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Effect of Nano urea fertilization and growing media on vegetative growth and quality attributes of *Philodendron scandens*

¹Palupunuri Vidyasree, ²Veenajoshi, ³N Seenivasan, ⁴P Gouthami and ⁵G Sathish

¹Post Graduate Student, College of Horticulture, Mojerla, Sri Konda Laxman Telangana State Horticultural University, Wanaparthy, Telangana, India

²Associate Professor of Horticulture, College of Horticulture, Mojerla, Sri Konda Laxman Telangana State Horticultural University, Wanaparthy, Telangana, India

³Professor of Horticulture, College of Horticulture, Mulugu, Sri Konda Laxman Telangana State Horticultural University, Siddipet, Telangana, India

⁴Assistant Professor of Crop Physiology, College of Horticulture, Mojerla, Sri Konda Laxman Telangana State Horticultural University, Wanaparthy, Telangana, India

⁵Assistant Professor of Agricultural Statistics, College of Horticulture, Mojerla, Sri Konda Laxman Telangana State Horticultural University, Wanaparthy, Telangana, India

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Corresponding Author: Palupunuri Vidyasree

Abstract

The study “Standardization of Nano Urea and Composition of Potting Media on Growth and Quality of *Philodendron scandens*” was conducted at the PG Research Block, College of Horticulture, Mojerla, SKLTSHU, during December 2021 to May 2022. A factorial randomized block design (FRBD) with two factors; six levels of nitrogen (N₀: control, N₁: conventional urea 2 g L⁻¹, N₂-N₅: Nano urea 0.5-2.0 ml L⁻¹) and four potting media compositions (M₁: Red Earth, M₂: Red Earth + Cocopeat 1:1, M₃: Red Earth + Cocopeat + FYM 1:1:1, M₄: Red Earth + Cocopeat + FYM 2:1:1) was used. Observations on growth, phenology, physiological, biochemical, and quality parameters were recorded. Results revealed that Nano urea at 2 ml L⁻¹ (N₅) significantly enhanced plant height, leaf number, leaf area, chlorophyll content, relative water content, ascorbic acid, leaf pH, and air pollution tolerance index (APTI). Among potting media, M₃ (Red Earth + Cocopeat + FYM, 1:1:1) produced the tallest plants, highest leaf number, and rapid bud sprouting due to improved water retention, aeration, and nutrient availability. The interaction of N₅ × M₃ consistently resulted in maximum vegetative growth and physiological efficiency. The study concludes that foliar application of Nano urea at 2 ml L⁻¹ combined with an enriched potting media of Red Earth, Cocopeat, and FYM (1:1:1) is optimal for sustainable production of *Philodendron scandens*, improving both ornamental quality and air pollution tolerance.

Keywords: *Philodendron scandens*, Nano urea, potting media, growth, chlorophyll, air pollution tolerance index

Introduction

Rapid industrialization and urbanization have resulted in a large-scale migration of population from rural to urban areas, leading to congested cities where people spend nearly 80-90% of their time indoors (USEPA, 2001). Indoor air quality is often inferior to outdoor air due to the accumulation of volatile organic compounds (VOCs) emitted from carpets, furniture, paints, wood panels, and cooking activities (Carpenter, 1998) [10]. According to the United States Environmental Protection Agency (USEPA), indoor pollutant levels may be up to 100 times higher than outdoor levels, posing serious health risks (USEPA, 2001). Prolonged exposure to indoor pollutants such as benzene, formaldehyde, and trichloroethylene has been associated with “Sick Building Syndrome,” characterized by symptoms such as headache, dizziness, nausea, eye irritation, and reduced concentration (Brasche *et al.*, 1999; Carrer *et al.*, 1999) [9, 11]. Indoor ornamental foliage plants have gained

prominence due to their ability to remove airborne contaminants, particularly VOCs, thereby improving indoor air quality (Abbritti and Muzi, 1995; Krzyanowski, 1999; American Lung Association, 2001) [2, 5]. Additionally, foliage plants contribute to psychological well-being by reducing stress associated with urban living. Cut foliage cultivation has emerged as a commercially important sector owing to its year-round production, low investment, and environmental benefits. Globally, flowers and foliage account for approximately 52.45% of total floriculture trade, with developing countries such as India, China, and Thailand emerging as major producers (APEDA, 2014) [6]. The increasing preference for potted foliage plants is primarily due to limited ground space in urban environments.

Foliage plants belong to diverse botanical groups and are valued for their adaptability and ornamental appeal. Among them, *Philodendron scandens* (syn. *P. oxycardium*, *P.*

cordatum), a member of the family Araceae, is one of the most popular indoor foliage plants. The genus *Philodendron* comprises nearly 700 species, making it the second largest genus in Araceae (Croat and Thomas, 1997). Native to Mexico, Brazil, and the West Indies, *Philodendron scandens* is widely appreciated for its evergreen nature, attractive heart-shaped leaves, shade tolerance, and ability to remove indoor air pollutants such as formaldehyde, making it suitable for interior landscaping (Wolverton *et al.*, 1989)^[41]. Successful cultivation of foliage plants largely depends on appropriate nutrient management and suitable potting media. Excessive use of conventional chemical fertilizers has resulted in low nutrient use efficiency, with 40-70% of applied nitrogen lost to the environment, causing economic loss and environmental pollution (Naderi and Danesh, 2013)^[30]. Nano-fertilizers have emerged as efficient alternatives, offering controlled and targeted nutrient delivery with reduced losses (Liu and Lal, 2015)^[26]. Nano urea, containing 4% nitrogen with particle sizes of 20-50 nm, enhances nitrogen use efficiency through foliar absorption, phloem translocation, and gradual release within plant tissues (Kantwa and Yadav, 2022)^[20].

Along with nutrient management, the choice of potting media plays a vital role in container-grown plants by providing physical support, adequate aeration, water retention, and nutrient availability. Soilless media are increasingly preferred due to their uniformity, low bulk density, excellent aeration, and ease of handling (Farzad *et al.*, 2011)^[17]. With the rising demand for container-grown ornamental plants for domestic and export markets, evaluating suitable potting media combinations using locally available materials is essential for sustainable production. In view of these considerations, the present study entitled “Standardization of Nano Urea and Composition of Potting Media on Growth and Quality of *Philodendron scandens*” was undertaken to identify the optimum dose of Nano urea and the most suitable potting media composition for enhanced growth and quality of this important ornamental foliage plant.

Methods and materials The experiment entitled “Standardization of Nano Urea and Composition of Potting Media on Growth and Quality of *Philodendron scandens*” was conducted during Rabi 2021-22 (December 2021 to May 2022) at the PG Research Block, College of Horticulture, Mojerla, SKLTSHU. The study was laid out in a Factorial Randomized Block Design (FRBD) with two factors, 24 treatment combinations, and three replications, using Heart leaf philodendron (*Philodendron scandens*, family Araceae) as the test crop. Factor I comprised six nitrogen treatments: N₀ (control, no spray), N₁ (conventional urea @ 2 g L⁻¹), and Nano urea at N₂ (0.5 ml L⁻¹), N₃ (1.0 ml L⁻¹), N₄ (1.5 ml L⁻¹), and N₅ (2.0 ml L⁻¹), while Factor II included four potting media compositions: M₁ (red earth), M₂ (red earth + cocopeat, 1:1), M₃ (red earth + cocopeat + FYM, 1:1:1), and M₄ (red earth + cocopeat + FYM, 2:1:1). Each replication consisted of 10 plants grown in 10 × 12 inch polybags, arranged in sunken beds. Plants were propagated using 15 cm long mid-stem cuttings with four nodes, treated with Carbendazim + Mancozeb followed by IBA (1000 ppm), and planted in the respective media. Nano urea and urea spray solutions were prepared as per treatment levels, with the first foliar spray applied at 35 days after

planting followed by five sprays at 15-day intervals.

Observations were recorded on growth, phenological, physiological, biochemical, and quality parameters using uniformly growing tagged plants. Growth parameters such as plant height, number of leaves, leaf length, width, and area were recorded at 65, 95, and 125 days after planting, while phenological parameters included days to bud sprouting and full leaf expansion. Physiological indices such as leaf area index and specific leaf area weight were estimated following standard procedures, and biochemical parameters including relative water content, chlorophyll content, ascorbic acid and leaf pH were determined at 125 days after planting. Quality attributes such as leaf colour (CIELAB values), air pollution tolerance index (APTI), and benefit-cost ratio were also assessed. The experimental data were subjected to analysis of variance (ANOVA) appropriate for FRBD using R Studio (version 2021.09.1 Build 372), and treatment differences were tested at the 5% level of significance.

Results and discussion Plant height exhibited significant variation in response to Nano urea application and potting media (Tables 1a, 1b; Fig. 1a,b,c). At 65 DAP, the tallest plants were observed under N₅ (2 ml L⁻¹ Nano urea; 24.23 cm), followed by N₄ (1.5 ml L⁻¹; 21.91 cm), whereas the control (N₀) recorded the shortest height (18.24 cm). Among media, M₃ (Red Earth + Cocopeat + FYM, 1:1:1) produced maximum height (24.18 cm), while M₁ (Red Earth alone) was the least effective (17.85 cm). The interaction effect of Nano urea and media was significant, with T₂₃ (N₅M₃) yielding the tallest plants (28.32 cm) and T₁ (N₀M₁) the shortest (15.91 cm). This trend persisted at 95 DAP and 125 DAP, where N₅ consistently enhanced height (31.64 and 38.98 cm, respectively), and the N₅M₃ combination produced the maximum height (37.39 and 46.29 cm). The enhanced plant height can be mechanistically explained by the superior foliar absorption and mobility of Nano urea. The extremely small particle size (<50 nm) allows Nano nitrogen to penetrate stomatal pores efficiently, improving nitrogen assimilation and amino acid synthesis, including tryptophan a precursor of indole-3-acetic acid (IAA), the principal auxin responsible for cell elongation and apical dominance (Sharma *et al.*, 2022; Sai Kumar *et al.*, 2022)^[36, 37]. Additionally, Nano urea provides sustained nutrient release, stimulating enzymatic activity, photosynthate translocation, and vegetative growth. Potting media also played a significant role. The combination of cocopeat and FYM in M₃ enhanced water retention, aeration, and nutrient availability, promoting root proliferation and nutrient uptake. The fibrous nature of cocopeat improved soil porosity and reduced bulk density, supporting optimal plant metabolic activity and vegetative elongation (Awang *et al.*, 2009; Nair and Bharathi, 2015)^[31]. These results align with El-Shawa *et al.* (2022)^[16] in *Philodendron* and Abdel-Salam (2018)^[1] in lettuce, where Nano urea significantly increased plant height.

