تنش‌های محیطی در علوم زراعی
Environmental Stresses In Crop Sciences
**Env. Stresses Crop Sci.**
**Vol. 15, No. 3, pp. 641-656 (Fall 2022)**

University of Birjand

*Original article*

http://dx.doi.org/10.22077/escs.2021.4016.1953

# Effect of zinc sulfate foliar application on morphological characteristics and yield of red beans (*Phaseolus vulgaris* L.) under different carbon dioxide- temperature and water stress

**S. Fallah[1], Kh. Azizi[2*], H. Eisvand[3], O. Akbarpour[4], N. Akbari[4]**

1. *PhD Student in Crop Ecology, Department of Agriculture and Plant Breeding, Faculty of Agriculture and Natural Resources, Lorestan University, Iran*
2. *Professor, Department of Agriculture and Plant Breeding, Faculty of Agriculture and Natural Resources, Lorestan University, Iran*
3. *Associate Professor, Department of Agriculture and Plant Breeding, Faculty of Agriculture and Natural Resources, Lorestan University, Iran*
4. *Assistant Professor, Department of Agriculture and Plant Breeding, Faculty of Agriculture and Natural Resources, Lorestan University, Iran*

Received 29 December 2020; Accepted 5 March 2021

## *Extended abstract*

### Introduction

Climate change (temperature, rainfall and flood patterns, etc.) has major and negative effects on agricultural production and water and land resources. Part of climate change is to reduce soil fertility (through erosion processes), increase the frequency of repeated pest attacks, reduce crop yields, and increase groundwater harvest periods by reducing water access. Zinc plays an essential role in the basic processes of plant life, namely cell division, stomata regulation and respiration. Apart from the increase in carbon dioxide emissions, high temperatures are also a major stressor that can lead to severe growth retardation and plant distribution. At higher concentrations, carbon dioxide increased photosynthetic carbon and increased organic matter, which in turn increased stem diameter of lentil plant (Shams, 2017) .

### Materials and methods

The composite experiment was performed as a factorial experiment in a completely randomized design with four replications. Irrigation at three levels (60, 80 and 100% of field capacity) as the first factor, foliar application of zinc sulfate fertilizer at two levels (no foliar application and 0.5 gl-1) as the second factor and environmental conditions at four levels (380_24, 380_31, 700_24 and 700_31 C/PPm (carbon dioxide) were the third factor. The studied traits were number of root nodes, root dry weight, stem height and diameter, number of leaves and grain yield. Data were analyzed using SAS 9.1 software and the mean of the treatments was compared with LSD test at 5% probability level.

### Results and discussion

Co-application of carbon dioxide, complete irrigation and complete irrigation and zinc sulfate increased the number of nodes. Increasing the concentration of carbon dioxide under severe drought stress increased root dry weight. Also, increasing the concentration of carbon dioxide under mild environmental stress caused plant height, diameter and grain yield. Increasing the concentration of carbon dioxide in full irrigation conditions increased the number of leaves. Increasing carbon dioxide

*Correspondent author: Khosrow Azizi; E-Mail: Kh.azizi1965@gmail.com.

increases water use, photosynthesis and net primary productivity by reducing stomatal conductance and transpiration, which ultimately increases biomass and yield.

Application of zinc sulfate under full irrigation conditions increased the total grain yield by 17.1 g/plant. Positive role of zinc in chlorophyll synthesis, and performance of optical photosystems can increase growth indices. The use of zinc chelate due to the role of zinc in the activity of plant enzymes and metabolisms, including plant hormones (auxin) has increased chlorophyll activity and photosynthesis, which finally has increased grain yield in the plant.

**Conclusion**

Increasing the concentration of carbon dioxide at lower temperatures and full irrigation and mild stress increased the majority of morphological traits. Also, application of zinc alone and with full irrigation increased some morphological traits and grain yield.

