested that combined foliar application of Zinc or Boron was highly effective to increase yield when comparison was made with soil applied Zn or B. These results are in line with those of Khan and Khan (1996) who reported positive effect on fruit yield of tomato when Zn and B were applied as foliar application. Haque *et al.* (2011) reported 58.59 t ha^{-1} when B was applied @ 6 kg ha^{-1} in addition to recommended dose of NPK fertilizers. Bhutto (2003) suggested 2.0% Zn and B application for maximization of fruit yield in tomato; while Alizai (2008) obtained 10,205.33 kg ha^{-1} from the plants supplied with higher Zn and B application in addition to recommended dose of NPK fertilizers. Patil *et al.* (2008) reported that boric acid resulted in maximum fruit yield of 30.50 t ha^{-1} in tomato; while Haque *et al.* (2011) reported 30.50 t ha^{-1} fruit yield in tomato when Zn and B were applied. The comparative analysis of the findings of the present research and when compared with the results reported from different parts of the world, it was assumed that Zn and B either applied as soil application or as foliar application improved the tomato growth and fruit yield. However, the improvement in the growth and fruit yield of tomato was more pronounced under foliar application of these micronutrients.

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Table: Effect of soil and foliar applied zinc and boron on vegetative and reproductive attributes of tomato cv. Pomodoro.

Treatments	**Days taken to flowering**	**Plant height (cm)**	**Number of branches plant^{-1}**	**Number of fruits plant^{-1}**	**Weight of fruits plant^{-1} (g)**	**Fruit yield plot^{-1} (kg)**	**Fruit yield (kg ha^{-1})**
T_1	50.33 c	50.0 e	8.44 d	23.0 e	711.67 d	12.297 e	11711.67 e
T_2	51.33 c	51.67 e	9.05 c	26.0 d	799.33 c	13.439 d	12799.33 d
T_3	51.67 c	53.67 d	9.28 c	26.67 c	805.0 c	13.445 d	12805.0 d
T_4	53.67 b	57.0 c	9.74 c	28.33 c	867.67 b	14.561 c	13867.67 c
T_5	55.0 b	61.0 b	11.07 b	30.67 b	899.0 b	15.644 b	14899.0 b
T_6	55.33 a	59.67 b	11.30 b	31.33 b	919.33 b	15.665 b	14919.33 b
T_7	58.0 a	63.67 a	13.27 a	36.67 a	1168.33 a	17.677 a	16835.0 a
S.E. ±	1.3412	1.0536	0.3941	0.8197	30.430	0.2134	203.20
LSD ($P \leq 0.05$)	2.9223	2.0358	0.8587	1.7860	66.300	0.4650	442.74
LSD ($P \leq 0.01$)	4.0969	3.8291	1.2039	2.5039	92.948	0.6518	620.69

T_1 – NPK @ 125-75-50 kg ha^{-1}; T_2 – T_1 + soil applied $ZnSO_4$ @ 4 kg ha^{-1}; T_3 – T_1 + soil applied Borax @ 2 kg ha^{-1}; T_4 – T_1 + soil applied $ZnSO_4$ and Borax @ 4 kg and 2 kg ha^{-1}, respectively.; T_5 – T_1 + foliar applied ZnSO4 @ 0.2% concentration; T_6 – T_1 + foliar applied boric acid @ 0.2% concentration; T_7 – T_1 + foliar applied $ZnSO_4$ and boric acid equally @ 0.2% concentration.

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