Plant Leaf number is directly associated with photosynthetic efficiency and ornamental value. Leaf number exhibited significant variation in response to Nano urea application and potting media (Tables 2a, 2b; Fig. 2a,b,c). At 65 DAP, N₅ produced the highest number of leaves (12.63), followed by N₄ (10.63), while N₀ recorded the lowest (7.34). Media effect was significant, with M₃ supporting the maximum

leaves (11.84) and M₁ the least (7.82). The interaction T₂₃ (N₅M₃) yielded 17.17 leaves at 65 DAP, increasing to 62.13 leaves at 125 DAP, demonstrating cumulative growth benefits of optimized nutrient-media combinations. The physiological mechanism underlying these observations is the promotion of cell division and differentiation by nitrogen, a vital component of chlorophyll, nucleic acids, and proteins. Enhanced chlorophyll synthesis increases photosynthetic activity, providing energy for leaf primordia development. Nano urea's higher surface area and rapid foliar absorption accelerate these processes, resulting in a higher number of fully expanded leaves (Sharma *et al.*, 2022; Minz *et al.*, 2021)^[29, 37], cocopeat- and FYM-enriched media further contributed by maintaining optimal moisture and aeration, facilitating nutrient diffusion to roots and sustaining leaf expansion. These findings corroborate those of Choudhary *et al.* (2020)^[14] in field crops and El-Shawa *et al.* (2022)^[16] in *Philodendron*, where integrated nutrient and media management enhanced foliar development.

Leaf area exhibited significant variation in response to Nano urea application and potting media (Tables 3a, 3b; Fig. 3a,b,c). Leaf area, a crucial determinant of photosynthetic capacity, was significantly influenced by Nano urea levels, media composition, and their interaction at all stages. At 125 DAP, N₅ recorded the highest leaf area (169.25 cm²), followed by N₄ (138.17 cm²), while N₀ was lowest (75.58

cm²). Media effects were significant, with M₃ producing the largest area (167.08 cm²) and M₁ the smallest (77.21 cm²). The N₅M₃ interaction yielded the maximum leaf area (213.49 cm²), demonstrating a synergistic effect of optimal nitrogen supply and balanced substrate composition. Physiologically, Nano urea promotes rapid nitrogen uptake, enhancing amino acid, protein, and chlorophyll synthesis, which stimulates cell division and elongation. FYM contributes additional macro- and micronutrients and improves microbial activity, further enhancing leaf expansion (Ajith Kumar *et al.*, 2021; Abdel-Salam *et al.*, 2018)^[1, 4]. Reduced bulk density and higher water retention in cocopeat-based media facilitate turgor-driven cell expansion, leading to larger leaves. These findings are in agreement with previous studies in *Philodendron* (El-Shawa *et al.*, 2022), maize (Ajith Kumar *et al.*, 2021), and lettuce (Abdel-Salam *et al.*, 2018)^[1, 4, 16].

In the present study, phenological observations like Number of Days for Bud Sprouting the number of days required for bud sprouting differed significantly among the potting media treatments (Table 4). The shortest duration for bud sprouting was observed in Red Earth + Cocopeat + FYM (1:1:1; M₃) and Red Earth + Cocopeat + FYM (2:1:1; M₄), both recording 8.77 days, whereas Red Earth alone (M₁) exhibited a markedly delayed bud sprouting period of 21.61 days.

Table 1a: Effect of Nano urea levels and composition of potting media on plant height (cm) at 65 and 95 days after planting in *Philodendron scandens*

Media Compo Sition	Nano Urea Levels													
	65 Days after Planting							95 Days after Planting						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	15.91	16.38	18.31	17.88	17.98	20.67	17.85 ^d	19.90	20.81	23.02	23.97	26.27	27.02	23.50 ^d
M ₂	16.11	17.41	18.92	18.81	19.45	20.91	18.60 ^c	20.08	21.94	23.92	24.94	27.07	28.22	24.36 ^c
M ₃	19.93	21.82	24.29	25.00	25.71	28.32	24.18 ^a	24.18	26.56	29.29	30.04	34.84	37.39	30.38 ^a
M ₄	21.03	20.91	23.92	24.01	24.47	27.02	24.04 ^b	25.14	25.53	28.65	29.52	30.86	33.93	28.94 ^b
MEAN	18.24 ^e	19.13 ^d	21.36 ^c	21.42 ^c	21.90 ^b	24.23 ^a		22.33 ^f	23.71 ^e	26.22 ^d	27.12 ^c	29.76 ^b	31.64 ^a	
	S.E.M			C.D. 5%				S.E.M			C.D. 5%			
N	0.05			0.15				0.05			0.15			
M	0.04			0.12				0.04			0.12			
N*M	0.11			0.30				0.10			0.30			

Table 1b: Effect of Nano urea levels and composition of potting media on plant height (cm) at 125 days after planting in *Philodendron scandens*

Media Composition	Nano Urea Levels						
	125 Days after Planting						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	23.27	27.21	28.09	28.98	30.93	33.38	28.64 ^d
M ₂	24.29	28.00	28.94	29.91	31.94	35.18	29.71 ^c
M ₃	28.06	32.25	33.79	36.31	40.04	46.29	36.12 ^a
M ₄	27.15	31.07	32.15	33.63	36.50	41.04	33.59 ^b
MEAN	25.69 ^f	29.63 ^e	30.74 ^d	32.21 ^c	34.86 ^b	38.98 ^a	
	S.E.M			C.D. 5%			
N	0.04			0.12			
M	0.06			0.10			
N*M	0.09			0.25			
N ₀ : Control (No sprays)	N ₃ : Nano urea 1 ml L ⁻¹			M ₁ : Red earth			
N ₁ : Urea 2 g L ⁻¹	N ₄ : Nano urea 1.5 ml L ⁻¹			M ₂ : Red earth + Cocopeat (1:1)			
N ₂ : Nano urea 0.5 ml L ⁻¹	N ₅ : Nano urea 2 ml L ⁻¹			M ₃ : Red earth + Cocopeat + FYM (1:1:1)			
				M ₄ : Red earth + Cocopeat + FYM (2:1:1)			

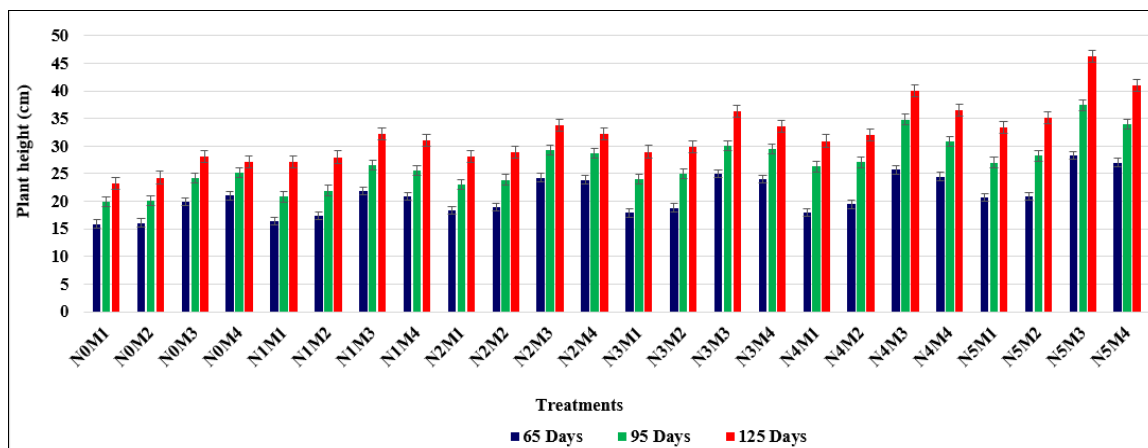


Fig 1a: Interaction effect of Nano urea levels and composition of potting media on plant height (cm) in *Philodendron scandens*

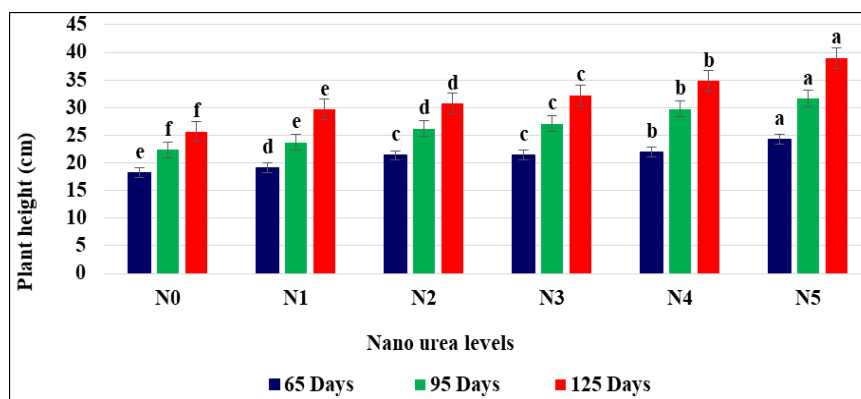


Fig 1b: Effect of Nano urea levels on plant height (cm) in *Philodendron scandens*

