

Effect of GA₃ (Gibberellic acid), CEPA (Ethephon) and CFL (Chlorflurenol) on biochemical parameters higher chlorophyll, protein and sugar of okra (Abelmoschus esculentus (L.) Moench)

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Abstract

The present study investigates the *Effect of GA₃ (Gibberellic acid), CEPA (Ethephon) and CFL (Chlorflurenol) on biochemical parameters higher chlorophyll, protein and sugar of okra (Abelmoschus esculentus (L.) Moench)*. The experiment was conducted under field conditions using a randomized block design with nine treatments and three replications. Growth parameters such as plant height, number of leaves, stem girth, and leaf area; yield attributes including number of fruits per plant, fruit length, fruit weight, and total yield; and biochemical parameters like chlorophyll content, soluble sugars, proteins, phenols, and water content were analysed. The results revealed that GA₃ at 10 mg L⁻¹ significantly enhanced plant height, leaf area, and yield compared to control, while CFL at 50 mg L⁻¹ improved branching, leaf number, and biochemical constituents. CEPA at lower concentration (100 mg L⁻¹) induced early flowering and fruiting, but higher concentrations inhibited growth. The combined use of GA₃ and CFL proved most beneficial, producing vigorous plants with higher photosynthetic pigment and protein content. The study concludes that the judicious use of plant bio regulators can enhance okra productivity and quality by modulating physiological and biochemical processes.

Keywords: Gibberellic Acid (GA₃), Ethephon (CEPA), Chlorflurenol (CFL), Biochemical Parameters, Okra (*Abelmoschus esculentus (L.) Moench*)

Introduction

Okra (*Abelmoschus esculentus* L. Moench) is an important tropical vegetable crop grown widely for its tender green fruits, which are a rich source of vitamins, minerals, and mucilage. Despite its adaptability, okra yields often remain sub-optimal due to physiological constraints, hormonal imbalance, and environmental stress. In recent years, the use of plant bio regulators (PBRs) has emerged as an effective approach to manipulate growth and productivity in vegetable crops. Bio regulators such as **Gibberellic Acid (GA₃)**, **Ethephon (CEPA)**, and **Cytokinin Formulations (CFL)** influence various physiological processes including cell division, elongation, differentiation, flowering, and senescence.

- **GA₃** promotes stem elongation and leaf expansion by stimulating enzyme production and cell elongation.
- **Cytokines** are known for promoting cell division, delaying senescence, and enhancing nutrient mobilization.
- **Ethephon**, an ethylene-releasing compound, regulates flowering, fruit set, and maturation but requires precise dosing as high concentrations may lead to early senescence.

Okra responds markedly to hormonal treatments, yet responses depend on type, concentration, and application timing. Few comparative studies have examined GA₃, CEPA, and CFL together, particularly in relation to biochemical changes such as chlorophyll, sugar, protein, and phenolic contents. Therefore, this study was undertaken to assess the **comparative efficacy of GA₃, CEPA, and CFL** on the growth, yield, and biochemical composition of okra seedlings. The objective was to determine optimal concentrations that maximize growth and productivity while maintaining quality.

Materials and Methods

Experimental Site and Design

The experiment was carried out at the Department of Botany Experimental Farm, during the kharif season. The soil was loamy with pH 6.8, moderate organic matter, and good drainage. The experiment followed a **Randomized Block Design (RBD)** with nine treatments and three replications.

Treatments

Three bio regulators—GA₃, CEPA, and CFL—were applied at different concentrations:

Treatment Code	Bio regulator	Concentration (mg L ⁻¹)
T ₁	Control	0
T ₂	GA ₃	1
T ₃	GA ₃	10
T ₄	CEPA	100
T ₅	CEPA	200
T ₆	CFL	25
T ₇	CFL	50
T ₈	GA ₃ (10) + CFL (50)	Combined
T ₉	GA ₃ (10) + CEPA (100)	Combined

Sprays were applied twice—at 30 and 45 days after sowing (DAS).

Parameters Recorded

- Growth parameters:** plant height, number of leaves, leaf area, stems girth.
- Yield attributes:** fruit length, average fruit weight, number of fruits per plant, total yield.
- Biochemical parameters:**
 - Chlorophyll a, b and total (Arnon, 1949 method)
 - Total soluble sugars (Anthrone method)
 - Total proteins (Lowry’s method)
 - Total phenols (Folin–Ciocalteu method)
 - Water content (fresh–dry weight difference)

Statistical Analysis

Data were analysed using ANOVA. Significant differences among treatment means were determined using LSD at 5% level. Correlation coefficients were calculated between growth and biochemical parameters.

Results and Discussion

A. Growth Parameters

The application of GA₃, CEPA, and CFL significantly affected growth parameters (Table 1).

GA₃ (10 mg L⁻¹) produced the tallest plants (78.6 cm), greatest leaf area (320.4 cm²), and highest number of leaves (22.3). The stimulation of cell elongation and division by GA₃ explains the enhanced vegetative growth. Similar results were reported by *Singh and Bhatnagar (2018)* in okra.

CFL (50 mg L⁻¹) resulted in increased branching and leaf number due to cytokinin’s role in stimulating cell division and delaying leaf senescence.

CEPA (100 mg L⁻¹) induced early flowering (by 3–5 days earlier than control), indicating ethylene’s role in flower initiation. However, CEPA at 200 mg L⁻¹ reduced plant height and leaf area due to its senescence-promoting effect.

