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INFLUENCE OF LIQUID NUTRITION AND FOLIAR APPLICATION OF GROWTH SUBSTANCES ON SUCKER GROWTH PARAMETERS OF SMALL CARDAMOM (*ELETTARIA CARDAMOMUM* MATON) CV. NJALLANI GREEN GOLD

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ABSTRACT

The present investigation was carried out at the Zonal Agricultural and Horticultural Research Station, Mudigere, from October 2024 to January 2025 to evaluate the effect of liquid nutrition and foliar growth substances on the growth and quality sucker production of small cardamom (*Elettaria cardamomum* Maton) cv. Njallani Green Gold. The experiment was laid out in a Factorial Randomized Complete Block Design with three replications, comprising three levels of liquid nutrition (N₀, N₁ and N₂) and six growth substances (G₁–G₆). Liquid nutrition was applied through drenching and growth regulators were administered as foliar sprays at bimonthly intervals. Significant variations were observed among treatments for all growth traits of suckers both at 60 and 120 DAT. The combined application of Urea (1 %) + DAP (1.5 %) + MOP (1 %) with GA₃ @ 250 ppm (T₁₇) recorded maximum pseudostem height (3.63 m), number of leaves per tiller (20.97), leaves per clump (255.49), leaf length (65.33 cm), leaf breadth (12.79 cm), leaf area (16.01 m²) and leaf area index (4.79) at 120 DAT. Similarly, at 120 DAT the combination of Urea (1 %) + DAP (1.5 %) + MOP (1 %) with benzyl adenine @ 250 ppm (T₁₆) recorded the highest pseudostem girth (9.00 cm). Whereas, the highest number of new suckers (10.86) and number of suckers per clump (48.33) were recorded in Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Humic acid @ 0.5 % (T₁₃). The treatment T₁₄ [Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Sea weed extract @ 0.5%] recorded the highest biochemical parameters [chlorophyll-a (1.64 mg g⁻¹), chlorophyll-b (0.64 mg g⁻¹) and total chlorophyll content (2.38 mg g⁻¹)] at 120 DAT. Overall, the results demonstrate that integrating liquid NPK nutrition with plant growth substances significantly improves vegetative growth, vigor and quality sucker production.

Keywords: Liquid nutrition, foliar application, Plant growth substances, Sucker production and Njallani Green Gold.

Introduction

Small cardamom (*Elettaria cardamomum* Maton), popularly known as the “Queen of Spices,” is valued for its pleasant aroma, flavor and medicinal properties. Originating from the Western Ghats of Southern India,

it is extensively used in food, beverages, perfumery and traditional medicine for its antioxidant, antimicrobial and digestive benefits (Padmakar *et al.*, 2023).

India is the second largest producer of small cardamom after Guatemala, with major cultivation in Kerala, Karnataka and Tamil Nadu. The small cardamom is a shallow-rooted, perennial crop that demands high soil fertility and adequate shade and moisture for optimal growth. The cultivar 'Njallani Green Gold', a Vazhukka type, is renowned for its vigorous growth and high yield potential under intensive systems.

Efficient sucker production is critical for large-scale propagation and area expansion. However, conventional nutrient delivery through soil application often results in nutrient loss due to leaching and fixation, especially in high-rainfall zones. Liquid nutrition through drenching offers a rapid and efficient means of supplying nutrients directly to the root zone, improving root development and plant vigor by better nutrient uptake. Similarly, foliar application of bio-stimulants and plant growth regulators (PGRs) enhances physiological functions, promotes chlorophyll synthesis and accelerates sucker emergence through improved nutrient assimilation and hormonal balance. Although studies in other crops highlight the benefits of these inputs, however, limited research exists on their combined influence on growth of suckers in small cardamom. Hence, the present study was undertaken to evaluate the effect of liquid nutrition and foliar application of growth substances on the growth and production of quality suckers in small cardamom cv. Njallani Green Gold.

Material and Methods

The field experiment was conducted in Zonal Agricultural and Horticultural Research Station,

Mudigere October 2024 to January 2025 to using one-year-old suckers vazukka cv. Njallani Green Gold, planted under *Gliricidia* shade at a spacing of 6 × 6 ft. The study was laid out in a Factorial Randomized Complete Block Design (FRCBD) with three replications, comprising of liquid nutrition and growth substances.