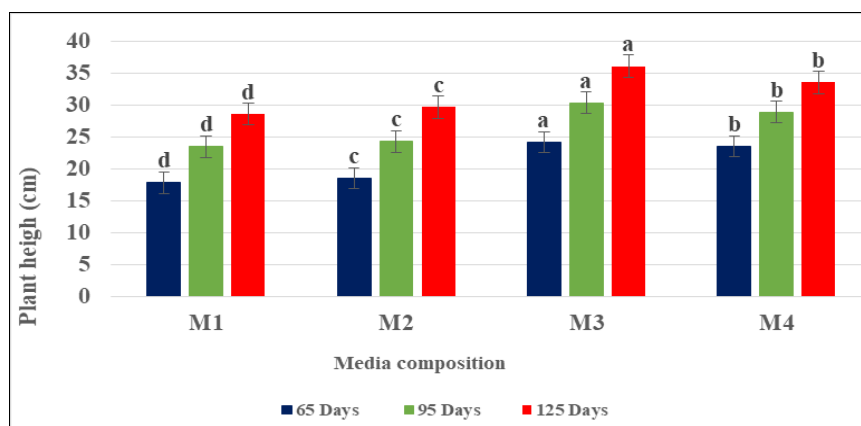


Fig 1c: Effect of composition of potting media on plant height (cm) in *Philodendron scandens*

Table 2a: Effect of Nano urea levels and composition of potting media on the number of leaves at 65 and 95 days of planting in *Philodendron scandens*

Media Compo Sition	Nano Urea Levels													
	65 Days after Planting							95 Days after Planting						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	6.17	7.10	7.53	7.93	8.57	9.63	7.82 ^d	12.23	15.13	16.07	17.37	19.37	23.10	17.21 ^d
M ₂	6.57	7.57	7.80	8.23	9.10	10.27	8.26 ^c	13.30	16.30	17.20	18.43	20.27	23.43	18.16 ^c
M ₃	8.53	9.47	10.17	12.37	13.37	17.17	11.84 ^a	15.33	19.23	22.27	23.40	27.37	33.40	23.50 ^a
M ₄	8.10	9.17	9.60	10.30	11.47	13.43	10.34 ^b	14.23	16.13	20.30	21.17	25.43	29.10	21.06 ^b
MEAN	7.34 ^f	8.33 ^e	8.78 ^d	9.71 ^c	10.63 ^b	12.63 ^a		13.78 ^f	16.70 ^e	18.96 ^d	20.09 ^c	23.11 ^b	27.26 ^a	
	S.E.M		C.D. 5%					S.E.M		C.D. 5%				
N	0.05		0.13					0.07		0.21				
M	0.04		0.11					0.06		0.17				
N*M	0.09		0.27					0.15		0.41				

Table 2b: Effect of Nano urea levels and composition of potting media on number of leaves at 125 days after planting in *Philodendron scandens*

Media Composition	Nano Urea Levels						
	125 Days after Planting						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	21.50	25.23	27.20	30.37	35.33	43.43	30.51 ^d
M ₂	24.27	27.37	30.40	33.27	38.87	47.27	33.57 ^c
M ₃	34.37	44.33	46.23	49.33	54.30	62.13	48.45 ^a
M ₄	31.27	40.30	42.33	44.43	48.40	56.07	43.80 ^b
MEAN	27.85 ^f	34.31 ^e	36.54 ^d	39.35 ^c	44.23 ^b	52.23 ^a	
	S.E.M			C.D. 5%			
N	0.07			0.21			
M	0.06			0.17			
N*M	0.15			0.41			
N ₀ : Control (No sprays)		N ₃ : Nano urea 1 ml L ⁻¹		M ₁ : Red earth			
N ₁ : Urea 2 g L ⁻¹		N ₄ : Nano urea 1.5 ml L ⁻¹		M ₂ : Red earth + Cocopeat (1:1)			
N ₂ : Nano urea 0.5 ml L ⁻¹		N ₅ : Nano urea 2 ml L ⁻¹		M ₃ : Red earth + Cocopeat + FYM (1:1:1)			
				M ₄ : Red earth + Cocopeat + FYM (2:1:1)			

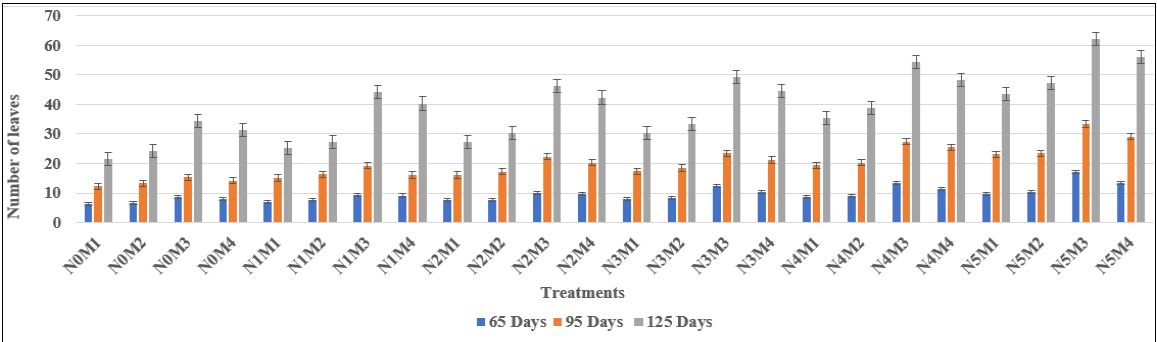


Fig 2a: Interaction effect of Nano urea levels and composition of potting media on number of leaves in *Philodendron scandens*

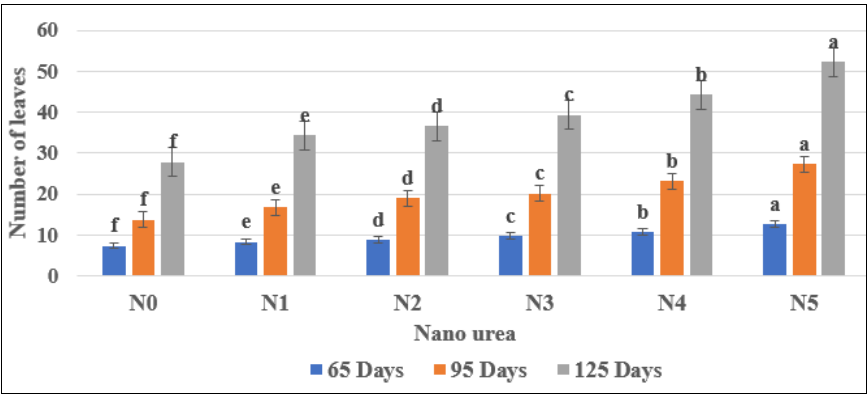


Fig 2b: Effect of Nano urea levels on number of leaves

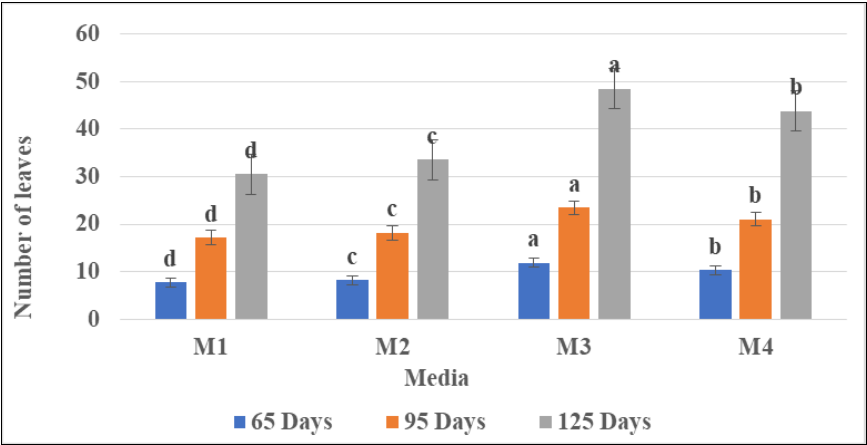


Fig 2c: Effect of composition of potting media on number of leaves

N ₀ : Control (No sprays)	N ₃ : Nano urea 1 ml L ⁻¹	M ₁ : Red earth
N ₁ : Conventional Urea 2 g L ⁻¹	N ₄ : Nano urea 1.5 ml L ⁻¹	M ₂ : Red earth + Cocopeat (1:1)
N ₂ : Nano urea 0.5 ml L ⁻¹	N ₅ : Nano urea 2 ml L ⁻¹	M ₃ : Red earth + Cocopeat + FYM (1:1:1)
		M ₄ : Red earth + Cocopeat + FYM (2:1:1)

Table 3a: Effect of Nano urea levels and composition of potting media on leaf area (cm²) at 65 and 95 days after planting in *Philodendron scandens*