***Keywords*:** Bean, $CO_2$ Concentration, Drought, Growth indices, Seed yield

**Table 1. Specifications of fertilizer used in this experiment**

| The amount of elements in liquid fertilizer as a percentage | Decomposition of liquid fertilizer solution |
|---|---|
| 4% | Chelate zinc |
| 4% | Solution zinc |
| 1% | Sulfur |

**Table 2. Results of soil texture analysis**

| Soil texture | S | EC | pH | SAR | Organic carbon | K | P | N |
|---|---|---|---|---|---|---|---|---|
| Silt, clay, loam | % | dS m$^{-1}$ | | ppm | % | ----- ppm ----- | | % |
| | 16 | 0.29 | 7.18 | 19 | 0.31 | 80 | 6.5 | 0.026 |

**Table 3. Combined analysis of Zn chelate foliar application on morphological traits and grain yield under temperature-carbon dioxide and water stress**

| Sources of variance | Df | Number of root nodule | Root dry weight | Plant height | Stem diameter | Number of leaf | Grain yield |
|---|---|---|---|---|---|---|---|
| **Condition (C)** | 3 | 617.9** | 410** | 292.3** | 17.5** | 521.5** | 45.07** |
| **Rep(Condition)** | 12 | 5.4 | 1.70 | 6.5 | 0.318 | 6.4 | 0.681 |
| **Water stress (WS)** | 2 | 1996.2** | 112.7** | 1849.4** | 46.9** | 2244.1** | 984.69** |
| **C*WS** | 6 | 17.8** | 4.8* | 48** | 3.2** | 75.5** | 5.48** |
| **Zn** | 1 | 742.5** | 0.259 | 68.3** | 0.80* | 2.3 | 134.42** |
| **C*Zn** | 3 | 16.8* | 5.6* | 7.7 | 0.34 | 8.6* | 0.6091 |
| **WS*Zn** | 2 | 183.5** | 1.06 | 13.5 | 0.01 | 1.9 | 26.71** |
| **C*WS*Zn** | 6 | 3.52 | 1.65 | 8.58 | 0.33 | 2.20 | 0.3871 |
| **Error** | 60 | 4.38 | 1.79 | 9.31 | 0.16 | 2.57 | 0.42 |
| **CV (%)** | | *10.3* | *6.9* | *8.7* | *10.5* | *6.2* | *5.37* |

* and ** significant at 0.05and 0.01 probability levels, respectively.

**Table 4. Mean comparison of interaction of temperature-carbon dioxide conditions and water stress on morphological traits and bean grain yield**

| Treatmen | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Conditions ($CO_2$/Temperature)** | **Water stress** | **Number of root nodule** | **Root dry weight** | **Plant height** | **Stem diameter** | **Number of leaf** | **Grain yield** |
| | | pre plant | g/Plant | cm | | pre plant | g/plant |
| **380_24** | **100%FC** | $23.3^{d}$ | $13.1^{g}$ | $42.1^{a}$ | $3.5^{c}$ | $26.2^{c}$ | $14.8^{b}$ |
| | **80%FC** | $22.5^{d}$ | $12.8^{g}$ | $42.2^{a}$ | $3.3^{c}$ | $24.6^{d}$ | $13.5^{cd}$ |
| | **60%FC** | $9.7^{g}$ | $15.4^{f}$ | $24.5^{f}$ | $2.3^{d}$ | $15^{f}$ | $5.6^{f}$ |
| **380_31** | **100%FC** | $18^{e}$ | $17.5^{e}$ | $31.4^{d}$ | $3.4^{c}$ | $24.7^{cd}$ | $13.9^{c}$ |
| | **80%FC** | $17.1^{e}$ | $17^{e}$ | $34.5^{c}$ | $3.5^{c}$ | $24.7^{cd}$ | $12.9^{d}$ |
| | **60%FC** | $6.8^{h}$ | $22^{bc}$ | $24.7^{f}$ | $2.3^{d}$ | $15^{f}$ | $4.8^{g}$ |
| **700_24** | **100%FC** | $28.8^{bc}$ | $20.3^{d}$ | $43.4^{a}$ | $5.3^{b}$ | $37.2^{a}$ | $16.7^{a}$ |
| | **80%FC** | $27.5^{c}$ | $20.2^{d}$ | $43.5^{a}$ | $5.8^{a}$ | $36.3^{ab}$ | $16.7^{a}$ |
| | **60%FC** | $14.3^{f}$ | $22.6^{bc}$ | $28.5^{de}$ | $2.4^{d}$ | $16.3^{f}$ | 6.8e |
| **700_31** | **100%FC** | $31.1^{a}$ | $21.6^{c}$ | $38.3^{b}$ | $5.4^{b}$ | $35^{b}$ | $16.7^{a}$ |
| | **80%FC** | $30.5^{ab}$ | $23^{b}$ | $38.9^{b}$ | $5.7^{ab}$ | $35.7^{ab}$ | $16.78^{a}$ |
| | **60%FC** | $13.8^{f}$ | $25.8^{a}$ | 26.8e$^{f}$ | $2.6^{d}$ | $18^{e}$ | $5.5^{f}$ |

