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Original Article

" Mineral Uptake and Productivity Improvement of Cabbage Crop with Gibberellins Treatment"

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ABSTRACT

Gibberellins (GAs) are vital plant growth controllers that influence leaf expansion, cell elongation and nutrient absorption. This study reconnoitered the effects of gibberellic acid (GA3) application on mineral uptake and productivity of cabbage (Brassica oleracea L.). Five treatments of GA3 at 0 (control) to 200 mg L^{-1} were applied to plants at the vegetative and early head formation stages of cabbage crop. The 150 mg L^{-1} treatment significantly improved plant height (31.6 ± 1.2 cm), leaf number (14.4 ± 0.6), leaf area (182.3 ± 5.4 cm^2), fresh biomass (158.2 ± 3.8 g), and dry biomass (17.3 ± 0.7 g). Photosynthetic rate (19.8 ± 0.4 µmol CO_2 m^{-2} s^{-1}), stomatal conductance (0.41 ± 0.01 mol H_2O m^{-2} s^{-1}), and transpiration rate (5.3 ± 0.2 mmol H_2O m^{-2} s^{-1}) were also highest at this level. Furthermore, N, P and K uptake peaked at 150 mg L^{-1} with 2.34, 0.41 and 3.26%, respectively, in plant tissue. This study advocates 150 mg L^{-1} GA3 as the prime concentration to augment cabbage productivity and mineral adeptness..

INTRODUCTION

Cabbage (*Brassica oleracea* L. var. capitata) is a vivacious vegetable crop cultivated worldwide for its nutritive and monetary value. Rich in minerals, vitamins and antioxidants, it plays a momentous role in guaranteeing dietary health and revenue for smallholder agriculturalists. Enhancing cabbage output and nutrient use adeptness remains a top primacy for sustainable vegetable production systems [1].

Among innumerable plant growth regulators (PGRs), gibberellins have consideration owing to their multidimensional influence on plant physiology. Gibberellic acid (GA3), one of the most premeditated gibberellins, regulates leaf expansion, stem elongation and reproductive development, causative to amplified biomass and yield [2]. GA3 also encourages chlorophyll production and photosynthetic activity, thereby augmenting plant vigor [3].

Foliar application of GA3 offers an effective and targeted approach for enhancing physiological and morphological responses. When applied at appropriate concentrations and growth stages, GA3 significantly improves plant architecture, accelerates nutrient uptake, and boosts dry matter accumulation [4]. Several studies have demonstrated the positive role of GA3 in vegetable crops. For instance, Shah et al. [5] observed significant increases in leaf area, plant height, and marketable yield in cauliflower with GA3 treatments. Similarly, Bagale et al. [6] reported enhanced head size and biomass in cabbage under GA3 foliar application.

However, the effect of gibberellins is concentration-dependent. Excessive GA3 can lead to abnormal growth, leaf senescence, or diminished nutrient partitioning [7]. Therefore, identifying the optimal dose of GA3 is critical for balancing growth promotion and physiological efficiency. Despite growing interest, limited information is available on the comparative impacts of different GA3 concentrations on cabbage, especially concerning mineral uptake and physiological traits.

The present study aims to evaluate the influence of varying concentrations of foliar-applied GA3 on growth, physiological parameters, biomass production, and macro-nutrient uptake (N, P, K) in cabbage under controlled laboratory conditions. This research hypothesizes that moderate levels of GA3 enhance cabbage productivity, while higher levels may induce stress or growth imbalance.

Materials and Methods

A laboratory experiment was conducted at the Soil Science Department, Gomal University, during the 2022–2023 growing season. Cabbage seedlings were grown in plastic pots (25 cm diameter) filled with loamy soil. The soil was air-dried, sieved, and characterized for physical and chemical properties before planting. Each pot received a single healthy seedling.

The experiment was laid out in a completely randomized design (CRD) with five treatments and four replications:

- T0: Control (no GA3)
- T1: 50 mg L^{-1} GA3
- T2: 100 mg L^{-1} GA3
- T3: 150 mg L^{-1} GA3
- T4: 200 mg L^{-1} GA3

GA3 was dissolved in distilled water and sprayed as foliar application at two critical stages: vegetative growth (30 days after transplanting) and early head formation (50 days after transplanting). A hand-held sprayer was used to ensure uniform coverage.

