IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Evaluating Role Of Soluble Silica On Growth And Photosynthetic Pigments Of Chickpea Grown In Bio-Enzyme Enriched Soil

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Abstract

Cicer arietinum, commonly referred to as chickpea, is an annual legume crop that belongs to the Fabaceae family. It has an upright growth habit and typically reaches a height ranging from 20 to 60 centimetres. This study investigates the effects of soluble silica on growth and photosynthetic pigments of chickpea sown in bio-enzyme treated soil. Bio-enzymes, natural growth promoters derived from organic sources, are known to enhance soil fertility and plant health. Soluble silica, a beneficial element for crop growth, was sprayed at different concentrations. The soil treated with varied dilutions of bio-enzyme a day before sowing and continued after every 15 days. The foliar spray of varied dilutions of soluble silica was given after 15 days of sowing and continued after every 15 days. The present study results showed notable (p-value<0.05) increase in initial growth metrics and photosynthetic pigments of chickpea grown in soil treated with 2 ml/litre of bio-enzyme and foliar application of 10 ml/litre soluble silica compared to control and to the other treatments as bio-enzyme or soluble silica alone, or in combination. These findings suggest that integrating foliar application of soluble silica with bio-enzyme treated soil on chickpea could have significant boost up effects on crop height including the number of branches and leaf numbers along with photosynthetic pigments.

Key Words – Carotenoids, Chlorophyll, *Cicer arietinum*, Plant Height.

1.Introduction

Cicer arietinum (chickpea), is an annual legume from the Fabaceae family. It has small leaflets, white or violet flowers, and pods containing 2-3 seeds. Chickpeas are rich in protein, carbohydrates, fats, and essential minerals like calcium, phosphorus, and iron. They are also valuable for animal feed and soil nitrogen fixation. (Yadav et al.,2017)

Silicon, though not essential, plays a crucial role in plant growth. Soluble silica from sources like rice husk ash or diatomaceous earth strengthens plant cell walls, improves resistance to stress, enhances photosynthesis and nutrient uptake. It also benefits soil by improving composition, water retention, and reducing salinity impacts. (Rangwala et al.,2018)

Bio-enzyme is produced through the fermentation of fruit and vegetable peel waste combined with brown sugar and water. This eco-friendly mixture has proven to be highly effective in accelerating composting and significantly reducing infestations from pest according to Saravan et al. (2013). Bio-enzymes, natural catalysts derived from plants, animals, or microbes, promote plant growth by improving nutrient uptake, root development, and overall health. They also assist in organic waste decomposition and soil remediation, enhancing agricultural sustainability. (Ofosu-Anim et. al., 2007). Additionally, vegetable waste can produce volatile fatty acids and nitrogen compounds during decomposition, which are beneficial for plant growth and soil health (Bo et al., 2007). The naturally chelated elements found in bio-enzymes aid in better cell division and enlargement, which raises the amount of chlorophyll and promotes the plant's overall growth. (Manna et al.,2015)

The objective of the work was to evaluate potential of soluble silica on growth and photosynthetic pigments of chickpea grown in soil treated with bio-enzyme.

2.Material and Method

The study was conducted in the Department of Biochemistry, Govt. Holkar Science College, Indore from November 2023 - March 2024.

The crop selected for the study was chickpea (*Cicer arietinum*). Each block having dimensions 150 cm × 90 cm were sowed with 72 seeds of chickpea. The Chickpea seeds were given 10 different treatments in 10 blocks.

Table. 1 Showing varied treatments applied on chickpea:

S. No.	Coding	Treatment given
1.	C	Water only
2.	T1	1ml Bio-enzyme/litre
3.	T2	2 ml Bio-enzyme/litre
4.	T3	3 ml Bio-enzyme/litre
5.	T4	7.5 ml soluble silica/litre
6.	T5	10 ml soluble silica/litre
7.	T6	12.5 ml soluble silica/litre
8.	T7	1 ml Bio-enzyme/litre +10ml soluble silica/litre
9.	T8	2 ml Bio-enzyme/litre +10ml soluble silica/litre
10.	T9	3 ml Bio-enzyme/litre +10ml soluble silica/litre

Treatments of bio-enzyme in soil were given before the day of sowing seeds. Soluble silica was applied as foliar spray and bio-enzyme was supplied in soil at the interval of every 15 days after sowing.

Parameters studied:

1. Number of leaves per rachis

2. Number of branches per plant

3. Shoot length was measured using a standard centimetre scale.

4. Chlorophylls and carotenoids content-

Chlorophyll content was estimated following the method described by Lichtenthaler and Wellburn (1983). Leaf samples were extracted using 80% acetone, and the absorbance of the resulting extracts was measured at 646 nm, 663 nm, and 470 nm. These absorbance values were used for the spectrophotometric determination of chlorophyll a, chlorophyll b, and carotenoids, and the concentrations were calculated using the corresponding formulae.