Media Composition	Nano Urea Levels													
	65 Days after Planting							95 Days after Planting						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	30.13	39.05	39.82	42.60	45.60	60.57	42.96 ^d	33.96	52.34	56.24	60.92	67.75	86.29	59.58 ^d
M ₂	44.84	58.25	61.41	65.10	68.02	88.24	64.31 ^c	50.42	79.98	83.83	87.82	91.68	129.66	87.23 ^c
M ₃	81.29	103.05	108.69	108.85	110.35	147.38	109.93 ^a	98.62	134.52	141.44	149.72	151.21	186.75	143.71 ^a
M ₄	65.67	84.90	88.11	88.37	92.01	126.75	90.97 ^b	80.81	109.01	116.91	123.57	135.67	168.22	122.37 ^b
MEAN	55.49 ^c	71.31 ^b	74.51 ^b	76.23 ^b	79.00 ^b	105.73 ^a		65.95 ^e	93.96 ^d	99.60 ^{cd}	105.51 ^{bc}	111.58 ^b	142.73 ^a	
	S.E.M			C.D. 5%				S.E.M			C.D. 5%			
N	1.36			3.87				1.18			3.36			
M	1.11			3.16				0.99			2.74			
N*M	2.72			7.73				2.36			6.712			

Table 3b: Effect of Nano urea levels and composition of potting media on leaf area (cm²) at 125 days after planting in *Philodendron scandens*

Media Composition	Nano Urea Levels						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	39.38	67.58 ^a	76.07	80.08	87.11	113.04	77.21 ^d
M ₂	59.83	95.05 ^a	104.38	112.82	126.13	157.75	109.33 ^c
M ₃	115.16	160.18	166.82	171.54	175.26	213.49	167.08 ^a
M ₄	87.95	136.41	148.87	152.28	164.18	192.70	147.06 ^b
MEAN	75.58 ^e	114.80 ^d	124.04 ^c	129.18 ^c	138.17 ^b	169.25 ^a	
	S.E.M			C.D. 5%			
N	1.03			2.94			
M	0.85			2.40			
N*M	2.07			5.89			
N ₀ : Control (No sprays)	N ₃ : Nano urea 1 ml L ⁻¹			M ₁ : Red earth			
N ₁ : Urea 2 g L ⁻¹	N ₄ : Nano urea 1.5 ml L ⁻¹			M ₂ : Red earth + Cocopeat (1:1)			
N ₂ : Nano urea 0.5 ml L ⁻¹	N ₅ : Nano urea 2 ml L ⁻¹			M ₃ : Red earth + Cocopeat + FYM (1:1:1)			
				M ₄ : Red earth + Cocopeat + FYM (2:1:1)			

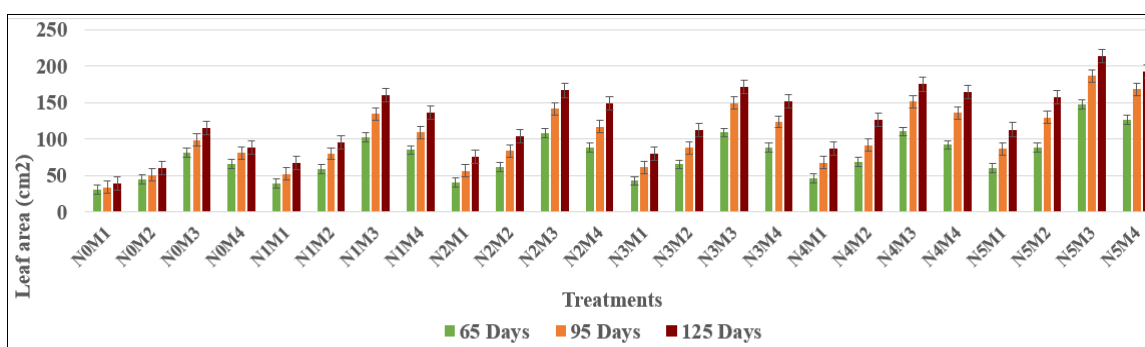


Fig 3a: Interaction effect of Nano urea levels and media composition of potting media on leaf area (cm²) in *Philodendron scandens*

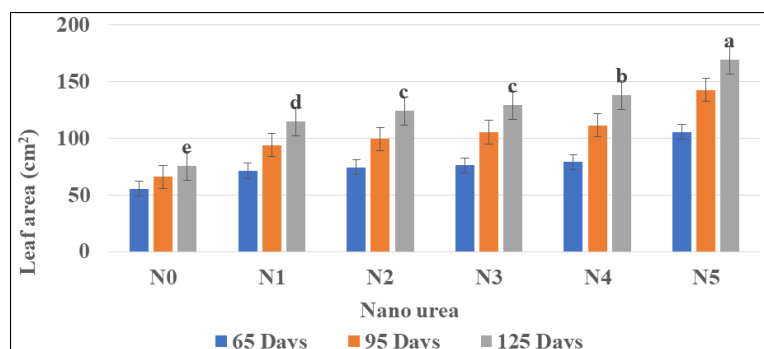


Fig 3b: Effect of Nano urea levels on leaf area (cm²) in *Philodendron scandens*

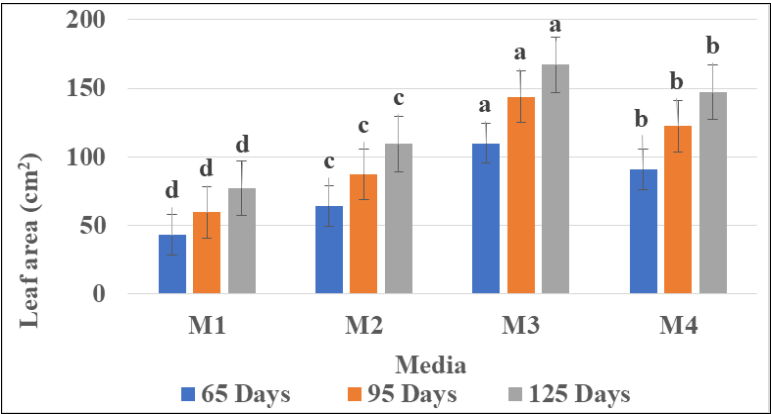


Fig 3c: Effect of composition of potting media on leaf area (cm²) in *Philodendron scandens*

N ₀ : Control (No sprays)	N ₃ : Nano urea 1 ml L ⁻¹	M ₁ : Red earth
N ₁ : Conventional Urea 2 g L ⁻¹	N ₄ : Nano urea 1.5 ml L ⁻¹	M ₂ : Red earth + Cocopeat (1:1)
N ₂ : Nano urea 0.5 ml L ⁻¹	N ₅ : Nano urea 2 ml L ⁻¹	M ₃ : Red earth + Cocopeat + FYM (1:1:1)
		M ₄ : Red earth + Cocopeat + FYM (2:1:1)

The early initiation of bud sprouting in M3 and M4 can be attributed to the improved physical, chemical, and biological properties of these substrates. Cocopeat significantly enhances water-holding capacity, porosity, and aeration, thereby ensuring adequate oxygen supply to developing roots and meristematic tissues, which is essential for cell division and bud break (Kavana and Chandrashekar, 2012; Kaushal *et al.*, 2020) ^[22, 23]. The presence of FYM further improves nutrient availability by supplying readily mineralizable nitrogen, phosphorus, potassium, and trace elements, which stimulate enzymatic activity and meristem differentiation (Masood *et al.*, 2014) ^[28]. In contrast, Red Earth (M1) is comparatively compact, low in organic matter, and deficient in readily available nutrients, resulting in poor root proliferation and delayed physiological activation of buds. Similar reductions in sprouting time due to enriched growing media have been reported in strawberry (Kipkosgei *et al.*, 2003), spider plant, and palm (Ngetich *et al.*, 2011). These findings clearly demonstrate that substrate composition plays a pivotal role in regulating early metabolic activity and successful establishment of *Philodendron* cuttings. The duration required for full leaf

expansion was also significantly influenced by potting media composition. The shortest time for full leaf expansion was recorded in M3 (3.32 days), followed by M4 (4.38 days), while M1 (6.24 days) required the longest period. Rapid leaf expansion in M3 and M4 can be attributed to the synergistic interaction between cocopeat and FYM, which ensures continuous moisture availability, improved aeration, and sustained nutrient supply. Cocopeat maintains uniform substrate moisture, preventing transient water stress that can delay cell enlargement, while FYM enhances nutrient uptake efficiency and supports metabolic processes involved in leaf cell elongation and differentiation (Masood *et al.*, 2014) ^[28]. Faster leaf expansion increases the photosynthetically active surface area at an early stage, enabling higher carbohydrate production and improved energy availability for subsequent vegetative growth. Similar observations have been reported in ornamental crops grown under organic-enriched substrates, where rapid leaf expansion was associated with enhanced plant vigor and canopy development (Kipkosgei *et al.*, 2003; Ngetich *et al.*, 2011). The results emphasize that optimized substrate composition is crucial for achieving early vegetative uniformity and improved growth efficiency in *Philodendron*.

Table 4: Effect of composition of potting media on number of days taken for sprouting (days) and number of days taken for full leaf expansion (days) in *Philodendron scandens*

Media composition	Number of days taken for sprouting (days)	Number of days taken for full leaf expansion (days)
M ₁	21.61	6.24
M ₂	15.50	5.02
M ₃	8.77	3.32
M ₄	10.52	4.38
M ₁ : Red earth M ₃ : Red earth + Cocopeat + FYM (1:1:1)		
M ₂ : Red earth + Cocopeat (1:1) M ₄ : Red earth + Cocopeat + FYM (2:1:1)		

Physiological parameters reflect the functional efficiency of plants in terms of photosynthesis, biomass accumulation, and resource allocation. Leaf Area Index (LAI) LAI exhibited significant variation due to Nano urea levels, potting media, and their interactions (Tables 5a, 5b; Fig. 4a,b,c). At 65 DAP, LAI ranged from 0.68 (N0M1) to 1.89 (N5M3); at 95 DAP, from 1.88 to 5.14; and at 125 DAP,

from 4.67 to 13.49, with the maximum consistently recorded under N5M3. The superior LAI observed in Nano urea-treated plants, particularly at 2 ml L⁻¹ (N5), can be attributed to the high nitrogen use efficiency of Nano urea, which facilitates rapid absorption through foliar tissues and efficient translocation within the plant system. Nitrogen plays a vital role in chlorophyll synthesis, protein formation,

and enzymatic activity, all of which directly influence leaf expansion, leaf number, and plant height (Ahmed *et al.*, 2016) [3]. The interaction with enriched potting media (M3 and M4) further enhanced LAI due to improved root growth, sustained nutrient availability, and favorable moisture regimes. Higher LAI translates into greater photosynthetic surface area, resulting in enhanced carbohydrate production and dry matter accumulation. These findings are in agreement with earlier reports in ornamental and field crops, where Nano fertilizers significantly increased leaf area and biomass due to improved nutrient efficiency (Khalil *et al.*, 2019) [24].

