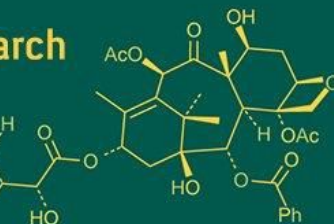


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Biochemical responses and air pollution tolerance of *philodendron scandens* to Nano urea under different potting media

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Abstract

Urban air pollution and shrinking green spaces necessitate the use of pollution-tolerant ornamental foliage plants for sustainable urban landscaping. The present study, “Biochemical Responses and Air Pollution Tolerance of *Philodendron scandens* to Nano Urea under Different Potting Media”, was conducted at the College of Horticulture, Mojerla, SKLTSHU, from December 2021 to May 2022. The experiment was laid out in a Factorial Randomized Block Design with six nano urea levels and four potting media compositions. At 125 days after planting, nano urea significantly improved biochemical traits and Air Pollution Tolerance Index (APTI). Nano urea @ 2 ml L⁻¹ recorded the highest relative water content (92.17%), leaf pH (5.43), total chlorophyll (2.49 mg g⁻¹) and APTI (12.30), along with greater leaf greenness (L* 40.2; a* -0.76), compared to the control. Among potting media, M3 showed higher relative water content (80.37%) and leaf pH (4.93), while M4 registered the highest chlorophyll content (1.75 mg g⁻¹). Interaction effects were non-significant. The study concludes that foliar application of nano urea at 2 ml L⁻¹, combined with organically enriched potting media, effectively enhances biochemical traits and air pollution tolerance of *Philodendron scandens*, supporting its suitability for urban and vertical landscaping.

Keywords: *Philodendron scandens*, nano urea, potting media, total chlorophyll, relative water content, leaf pH, Air Pollution Tolerance Index (APTI), urban landscaping

Introduction

Rapid urbanization and industrial growth have resulted in elevated levels of air pollutants such as sulfur dioxide (SO₂), nitrogen oxides (NO_x) and particulate matter, which adversely affect plant health and urban environmental quality (Prajapati and Tripathi, 2008; Rai *et al.*, 2013) [19, 20]. In this context, ornamental foliage plants play a dual role by enhancing aesthetic value and mitigating air pollution through absorption, adsorption and accumulation of pollutants on leaf surfaces (Escobedo *et al.*, 2011) [8]. The ability of plants to tolerate polluted environments is commonly assessed using the Air Pollution Tolerance Index (APTI), which integrates key biochemical and physiological parameters such as relative water content, leaf pH, total chlorophyll and ascorbic acid content (Singh and Rao, 1983; Ogunkunle *et al.*, 2015) [25, 16]. Plants with higher APTI values are considered more suitable for urban and vertical landscaping.

Nitrogen nutrition is a major determinant of plant growth, chlorophyll synthesis, water relations and stress tolerance. Conventional nitrogen fertilizers often exhibit low nitrogen use efficiency, leading to nutrient losses and environmental contamination (Peng *et al.*, 2007) [18]. Recently, nano urea has gained attention as an efficient nitrogen source due to its controlled release, higher absorption efficiency and reduced losses, resulting in improved chlorophyll content and physiological performance (Bondada *et al.*, 2003; Abdel-Salam, 2018) [4, 1]. However, studies evaluating the role of nano urea on biochemical traits linked to pollution tolerance in ornamental foliage plants are limited. Potting media composition also significantly influences plant performance by affecting moisture retention, aeration and nutrient availability. Organic amendments such as cocopeat and farmyard manure (FYM) are known to improve substrate properties and support better biochemical and physiological

responses in container-grown ornamentals (Rameshkumar *et al.*, 2018; Swami *et al.*, 2018) [22, 26]. Despite increasing interest in pollution-tolerant ornamental plants for urban and vertical landscapes, limited information is available on the combined influence of nano urea nutrition and potting media composition on biochemical attributes and air pollution tolerance of foliage plants. *Philodendron scandens*, a widely used ornamental species, has received little scientific attention with respect to its response to nano urea application and its potential for pollution mitigation based on APTI parameters. In view of the above, the present study was undertaken to standardize nano urea levels and potting media composition and to evaluate their effects on biochemical parameters and Air Pollution Tolerance Index of *Philodendron scandens*, with the objective of identifying suitable nutrient and media combinations for enhancing its performance and suitability for urban and vertical landscaping.

