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ORIGINAL ARTICLE

Zinc Fertilization in Soil with the Application of Citric Acid and Extract of Some Plants on Growth and Biochemical Constituents of Tomato (*Solanum lycopersicum* L.)

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ABSTRACT

To study the effect of zinc fertilization with the applications of some plant extracts (*Cannabis*, *Vernonia*, and *Parthenium* spp.) and citric acid a field experiment was conducted. Growth (length, dry weight), some biochemical constituents (pigments and protein contents; and activity of catalase and peroxidase). The parameters of reproductive yield (size, number, and weight of fruit) were evaluated in test plants tomato (*Solanum lycopersicum* L.). Maximum promotory effects with respect to dry weight, pigments, and protein contents were observed at the $ZnSO_4$ application with citric acid in the soil, followed by the *Parthenium* extract (20%). Other plants (*Vernonia* and *Cannabis*) extracts (20%) and a single application of $ZnSO_4$ showed less promotory effects on the above parameters. Among the above plant extracts maximum positive effects, *Parthenium* extract (20%) was observed on dry weight (+45%), length (+ 39%), and protein content (+ 595%) in tomatoes.

KEY WORDS: Biochemical constituents, Citric acid, Plant extracts, Reproductive yield, Tomato, Zinc fertilization

INTRODUCTION

Micronutrient disorder and decline in crop production are big global problems for food security (Pandey, 2014). In India, about 50% area is zinc deficient (Shukla *et al.*, 2021, Sucharita *et al.*, 2023), and much frequent in tropical and sub-tropical regions where soil is in the alkaline range of pH (Kannaujiya & Pandey, 2013). In these regions, zinc deficiency is more prominent as compared to other essential micronutrients such as iron (19.2%), copper (11.4%), and manganese (17.4%) (Shukla *et al.*, 2021). Zinc is a significant micronutrient involved in more than300 enzymes in cellular metabolism as an activator and also a constituent of many biomolecules (Sharma, 2006: Pandey, 2020). Soil factors such as texture, pH, organic matter content, salt concentrations, calcareousness etc. greatly influence zinc availability in the soil. Thus, plants have been facing severe zinc deficiency problems due to these soil factors (Brady & Weil, 2017), and ultimately declining crop production. Low zinc in plants adversely affects cellular metabolism by forming elevated reactive oxygen species (ROS) and inhibiting many enzymatic activities (Verma & Pandey, 2020).

Zinc management in the soil in easy sustainable ways affects zinc availability in soil whichmay mitigate these deficiency problems in plants. Application of chelates in the soil may improve zinc availability. A large variety of wildly growing plant extracts can improve soil factors conditions and behave like chelates in a naturally sustainable way (Chong & Lee, 2013; Khan & Saeed, 2021).

The least information is available on the effect of organic chelates or wildly growing specific plant extracts in the soil application on the enhancement of zinc availability and related effects in plants. Tomato is a frequently growing vegetable crop in sub-tropical regions of India. Therefore, the study was made on the effects of applications of chelate (citric acid) and extract (20%) of some wildly growing plants (*Parthenium*, *Cannabis* and *Vernonia* spp.) on the growth, some biochemical constituents and reproductive yield of tomato (*Solanum lycopersicum* L.) grown in the soil from subtropical region (Lucknow District).

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Table 1: Physio-chemical properties of the composite soil (Badshahbagh Area, Lucknow, UP) used in the Experiment

Parameters	Values
Bulk Density (g/cc)	1.35 ± 0.05
Particle Density (g/cc)	2.66 ± 0.05
Pore Space (%)	47.5 ± 1.5
Water holding capacity (mm/cm depth of soil)	1.52 ± 1.0
Texture (%)	Sandy Loam
Color	Light gray
Soil pH (1:2.5 soil–water extract at 25°C)	7.5 ± 0.1
Electrical Conductance (mmhos/cm)	0.33 ± 0.1
Organic Matter Content (%)	0.28 ± 0.05
Available Zinc (ppm)	0.51 ± 0.05

MATERIALS AND METHODS

A field experiment was conducted in the Badshah Baugh area of Lucknow district (UP) Lucknow University Campus, a composite soil sample was collected and analyzed for some important properties related to soil texture, density, porosity, organic matter content, soil pH, calcareousness, electrical conductivity, water holding capacity, and available zinc before sowing the *S. lycopersicum* L. (tomato) plant. The study aimed to explore the effect of zinc fertilization with the application of some wildly growing plant extracts these plants were (*Cannabis, Vernonia* and *Parthenium*) and citric acid (10 µM) along with the application of $ZnSO_4$@ 25 kg ha^{-1} in the soil. A study was made to observe growth (length and dry weight), and some biochemical constituents (pigment and protein contents and activity of catalase and peroxidase) in test plants.Also fruiting quality (number, size and weight) was observed. Visible symptoms in response to treatments exhibited on plants were observed *viz.* I–Untreated, II-$ZnSO_4$ (25 kg ha^{-1}), III- $ZnSO_4$ (25 kg ha^{-1}) + citric acid (10µm) IV - plant extract (20%) of *Parthenium,* (V), *Vernonia* and (VI)*Cannabis* applied along with $ZnSO_4$ @25 kg ha^{-1} uniformly in the soil.