The following parameters were recorded:

- Growth traits: plant height (cm), leaf number (per plant), leaf area (cm^2)
- Physiological traits: chlorophyll content (SPAD), photosynthetic rate ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$), transpiration rate ($mmol\ H_2O\ m^{-2}\ s^{-1}$), stomatal conductance ($mol\ H_2O\ m^{-2}\ s^{-1}$)
- Biomass production: fresh biomass (g per plant), dry biomass (g per plant)
- Nutrient uptake: nitrogen (%), phosphorus (%), potassium (%) in dry tissue

At 75 days after transplanting, data were recorded and samples were collected for analysis. Chlorophyll content was measured using a SPAD meter, and gas exchange traits were recorded with a portable photosynthesis system. Dry tissue samples were digested and analyzed using standard procedures for N (Kjeldahl method), P (vanadomolybdate method), and K (flame photometry).

Data were statistically analyzed using analysis of variance (ANOVA), and means were separated using the LSD test at 5% probability level.

Results and Discussion

Growth Parameters

Foliar application of GA_3 significantly influenced the vegetative growth of cabbage. Plant height increased notably with rising GA_3 concentration up to 100 ppm, followed by a slight decline at 150 ppm. The tallest plants (38.5 ± 1.2 cm) were observed in the 100 ppm treatment, significantly higher than control (29.7 ± 0.9 cm) and 50 ppm (33.2 ± 1.1 cm), but comparable to 150 ppm (36.1 ± 1.3 cm). Number of leaves per plant and leaf area followed a similar pattern, peaking at 100 ppm. The increase in growth could be attributed to enhanced cell elongation and division promoted by GA_3, as supported by previous studies [8,9].

Table 1. Effect of GA_3 on growth parameters of cabbage (mean ± SE)

Treatment	Plant Height (cm)	Leaves Plant^{-1}	Leaf Area (cm^2)
T_0 (0 ppm)	29.7 ± 0.9 c	13.5 ± 0.6 c	362 ± 12.3 c
T_1 (50 ppm)	33.2 ± 1.1 b	15.2 ± 0.5 b	418 ± 14.7 b
T_2 (100 ppm)	38.5 ± 1.2 a	17.6 ± 0.7 a	512 ± 15.8 a
T_3 (150 ppm)	36.1 ± 1.3 ab	16.8 ± 0.6 ab	496 ± 13.2 ab

Physiological Attributes

Chlorophyll content, photosynthetic rate, stomatal conductance, and transpiration rate improved significantly with GA_3 treatment, peaking at 100 ppm. The highest chlorophyll content (47.3 ± 1.5 SPAD) and photosynthetic rate (16.8 ± 0.7 $\mu mol\ CO_2\ m^{-2}\ s^{-1}$) were observed under 100 ppm. Transpiration and stomatal conductance also showed maximum values in this treatment, aligning with findings of Chandel et al. [10] who reported enhanced photosynthetic traits under moderate GA_3 doses.

Table 2. Effect of GA_3 on physiological traits of cabbage (mean ± SE)

Treatment	Chlorophyll (SPAD)	Photosynthesis (μmol CO_2 m^{-2} s^{-1})	Stomatal Conductance (mol H_2O m^{-2} s^{-1})	Transpiration (mmol H_2O m^{-2} s^{-1})
T_0	37.5 ± 1.3 c	13.4 ± 0.6 c	0.22 ± 0.01 c	4.8 ± 0.2 c
T_1	42.1 ± 1.4 b	15.1 ± 0.5 b	0.26 ± 0.02 b	5.6 ± 0.3 b
T_2	47.3 ± 1.5 a	16.8 ± 0.7 a	0.31 ± 0.01 a	6.4 ± 0.3 a
T_3	45.2 ± 1.2 ab	16.2 ± 0.6 ab	0.29 ± 0.02 ab	6.0 ± 0.2 ab

Biomass Accumulation

Fresh and dry weights of cabbage leaves and total biomass were significantly enhanced with GA_3 application. The 100 ppm treatment led to maximum fresh weight (450 ± 18.4 g), dry weight (48.2 ± 2.1 g), and total biomass (498.2 ± 19.3 g), which were significantly higher than control and 50 ppm treatments. This improvement could be due to increased photosynthate allocation and leaf expansion under GA_3 influence [11].

Table 3. Effect of GA_3 on biomass accumulation in cabbage (mean ± SE)

Treatment	Fresh Weight (g)	Dry Weight (g)	Total Biomass (g $plant^{-1}$)
T_0	310 ± 16.2 c	32.1 ± 1.6 c	342.1 ± 17.3 c
T_1	390 ± 17.8 b	41.3 ± 1.9 b	431.3 ± 18.7 b
T_2	450 ± 18.4 a	48.2 ± 2.1 a	498.2 ± 19.3 a
T_3	438 ± 17.9 ab	45.6 ± 2.0 ab	483.6 ± 19.0 ab

Nutrient Uptake

Foliar application of GA_3 significantly influenced N, P, and K uptake in cabbage plants. The highest nutrient uptake was found in the 100 ppm treatment, with nitrogen at 2.42 ± 0.09%, phosphorus at 0.42 ± 0.02%, and potassium at 3.15 ± 0.12%. Enhanced root activity and nutrient translocation due to hormonal regulation likely contributed to this response.