Liquid nutrition treatments included three levels: N₀: RDF @ 48:48:96 g per plant (Control), N₁: Urea (0.5 %) + DAP (1 %) + MOP (0.5 %) and N₂: Urea (1 %) + DAP (1.5 %) + MOP (1 %). The respective nutrient quantities were dissolved in water and drenched at 2 L per clump thrice at bimonthly intervals.

Growth substance treatments included six levels: G₁: Humic acid (0.5 %), G₂: Seaweed extract (0.5 %), G₃: Triacantanol (0.5 %), G₄: Benzyl adenine (250 ppm), G₅: Gibberellic acid (250 ppm) and G₆: Cycocel (1000 ppm). Each growth substances solution was prepared to and foliar sprayed at 0.5 L per clump thrice at bimonthly intervals.

Observations were recorded on five randomly tagged clumps per treatment. Growth parameters such as pseudostem height, girth, number of suckers and leaves, leaf area and leaf area index were measured at 60 and 120 days after treatment (DAT). Chlorophyll content (chlorophyll a, b and total) was estimated using the DMSO method (Shoaf and Lium, 1976).

The experimental data were subjected to statistical analysis following the procedure of Gomez and Gomez (1984) to test the significance of treatment effects and critical difference (CD) at 5 % was used for mean comparison.

Results and Discussion

Table 1: Effect of liquid nutrition and growth substances on suckers growth parameters of cv. Njallani Green Gold

Treatments	Pseudostem height (m)		Pseudostem girth (cm)	
	60 DAT	120 DAT	60 DAT	120 DAT
Liquid nutrition (N)				
N ₀ : RDF - 48:48:96 g per plant (Control)	1.68	2.64	6.91	7.18
N ₁ : Urea (0.5 %) + DAP (1 %) + MOP (0.5 %)	2.01	2.76	6.53	8.24
N ₂ : Urea (1 %) + DAP (1.5 %) + MOP (1 %)	2.22	2.87	7.56	8.28
S.Em±	0.05	0.04	0.08	0.12
CD @ 5 %	0.14	0.13	0.23	0.33
Growth Substances (G)				
G ₁ : Humic acid @ 0.5 %	1.77	2.66	6.69	7.53
G ₂ : Sea weed extract @ 0.5 %	1.82	2.68	6.35	7.54
G ₃ : Triacantanol @ 0.5 %	1.89	2.84	7.22	8.05
G ₄ : Benzyl adenine @ 250 ppm	1.91	2.74	7.33	8.16

G₅ : Gibberellic acid @ 250 ppm	2.43	3.06	7.21	8.09
G₆ : Cycocel @ 1000 ppm	1.99	2.55	7.19	8.04
S.Em±	0.07	0.06	0.11	0.16
CD @ 5 %	0.20	0.18	0.33	0.47
Interaction (N × G)				
T₁: N₀G₁	1.51	2.71	6.81	6.83
T₂: N₀G₂	1.55	2.57	6.17	6.50
T₃: N₀G₃	1.67	2.86	7.32	7.36
T₄: N₀G₄	1.80	2.68	6.92	7.13
T₅: N₀G₅	1.72	2.57	6.37	7.33
T₆: N₀G₆	1.82	2.45	7.90	7.95
T₇: N₁G₁	1.87	2.73	6.07	7.73
T₈: N₁G₂	1.82	2.85	6.52	8.00
T₉: N₁G₃	1.92	2.48	6.72	8.13
T₁₀: N₁G₄	1.84	2.89	6.48	8.33
T₁₁: N₁G₅	2.64	2.98	7.40	8.53
T₁₂: N₁G₆	1.97	2.63	5.97	8.73
T₁₃: N₂G₁	1.94	2.55	7.20	8.03
T₁₄: N₂G₂	2.08	2.63	6.37	8.13
T₁₅: N₂G₃	2.06	3.17	7.62	8.67
T₁₆: N₂G₄	2.10	2.65	8.60	9.00
T₁₇: N₂G₅	2.94	3.63	7.86	8.40
T₁₈: N₂G₆	2.19	2.57	7.71	7.43
S.Em±	0.12	0.11	0.20	0.28
CD @ 5 %	0.34	0.31	0.57	0.81