Table 1: Effect of Bio regulators on Growth Parameters of Okra

Treatment	Plant Height (cm)	No. of Leaves	Leaf Area (cm ²)	Stem Girth (cm)
Control	58.4	14.2	210.3	2.10
GA ₃ 1 mg L ⁻¹	65.8	16.5	245.6	2.30
GA ₃ 10 mg L ⁻¹	78.6	22.3	320.4	2.65
CEPA 100 mg L ⁻¹	62.7	18.0	260.2	2.25
CEPA 200 mg L ⁻¹	52.3	12.4	195.7	2.00
CFL 25 mg L ⁻¹	70.4	19.8	270.8	2.40

Treatment	Plant Height (cm)	No. of Leaves	Leaf Area (cm ²)	Stem Girth (cm)
CFL 50 mg L ⁻¹	75.1	21.0	310.6	2.60
GA ₃ (10) + CFL (50)	80.2	23.1	325.7	2.68
GA ₃ (10) + CEPA (100)	74.0	20.0	295.8	2.55

B. Yield Attributes

Maximum yield was obtained in GA₃ (10 mg L⁻¹) followed closely by CFL (50 mg L⁻¹) and the GA₃ + CFL combination. The increase in yield attributes is attributed to better photosynthetic efficiency and nutrient translocation toward fruits.

CEPA at low concentration enhanced early yield but reduced final yield at high concentration due to accelerated maturity.

Table 2: Effect of Bio regulators on Yield Attributes of Okra

Treatment	No. of Fruits/Plant	Fruit Length (cm)	Fruit Weight (g)	Yield (t/ha)
Control	12.5	10.4	13.5	9.5
GA ₃ 1 mg L ⁻¹	14.8	11.2	14.8	10.6
GA ₃ 10 mg L ⁻¹	19.2	13.5	18.6	13.8
CEPA 100 mg L ⁻¹	16.0	11.5	15.0	11.2
CEPA 200 mg L ⁻¹	11.8	9.0	12.0	8.3
CFL 25 mg L ⁻¹	17.2	12.4	16.5	12.4
CFL 50 mg L ⁻¹	18.6	13.0	17.5	13.0
GA ₃ + CFL	19.5	13.8	19.0	14.2
GA ₃ + CEPA	17.8	12.7	16.8	12.8

C. Biochemical Composition

GA₃ and CFL treatments significantly increased chlorophyll, total sugar, and protein content, while CEPA enhanced phenolic compounds (Table 3).

Table 3: Effect of Bio regulators on Biochemical Constituents of Okra Leaves

Treatment	Total Chlorophyll (mg/g FW)	Sugars (mg/g)	Protein (mg/g)	Phenols (mg/g)
Control	1.75	14.2	16.5	5.4
GA ₃ 10 mg L ⁻¹	2.38	20.8	22.4	6.0
CEPA 100 mg L ⁻¹	1.92	17.0	18.3	7.5
CFL 50 mg L ⁻¹	2.25	19.5	21.8	6.8
GA ₃ + CFL	2.45	21.0	23.0	6.9

The increase in chlorophyll and protein content under GA₃ and CFL treatments suggests improved nitrogen assimilation and delayed senescence. CEPA enhanced phenolic accumulation, indicating activation of secondary metabolism and stress tolerance.

Summary of Findings

1. **GA₃ (10 mg L⁻¹)** showed maximum growth and yield.
2. **CFL (50 mg L⁻¹)** improved leaf number, chlorophyll, and protein contents.
3. **CEPA (100 mg L⁻¹)** induced early flowering but high dose (200 mg L⁻¹) reduced growth.
4. **Combination of GA₃ + CFL** resulted in highest overall performance in terms of vegetative and biochemical parameters.
5. Chlorophyll and protein contents were positively correlated with yield ($r = 0.82$).
6. Excessive CEPA caused premature senescence and yield reduction.

Discussion

The improved growth and yield due to GA₃ and CFL are attributed to hormonal modulation of physiological processes. GA₃ enhances cell elongation, stimulates hydrolytic enzymes, and promotes photosynthetic efficiency. Cytokines delay senescence and improve nutrient mobilization, resulting in sustained growth. Their combined use produced synergistic effects.

CEPA, at low concentrations, releases ethylene which accelerates flowering and fruit set. However, at higher doses, ethylene promotes leaf abscission and chlorophyll degradation, leading to decreased yield.

The observed increase in chlorophyll and protein content under GA₃ and CFL treatments indicates enhanced photosynthetic rate and nitrogen metabolism. Increased sugars confirm improved source–sink translocation. Phenolic accumulation in CEPA treatments enhances antioxidant potential, contributing to fruit quality.

These findings align with earlier works of *Pandey et al. (2019)*, *Mehta and Patel (2017)*, and *Ali et al. (2021)*, demonstrating that optimal bio regulator use can effectively manipulate growth and productivity of okra.

Conclusion

The study concludes that **plant bio regulators significantly influence the physiological, yield, and biochemical traits** of okra. Among treatments, GA₃ (10 mg L⁻¹) and CFL (50 mg L⁻¹) individually enhanced vegetative growth and yield, while GA₃ + CFL combination was most effective overall. CEPA (100 mg L⁻¹) promoted early flowering but required cautious use to avoid over-accumulation of ethylene.

The improved chlorophyll, sugar, and protein contents under GA₃ and CFL treatments indicate enhanced metabolic efficiency and nutritional quality. Hence, moderate doses of GA₃ and CFL can be recommended to farmers for improving okra productivity in sustainable systems.

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