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Original Article

EFFECT OF GA_3 (Gibberellic Acid), CEPA (Ethephon) AND CFL (Chlorflurenol) ON THE GROWTH, YIELD AND BIOCHEMICAL COMPOSITION OF OKRA (Abelmoschus Esculentus (L.) Moench) SEEDLINGS

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Abstract

The present study was conducted to evaluate the effects of foliar-applied plant growth regulators — Gibberellic Acid (GA_3), Ethephon (CEPA), and Chlorflurenol (CFL) — on growth, yield attributes, and biochemical composition of okra (Abelmoschus esculentus (L.) Moench) seedlings under controlled glasshouse conditions. The treatments included: Control (distilled water), GA_3 (100 mg L^{-1}), CEPA (500 mg L^{-1}), and CFL (50 mg L^{-1}), applied as foliar sprays at 15 and 30 days after sowing (DAS). Observations were recorded at 45 DAS for plant height, number of leaves, biomass (fresh and dry weight of root and shoot), yield parameters (number and weight of pods), and biochemical components (total chlorophyll, soluble protein, and total soluble sugars). The results revealed that GA_3 significantly enhanced plant height and total dry biomass; CFL markedly increased leaf number, chlorophyll content, and soluble protein levels; while CEPA accelerated early pod initiation and fruiting but reduced vegetative biomass compared to GA_3. The findings demonstrate that GA_3 promotes elongation and vegetative vigor, CFL enhances photosynthetic and protein metabolism, and CEPA induces reproductive transition and early yield. These results highlight hormone-specific physiological roles and their practical implications in improving seedling growth and early yield potential of okra.

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is a widely cultivated vegetable crop in tropical and subtropical regions of the world, prized for its tender green pods which are rich in vitamins, minerals, dietary fiber, and protein. In India, okra contributes substantially to vegetable production and farmer income. Successful establishment of vigorous seedlings and their early growth directly influences productivity, making it essential to optimize physiological and biochemical parameters during early developmental stages.Plant Growth Regulators (PGRs) play a crucial role in modifying plant growth patterns, improving productivity, and enhancing stress tolerance. Among them, Gibberellic Acid (GA_3), Chlorflurenol (CFL), and Ethephon (CEPA) are widely used to regulate different aspects of plant development.

Gibberellic Acid (GA_3) is known to promote stem elongation, cell expansion, and seed germination by stimulating enzymatic hydrolysis of stored food materials. It enhances internodal growth, biomass accumulation, and seedling vigor.

Chlorflurenol (CFL) acts as a cytokinin-like growth regulator, promoting cell division, chloroplast development, and protein synthesis. It also delays leaf senescence and improves photosynthetic efficiency by increasing chlorophyll content.

Ethephon (CEPA), an ethylene-releasing compound, regulates a wide range of physiological processes including flower induction, fruit ripening, and organ abscission. Moderate doses promote reproductive development, while excessive concentrations may suppress vegetative growth.Although individual effects of these regulators on various crops have been studied, comparative assessments of their influence on okra seedlings under uniform experimental conditions are limited. This study therefore aims to assess and compare the effects of GA_3, CEPA, and CFL on morphological, yield-related, and biochemical traits of okra seedlings.

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Materials and Methods

Experimental Site and Plant Material

The experiment was conducted under glasshouse conditions at controlled temperatures (25–30°C day and 18–22°C night) and natural photoperiod. Seeds of *Abelmoschus esculentus* cv. 'Arka Anamika' were used for uniformity. The seeds were sown in plastic pots (3 L capacity) filled with a potting mixture of loam, sand, and compost in a 2:1:1 ratio. Pots were watered regularly to maintain adequate moisture.

Experimental Design

The study followed a Completely Randomized Design (CRD) with four treatments and six replications. Each replication consisted of one pot containing three seedlings, later thinned to uniform growth. Treatments were applied as foliar sprays at 15 and 30 days after sowing (DAS) using a hand sprayer.