Chlorophyll a in mg/g tissue = 12.21 (A_{663}) – 2.81 (A_{646}) ×V/1000 ×W

Chlorophyll b in mg/g tissue = 20.13 (A_{646}) – 5.03 (A_{663}) ×V/1000 ×W

Carotenoid in mg/g tissue =

[1000 (A_{470}) – 3.27 (chl a) – 104 (chl b) / 229] ×V/1000 ×W

3.Result and discussion:

Results were observed after 90th days of sowing. Values are expressed as Mean ± SD. p-value was calculated to assess significant difference as compared to control.

Table. 2 Effect of different treatments on growth metrics of chickpea

Treatments	Height (in cm)	Number of Shoot Branch	Number of leaves
C	40±5	2±1	10.3±1.1
T1	43.3±6.6 ^{NS} (8.3%)	3.3±0.57 ^{NS} (65%)	10±1^{NS} (-3.2%)
T2	34.6±5.5^{NS} (-13.3%)	4.3±0.57* (115%)	11±2 ^{NS} (6.5%)
T3	48±1 ^{NS} (20%)	3.7±0.57 ^{NS} (85%)	11±2 ^{NS} (6.5%)
T4	50±4.5 ^{NS} (25%)	4±1 ^{NS} (100%)	10.67±1.5 ^{NS} (3.2%)
T5	47±2.6 ^{NS} (17.5)	4.3±0.57* (115%)	12±2.6 ^{NS} (16.1%)
T6	40.6±3.05 ^{NS} (1.7%)	3.7±0.57 ^{NS} (85%)	11±2 ^{NS} (6.5%)
T7	53.3±4.16* (33.3%)	4.3±0.57* (115%)	12±1 ^{NS} (16.1)
T8	58.6±1.5** (46.7%)	5.3±1.1* (165%)	13.6±1.1* (32.3%)
T9	52.3±4.04* (30.8%)	5±1* (150%)	13±2 ^{NS} (25.8%)

^{NS} indicates p-value > 0.05 and is not significant, *indicates Significant p-value < 0.05, ** indicates Highly Significant p-value <0.01, *** indicates Extremely Significant p-value < 0.001. Parenthesis indicates percent increase/decrease as compared to control.

3.1Growth Parameters:

In current study, as seen in table 2 there was significant increase observed in plant height in T7, T8 and T9 compared to control. Notably, the highest increment was recorded in T8 with all the studied growth parameters. Rizwan et al. (2015) reported that silica increased plant growth by balancing water and nutrient uptake. Goyal et al. (2022) has found that silica sprays have significantly increased plant height in the drought stressed plants in order, 7.5 ml L^{-1} <12.5 ml L^{-1} <10 ml L^{-1}. According to Aouz et al. (2023) taller plants (54.77 cm) with higher number of leaves per plant (LPP: 11.75) were recorded following treatment with Si. The present study findings are consistent with Kowalska et al. (2020), who reported that foliar application of Orthosilicic acid (24% Si) enhanced plant height as well as the number and weight of ears in spring wheat. In 2015, Sau et al. observed an increase in plant height and number of leaves per branch by the application of bio-enzyme, showing a positive effect on plant growth. Similarly, Manna et al. (2012) suggested that the enhanced plant growth was observed with bio-enzyme application in presence of cytokinin and auxin precursors. These phytohormonal compounds promote cell division and cell enlargement, thereby facilitating accelerated vegetative growth. Application of bio-enzyme as biofertilizer also showed faster growth and better content of photosynthetic pigments in chickpea seedlings (Singh et al., 2020).

Table. 3 Effect of different treatments on photosynthetic pigments of chickpea leaves

Treatments	Chl a (mg/g)	Chl b (mg/g)	Carotenoids (mg/g)
C	4.21±0.2	2.4±0.3	5.34±0.12
T1	4.34±0.5 NS (3.16%)	3.15±0.35 NS (26.6%)	4.74±0.07 NS (-11.2%)
T2	6.64±0.1 NS (57.8%)	3.58±0.53* (43.8%)	7.98±1.12* (49.6%)
T3	5.58±0.9 NS (32.6%)	3.61±0.19** (44.7%)	5.87±0.1** (10%)
T4	5.2±0.3** (23.6%)	3.47±0.32** (39.03%)	6.87±1.08 NS (28.18%)
T5	6.59±0.6** (56.6%)	3.97±0.11** (60.2%)	7.17±0.28*** (34.9%)
T6	4.9±0.6 NS (16.4%)	3.58±0.71 NS (43.7%)	5.87±0.10** (10%)
T7	5.25±0.4* (24.8%)	3.82±0.37** (53.3%)	6.6±0.42** (23.7%)
T8	7.86±0.4*** (86.7%)	4.75±0.32*** (90.6%)	9.17±0.92** (71.6%)
T9	6.49±0.6 NS (54.3%)	4.2±0.50 NS (68.4%)	8.32±0.86** (56.1%)

NS indicates p-value > 0.05 and is not significant, *indicates Significant p-value < 0.05, ** indicates Highly Significant p-value <0.01, *** indicates Extremely Significant p-value < 0.001. Parenthesis indicates percent increase/decrease as compared to control.