Specific Leaf Area (SLA) exhibited significant differences among treatments at all growth stages (Tables 6a, 6b; Fig. 5a, b, c). The highest SLA values were consistently recorded in enriched media combinations, particularly M3, while the lowest values were observed under higher Nano urea concentrations (N5). Higher SLA in M3 indicates the production of thinner leaves with a larger surface area per unit dry mass, which favors rapid photosynthesis and efficient light interception. Conversely, the reduction in SLA at higher Nano urea levels suggests the development of thicker leaves with greater dry matter accumulation, reflecting enhanced structural investment. SLA is a key functional trait linking carbon gain and water-use efficiency, and higher SLA is generally associated with faster growth and greater resource acquisition (Cheng *et al.*, 2016) [12].

The results further suggest that moderate nutrient availability promotes optimal leaf morphology, while excessive nitrogen may shift biomass allocation toward leaf thickening rather than expansion (Cornelissen, 2003) [15]. FYM and cocopeat likely contributed to improved biomass accumulation and leaf development by enhancing nutrient availability and root activity (Van Averbeke *et al.*, 2007) [40].

RWC (Relative Water Content, %) The mean data pertaining to RWC (Relative Water Content, %) in leaves as influenced by Nano urea levels and media composition at 125 days after planting is presented in Table 7. Among the different levels of Nano urea, maximum Relative Water Content (92.17%) of a leaf was recorded with Nano urea spray N5 (2 ml L⁻¹) which is followed by N4 (Nano urea 1.5 ml L⁻¹) (84.57%) while minimum (72.05%) Relative Water Content of a leaf was noticed in N0 (No spray). Among different composition of potting media, maximum Relative Water Content of a leaf (80.37%) was recorded in M3 (Red Earth + Coco peat + FYM (1:1:1)) followed by M4 (Red Earth + Coco peat + FYM (2:1:1)) (79.87%) and M2 (Red Earth + Coco peat (1:1)) (79.71%) which were on par with each other whereas minimum (78.9%) Relative Water Content of a leaf was recorded in M1 (Red Earth). Interaction effect on Relative Water Content of a leaf was found to be insignificant. Here the variation in relative water content (RWC) of leaves observed in the

Table 5a: Effect of Nano urea levels and composition of potting media on Leaf Area Index at 65 and 95 days after planting in *Philodendron scandens*

Media Composition	Nano Urea Levels													
	65 Days after Planting							95 Days after Planting						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	0.678	0.78	0.828	0.872	0.942	1.059	0.86 ^d	1.882	2.328	2.471	2.671	2.979	3.553	2.647 ^d
M ₂	0.722	0.832	0.857	0.905	1.00	1.128	0.907 ^c	2.046	2.507	2.646	2.835	3.117	3.604	2.792 ^c
M ₃	0.938	1.041	1.117	1.359	1.469	1.887	1.302 ^a	2.358	2.958	3.425	3.599	4.209	5.137	3.615 ^a
M ₄	0.89 ⁱ	1.008	1.055	1.132	1.26	1.477	1.137 ^b	2.189	2.481	3.122	3.256	3.912	4.476	3.239 ^b
MEAN	0.807 ^f	0.915 ^e	0.965 ^d	1.067 ^c	1.168 ^b	1.388 ^a		2.119 ^f	2.569 ^e	2.916 ^d	3.09 ^c	3.554 ^b	4.193 ^a	
	S.E.M			C.D. 5%				S.E.M			C.D. 5%			
N	0.0051			0.0146				0.0112			0.0319			
M	0.0042			0.0119				0.0092			0.0261			
N*M	0.0102			0.0291				0.0224			0.0638			

Table 5b: Effect of Nano urea levels and composition of potting media on Leaf Area Index at 125 days after planting in *Philodendron scandens*

Media Composition	Nano Urea Levels						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	4.67	5.48	5.91	6.59	7.67	9.43	6.63 ^d
M ₂	5.27	5.94	6.60	7.22	8.44	10.26	7.29 ^c
M ₃	7.46	9.63	10.04	10.71	11.79	13.49	10.52 ^a
M ₄	6.79	8.75	9.19	9.65	10.51	12.17	9.51 ^b
MEAN	6.05 ^f	7.45 ^e	7.94 ^d	8.54 ^c	9.60 ^b	11.34 ^a	
	S.E.M			C.D. 5%			
N	0.016			0.05			
M	0.013			0.04			
N*M	0.032			0.09			
N ₀ : Control (No sprays)		N ₃ : Nano urea 1 ml L ⁻¹			M ₁ : Red earth		
N ₁ : Urea 2 g L ⁻¹		N ₄ : Nano urea 1.5 ml L ⁻¹			M ₂ : Red earth + Cocopeat (1:1)		
N ₂ : Nano urea 0.5 ml L ⁻¹		N ₅ : Nano urea 2 ml L ⁻¹			M ₃ : Red earth + Cocopeat + FYM (1:1:1)		
					M ₄ : Red earth + Cocopeat + FYM (2:1:1)		

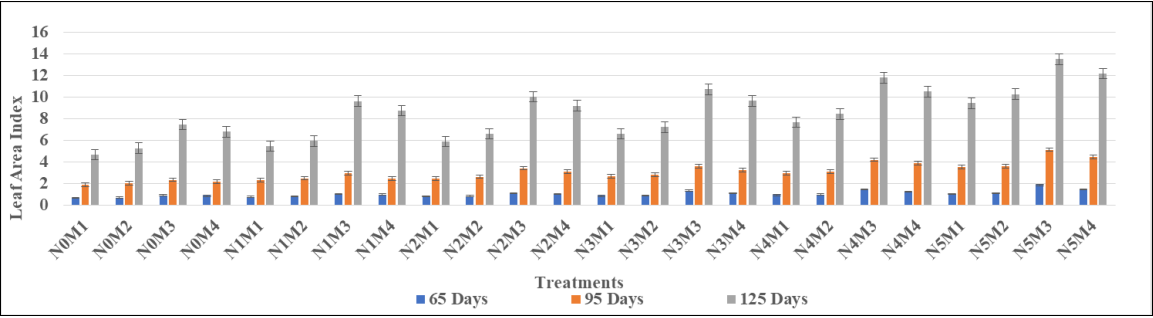


Fig 4a: Interaction effect of Nano urea levels and composition of potting media on Leaf Area Index in *Philodendron scandens*

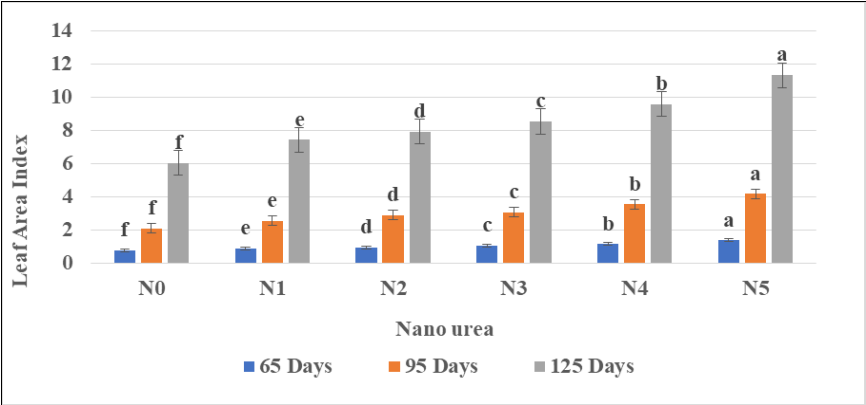


Fig 4b: Effect of Nano urea levels on Leaf Area Index in *Philodendron scandens*

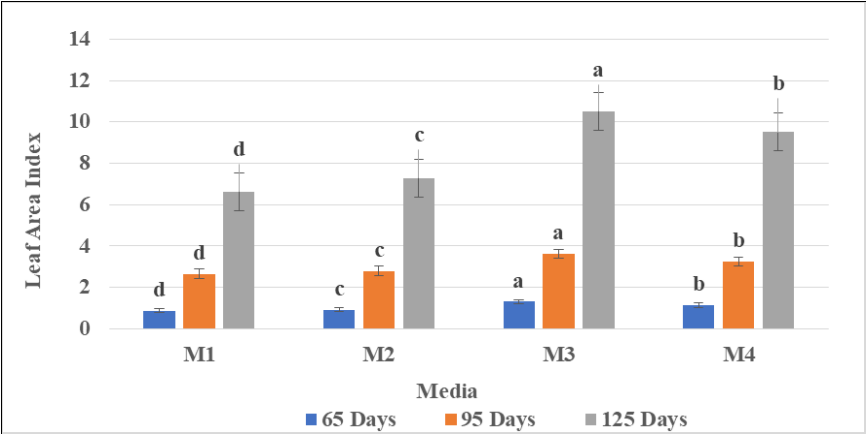


Fig 4c: Effect of composition of potting media Leaf Area Index in *Philodendron scandens*