The data recorded on suckers growth parameters of small cardamom clumps treated with liquid nutrition and growth substances are presented in Table 1. The clumps treated with Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Gibberellic acid @ 250 ppm (T₁₇) recorded the highest pseudostem height (2.94 and 3.63 m) at 60 and 120 DAT, respectively. This might be due to timely supply of balanced nutrients through liquid nutrition, ensuring better availability and uptake by the roots. Nitrogen, being a major component of proteins, nucleic acids and chlorophyll, promotes cell division, elongation and overall vegetative growth. Application of GA₃ enhanced vegetative growth by promoting cell division, elongation and auxin metabolism, It improved shoot growth by enhancing cell wall extensibility and tissue development. Similar results were obtained by Divyabharathi *et al.* (2023) in small cardamom with combined application of macro and micronutrients and Kharde *et al.* (2023) with NPK application; In ginger by Nayak *et al.* (2020) with 30 per cent of RDF (NPK)

as foliar spray; Manjunatha *et al.* (2023) with 200 per cent RDF through fertigation; Aswani *et al.* (2025) with 150 per cent of RDF; In turmeric by Sadarunnisa *et al.* (2010).

The pseudostem girth (8.60 and 9.00 cm) was recorded maximum in Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Benzyl Adenine @ 250 ppm (T₁₆) at 60 and 120 DAT, respectively [Table 1]. The increase in pseudostem girth might be due to better utilization of dissolved nutrients ensured efficient uptake of nitrogen, a key component of chlorophyll and proteins, enhancing photosynthetic efficiency. Benzyl adenine, a potent cytokinin, promotes shoot elongation contributing to improved plant growth. The results of the present study are in agreement with Kharde *et al.* (2023) due to potassium levels in small cardamom; Nayak *et al.* (2020) with 30 per cent of RDF (NPK) as foliar spray in ginger; Ahmed *et al.* (2022) in fennel; Abdel-Hamid, (2020) in sweet basil and Liu *et al.* (2018) in Indian sandalwood.

Table 2 : Effect of liquid nutrition and growth substances on number of leaves of small cardamom suckers cv. Njallani Green Gold

Treatments	Number of leaves per tiller		Number of leaves per clump	
	60 DAT	120 DAT	60 DAT	120 DAT
Liquid nutrition (N)				
N ₀ : RDF - 48:48:96 g per plant (Control)	11.24	12.54	126.91	180.50
N ₁ : Urea (0.5 %) + DAP (1 %) + MOP (0.5 %)	11.01	13.11	127.83	170.83
N ₂ : Urea (1 %) + DAP (1.5 %) + MOP (1 %)	12.02	15.04	137.55	195.80
S.Em±	0.13	0.24	2.56	3.69
CD @ 5 %	0.38	0.69	7.36	10.60
Growth Substances (G)				
G ₁ : Humic acid @ 0.5 %	11.01	12.83	129.63	187.22
G ₂ : Sea weed extract @ 0.5 %	10.75	13.35	127.08	170.41
G ₃ : Triacontanol @ 0.5 %	11.75	12.80	144.56	189.78
G ₄ : Benzyl adenine @ 250 ppm	11.09	13.51	107.00	194.22
G ₅ : Gibberellic acid @ 250 ppm	12.44	15.98	157.25	195.53
G ₆ : Cycocel @ 1000 ppm	11.50	12.93	119.08	157.11
S.Em±	0.19	0.34	3.62	5.22
CD @ 5 %	0.54	0.97	10.41	15.00
Interaction (N × G)				
T ₁ : N ₀ G ₁	10.59	11.81	121.33	197.22
T ₂ : N ₀ G ₂	10.90	11.26	127.56	167.22
T ₃ : N ₀ G ₃	11.44	12.63	123.45	175.22
T ₄ : N ₀ G ₄	11.15	12.52	131.56	187.22
T ₅ : N ₀ G ₅	10.55	13.56	131.11	194.56
T ₆ : N ₀ G ₆	12.82	13.48	126.45	161.56
T ₇ : N ₁ G ₁	11.11	11.29	128.22	155.89
T ₈ : N ₁ G ₂	9.79	14.52	121.22	206.67
T ₉ : N ₁ G ₃	12.79	13.15	154.44	191.78
T ₁₀ : N ₁ G ₄	10.67	12.59	109.22	180.22
T ₁₁ : N ₁ G ₅	11.34	13.41	136.11	136.56
T ₁₂ : N ₁ G ₆	10.36	13.67	117.78	153.89
T ₁₃ : N ₂ G ₁	11.33	15.37	139.33	208.56
T ₁₄ : N ₂ G ₂	11.57	14.26	132.45	137.33
T ₁₅ : N ₂ G ₃	11.01	12.63	155.78	202.33
T ₁₆ : N ₂ G ₄	11.45	15.41	80.22	215.22
T ₁₇ : N ₂ G ₅	15.43	20.97	204.52	255.49
T ₁₈ : N ₂ G ₆	11.32	11.63	113.00	155.89
S.Em±	0.33	0.59	6.28	9.04
CD @ 5 %	0.94	1.68	18.04	25.97

