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Influence of amino-chelated micronutrient foliar fertilizers on growth dynamics of soybean

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Abstract

A field experiment was conducted during the *kharif* seasons of 2023-24 and 2024-25 at the Experimental Farm, Department of Agronomy, VNMKV, Parbhani to evaluate the impact of different amino acid based micronutrient foliar fertilizer on growth rate of soybean. The experiment was conducted in a Randomized Block Design (RBD) with three replications and eleven treatments, namely: RDF (30:60:30 NPK kg ha⁻¹) (T₁), RDF + MS Grade I Micronutrient fertilizer (recommended dose) (T₂), and RDF + MS Grade II @ 2 ml/lit twice at 30 and 45 DAS (foliar application) (T₃), RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS (T₄), RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS (T₅), RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS (T₆), RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS (T₇), RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS (T₈), RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS (T₉), RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS (T₁₀), RDF + Absolute control (T₁₁). The gross plot size was 5.4 m × 4.5 m, while the net plot size was 4.5 m × 4.2 m. During experiments Physiological parameters including absolute growth rate (AGR) of plant height, dry matter accumulation, and crop growth rate (CGR) were recorded at different growth stages. Results revealed that among different treatments application of RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS (T₁₀) produced the highest values for physiological parameters including absolute growth rate (AGR) of plant height, absolute growth rate for (AGR) dry matter accumulation, relative growth rate (RGR) and crop growth rate (CGR), whereas the absolute control (T₁₁) recorded the lowest values. Therefore, micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS in conjunction with recommended dose of fertilizer proved most effective in enhancing physiological growth of soybean under rainfed conditions.

Keywords: Amino-chelates, growth, AGR, RGR, CGR, soybean

Introduction

The green revolution has greatly increased the food crop production in India, but The green revolution has greatly increased the food crop production in India, but continuous cultivation of high-yielding crop varieties has led to the depletion of native micronutrient soil fertility and now most of the soils are showing signs of fatigue for sustaining higher crop production to meet the increasing food demand of the country. In the post-Green Revolution period, deficiencies of micronutrients have constrained sustainable growth in the productivity of several field crops. Micronutrient deficiencies in crop plants are widespread because of increased micronutrient demands from intensive cropping practices and adaptation of high-yielding cultivars which may have higher micronutrient demand, enhanced production of crops on marginal soils that contain low levels of essential nutrients, increased use of high analysis fertilizers with low amounts of micronutrient contamination, decreased use of animal manures, composts, and crop residues; use of soils that are inherently low in micronutrient reserves, and involvement of natural and anthropogenic factors that limit adequate plant availability and create element imbalances (Fageria *et al.*, 2002) [5]. To reduce malnutrition it is imperative to supply crops with micronutrients in addition to the macronutrients required for plant growth. The efficiency of inorganic micronutrients applied to soils is low as they become easily fixed to soil particles (Xie *et al.*, 2020) [10]. Moreover, the process usually requires the application of large quantities of fertilizer, which can be costly.

Physical constraints such as high bulk density layers or pans, poor structure and texture, surface sealing and crusting, high or low water holding capacity, water logging, and extreme drying