N ₀ : Control (No sprays)	N ₃ : Nano urea 1 ml L ⁻¹	M ₁ : Red earth
N ₁ : Conventional Urea 2 g L ⁻¹	N ₄ : Nano urea 1.5 ml L ⁻¹	M ₂ : Red earth + Cocopeat (1:1)
N ₂ : Nano urea 0.5 ml L ⁻¹	N ₅ : Nano urea 2 ml L ⁻¹	M ₃ : Red earth + Cocopeat + FYM (1:1:1)
		M ₄ : Red earth + Cocopeat + FYM (2:1:1)

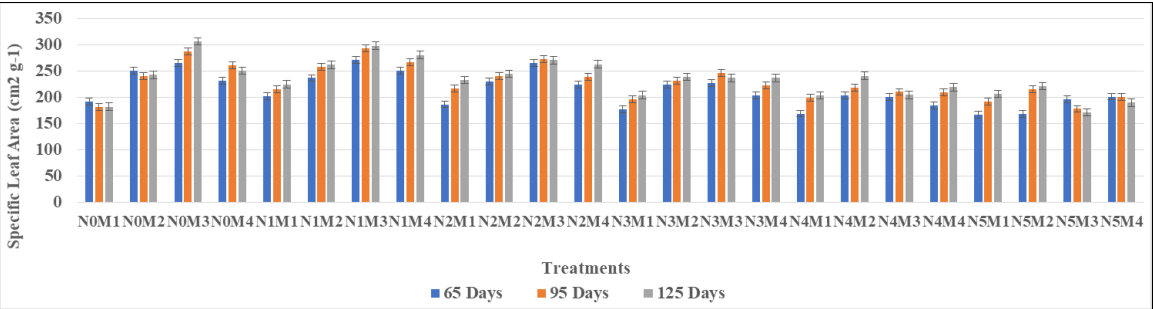


Fig 5a: Interaction effect of Nano urea levels and composition of potting media on Specific Leaf Area (cm² g⁻¹) *Philodendron scandens*

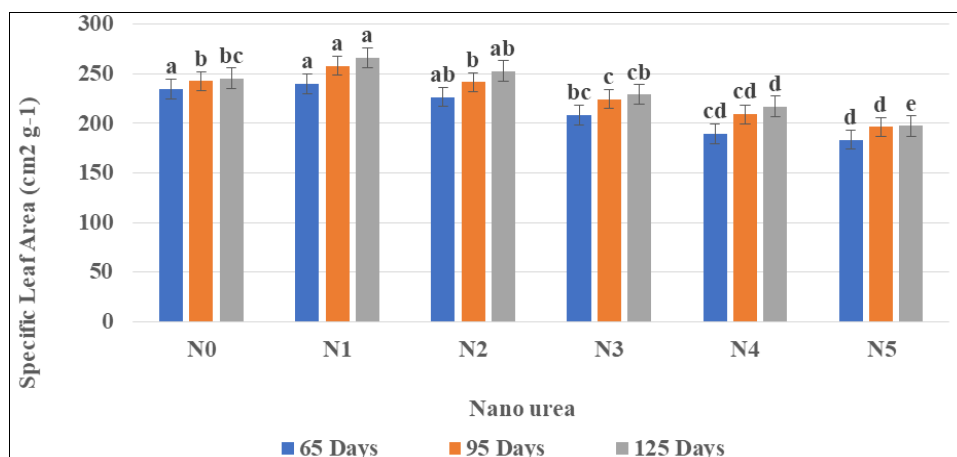


Fig 5b: Effect of Nano urea levels on Specific Leaf Area (cm² g⁻¹)

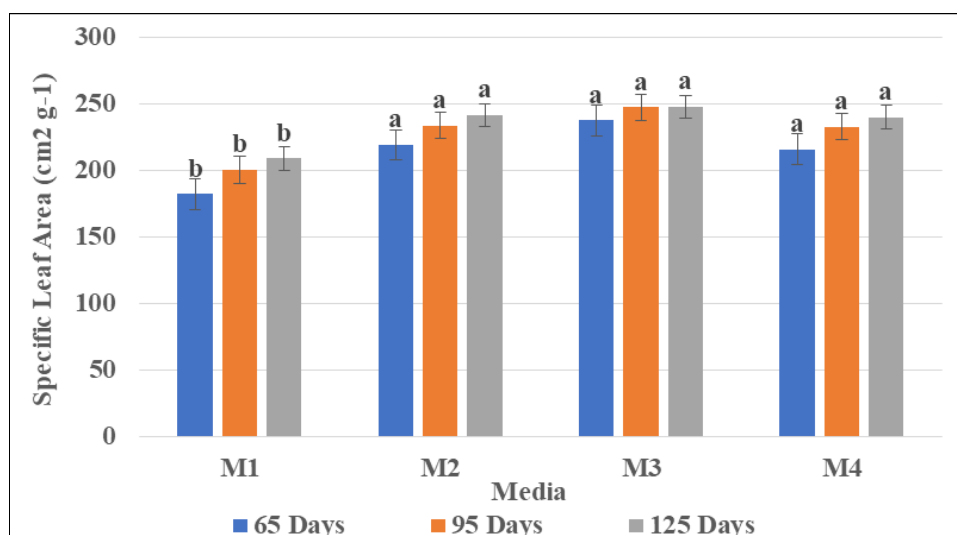


Fig 5c: Effect of composition of potting media on Specific Leaf Area (cm² g⁻¹)

N ₀ : Control (No sprays)	N ₃ : Nano urea 1 ml L ⁻¹	M ₁ : Red earth
N ₁ : Conventional Urea 2 g L ⁻¹	N ₄ : Nano urea 1.5 ml L ⁻¹	M ₂ : Red earth + Cocopeat (1:1)
N ₂ : Nano urea 0.5 ml L ⁻¹	N ₅ : Nano urea 2 ml L ⁻¹	M ₃ : Red earth + Cocopeat + FYM (1:1:1)
		M ₄ : Red earth + Cocopeat + FYM (2:1:1)

present study indicates a pronounced influence of Nano urea application and potting media composition on plant water status. Higher RWC values recorded with increasing levels of Nano urea suggest improved cellular hydration and water retention capacity in *Philodendron scandens*. The maximum RWC observed under Nano urea spray at 2 ml L⁻¹ may be attributed to the role of nitrogen in enhancing leaf succulency and osmotic adjustment. Nitrogen is known to increase the accumulation of soluble proteins and osmolytes, which improve cell turgidity and water-holding capacity of leaf tissues. Similar findings were reported by Umnajkitikorn *et al.* (2021) [39], who demonstrated that increased nitrogen availability significantly enhances leaf succulence and relative water content, thereby improving plant tolerance to environmental stress.

The comparatively higher RWC recorded in organically enriched potting media containing coco peat and FYM could be due to improved moisture retention, porosity and nutrient availability. Coco peat enhances water-holding capacity, while FYM improves soil structure and microbial

activity, collectively facilitating better root water uptake and sustained leaf hydration. Comparable observations were reported by Swami *et al.* (2018) and Rameshkumar *et al.* (2019) [35, 38] in foliage plants grown in organic substrate combinations. The absence of a significant interaction between Nano urea levels and media composition suggests that each factor independently contributed to the enhancement of RWC. Overall, increased RWC under higher Nano urea levels and improved media composition reflects better plant water relations, which is a key physiological attribute associated with enhanced stress tolerance and growth performance in ornamental foliage plants.

The mean data pertaining to Total Chlorophyll content (mg g⁻¹) of leave as influenced by Nano urea levels and media composition at 125 days after planting is presented in Table 8 in Fig 6a, b. Among the different levels of Nano urea, maxim Total Chlorophyll content (2.491 mg g⁻¹) of leaf was recorded with Nano urea spray N₅ (2 ml L⁻¹) followed by N₄ (Nano urea 1.5 ml L⁻¹) (2.144 mg g⁻¹) while

minimum (0.998 mg g⁻¹) Total Chlorophyll content of a leaf was noticed in N0 (No spray). Among different composition of potting media, maximum Total Chlorophyll content (mg g⁻¹) was recorded in M4 (Red Earth +Coco peat + FYM (2:1:1) (1.751 mg g⁻¹) followed by M3 (Red Earth + Coco peat + FYM (1:1:1) (1.716 mg g⁻¹) and M2 (Red Earth + Coco peat (1:1)) (1.688 mg g⁻¹) which were on par with each other while minimum (1.593 mg g⁻¹) Total Chlorophyll content was recorded in M1 (Red Earth). Total chlorophyll content of leaves varied significantly in response to Nano urea levels and potting media composition at 125 days after planting. Increasing levels of Nano urea resulted in a progressive increase in chlorophyll content, indicating enhanced photosynthetic potential in *Philodendron scandens*. The highest total chlorophyll content was recorded with Nano urea spray at 2 ml L⁻¹ (N5), followed by 1.5 ml L⁻¹ (N4), while the lowest chlorophyll content was observed in the control treatment without Nano urea application. The increase in chlorophyll content under higher Nano urea levels may be attributed to improved nitrogen use efficiency associated with Nano-formulated fertilizers, which enhances nitrogen availability and uptake. Since nitrogen is a fundamental constituent of the chlorophyll molecule, adequate nitrogen supply directly influences chlorophyll biosynthesis and chloroplast development (Peng *et al.*, 2007; Bondada *et al.*, 2003; Hudson *et al.*, 2007) [8, 19, 32].

