

“Triacontanol-Mediated Regulation Of Growth Dynamics And Symbiotic Nitrogen Fixation In Pigeon Pea (*Cajanus Cajan*)”

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Abstract

Triacontanol (TRIA), a naturally occurring 30 ‘C’ long-chain aliphatic alcohol, functions as a potent plant biostimulant influencing physiological and metabolic activities specially in higher plants. The present study evaluated the impact of graded concentrations of triacontanol on growth performance, nodulation behavior, and nitrogenase activity in pigeon pea (*Cajanus cajan*). A field experiment was conducted using a randomized block design with four treatments (0, 0.5, 1.0, and 1.5 ppm TRIA). Foliar sprays were applied during vegetative and pre-flowering stages. Observations included plant height, leaf area index, dry biomass, nodule count, nodule dry weight, and nitrogenase enzyme activity determined by acetylene reduction assay. The 1.0 ppm treatment significantly enhanced vegetative growth parameters and symbiotic efficiency compared to untreated controls. Enhanced nitrogenase activity suggests improved biological nitrogen fixation under optimal triacontanol concentration. These findings indicate that triacontanol application may represent a viable strategy for improving productivity and nitrogen-use sustainability in pigeon pea cultivation systems.

Keywords: Triacontanol, Pigeon pea, Nodulation, Nitrogenase activity, Biological nitrogen fixation, Biostimulant

1. Introduction

Leguminous crops occupy a strategic position in sustainable agricultural systems due to their intrinsic capacity to fix atmospheric nitrogen through symbiotic associations with rhizobial bacteria. Among them, pigeon pea (*Cajanus cajan*) is widely cultivated across tropical and semi-arid regions, particularly in South Asia. In addition to serving as a dietary protein source, pigeon pea contributes significantly to soil fertility restoration.

The efficiency of biological nitrogen fixation (BNF) depends upon successful nodule formation, metabolic activity of bacteroids, and effective carbon allocation from shoots to roots. However, nodulation performance is frequently influenced by soil conditions, environmental variability, and physiological limitations. Plant biostimulants have emerged as environmentally compatible tools to enhance crop productivity. Triacontanol (TRIA), a naturally occurring C-30 fatty alcohol present in plant cuticular waxes, has been reported to stimulate photosynthetic processes, enhance enzymatic activities, and promote biomass accumulation. Although its growth-promoting effects have been documented in cereals and horticultural crops, its influence on symbiotic nitrogen fixation in pigeon pea remains insufficiently explored.

The present investigation was undertaken to examine whether triacontanol application could simultaneously enhance vegetative growth and nodulation efficiency in pigeon pea under field conditions.

2. Materials and Methods

2.1 Experimental Location and Soil Characteristics

The study was conducted during the Kharif season at an experimental field in Village Pindahara Block Beruarbari Ballia Uttar Pradesh, India. The soil was sandy loam with moderate organic carbon content and near-neutral to slightly alkaline pH.

2.2 Experimental Design and Treatment Structure:-

The experiment was arranged in a Randomized Block Design (RBD) with three replications. Four treatments were established:

T₀ – Control (distilled water spray)

T₁ – 0.5 ppm triacontanol

T₂ – 1.0 ppm triacontanol

T₃ – 1.5 ppm triacontanol

Foliar applications were administered at 25 and 45 days after sowing.

2.3 Growth Assessment:-

Growth parameters were recorded at regular intervals and included:

1- Plant height (cm)

2- Leaf area index (LAI)

3- Shoot and root dry matter (g plant⁻¹)

4- Root length (cm)

2.4 Nodulation and Nitrogenase Activity

At flowering stage, plants were carefully uprooted to record:

a-Number of nodules per plant

b-Nodule dry mass

c-Nitrogenase activity determined using the d-acetylene reduction assay (ARA)

2.5 Statistical Analysis

Data were subjected to analysis of variance (ANOVA). Treatment means were compared at a 5% probability level using appropriate statistical tests.

3. Results:-

3.1 Vegetative Growth Response:-

Triacontanol-treated plants exhibited a statistically significant improvement in vegetative attributes compared to control plants. Among the tested concentrations, 1.0 ppm demonstrated the highest increase in plant height and leaf area index. Dry matter accumulation in shoots increased substantially under T₂ treatment, suggesting enhanced assimilate production and partitioning. Root biomass also showed improvement, indicating a favorable effect on below-ground development.

The highest concentration (1.5 ppm) did not proportionally enhance growth, indicating a concentration-dependent response.

3.2 Nodulation Characteristics:-

Application of triacontanol significantly influenced nodulation parameters. Plants treated with 1.0 ppm recorded a greater number of nodules per plant and increased nodule dry mass relative to untreated control. Improved root growth likely facilitated enhanced rhizobial colonization and infection thread development.

3.3 Nitrogenase Activity:-

Nitrogenase activity showed marked enhancement under 1.0 ppm treatment. The elevated acetylene reduction rates indicate improved nitrogen-fixing efficiency. These results suggest that triacontanol not only increases nodule number but also enhances their functional activity.

4. Discussion:-

The stimulatory effects of triacontanol on plant growth may be attributed to its role in regulating metabolic pathways associated with photosynthesis and energy production. Enhanced chlorophyll synthesis and activation of key enzymes such as Rubisco could contribute to improved carbon assimilation. Improved nodulation may result from enhanced root architecture and increased carbon availability to developing nodules. Biological nitrogen fixation is an energy-intensive process; therefore, enhanced photosynthate supply under triacontanol treatment likely supports increased nitrogenase activity. The observation that moderate concentration (1.0 ppm) yielded maximum benefit reinforces the concept that plant growth regulators exhibit optimal effectiveness within a narrow concentration range. Excessive application may disrupt physiological balance.

5. Implications for Sustainable Agriculture:-

The findings hold practical relevance for pulse production systems:

- 1- Potential reduction in chemical nitrogen fertilizer inputs
- 2- Improvement in soil fertility through enhanced BNF
- 3- Increased productivity under low-input farming
Alignment with eco-friendly agricultural practices
- 4- Triacontanol may serve as a complementary component in integrated nutrient management strategies.

6. Conclusion:-

The present investigation demonstrates that foliar application of triacontanol positively influences vegetative growth, nodulation, and nitrogenase activity in pigeon pea (*Cajanus cajan*). The 1.0 ppm concentration was identified as the most effective treatment under field conditions. Adoption of triacontanol as a biostimulant may contribute to enhanced productivity and sustainable nitrogen management in pigeon pea cultivation.

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