or poor aeration can also reduce NUE (Baligar *et al.*, 2001) [4]. The current status of nutrient use efficiency is quite low in the case of micronutrients (< 2 %) due to deterioration in the chemical, physical, and biological health of the soil and the conditions that restrict root growth in soil for uptake of nutrients (Reena *et al.*, 2018). The foliar application of micronutrients is 6 to 20 times more useful than the soil application and improves nutrition (Arif *et al.*, 2006) [3]. Its efficiency requires less amount of fertilizer compared to soil application and is independent of soil composition, therefore under certain circumstances, it can be more economical and effective than soil fertilization (Fageria *et al.*, 2009) [6]. Moreover, the use of foliar nutrients on leaves may be more target-oriented and environmentally friendly because nutrients are directly applied to the plant in limited amounts, thus helping to reduce the environmental impact associated with soil fertilization (Fernández and Eichert, 2009) [7]. The foliar application also minimizes the leaching loss of nutrients which is more common in soil application (Neuman, 1982). When nutrients are applied to soils, they are absorbed by plant roots and translocated to aerial parts while in foliar application micronutrients are instantly available to the targeted plant part. In the case of foliar application, the nutrients penetrate the cuticle of the leaf or the stomata and then enter the cells. Hence, crop response occurs in a short time in foliar application compared to soil application. Applying a foliar spray of micronutrient fertilizers is an effective option to enhance plant nutrient-use efficiency (NUE) (Fageria *et al.*, 2009) [6]. Soybean (*Glycine max* (L.) Merrill) is a major leguminous crop that originated in Eastern Asia, particularly China, and was later introduced into India through Himalayan trade routes. Owing to its exceptional nutritional composition containing 40-42% protein and 18-22% oil it has become one of the most important global crops for plant-based protein and edible oil. Soybean meal is widely used in poultry and aquaculture feeds because of its balanced amino acid profile, rich lysine content, antioxidants, minerals, and fiber. Due to its nutritional richness and broad industrial utility, soybean is often described as the “Golden Bean” and “Miracle Bean.” In India, soybean cultivation is mainly concentrated in Madhya Pradesh and Maharashtra, together accounting for more than 82% of the national acreage. In 2023-24, global soybean production was estimated at 394.80 million tonnes, while India produced 115.28 lakh tonnes (Anonymous, 2025) [1, 2].

Materials and methods

A field experiment was conducted during the *kharif* seasons of 2023-24 and 2024-25 at the Experimental Farm, Department of Agronomy, VNMKV, Parbhani to evaluate the effect of amino-chelated micronutrient foliar fertilizers on growth dynamics of soybean. The experiment was conducted in a Randomized Block Design (RBD) with three replications and eleven treatments, namely: RDF (30:60:30 NPK kg ha⁻¹) (T₁), RDF + MS Grade I Micronutrient fertilizer (recommended dose) (T₂), and RDF + MS Grade II @ 2ml/lit twice at 30 and 45 DAS (foliar application) (T₃), RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS (T₄), RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS (T₅), RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS (T₆), RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS (T₇), RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS (T₈), RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS (T₉), RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS (T₁₀), RDF + Absolute control (T₁₁). The experiment was carried out on the same site with same randomization during both the years. Physiological parameters such as absolute growth rate for plant height and dry matter accumulation, and crop growth rate

were recorded at different growth stages and analyzed statistically using ANOVA appropriate for the randomized block design.

Absolute growth rate for plant height

The Absolute Growth Rate (AGR) is the total gain in plant height by the plant within the specific time interval. Absolute growth rate for plant height is expressed as cm day⁻¹ plant⁻¹ and is calculated by the formula given by Richards (1969) as follows.

$$(H_2 - H_1) \text{ AGR (Plant height) (cm day}^{-1} \text{ plant}^{-1}) = \frac{H_2 - H_1}{t_2 - t_1} \times 100$$

Where,

H₂ and H₁ are plant height (cm) at time t₂ and t₁, respectively.

The Absolute Growth Rate (AGR) is the total gain in dry matter by the plant within the specific time interval and expressed as g day⁻¹ plant⁻¹ for dry matter accumulation plant⁻¹

$$(W_2 - W_1) \text{ AGR (Dry matter) (g day}^{-1} \text{ plant}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1} \times 100$$

Where,

W₂ and W₁ are the dry weight (g) plant at time t₂ and t₁, respectively.

Relative growth rate (RGR)

Increase in dry matter of plant is a process of continuous compound interest wherein the increment in any interval adds to the ‘capital’ for subsequent growth. This rate of increment is called as Relative Growth Rate (RGR), which was worked out as per formula given by Fisher (1921) and expressed in g g⁻¹ day⁻¹ plant⁻¹.

$$\text{Log}_e W_2 - \text{Log}_e W_1$$

$$\text{RGR (g g}^{-1} \text{ day}^{-1}) = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where,

W₁ and W₂ are the weights of dry matter in g per plant at times t₁ and t₂, respectively and t₂ - t₁ is the time interval in days.

Log_e = natural logarithm to the base ‘e’ = 2.3026.