Plant extracts (20%) and Citric acid were applied twice in the field in 15 days gap.

Some important biochemical constituents were determined at 75 days of the tomato growth.

Pigment content by Licthenthaler & Welbern (1983) and Protein content by Lowry *et al.* (1951) were determined. Catalase activity by Euler & Josephson (1927) and Peroxidase activity by Luck (1963).

An average value of data is presented in the table. All the data were statistically analyzed and tested for significance using student't'-test.

RESULTS AND DISCUSSION

A field experiment was conducted to see the effect of various modes of Zinc fertilization in soil (@ 25kg ha^{-1} $ZnSO_4$) with a natural chelant citric acid and extract (20%) of some wildly growing plants (*Parthenium*, *Vernonia* and *Cannabis* spp.) on growth, some biochemical constituents (Pigments protein content) including antioxidative enzymes catalase and peroxidase activities. Field soil was evaluated zinc deficient (< 0.5 ppm, DTPA extractable available zinc) (Sharma, 2006). The soil was low in organic matter content (< 0.4%), moderate electrical conductance (< 0.3 mS/cm) and bulk density (1.35 g/cc) with texture

Table 2: Effect of Zinc fertilization in soil with some wildly growing plant extract (20%) and citric acid on growth and some biochemical constituents in Tomato

Parameters	I	II	III	IV	V	VI
Length (cm)	43±1.4(0.0)	53±1.4(+23)	56±1.5**(+30)	60±1.5*(+39)	54±1.8(+25)	55±1.1(+27)
Dry weight (g)	17.5±0.8(0.0)	18.1±0.8(+3.4)	33.88±0.8*(+93)	25.4±0.7**(+45)	19.4±0.8(+10)	20.1±0.8(+14)
Fruits/Plant	6±1.0(0.0)	10±0.5(+66)	17±0.5(+183)	14±1.0(+133)	7*±0.5(+16)	12±0.5(+100)
Weight of Fruit(g)	59.26(0.0)	41.42 (+16.4)	45.12(+115)	55.83(+119)	52.03(+2.4)	48.35**(+63)
Chlorophyll a (mg g^{-1} fr. wt.)	1.4±0.3(0.0)	1.5±0.3(+7.14)	1.6±0.3**(+14.2)	1.7±0.3*(+21.4)	1.4±0.3(+0.0)	1.4±0.2(+0.0)
Chlorophyll b (mg g^{-1} fr. wt.)	0.60±0.5(0.0)	0.69±0.3(+15)	0.70±0.3(+16.6)	0.74±0.3(+23)	0.72±0.3**(+20)	0.68±0.3(+13)

Treatments: I–Untreated Soil (control), II–$ZnSO_4$, III–$ZnSO_4$ + citric acid (10 µm), IV–$ZnSO_4$ +*Parthenium* extract, V–$ZnSO_4$ + *Vernonia* extract and VI–$ZnSO_4$ + *Cannabis* extract.
$ZnSO_4$ applied @25 kg ha^{-1} uniformly in each treatment.
Parenthesis indicates percentage decrease (-) or increase (+) over control, ± S.E. (n = 3).
* - Value significant at P < 0.05 level and ** - value significant at P < 0.01 level.