The number of leaves of small cardamom suckers of cv. Njallani Green Gold, due to application of liquid nutrition and growth substances are presented in Table 2. The number of leaves per tiller (15.43 and 20.97) and number of leaves per clump (204.52 and 255.49) was found to be maximum in the clumps treated with Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Gibberellic acid @ 250 ppm (T₁₇) at 60 and 120 DAT, respectively. The increase in the number of leaves may be attributed to balanced nutrient availability in the root zone along with the growth-promoting effect of GA₃. Adequate nitrogen, phosphorus and potassium

enhanced photosynthetic activity, leading to higher assimilate production. GA₃ stimulated rapid vegetative development, improving the plant's capacity to capture sunlight efficiently. Together, these factors resulted in the production of more leaves per tiller and per clump. The present findings are in agreement with Divyabharathi *et al.* (2023) with application of macronutrients and Kharde *et al.* (2023) with NPK application in small cardamom; Ajithkumar and Jayachandran (2001) with NPK fertilizers in ginger; Venugopal and Pariari (2019) in turmeric; In kokum, Deshmukh *et al.* (2023).

Table 3 : Effect of liquid nutrition and growth substances on leaf parameters of small cardamom suckers of cv. Njallani Green Gold

Treatments	Leaf length (cm)		Leaf breadth (cm)		Leaf area per plant (m ²)		Leaf area index	
	60 DAT	120 DAT	60 DAT	120 DAT	60 DAT	120 DAT	60 DAT	120 DAT
Liquid nutrition (N)								
N ₀ : RDF - 48:48:96 g per plant (Control)	43.08	51.93	9.03	10.20	3.71	7.16	1.11	2.14
N ₁ : Urea (0.5 %) + DAP (1 %) + MOP (0.5 %)	45.81	54.16	9.82	10.89	4.30	7.50	1.29	2.24
N ₂ : Urea (1 %) + DAP (1.5 %) + MOP (1 %)	46.90	54.46	10.30	11.26	5.18	9.21	1.55	2.75
S.Em±	0.85	0.76	0.07	0.19	0.11	0.26	0.03	0.08
CD @ 5 %	2.43	2.19	0.19	0.55	0.32	0.76	0.10	0.23
Growth Substances (G)								
G ₁ : Humic acid @ 0.5 %	45.25	50.14	9.29	10.82	4.12	7.59	1.23	2.27
G ₂ : Sea weed extract @ 0.5 %	44.99	53.82	9.48	10.39	4.08	7.14	1.22	2.13
G ₃ : Triacontanol @ 0.5 %	45.30	48.84	9.49	10.74	4.68	7.46	1.40	2.23
G ₄ : Benzyl adenine @ 250 ppm	43.96	54.59	9.69	10.67	3.37	8.47	1.01	2.53
G ₅ : Gibberellic acid @ 250 ppm	48.93	57.56	10.45	11.69	6.33	10.20	1.89	3.05
G ₆ : Cycocel @ 1000 ppm	43.15	56.15	9.90	10.36	3.80	6.86	1.14	2.05
S.Em±	1.20	1.08	0.09	0.27	0.16	0.37	0.05	0.11
CD @ 5 %	3.44	3.09	0.27	0.77	0.45	1.08	0.13	0.32
Interaction (N × G)								
T ₁ : N ₀ G ₁	40.59	51.11	8.29	9.20	3.06	6.96	0.92	2.08
T ₂ : N ₀ G ₂	41.63	55.16	9.05	9.88	3.61	6.86	1.08	2.05
T ₃ : N ₀ G ₃	47.39	48.18	8.55	10.87	3.76	6.88	1.12	2.06
T ₄ : N ₀ G ₄	43.06	50.15	9.04	11.13	3.84	7.83	1.15	2.34
T ₅ : N ₀ G ₅	44.10	53.17	10.22	10.32	4.43	7.98	1.33	2.39
T ₆ : N ₀ G ₆	41.69	53.83	9.01	9.78	3.56	6.45	1.06	1.93
T ₇ : N ₁ G ₁	49.60	50.18	10.98	11.29	5.24	6.62	1.57	1.98
T ₈ : N ₁ G ₂	47.10	55.84	8.21	10.02	3.52	8.69	1.05	2.60
T ₉ : N ₁ G ₃	42.56	52.16	9.84	10.79	4.86	8.09	1.45	2.42
T ₁₀ : N ₁ G ₄	41.79	54.48	10.60	11.01	3.62	8.10	1.08	2.42
T ₁₁ : N ₁ G ₅	47.26	54.18	9.22	11.95	4.44	6.61	1.33	1.98
T ₁₂ : N ₁ G ₆	46.57	58.13	10.07	10.21	4.14	6.86	1.24	2.05
T ₁₃ : N ₂ G ₁	45.56	49.14	8.61	11.96	4.08	9.20	1.22	2.75
T ₁₄ : N ₂ G ₂	46.23	50.46	11.19	11.28	5.11	5.87	1.53	1.75
T ₁₅ : N ₂ G ₃	45.95	46.18	10.07	10.56	5.43	7.40	1.62	2.21
T ₁₆ : N ₂ G ₄	47.05	59.14	9.42	9.86	2.65	9.48	0.79	2.83
T ₁₇ : N ₂ G ₅	55.42	65.33	11.91	12.79	10.13	16.01	3.03	4.79
T ₁₈ : N ₂ G ₆	41.18	56.50	10.61	11.08	3.70	7.28	1.11	2.18
S.Em±	2.07	1.86	0.16	0.47	0.27	0.65	0.08	0.19
CD @ 5 %	5.95	5.35	0.46	1.34	0.78	1.86	0.23	0.56