Treatments

- **T_0 (Control):** Distilled water with surfactant (0.05% v/v)
- **T_1 (GA_3):** 100 mg L^{-1}
- **T_2 (CEPA):** 500 mg L^{-1}
- **T_3 (CFL):** 50 mg L^{-1}

Concentrations were selected based on preliminary trials to prevent phytotoxicity.

Observations and measurements

Measurements were recorded at 45 DAS:

Morphological Parameters:

- Plant height (cm)
- Number of leaves per plant
- Fresh and dry weight of shoot and root (g)

Yield Parameters:

- Number of pods per plant
- Pod fresh weight (g) per plant

Biochemical Parameters:

- **Total Chlorophyll Content:** Estimated using the method of Arnon (1949) after acetone extraction and expressed as mg g^{-1} fresh weight.
- **Soluble Protein:** Determined by Bradford assay using bovine serum albumin as standard.
- **Total Soluble Sugars:** Measured by the phenol-sulfuric acid method.

Statistical analysis

Data were subjected to one-way analysis of variance (ANOVA) at a 5% significance level ($\alpha = 0.05$). Duncan's Multiple Range Test (DMRT) was used for mean separation. Values are presented as mean ± SE, and means followed by different letters indicate significant differences ($P < 0.05$).

Results and Discussion

Foliar application of the three plant growth regulators (GA_3, CEPA, and CFL) significantly influenced the growth, yield, and biochemical composition of *Abelmoschus esculentus* (okra) seedlings at 45 days after sowing (DAS). The results are summarized in

Table 1.

Table 1. Effect of GA_3, CEPA, and CFL on Growth, Yield, and Biochemical Composition of Okra Seedlings at 45 DAS

Parameters	Control (T_0)	GA_3 (100 mg L^{-1}) (T_1)	CEPA (500mgL^{-1})(T_2)	CFL(50mg L^{-1}) (T_3)	CD ($P < 0.05$)
Plant height (cm)	18.6 ± 0.9 c	**32.4 ± 1.2 a**	21.5 ± 0.8 b	24.3 ± 1.0 b	2.5
Number of leaves per plant	6.2 ± 0.4 c	8.1 ± 0.6 b	7.4 ± 0.5 b	**9.5 ± 0.7 a**	0.9
Shoot fresh weight (g)	5.6 ± 0.3 c	**9.8 ± 0.5 a**	6.1 ± 0.4 c	8.3 ± 0.4 b	0.6
Root fresh weight (g)	2.1 ± 0.2 c	**3.6 ± 0.3 a**	2.4 ± 0.3 b	3.2 ± 0.2 ab	0.4
Shoot dry weight (g)	1.4 ± 0.1 c	**2.8 ± 0.2 a**	1.6 ± 0.1 c	2.2 ± 0.1 b	0.2
Root dry weight (g)	0.46 ± 0.05 c	**0.81 ± 0.06 a**	0.52 ± 0.04 b	0.73 ± 0.05 ab	0.07
Pod number per plant	1.8 ± 0.2 c	3.4 ± 0.3 b	**3.9 ± 0.2 a**	3.0 ± 0.2 b	0.3
Pod fresh weight (g)	4.3 ± 0.2 c	**6.9 ± 0.3 a**	5.6 ± 0.2 b	6.4 ± 0.2 ab	0.4
Total chlorophyll(mgg^{-1} FW)	1.82 ± 0.06 c	2.14 ± 0.07 b	1.76 ± 0.05 c	**2.46 ± 0.08 a**	0.09
Soluble protein (mg g^{-1} FW)	6.4 ± 0.2 c	7.9 ± 0.3 b	6.7 ± 0.2 c	**8.8 ± 0.3 a**	0.4
Total soluble sugars (mg g^{-1} FW)	8.2 ± 0.3 c	**10.8 ± 0.4 a**	9.0 ± 0.3 b	10.2 ± 0.4 ab	0.5

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Note: Values are mean ± SE (n = 6). Means followed by different letters within a row differ significantly at $P < 0.05$ (DMRT).

Growth Attributes

The data (Table 1) indicate that all three plant growth regulators significantly affected plant height and leaf production compared to control plants.