Crop growth rate (CGR) (g m⁻² day⁻¹)

The crop growth rate is commonly used for the determination of production efficiency of plant stand. CGR represents total dry matter productivity of the community per unit land area over a certain time span. CGR enables comparison to be made between stand communities of different types in different habitat (Watson, 1952). This is determined by using the following formula.

$$W_2 - W_1 \text{ CGR (g day}^{-1} \text{ m}^{-2}) = \frac{W_2 - W_1}{t_2 - t_1} \times p$$

Where,

W₂ = dry weight of plant at time t₂ (g plant⁻¹)

W₁ = dry weight of plant at time t₁ (g plant⁻¹)

p = spacing

Results and Discussion

Physiological growth dynamics

Growth functions are the measures of growth rates in different growth parameters of plant.

Growth analysis

Growth functions are the measures of growth rates in different

growth parameters of plant. The data calculated on these aspects were not subjected to 'F' test of variance and the results are interpreted based on mean values.

Absolute growth rate (AGR) for plant height (cm day⁻¹ plant⁻¹) Mean values of AGR for plant height recorded at various growth stages in both the seasons 2023-24 and 2024-25 are shown in Table 3.1 and 3.2.

Table 1: Mean AGR for plant height (cm day⁻¹ plant⁻¹) of soybean as influenced by different treatments at various growth stages during year 2023-24

Tr. no	Treatments	Absolute growth rate (AGR) for plant height (cm day ⁻¹ plant ⁻¹)				
		0-30	31-45	46-60	61-75	76- At harvest
T ₁	RDF (30:60:30 NPK kg ha ⁻¹)	0.471	0.455	0.466	0.302	0.009
T ₂	RDF + MS Grade I Micronutrient fertilizer (recommended dose)	0.503	0.488	0.476	0.311	0.011
T ₃	RDF + MS Grade II @ 2ml/lit twice at 30 and 45 DAS (foliar application)	0.516	0.497	0.496	0.311	0.013
T ₄	RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS	0.488	0.458	0.471	0.309	0.010
T ₅	RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS	0.541	0.510	0.556	0.322	0.016
T ₆	RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS	0.531	0.506	0.497	0.317	0.014
T ₇	RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS	0.559	0.513	0.565	0.324	0.017
T ₈	RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS	0.592	0.696	0.740	0.335	0.020
T ₉	RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS	0.571	0.518	0.582	0.325	0.018
T ₁₀	RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS	0.610	0.707	0.758	0.346	0.021
T ₁₁	Absolute control	0.463	0.241	0.340	0.297	0.008
	General mean	0.531	0.508	0.541	0.318	0.014

In the first year of the experiment, the absolute growth rate for height increased significantly between the periods of 0-30 and 46-60 days after sowing (DAS), after which the growth rate gradually decreased until harvest. The mean AGR for height at the intervals

of 0-30, 31-45, 46-60, 61-75, and 76 until harvest were recorded as 0.531, 0.508, 0.541, 0.318, and 0.014 cm day⁻¹ plant⁻¹, respectively. A comparable trend was observed in the second year of the experiment.

Table 2: Mean AGR for plant height (cm day⁻¹ plant⁻¹) of soybean as influenced by treatments at different growth stages during year 2024-25

Tr. no	Treatments	Mean AGR for plant height (cm day ⁻¹ plant ⁻¹)				
		0-30	31-45	46-60	61-75	76-At harvest
T ₁	RDF (30:60:30 NPK kg ha ⁻¹)	0.420	0.313	0.449	0.312	0.010
T ₂	RDF + MS Grade I Micronutrient fertilizer (recommended dose)	0.449	0.325	0.550	0.230	0.013
T ₃	RDF + MS Grade II @ 2ml/lit twice at 30 and 45 DAS (foliar application)	0.454	0.350	0.564	0.234	0.013
T ₄	RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS	0.432	0.319	0.519	0.313	0.011
T ₅	RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS	0.470	0.372	0.636	0.245	0.015
T ₆	RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS	0.460	0.362	0.629	0.238	0.014
T ₇	RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS	0.512	0.389	0.594	0.252	0.015
T ₈	RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS	0.547	0.544	0.765	0.379	0.016
T ₉	RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS	0.525	0.412	0.619	0.265	0.015
T ₁₀	RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS	0.552	0.572	0.768	0.386	0.016
T ₁₁	Absolute control	0.374	0.146	0.379	0.266	0.006
	General mean	0.472	0.373	0.588	0.284	0.013

Absolute growth rate (AGR) for dry matter (G day⁻¹ plant⁻¹)
Data regarding the Average Growth Rate (AGR) for dry matter

(cm day⁻¹ plant⁻¹) across various treatments at different growth stages during both seasons is illustrated in Tables 3.3 and 3.4.