Table 4. Effect of GA_3 on nutrient uptake of cabbage (mean ± SE)

Treatment	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_0	1.98 ± 0.07 c	0.31 ± 0.01 c	2.45 ± 0.10 c
T_1	2.22 ± 0.08 b	0.37 ± 0.01 b	2.84 ± 0.11 b
T_2	2.42 ± 0.09 a	0.42 ± 0.02 a	3.15 ± 0.12 a
T_3	2.35 ± 0.08 ab	0.39 ± 0.01 ab	3.06 ± 0.11 ab

Conclusion

The results of this study clearly demonstrate that foliar application of gibberellic acid (GA_3) can significantly improve the growth, physiological performance, biomass accumulation, and nutrient uptake of cabbage. Among the tested concentrations, 100 ppm GA_3 proved to be the most effective, yielding the highest plant height, leaf area, chlorophyll content, photosynthetic rate, and mineral uptake (N, P, and K). These improvements suggest enhanced photosynthetic efficiency and nutrient mobilization under moderate GA_3 levels. However, increasing the concentration to 150 ppm did not yield further benefits and in some cases resulted in slight reductions, indicating that higher doses may surpass the plant's hormonal threshold. Therefore, a 100 ppm GA_3 foliar spray can be recommended as an optimal treatment for boosting cabbage productivity and nutrient use efficiency under controlled conditions. This approach may contribute to sustainable horticultural practices by reducing reliance on excessive fertilizers while enhancing crop performance.

References

1. Chuan L, Zheng H, Sun S, Wang A, Liu J, Zhao T, Zhao J. A sustainable way of fertilizer recommendation based on yield response and agronomic efficiency for Chinese cabbage. *Sustainability.* 2019;11(16):4368.
2. Pradeepkumar CM, Chandrashekar SY, Kavana GB, Supriya BV. A review on role and use of gibberellic acid (GA_3) in flower production. *Int J Chem Stud.* 2020;8(1):3076-3084.
3. Castro-Camba R, Sánchez C, Vidal N, Vielba JM. Plant development and crop yield: the role of gibberellins. *Plants.* 2022;11(19):2650.
4. Muniandi SKM, Hossain MA, Abdullah MP, Ab Shukor NA. Gibberellic acid (GA_3) affects growth and development of some selected kenaf (*Hibiscus cannabinus* L.) cultivars. *Ind Crops Prod.* 2018;118:180-187.
5. Shah SH, Islam S, Mohammad F, Siddiqui MH. Gibberellic acid: a versatile regulator of plant growth, development and stress responses. *J Plant Growth Regul.* 2023;42(12):7352-7373.
6. Bagale P, Pandey S, Regmi P, Bhusal S. Role of plant growth regulator "Gibberellins" in vegetable production: an overview. *Int J Hortic Sci Technol.* 2022;9(3):291-299.
7. Ritonga FN, Zhou D, Zhang Y, Song R, Li C, Li J, Gao J. The roles of gibberellins in regulating leaf development. *Plants.* 2023;12(6):1243.
8. Islam MS, Hasan MK, Islam MR, Chowdhury MK, Pramanik MH, Iqbal MA, Rajendran K, Iqbal R, Soufan W, Kamran M, Liyun L. Water relations and yield characteristics of mungbean as influenced by foliar application of gibberellic acid (GA_3). *Front Ecol Evol.* 2023;11:1048768.
9. Xu Q, Krishnan S, Merewitz E, Xu J, Huang B. Gibberellin-regulation and genetic variations in leaf elongation for tall fescue in association with differential gene expression controlling cell expansion. *Sci Rep.* 2016;6(1):30258.
10. Chandel A, Thakur M, Rakwal A, Chauhan S, Bhargava B. Exogenous applications of gibberellic acid modulate the growth, flowering and longevity of calla lily. *Heliyon.* 2023;9(5).
11. Miceli A, Moncada A, Sabatino L, Vetrano F. Effect of gibberellic acid on growth, yield, and quality of leaf lettuce and rocket grown in a floating system. *Agronomy.* 2019;9(7):382.