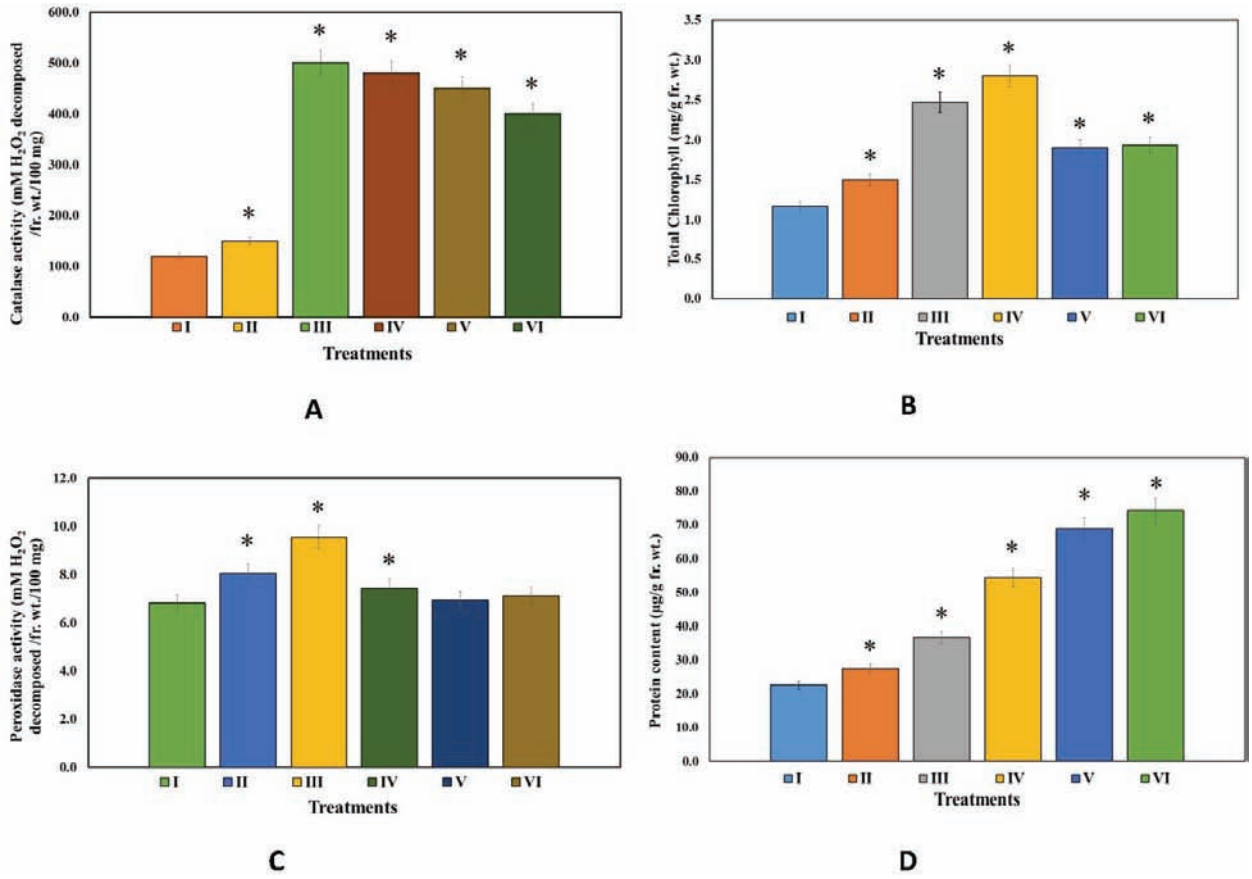

Fig. 1. Effect of Zinc fertilization in soil with some wildly growing plant extract (20%) and citric acid on A–Catalase activity, B–Total chlorophyll, C–Peroxidase activity and D Protein content. Treatments: I–Untreated Soil (control), II–$ZnSO_4$, III–$ZnSO_4$ + citric acid (10 µm), IV–$ZnSO_4$ + *Parthenium* extract, V–$ZnSO_4$ + *Vernonia* extract and VI–$ZnSO_4$ + *Cannabis* extract. $ZnSO_4$ applied @25 kg ha^{-1} uniformly in each treatment

sandy loam (Table 1). These parameters showed moderate soil fertility conditions (Brandy & Weil, 2017). Three weeks tomato plant was grown and transplanted (with same weight andlength) in the soil. Before the transplantation soil was fertilized with $ZnSO_4$ @ 25 kg ha^{-1}in the field from treatment I to VI and treatment I was untreated soil was taken as control. Zinc fertilization improved length and dry weight production by 23 and 3.4% respectively due to the zinc-induced growth effect (Pandey, 2020). Zinc supplied with citric acid in the soil showed maximum promotion of growth with respect to the length (+ 30%) and dry weight (+93%). Results also followed at the applications of $ZnSO_4$ and *Parthenium* extract increased length by 39 and dry weight by 45%. Promotory effects on growth could be attributed to the facilitation of Zn availability to the tomato in adequate amounts by citric acid and *Parthenium* extract (Rady, 2019). Applications of citric acid and *Parthenium* extract (20%) improved pigments content in tomatoes, prominently. While least positive effect on pigments content was noted at the applications of *Vernonia* and *Cannabis* extract in the soil (Table 2). Maximum total chlorophyll content was determined in tomatoes at citric acid and *Parthenium* extract applied soil might be due to more availability and Zinc uptake in tomato plants (Srivastava *et al.*, 2010). Tomatoes grown in the treated soil showed improvement in protein content. But the maximum protein content in tomato was increased at *Parthenium* extract applied to soil by (+595%) followed citric acid (+351%). These results indicated chelation and stabilization effect of *Parthenium* and citric acid for the zinc (Rady, 2019) which could facilitate the uptake of Zn in tomatoes, adequately (Badamasi *et al.*, 2020). Applications of citric acid and phytoextracts of wild plants increased catalase and peroxidase activities with $ZnSO_4$ applications in the soil. But citric acid and *Parthenium* extract were found to be most effective. Single

application of $ZnSO_4$ indicated the least promotory effects on both the antioxidative enzymes (Abid & Pandey, 2022).

Increased activity of catalase and peroxidase, might be due to reduction in stresses in tomato (Pandey *et al.*, 2002) due to Zn deficiency by chelating action–induced Zn uptake. Thus, the study concluded that many soil factors that reduce Zn uptake in tomatoes may be enhanced with the application of organic chelate (citric acid) as well as phytoextract of wildly growing plants with proper testing and study.

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