Table 3: Mean AGR for dry matter (g day⁻¹ plant⁻¹) of soybean as influenced by different treatments at various growth stages during year 2023-24

Tr. no	Treatments	Days After Sowing (DAS)				
		0-30	31-45	46-60	61-75	76- At harvest
T ₁	RDF (30:60:30 NPK kg ha ⁻¹)	0.101	0.151	0.281	0.135	0.068
T ₂	RDF + MS Grade I Micronutrient fertilizer (recommended dose)	0.108	0.151	0.298	0.143	0.074
T ₃	RDF + MS Grade II @ 2ml/lit twice at 30 and 45 DAS (foliar application)	0.111	0.152	0.303	0.146	0.076
T ₄	RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS	0.100	0.150	0.285	0.139	0.070
T ₅	RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS	0.117	0.153	0.309	0.153	0.082
T ₆	RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS	0.112	0.138	0.307	0.149	0.080
T ₇	RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS	0.113	0.153	0.311	0.165	0.087
T ₈	RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS	0.118	0.214	0.358	0.175	0.110
T ₉	RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS	0.114	0.163	0.315	0.167	0.090
T ₁₀	RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS	0.119	0.225	0.361	0.180	0.112
T ₁₁	Absolute control	0.088	0.071	0.249	0.119	0.061
	General mean	0.109	0.156	0.307	0.152	0.083

In the period of 2023-24, the Mean AGR for dry matter was observed to be 0.109, 0.156, 0.307, 0.152, and 0.083 g day⁻¹ plant⁻¹ for the intervals of 0-30, 31-45, 46-60, 61-75, and 76-at harvest, respectively. The AGR for dry matter exhibits a rapid

increase between the intervals of 0-30 and 46-60 days after sowing (DAS), followed by a decline from 61-75 DAS, and continues to decrease at the time of harvest.

Table 4: Mean AGR for dry matter ($\text{g day}^{-1} \text{plant}^{-1}$) of soybean as influenced by different treatments at various growth stages during year 2024-25

Tr. no	Treatments	Mean AGR for dry matter ($\text{g day}^{-1} \text{plant}^{-1}$)				
		0-30	31-45	46-60	61-75	76- At harvest
T ₁	RDF (30:60:30 NPK kg ha^{-1})	0.093	0.140	0.240	0.131	0.039
T ₂	RDF + MS Grade I Micronutrient fertilizer (recommended dose)	0.096	0.155	0.258	0.144	0.043
T ₃	RDF + MS Grade II @ 2ml/lit twice at 30 and 45 DAS (foliar application)	0.097	0.167	0.275	0.152	0.045
T ₄	RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS	0.094	0.143	0.245	0.135	0.040
T ₅	RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS	0.102	0.173	0.286	0.161	0.051
T ₆	RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS	0.099	0.169	0.277	0.155	0.048
T ₇	RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS	0.104	0.175	0.291	0.166	0.054
T ₈	RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS	0.107	0.233	0.346	0.208	0.067
T ₉	RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS	0.105	0.182	0.299	0.171	0.057
T ₁₀	RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS	0.109	0.239	0.355	0.215	0.070
T ₁₁	Absolute control	0.087	0.096	0.194	0.096	0.030
	General mean	0.099	0.170	0.279	0.158	0.049

Relative growth rate (RGR) for dry matter ($\text{g g}^{-1} \text{plant}^{-1}$)

The data pertaining to mean relative growth rate (RGR) for dry matter ($\text{g g}^{-1} \text{day}^{-1}$) as influenced by different treatments during 2023-24 and 2024-25 are presented in Table 4.19 and 4.20. The

maximum mean value of RGR for dry matter was observed during 31-45 DAS which was $\text{g g}^{-1} \text{day}^{-1}$ and then decreased between 46-60 DAS.