Leaf parameters as influenced by application of liquid nutrition and growth substances are presented in Table 3. The maximum leaf length (55.42 and 65.33 cm), leaf breadth (11.91 and 12.79 cm), leaf area per clump (10.13 and 16.01 m²) and leaf area index (3.03 and 4.79) was recorded in T₁₇ [Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Gibberellic acid @ 250 ppm] at 60 and 120 DAT, respectively. This might be due to the synergistic effect of liquid NPK nutrition and GA₃, which enhanced leaf length, breadth and the number of leaves per clump. Frequent liquid nutrient application improved root proliferation and nutrient uptake by continuously replenishing nutrients in the root

depletion zone. This efficient nutrient supply, along with GA₃ induced cell division and cell wall extensibility, promoted vigorous leaf expansion. Consequently, the combined action of nutrients and GA₃ resulted in higher leaf area and an overall increase in leaf area index. These results follow findings of Divyabharathi *et al.* (2023) with application of macronutrients in small cardamom; Ajithkumar and Jayachandran (2001); Manjunatha *et al.* (2023); Aswani *et al.* (2025) and Nayak *et al.* (2020) in ginger; Gawande *et al.* (2020) and Nikam *et al.* (2020) in turmeric.

Table 4 : Effect of liquid nutrition and growth substances on sucker parameters of cv. Njallani Green Gold