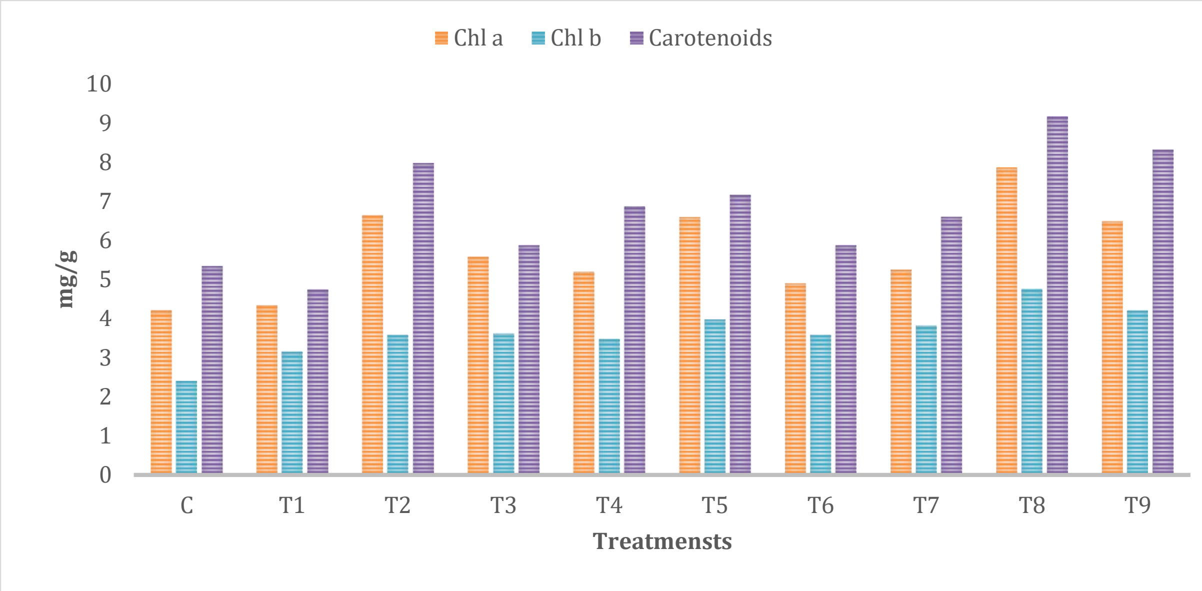

Fig. 1 Effect of different treatments on Photosynthetic Pigments of chickpea leaves

3.2Photosynthetic Pigments

In the present study, as seen in table 3, highly significant change in the levels of chlorophyll a in T4 and T5, significant change in T7 and extremely significant change in T8 was observed. The chlorophyll b level was significantly increased in all the given treatments except T6 and T9. The increase in carotenoids level in T2 was significant, in T3, T4, T6, T7, T8, T9 was highly significant and in T5 treatment was extremely significant. The chlorophyll content is known as tolerance index to water stress in plants (Hosseinzadeh et al., 2016). Beneficial role of soluble silica in enhancing chlorophyll content in onion Leaves was studied and all the three concentrations of silica viz, 7.5, 10, 12.5 ml/ litre have the same effect on chlorophyll and carotenoid content (Rangwala et al., 2019). According to the findings of Ofosu-Anim et al. (2007), higher concentrations of Biozyme may result in a reduction in leaf chlorophyll content and increase in Biozyme concentration was accompanied by a noticeable decline in total soluble sugar levels. This reduction in chlorophyll content, potentially linked to elevated hormone levels, may account for the observed physiological changes. Mitra and Mandal (2012) reported that the replacement of chemical fertilizers with bio-enzyme led to a significant increase in the total chlorophyll content in rice plants. El-Bassiouny et al. (2016) demonstrated that ascorbic acid present in orange peel extract mitigates the effects of water deficit stress and significantly enhances the levels of chlorophylls, carotenoids, and other photosynthetic pigments in quinoa plants. In the study conducted by Patidar et al. (2023) in mung bean shows similar results with significant increase in chlorophyll a and b content by supplementation of all the dilutions used with 2 ml/litre diluted bio-enzyme giving best results.

Conclusions

The results indicate that soluble silica when applied to chickpea grown in bio-enzyme supplemented soil, positively affect its growth and photosynthetic pigment content. The most effective treatment, which showed the greatest improvement, is combination of soil treated with 2 ml/litre of bio-enzyme along with foliar application of 10 ml/litre soluble silica. Bio-enzyme or soluble silica applied alone can also enhance growth and photosynthetic pigments of chickpea. However, their combination can be used to further improve the growth of chickpea. Further research and practical application of this treatment on other crops are crucial to fully understand its potential and optimize its use in agriculture.

Acknowledgement

We would like to express our sincere gratitude to Principal, Govt. (Model, Autonomous) Science College, Indore, for providing agricultural field and necessary laboratory facilities. We are also grateful for Mr. Nagesh Vyas and Mr. Rohan Gupta for providing soluble silica and to Bio-enzyme Entrepreneur Academy of India for providing Bio-enzyme and also to DST FIST for providing laboratory facilities.

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