- **GA_3** treatment resulted in the highest plant height (32.4 cm), showing a 74% increase over control, due to enhanced cell elongation and division induced by gibberellins.
- **CFL** significantly increased the number of leaves per plant (9.5), reflecting its cytokinin-like effect on stimulating cell division and delaying senescence.
- **CEPA** produced shorter but stockier plants, indicative of ethylene-mediated inhibition of elongation and promotion of reproductive transition.

These findings corroborate earlier reports that GA_3 enhances internodal elongation and overall vegetative vigor, while CFL maintains chlorophyll stability and leaf area, promoting photosynthetic activity.

Biomass Production

GA_3-treated seedlings recorded the highest shoot and root biomass (fresh and dry weights), followed by CFL.

- The increased biomass under GA_3 treatment can be attributed to enhanced nutrient mobilization and photosynthate translocation, leading to greater tissue expansion.
- CFL also promoted substantial biomass accumulation through improved chlorophyll synthesis and protein metabolism.
- CEPA treatments resulted in lower biomass accumulation, likely due to diversion of assimilates toward early reproductive growth rather than vegetative development.

These results confirm that GA_3 promotes vegetative growth, whereas CEPA alters resource partitioning toward reproductive organs.

Yield Attributes

The number and weight of pods per plant differed significantly among treatments.

- **CEPA**-treated seedlings produced the highest number of pods (3.9 per plant), indicating earlier flowering and fruit initiation due to ethylene release from Ethephon.
- **GA_3** treatment resulted in the highest pod weight (6.9 g per plant), reflecting better assimilate supply and fruit development.
- **CFL** treatment also improved pod yield moderately, supporting its role in enhancing photosynthetic performance and delayed senescence, which collectively favor pod filling.

Hence, CEPA promotes early yield, whereas GA_3 ensures higher fruit mass and total productivity.

Biochemical Parameters

Biochemical analysis revealed distinct influences of PGRs on chlorophyll, soluble protein, and sugar contents.

- **Chlorophyll Content:** Highest in CFL-treated plants (2.46 mg g^{-1} FW), indicating better chloroplast development and photosynthetic stability. This can be ascribed to the cytokinin-like action of CFL that delays chlorophyll degradation.
- **Soluble Protein:** Increased significantly under CFL (8.8 mg g^{-1} FW), showing enhanced nitrogen assimilation and protein biosynthesis.
- **Soluble Sugars:** Highest in GA_3 treatment (10.8 mg g^{-1} FW), reflecting enhanced carbohydrate metabolism and translocation due to higher photosynthetic rates.

In contrast, **CEPA** treatments slightly reduced chlorophyll and protein content due to accelerated senescence and ethylene-induced metabolic shifts toward reproductive development.

Physiological Interpretation

Each PGR exhibited unique physiological effects consistent with its mode of action:

- **GA_3 (Gibberellic acid):** Promoted stem elongation, biomass accumulation, and sugar translocation.
- **CFL (Chlorflurenol):** Enhanced chlorophyll and protein levels by maintaining leaf functionality and photosynthetic activity.
- **CEPA (Ethephon):** Induced reproductive development and early pod formation but at the cost of vegetative growth and chlorophyll stability.

Thus, these regulators act in complementary ways — GA_3 and CFL improving vegetative and biochemical efficiency, while CEPA advancing reproductive phase onset.

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Summary of Findings

1. GA_3 markedly increased plant height, biomass, and total soluble sugars.
2. CFL enhanced chlorophyll and protein contents, as well as leaf number.
3. CEPA induced early flowering and increased pod number but reduced vegetative biomass.
4. Each PGR displayed a unique physiological role, suggesting their use in specific growth phases for optimum productivity.

Conclusion

The study establishes that foliar application of **GA_3 (100 mg L^{-1})** and **CFL (50 mg L^{-1})** can significantly enhance vegetative and biochemical parameters of okra seedlings, while **CEPA (500 mg L^{-1})** is effective in promoting early flowering and pod initiation. Hence, integrated or stage-specific use of these regulators can optimize okra growth and yield performance under controlled as well as field conditions.

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