Table 5: Mean RGR for dry matter ($\text{g g}^{-1} \text{plant}^{-1}$) of soybean as influenced by different treatments at various growth stages during year 2023-24

Tr. no	Treatments	Mean RGR for dry matter ($\text{g g}^{-1} \text{plant}^{-1}$)				
		0-30	31-45	46-60	61-75	76- At harvest
T ₁	RDF (30:60:30 NPK kg ha^{-1})	0.037	0.039	0.037	0.013	0.006
T ₂	RDF + MS Grade I Micronutrient fertilizer (recommended dose)	0.039	0.040	0.035	0.013	0.006
T ₃	RDF + MS Grade II @ 2ml/lit twice at 30 and 45 DAS (foliar application)	0.040	0.040	0.035	0.013	0.006
T ₄	RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS	0.037	0.040	0.037	0.013	0.006
T ₅	RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS	0.042	0.039	0.033	0.013	0.006
T ₆	RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS	0.040	0.041	0.032	0.013	0.006
T ₇	RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS	0.041	0.040	0.034	0.014	0.006
T ₈	RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS	0.042	0.043	0.048	0.013	0.007
T ₉	RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS	0.041	0.039	0.036	0.014	0.007
T ₁₀	RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS	0.043	0.044	0.039	0.013	0.007
T ₁₁	Absolute control	0.032	0.046	0.023	0.014	0.006
	General mean	0.039	0.040	0.036	0.013	0.006

The mean relative growth rate (RGR) for dry matter ($\text{g g}^{-1} \text{day}^{-1}$) of soybean was influenced by different treatments during both the years of investigation *i.e.* 2023-24 and 2024-25. The T₁₀ (RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS)

resulted in maximum mean relative growth rate (RGR) for dry matter at all the growth intervals from sowing up to harvest, while absolute control (T₁₁) recorded lowest RGR during both the years of investigation.

Table 6: Mean RGR for dry matter ($\text{g g}^{-1} \text{plant}^{-1}$) of soybean as influenced by different treatments at various growth stages during 2024-25

Tr. no	Treatments	Days After Sowing (DAS)				
		0-30	31-45	46-60	61-75	76- At harvest
T ₁	RDF (30:60:30 NPK kg ha^{-1})	0.0341	0.0375	0.0368	0.0139	0.0036
T ₂	RDF + MS Grade I Micronutrient fertilizer (recommended dose)	0.0351	0.0396	0.0371	0.0142	0.0038
T ₃	RDF + MS Grade II @ 2ml/lit twice at 30 and 45 DAS (foliar application)	0.0356	0.0413	0.0378	0.0143	0.0037
T ₄	RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS	0.0344	0.0377	0.0370	0.0141	0.0037
T ₅	RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS	0.0372	0.0411	0.0377	0.0145	0.0040
T ₆	RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS	0.0364	0.0410	0.0374	0.0143	0.0039
T ₇	RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS	0.0379	0.0406	0.0377	0.0147	0.0042
T ₈	RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS	0.0389	0.0491	0.0382	0.0155	0.0043
T ₉	RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS	0.0382	0.0416	0.0378	0.0148	0.0043
T ₁₀	RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS	0.0396	0.0492	0.0383	0.0156	0.0044
T ₁₁	Absolute control	0.0321	0.0292	0.0360	0.0125	0.0035
	General mean	0.036	0.041	0.037	0.014	0.0040

The mean relative growth rate (RGR) for dry matter ($\text{g g}^{-1} \text{day}^{-1}$) of soybean was influenced by different treatments during both the years of investigation *i.e.* 2023-24 and 2024-25. The T₁₀ (RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS) resulted in maximum mean relative growth rate (RGR) for dry matter at all the growth intervals from sowing up to harvest, while absolute control (T₁₁) recorded lowest RGR during both the years

of investigation.

Crop growth rate ($\text{g m}^{-2} \text{day}^{-1}$)

The crop growth rate (CGR), which is quantified as the accumulation of dry matter per day per unit area, was evaluated during the *khari*f seasons of 2023-24 and 2024-25, with

Table 7: Mean Crop Growth Rate (CGR) ($\text{g m}^{-2} \text{day}^{-1}$) of soybean as influenced by different treatments at various growth stages during year 2023-24