Treatments	Number of new suckers emerged		Number of suckers per clump	
	60 DAT	120 DAT	60 DAT	120 DAT
Liquid nutrition (N)				
N ₀ : RDF - 48:48:96 g per plant (Control)	6.50	3.82	30.55	34.36
N ₁ : Urea (0.5 %) + DAP (1 %) + MOP (0.5 %)	7.36	3.57	31.46	35.03
N ₂ : Urea (1 %) + DAP (1.5 %) + MOP (1 %)	7.70	5.37	32.36	37.73
S.Em±	0.10	0.18	0.49	0.54
CD @ 5 %	0.28	0.53	1.40	1.56
Growth Substances (G)				
G ₁ : Humic acid @ 0.5 %	8.28	5.99	33.52	39.51
G ₂ : Sea weed extract @ 0.5 %	7.32	3.89	31.21	35.09
G ₃ : Triacontanol @ 0.5 %	7.06	3.96	31.95	35.92
G ₄ : Benzyl adenine @ 250 ppm	5.57	4.67	28.72	33.38
G ₅ : Gibberellic acid @ 250 ppm	8.23	3.85	32.51	36.36
G ₆ : Cycocel @ 1000 ppm	6.65	3.15	30.84	33.99
S.Em±	0.14	0.26	0.69	0.77
CD @ 5 %	0.39	0.75	1.98	2.21
Interaction (N ×G)				
T ₁ : N ₀ G ₁	6.37	4.22	31.85	36.07
T ₂ : N ₀ G ₂	6.69	3.56	29.43	32.98
T ₃ : N ₀ G ₃	4.85	3.00	30.36	33.36
T ₄ : N ₀ G ₄	5.24	4.78	27.82	32.60
T ₅ : N ₀ G ₅	8.76	3.78	32.30	36.08
T ₆ : N ₀ G ₆	7.08	3.55	31.53	35.08
T ₇ : N ₁ G ₁	8.66	2.89	31.23	34.12
T ₈ : N ₁ G ₂	6.96	4.56	31.37	35.92
T ₉ : N ₁ G ₃	8.46	3.67	32.17	35.84
T ₁₀ : N ₁ G ₄	4.82	5.00	28.49	33.49
T ₁₁ : N ₁ G ₅	7.58	2.33	32.27	34.61
T ₁₂ : N ₁ G ₆	7.66	3.00	33.22	36.23
T ₁₃ : N ₂ G ₁	9.83	10.86	37.47	48.33
T ₁₄ : N ₂ G ₂	8.32	3.55	32.83	36.38
T ₁₅ : N ₂ G ₃	7.86	5.22	33.33	38.55
T ₁₆ : N ₂ G ₄	6.66	4.22	29.84	34.06
T ₁₇ : N ₂ G ₅	8.34	5.45	32.96	38.40
T ₁₈ : N ₂ G ₆	5.22	2.89	27.77	30.66
S.Em±	0.24	0.45	1.20	1.33
CD @ 5 %	0.68	1.29	3.44	3.83

The data recorded on sucker parameters of indicated that, the clumps (Table 4) treated with Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Humic acid @ 0.5 % (T₁₃) recorded the highest number of new suckers emerged (9.83 and 10.86) and total number of suckers per clump (37.47 and 48.33) at 60 and 120 DAT, respectively. This might be due to higher nitrogen through liquid nutrition enhanced vegetative growth by improving nutrient uptake and metabolic

activity, promoting carbohydrate synthesis and translocation. Humic acid promotes plant growth by exhibiting gibberellin and auxin like activity, leading to increased suckering and root development. Similar results were obtained by Thimmarayappa *et al.* (2000) and Kharde *et al.* (2023) in small cardamom; In ginger, Nayak *et al.* (2020) and Aswani *et al.* (2025); Parikh *et al.* (2023) with humic acid in turmeric.

Table 5 : Effect of liquid nutrition and growth substances on biochemical parameters of cv. Njallani Green Gold