With respect to potting media composition, media enriched with coco peat and FYM recorded higher chlorophyll content compared to red earth alone. Improved physical and chemical properties of these media, such as enhanced moisture retention, aeration and nutrient availability, might have facilitated better nitrogen uptake and assimilation, thereby supporting chlorophyll synthesis. Similar observations have been reported by Abdel-Salam (2018) [1] in lettuce and El-Shawa *et al.* (2022) [16] in *Philodendron*, who documented significant increases in leaf chlorophyll content with improved nitrogen nutrition and growing media conditions. The non-significant interaction between Nano urea levels and media composition indicates that both factors independently influenced chlorophyll accumulation. Overall, the enhanced chlorophyll content observed under higher Nano urea application reflects improved photosynthetic efficiency and physiological vigor, contributing positively to growth performance and stress tolerance of *Philodendron scandens*.

Ascorbic acid content (mg g⁻¹) of a leaf as influenced by Nano urea levels and media composition at 125 days after planting is presented in Table 9. Among the different levels of Nano urea, maximum (3.892 mg g⁻¹) Ascorbic acid content of leaves was recorded with Nano urea spray N5 (2 ml L⁻¹) followed by N4 (Nano urea 1.5 ml L⁻¹) (2.865 mg g⁻¹) while minimum (0.811 mg g⁻¹) Ascorbic acid content was noticed in N0 (No spray). Composition of potting media and interaction effect of Nano urea levels with media composition on Ascorbic acid in leaf was found to be insignificant. High and inadequate supply of nitrogen can decrease the Ascorbic acid content (Feyman *et al.*, 1991, Lee *et al.*, 2000). Chiesa *et al.* (2009) [13, 18, 25] reported that high N (150 kg ha⁻¹) increased ascorbic acid content in lettuce. Variation in accumulation of ascorbic acid content at different rates of N applications altered with the findings of Mahlangu *et al.* (2016) [27]. In this experiment application of Nano urea increased the ascorbic acid it might be due to the timely released and high nitrogen use efficiency of Nano urea.

Leaf pH as influenced by Nano urea levels and media composition at 125 days after planting is presented in Table 10. Among the different levels of Nano urea, maximum (5.43) Leaf pH was recorded with Nano urea spray N5 (2 ml L⁻¹) followed by N4 (Nano urea 1.5 ml L⁻¹) (5.13) while minimum (4.2) Leaf pH of a leaf was noticed in N0 (No spray). Among different composition of potting media, maximum Leaf pH (4.93) was recorded in M3 (Red Earth + Coco peat + FYM (1:1:1) followed by M4 (Red Earth +Coco peat + FYM (2:1:1)) (4.85) which is on par with M2 (Red Earth + Coco peat (1:1) (4.81) while minimum Leaf pH (4.75) was recorded in M1 (Red Earth). Interaction effect for Leaf pH was found to be insignificant. Leaf pH is an important physiological parameter influencing the plant's tolerance to air pollutants, as it affects enzymatic activity, stomatal function and pollutant neutralization capacity. In the present study, leaf pH increased progressively with increasing levels of Nano urea, indicating improved physiological stability in *Philodendron scandens*. The highest leaf pH recorded under Nano urea spray at 2 ml L⁻¹ may be attributed to enhanced nitrogen availability, which promotes metabolic balance and reduces cellular acidity. Nitrogen nutrition is known to regulate organic acid metabolism and maintain ionic balance in leaf tissues, thereby resulting in comparatively higher leaf pH. Similar trends were reported b

Table 8: Effect of Nano urea levels and composition of potting media on Total Chlorophyll (mg g⁻¹) content in leaves at 125 days after planting of *Philodendron scandens*

Media Composition	Nano Urea Levels						MEAN
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	
M ₁	0.85	1.18	1.36	1.68	2.04	2.46	1.59 ^b
M ₂	0.98	1.22	1.54	1.83	2.08	2.47	1.69 ^a
M ₃	0.97	1.30	1.52	1.84	2.17	2.51	1.72 ^a
M ₄	1.19	1.22	1.58	1.70	2.29	2.53	1.75 ^a
MEAN	1.00 ^e	1.23 ^e	1.50 ^d	1.76 ^c	2.14 ^b	2.49 ^a	
	S.E.M			C.D. 1%			
N	0.04			0.13			
M	0.04			0.10			
N*M	0.09			0.26			

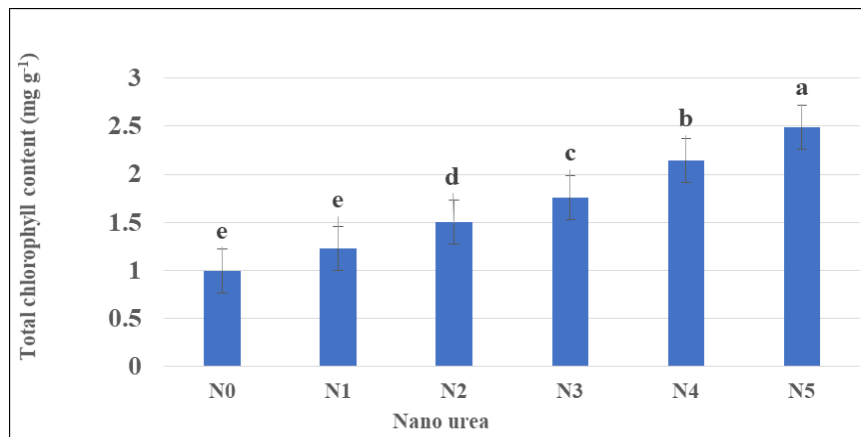


Fig 6a: Effect of Nano urea levels on Total chlorophyll content (mg g⁻¹) in leaves at 125 DAP in *Philodendron scandens*

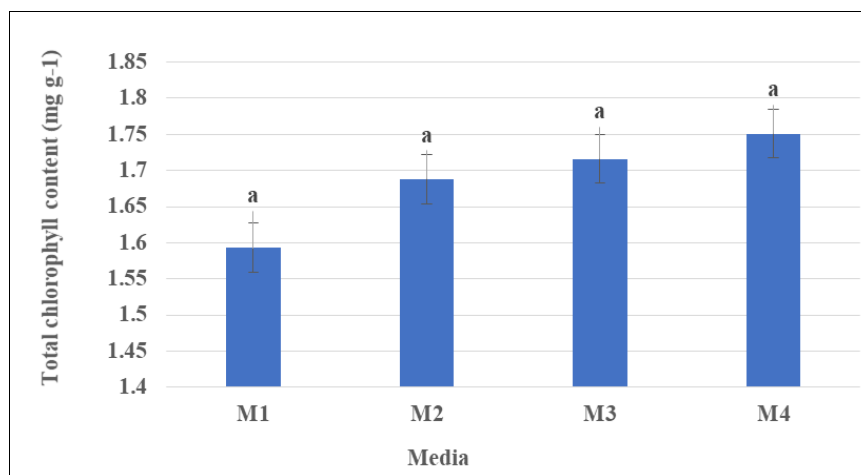


Fig 6b: Effect of composition of potting media on Total chlorophyll content in leaves at 125 DAP in *Philodendron scandens*

N ₀ : Control (No sprays)	N ₃ : Nano urea 1 ml L ⁻¹	M ₁ : Red earth
N ₁ : Conventional Urea 2 g L ⁻¹	N ₄ : Nano urea 1.5 ml L ⁻¹	M ₂ : Red earth + Cocopeat (1:1)
N ₂ : Nano urea 0.5 ml L ⁻¹	N ₅ : Nano urea 2 ml L ⁻¹	M ₃ : Red earth + Cocopeat + FYM (1:1:1)
		M ₄ : Red earth + Cocopeat + FYM (2:1:1)

Table 9: Effect of Nano urea levels and composition of potting media on Ascorbic acid content (mg g⁻¹) at 125 days after planting in leaves of *Philodendron scandens*

Media Composition	Nano Urea Levels						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	0.69	1.55	2.28	2.63	2.79	3.55	2.25
M ₂	0.86	1.64	2.19	2.61	2.90	3.72	2.32
M ₃	0.87	1.53	2.40	2.62	2.90	4.21	2.42
M ₄	0.83	1.51	2.38	2.76	2.88	4.09	2.41
MEAN	0.81 ^e	1.56 ^d	2.31 ^c	2.65 ^{bc}	2.87 ^b	3.89 ^a	
	S.E.M			C.D. 1%			
N	0.06			0.17			
M	0.05			0.14			
N*M	0.12			0.34			

Table 10: Effect of Nano urea levels and composition of potting media on pH of leaves at 125 days after planting in *Philodendron scandens*

Media Compo Sition	Nano Urea Levels 4						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
M ₁	4.10	4.45	4.77	4.86	5.03	5.27	4.75 ^b
M ₂	4.17	4.51	4.78	4.90	5.10	5.37	4.81 ^{ab}
M ₃	4.30	4.60	4.82	4.99	5.23	5.60	4.93 ^a
M ₄	4.21	4.54	4.79	4.94	5.17	5.46	4.85 ^{ab}
MEAN	4.20 ^e	4.52 ^d	4.79 ^c	4.92 ^c	5.13 ^b	5.43 ^a	
	S.E.M			C.D. 1%			

N	0.028	0.081
M	0.023	0.066
N*M	0.057	0.162
N ₀ : Control (No sprays)	N ₃ : Nano urea 1 ml L ⁻¹	M ₁ : Red earth
N ₁ : Urea 2 g L ⁻¹	N ₄ : Nano urea 1.5 ml L ⁻¹	M ₂ : Red earth + Cocopeat (1:1)
N ₂ : Nano urea 0.5 ml L ⁻¹	N ₅ : Nano urea 2 ml L ⁻¹	M ₃ : Red earth + Cocopeat + FYM (1:1:1)
		M ₄ : Red earth + Cocopeat + FYM (2:1:1)

Table 11: Effect of Nano urea levels and composition of potting media on APTI (Air Pollution Tolerance Index) at 125 days after planting in *Philodendron scandens*