Tr. no	Treatments	Mean Crop Growth Rate (CGR) ($\text{g m}^{-2} \text{day}^{-1}$)				
		0-30	31-45	46-60	61-75	76-At harvest
T ₁	RDF (30:60:30 NPK kg ha^{-1})	4.47	6.70	12.49	6.00	3.01
T ₂	RDF + MS Grade I Micronutrient fertilizer (recommended dose)	4.80	6.71	13.24	6.36	3.28
T ₃	RDF + MS Grade II @ 2ml/lit twice at 30 and 45 DAS (foliar application)	4.93	6.74	13.47	6.49	3.38
T ₄	RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS	4.44	6.67	12.67	6.18	3.11
T ₅	RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS	5.20	6.79	13.73	6.80	3.64
T ₆	RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS	4.96	6.13	13.64	6.62	3.57
T ₇	RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS	5.02	6.79	13.82	7.33	3.86
T ₈	RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS	5.26	9.53	15.91	7.78	4.89
T ₉	RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS	5.05	7.26	14.00	7.42	3.98
T ₁₀	RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS	5.30	10.00	16.04	8.00	4.97
T ₁₁	Absolute control	3.91	3.17	11.07	5.29	2.71
	General mean	4.85	6.95	13.64	6.75	3.67

During the year 2023-24 of the experiment, the crop growth rate for dry matter was initially low, but it increased significantly between 31-45 and 46-60 days after sowing (DAS), and then decreased as the crop approached maturity. The highest mean CGR of 13.64 was recorded at 60 days. A similar trend was observed in the second year of the experiment.

The maximum crop growth rate (CGR) was noted under the T₁₀

treatment (RDF + Micronutrient formulation III at 2 ml/lit at 30 and 45 DAS), followed by the T₈ treatment (RDF + Micronutrient formulation I at 2 ml/lit at 30 and 45 DAS). The minimum crop growth rate (CGR) was recorded in the absolute control treatment (T₁₁), where no fertilizers were applied. This trend was consistently observed at all growth stages and was similarly

Table 8: Mean Crop Growth Rate (CGR) ($\text{g m}^{-2} \text{day}^{-1}$) of soybean as influenced by different treatments at various growth stages during year 2024-25

Tr. no	Treatments	Days After Sowing (DAS)				
		0-30	31-45	46-60	61-75	76-At harvest
T ₁	RDF (30:60:30 NPK kg ha^{-1})	4.119	6.222	10.667	5.837	1.719
T ₂	RDF + MS Grade I Micronutrient fertilizer (recommended dose)	4.252	6.904	11.467	6.400	1.926
T ₃	RDF + MS Grade II @ 2ml/lit twice at 30 and 45 DAS (foliar application)	4.311	7.407	12.237	6.756	2.015
T ₄	RDF + EDTA-Chelated micronutrient (commercial) @ 2 ml/lit at 30 and 45 DAS	4.163	6.341	10.874	6.015	1.778
T ₅	RDF + Micronutrient formulation I @ 2 ml/lit at 30 DAS	4.519	7.704	12.711	7.170	2.252
T ₆	RDF + Micronutrient formulation II @ 2 ml/lit at 30 DAS	4.415	7.496	12.296	6.874	2.133
T ₇	RDF + Micronutrient formulation III @ 2 ml/lit at 30 DAS	4.622	7.763	12.919	7.378	2.400
T ₈	RDF + Micronutrient formulation I @ 2 ml/lit at 30 and 45 DAS	4.756	10.341	15.378	9.244	2.963
T ₉	RDF + Micronutrient formulation II @ 2 ml/lit at 30 and 45 DAS	4.667	8.089	13.274	7.615	2.548
T ₁₀	RDF + Micronutrient formulation III @ 2 ml/lit at 30 and 45 DAS	4.859	10.607	15.793	9.541	3.111
T ₁₁	Absolute control	3.881	4.267	8.622	4.267	1.333
	General mean	4.415	7.558	12.385	7.009	2.198

Conclusion

The following conclusion could be drawn from the two-year field experimentation.

Among the different treatments, T₁₀ treatment (RDF + Micronutrient formulation III at 2 ml/lit at 30 and 45 DAS) recorded higher values for absolute growth rate (AGR) for height, absolute growth rate (AGR) for dry matter accumulation, relative growth rate (RGR) and crop growth rate (CGR) at all growth stages, while The minimum crop growth rate (CGR) was recorded in the absolute control treatment (T₁₁),

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