Means followed by the same letter(s) were not significantly different according to LSD ($p<0.05$) test

**Table 5. Mean comparison of interaction of temperature-carbon dioxide and zinc sulfate conditions on a number of nodes and root dry weight**

| Treatmen | | | | |
|---|---|---|---|---|
| **Conditions ($CO_2$/Temperature)** | **Zn** | **Number of root nodule** | **Root dry weight** | **Number of leaf** |
| | g $l^{-1}$ | pre plant | g/Plant | pre plant |
| **380_24** | **0** | $16.66^{d}$ | $13.71^{e}$ | $21.66^{c}$ |
| | **0.5** | $20.41^{c}$ | $13.89^{e}$ | $22.25^{c}$ |
| **380_31** | **0** | $11^{e}$ | $19.44^{cd}$ | $21.25^{c}$ |
| | **0.5** | $17^{d}$ | $18.35^{d}$ | $21.75^{c}$ |
| **700_24** | **0** | $21.16^{c}$ | $20.42^{c}$ | $30.1^{a}$ |
| | **0.5** | $26^{b}$ | $21.71^{b}$ | $29.83^{ab}$ |
| **700_31** | **0** | $21.33^{c}$ | $23.49^{a}$ | $30.58^{a}$ |
| | **0.5** | $29^{a}$ | $23.53^{a}$ | $28.58^{b}$ |

Means followed by the same letter(s) were not significantly different according to LSD ($p<0.05$) test

**Table 6. Mean comparison of interaction of irrigation stress and zinc chelate on the number of root nodules and bean yield**

| Treatmen | | | |
|---|---|---|---|
| **Water stress** | **Zn** | **Number of root nodule** | **grain yield** |
| | g $l^{-1}$ | pre plant | g/plant |
| **100%Fc** | **0** | $21.4^{b}$ | $13.9^{b}$ |
| | **0.5** | $29.2^{a}$ | $17.1^{a}$ |
| **80%Fc** | **0** | $20^{b}$ | $13.1^{c}$ |
| | **0.5** | $28.8^{a}$ | $16.8^{a}$ |
| **60%Fc** | **0** | $11.1^{c}$ | $5.5^{d}$ |
| | **0.5** | $11.2^{c}$ | $5.8^{d}$ |

Means followed by the same letter(s) were not significantly different according to LSD ($p<0.05$) test

**Table 7. Mean comparison of the effect Zn sulfate on plant height and diameter**

| Treatmen Zn | Plant height | Stem diameter |
|---|---|---|
| g $l^{-1}$ | ------------- cm ------------ | |
| **0** | 34.08[b] | 3.74[b] |
| **0.5** | 35.77[a] | 3.92[a] |

Means followed by the same letter(s) were not significantly different according to LSD (p<0.05) test.