Media Compo Sition	Nano Urea Levels						MEAN
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	
M ₁	7.49	8.20	9.0	9.61	10.34	11.75	9.40 ^c
M ₂	7.72	8.31	8.92	9.68	10.48	12.22	9.56 ^b
M ₃	7.66	8.35	9.25	9.77	10.68	12.74	9.74 ^a
M ₄	7.64	8.31	9.18	9.72	10.66	12.49	9.67 ^a
MEAN	7.63 ^f	8.29 ^e	9.09 ^d	9.69 ^c	10.54 ^b	12.3 ^a	
	S.E.M			C.D. 1%			
N	0.06			0.18			
M	0.05			0.15			
N*M	0.13			0.36			

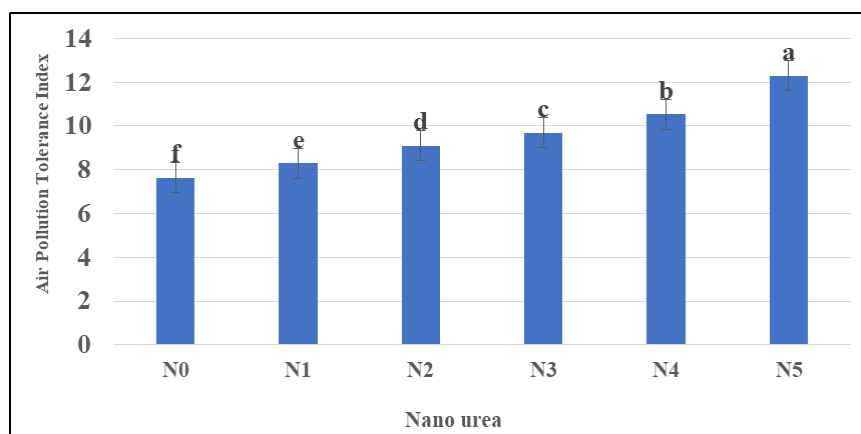


Fig 7a: Effect of Nano urea levels on APTI at 125 DAP

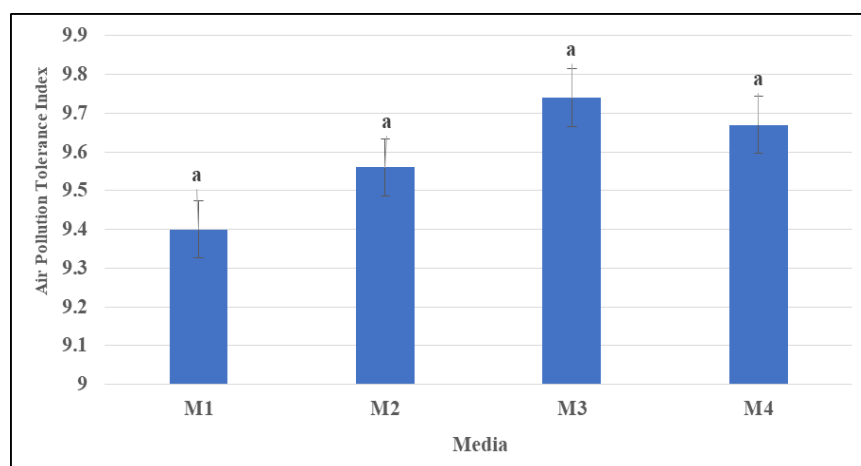


Fig 7b: Effect of composition of potting media on APTI at 125 DAP

N ₀ : Control (No sprays)	N ₃ : Nano urea 1 ml L ⁻¹	M ₁ : Red earth
N ₁ : Conventional Urea 2 g L ⁻¹	N ₄ : Nano urea 1.5 ml L ⁻¹	M ₂ : Red earth + Cocopeat (1:1)
N ₂ : Nano urea 0.5 ml L ⁻¹	N ₅ : Nano urea 2 ml L ⁻¹	M ₃ : Red earth + Cocopeat + FYM (1:1:1)

Prajapati and Tripathi (2008) and Singh *et al.* (2017) [33], who observed that plants receiving adequate nitrogen exhibited higher leaf pH and improved tolerance to atmospheric pollutants.

With respect to potting media composition, media enriched with coco peat and FYM recorded higher leaf pH values compared to red earth alone. The presence of organic components may have improved nutrient buffering capacity and reduced acidity in the rhizosphere, which in turn reflected in higher leaf pH. Comparable observations were documented by Swami *et al.* (2018) [38], who reported improved physiological parameters, including leaf pH, in ornamental plants grown in organically amended substrates. The non-significant interaction between Nano urea levels and media composition suggests that both factors independently influenced leaf pH. An increase in leaf pH is considered advantageous, as plants with relatively higher leaf pH possess greater neutralizing capacity against acidic air pollutants such as SO₂ and NO₂. Therefore, the enhanced leaf pH observed under higher Nano urea levels and improved media composition contributes positively to the overall air pollution tolerance of *Philodendron scandens*.

APTI (Air Pollution Tolerance Index) as influenced by Nano urea levels and media composition at 125 days after planting is presented in Table 11 and depicted in Fig 10a, b. Among the different levels of Nano urea, maximum (12.30) Air Pollution Tolerance Index was recorded with Nano urea spray N5 (2 ml L⁻¹) followed by N4 (Nano urea 1.5 ml L⁻¹) (10.54), N3 (Nano urea 1 ml L⁻¹) (9.69) while minimum (7.63) Air Pollution Tolerance Index was noticed in N0 (No spray). Among different composition of potting media, maximum Air Pollution Tolerance Index (9.74) was recorded in M3 (Red Earth + Coco peat + FYM (1:1:1)) and is on par with M4 (Red Earth + Coco peat + FYM (2:1:1)) (9.67) which is followed by M2 (Red Earth + Coco peat (1:1)) (9.56) while minimum (9.4) Air Pollution Tolerance Index was recorded in M1 (Red Earth). Interaction effect of Nano urea levels and media composition on APTI (Air Pollution Tolerance Index) was found to be insignificant. The variation in Air Pollution Tolerance Index (APTI) observed in the present study can be attributed to changes in key physiological and biochemical parameters such as leaf pH, relative water content (RWC), total chlorophyll and ascorbic acid content.

Higher APTI values recorded with increased Nano urea levels indicate improved physiological efficiency and stress tolerance in *Philodendron scandens*. The maximum APTI under Nano urea spray at 2 ml L⁻¹ may be due to enhanced nitrogen availability, which plays a crucial role in chlorophyll biosynthesis and maintenance of photosynthetic activity. Increased chlorophyll content has been widely associated with improved tolerance to air pollutants, as it reflects the plant's ability to sustain photosynthesis under stress conditions. Similar observations were reported by Prajapati and Tripathi (2008) and Singh *et al.* (2017) [33], who noted that plants with higher chlorophyll concentration and balanced leaf pH exhibited greater air pollution tolerance. Relative water content is another important determinant of APTI, as higher RWC enables plants to maintain cellular turgidity and dilute absorbed pollutants, thereby minimizing their toxic effects.

The improved APTI values under Nano urea treatments suggest better water relations and membrane stability, which corroborates the findings of Rai *et al.* (2013) and Kaur and

Nagpal (2017) [21, 34] in ornamental foliage plants exposed to polluted environments. Ascorbic acid acts as a major non-enzymatic antioxidant involved in scavenging reactive oxygen species generated due to air pollutants. The enhanced APTI in Nano urea-treated plants may therefore be linked to increased ascorbic acid synthesis, strengthening the antioxidative defense mechanism. Comparable results were documented by Seyyednejad *et al.* (2011) and Begum and Harikrishna (2010) [7], who reported a strong positive relationship between ascorbic acid content and APTI. Potting media composition also influenced APTI, with organically enriched media containing coco peat and FYM recording higher values. Improved physical properties such as moisture retention, aeration and nutrient availability in these media might have favored better physiological performance, resulting in enhanced APTI. Similar responses have been reported in ornamental and landscape plants grown in organic or mixed substrates by Swami *et al.* (2018) and Rameshkumar *et al.* (2019) [35, 38]. The non-significant interaction between Nano urea levels and media composition indicates that both factors independently contributed to the improvement of APTI without exhibiting interactive effects. Overall, the results confirm that enhancement of leaf pH, relative water content, total chlorophyll and ascorbic acid content leads to increased air pollution tolerance, supporting the suitability of *Philodendron scandens* as a pollution-tolerant ornamental species for urban landscapes.

Conclusions: The present study on *Philodendron scandens* demonstrated that both Nano urea application and potting media composition significantly influence growth, physiological, biochemical, and quality parameters of this important ornamental foliage plant. Among the Nano urea treatments, 2 ml L⁻¹ (N₅) consistently enhanced plant height, leaf number, leaf area, chlorophyll content, relative water content, ascorbic acid, leaf pH, and air pollution tolerance index (APTI), indicating improved vegetative vigor, photosynthetic efficiency, and stress tolerance. Among the potting media, the combination of Red Earth + Cocopeat + FYM (1:1:1; M₃) provided superior water retention, aeration, and nutrient availability, promoting early bud sprouting, rapid leaf expansion, and overall plant development. The interaction of N₅ and M₃ yielded the tallest plants with maximum leaf production and photosynthetic capacity, highlighting the synergistic effect of optimized nutrient supply and enriched substrate composition.

These findings suggest that foliar application of Nano urea at 2 ml L⁻¹, combined with a balanced potting media of Red Earth, Cocopeat, and FYM, can be recommended for the sustainable production of *Philodendron scandens*, enhancing both ornamental quality and air pollution tolerance. The study underscores the potential of integrating Nanotechnology-based fertilizers with organic-enriched substrates to improve nutrient use efficiency, reduce environmental impact, and achieve high-quality container-grown foliage plants suitable for urban landscapes and interior décor.

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