Treatments	Chlorophyll-a (mg/g)		Chlorophyll-b (mg/g)		Total chlorophyll content (mg/g)	
	60 DAT	120 DAT	60 DAT	120 DAT	60 DAT	120 DAT
Liquid nutrition (N)						
N ₀ : RDF - 48:48:96 g per plant (Control)	0.95	1.14	0.21	0.27	1.13	1.32
N ₁ : Urea (0.5 %) + DAP (1 %) + MOP (0.5 %)	0.93	1.08	0.21	0.29	1.21	1.39
N ₂ : Urea (1 %) + DAP (1.5 %) + MOP (1 %)	1.05	1.20	0.25	0.38	1.41	1.52
S.Em±	0.02	0.02	0.01	0.01	0.02	0.02
CD @ 5 %	0.06	0.07	0.03	0.03	0.06	0.06
Growth Substances (G)						
G ₁ : Humic acid @ 0.5 %	0.93	1.11	0.20	0.28	1.21	1.38
G ₂ : Sea weed extract @ 0.5 %	1.11	1.29	0.26	0.34	1.44	1.63
G ₃ : Triacontanol @ 0.5 %	0.99	1.17	0.19	0.32	1.23	1.40
G ₄ : Benzyl adenine @ 250 ppm	0.95	1.07	0.22	0.28	1.14	1.25
G ₅ : Gibberellic acid @ 250 ppm	0.98	1.14	0.22	0.32	1.36	1.60
G ₆ : Cycocel @ 1000 ppm	0.90	1.06	0.25	0.32	1.11	1.19
S.Em±	0.03	0.03	0.01	0.01	0.03	0.03
CD @ 5 %	0.08	0.09	0.04	0.04	0.09	0.08
Interaction (N xG)						
T ₁ : N ₀ G ₁	0.74	1.10	0.14	0.16	0.93	1.22
T ₂ : N ₀ G ₂	1.05	1.18	0.16	0.15	1.08	1.24
T ₃ : N ₀ G ₃	0.83	1.13	0.15	0.27	1.03	1.33
T ₄ : N ₀ G ₄	1.04	1.09	0.25	0.35	1.15	1.37
T ₅ : N ₀ G ₅	0.87	1.11	0.29	0.32	1.17	1.34
T ₆ : N ₀ G ₆	1.18	1.21	0.29	0.36	1.43	1.43
T ₇ : N ₁ G ₁	0.97	1.08	0.15	0.34	1.14	1.32
T ₈ : N ₁ G ₂	0.85	1.05	0.19	0.24	1.22	1.28
T ₉ : N ₁ G ₃	1.01	1.21	0.24	0.35	1.26	1.42
T ₁₀ : N ₁ G ₄	0.96	1.09	0.19	0.24	1.11	1.22
T ₁₁ : N ₁ G ₅	0.86	1.03	0.13	0.19	1.44	1.94
T ₁₂ : N ₁ G ₆	0.91	1.01	0.34	0.35	1.09	1.17
T ₁₃ : N ₂ G ₁	1.09	1.16	0.32	0.34	1.56	1.61
T ₁₄ : N ₂ G ₂	1.44	1.64	0.43	0.64	2.03	2.38
T ₁₅ : N ₂ G ₃	1.13	1.16	0.19	0.35	1.40	1.44
T ₁₆ : N ₂ G ₄	0.84	1.02	0.20	0.24	1.17	1.18
T ₁₇ : N ₂ G ₅	1.21	1.27	0.25	0.44	1.48	1.52
T ₁₈ : N ₂ G ₆	0.62	0.94	0.13	0.25	0.82	0.98
S.Em±	0.05	0.06	0.03	0.02	0.05	0.05
CD @ 5 %	0.14	0.16	0.08	0.06	0.15	0.14

The effect of liquid nutrition and growth substances on biochemical parameters is presented in Table 5. The maximum chlorophyll-a (1.44 and 1.64 mg g⁻¹), chlorophyll-b (0.43 and 0.64 mg g⁻¹) and total chlorophyll content (2.03 and 2.38 mg g⁻¹) was recorded in T₁₄ [Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Sea weed extract @ 0.5%] at 60 and 120 DAT, respectively. This might be due to balanced nutrient availability in the root zone which enhanced the nutrient uptake efficiency, supporting better metabolic activity. This promoted increased synthesis of chlorophyll content. The amino acids present in sea weed enhanced protein synthesis, supporting vital metabolic activities. This, in turn, led to increased production of photosynthetic pigment chlorophyll.

Similar conclusions were drawn by Divyabharathi *et al.* (2023) with macronutrients in small cardamom; Nayak *et al.* (2020) with 30 per cent RDF as foliar spray in ginger; Krishnamoorthy *et al.* (2013) with 125 per cent RDF as water soluble fertilizers in cocoa; Keerthishankar *et al.* (2019) and Fahl *et al.* (2014) with nitrogen supply in coffee.

Conclusion

The results of present investigation indicated that cardamom clumps treated with combined application of liquid nutrition and growth substances [Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Gibberellic acid @ 250 ppm: T₁₇] resulted in better performance with respect to pseudostem height, number of leaves per tiller,

number of leaves per clump, leaf length, leaf breadth, leaf area per plant and leaf area index. While, the clumps applied with liquid nutrition consisting of Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Humic acid @ 0.5 % [T₁₃] resulted in maximum number of new suckers emerged and number of suckers per clump. Whereas, the pseudostem girth was recorded maximum

in the clumps treated with Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Benzyl adenine @ 250 ppm (T₁₆).

With respect to the biochemical parameters (Chlorophyll-a, chlorophyll-b and total chlorophyll content) better performance was observed in the clumps supplied with Urea (1 %) + DAP (1.5 %) + MOP (1 %) + Sea weed extract @ 0.5 % [T₁₄].



Plate 1 : Close up view of clump and suckers of best treatment (T₁₇) for growth parameters

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