Materials and methods

The experiment was conducted in a shade net at the Floriculture block of College of Horticulture, Mojerla, Wanaparthi, situated at an altitude of 347.3 m above mean sea level on 78° 29' East longitude and 17° 19' North latitude. The experiment was conducted in Factorial Randomized Block Design with three replications and two factors with Factor 1 consisting of six levels of Nano urea (N₀-Without spray of Nano Urea, N₁- Conventional urea (2 g L⁻¹), N₂-0.5 ml L⁻¹, N₃-1.0 ml L⁻¹, N₄-1.5 ml L⁻¹, N₅-2.0 ml L⁻¹) and Factor 2 comprising of four levels of potting media (M₁-Red earth, M₂-Redearth +Cocopeat (1:1), M₃- Red earth + Cocopeat + FYM (1:1:1), M₄-Redearth + Cocopeat + FYM (2:1:1)). First spraying was done at 35 days after planting. Other sprays were applied at every 15-day interval for three months. A total of 6 sprays were carried out. Biochemical parameters, namely relative water content (RWC), total chlorophyll content, ascorbic acid content and leaf pH, were estimated using fully expanded leaves collected from the second or third node from the top of the shoot of all plants at 125 days after planting. Quality parameters, including leaf colour and Air Pollution Tolerance Index (APTI), were also assessed at 125 days after planting.

Relative water content (RWC)

Leaf samples were immediately weighed to record fresh weight (W₁) and immersed in distilled water for 2 hrs, blotted with filter paper (Whatman No. 1, Sigma Aldrich), and weighed again to measure turgid weight (W₂). Afterwards, leaves were placed in the oven at 70 °C for 48 hrs and reweighed to record the dry weight (W₃). RWCs were calculated using the following formula (Wweatherle 1950) [29].

$$RWC = \frac{W_1 - W_3}{W_2 - W_3} \times 100$$

Where, W₁ = fresh weight of the leaf, W₂ = turgid weight of the leaf, W₃ = dry weight of the leaf

Chlorophyll content

Estimation of chlorophyll content in leaves was carried out by the acetone extraction method (Arnon 1949). Each collected leaf sample was chopped finely and 100mg was

collected separately from each chopped leaf sample. These samples were submerged in volumetric flasks with 25 ml of 80% acetone solution in a refrigerator for 2 days. After 2 days, the total leaf extracts were absorbed into the acetone by leaving the pale coloured tissues of the chopped samples. Then, these pale coloured tissues were removed and the remaining solutions were collected separately from each volumetric flask. By using these collected samples, absorbance was taken at 663.2 nm and 646.8 nm using a spectrophotometer. Calculations were done using the formula.

Chlorophyll 'a' (mg/g Fresh Wt.)

$$(12.7 D_x \times 663.2 - 2.69 D_x \times 646.8) \times V/1000 W$$

Chlorophyll 'b' (mg/g Fresh Wt.)

$$(22.9 D_x \times 646.8 - 24.68 D_x \times 663.2) \times V/1000 W$$

Total Chlorophyll (mg/g Fresh Wt.)

$$\text{Chlorophyll a} + \text{Chlorophyll b}$$

Where, T.Ch.=Total Chlorophyll, D_x= Absorbance of extract at wavelength x (nm), V=Total volume of chlorophyll solution (ml), W=Weight of tissue extracted (gm)

Ascorbic acid Estimation of ascorbic acid has done by the titration method, i.e., by using the '2, 6 Dichlorophenol indophenol Titration method' (Sadasivam *et al.*, 1992; AOAC, 1990) [23, 2].

Leaf pH

The pH of leaf samples was measured at 20 °C using a pH meter (pH Tutor, EUTECH Instruments) with a combined glass electrode fitted. Before the experiment, the pH meter was standardized using standard buffers of pH 4.0 and 9.0 at 20 °C. Here, 2.5 g of fresh leaf sample was weighed with the help of an electronic weighing balance, and the sample was finely ground by using a mortar and pestle. 10 ml of distilled water was added to this ground sample, left for 15min and filtered to measure pH with an electric probe.

- **Quality parameters:** Quality parameters like Leaf colour and Air Pollution Tolerance Index (APTI) were measured at 125 days after planting.

Leaf colour

A Hunter CIELAB colorimeter measured leaf colour (Hunter *et al.*, 1987) [11]. CIELAB, developed by the International Commission on Illumination (CIE) or Hunter Lab, coordinates L*, a*, and b*, which have been successfully used for the description of plant colours (Jia *et al.* (2008) [12], Osmani *et al.* (2009)) [17].

There are three parameters or axes measured with this colorimeter: Colour brightness (L*) and Colour coordinates (a* and b*). The L* axis represents "Lightness" and ranges from "0" to "100" and "0" means no lightness and indicates absolute black; otherwise, "100" indicates white colour. The colour coordinates "a*" and "b*" do not have a certain range of measurement but can be positive or negative. "a*" value represents the red-green axis, positive values are reddish, negative values are green, while 0 is neutral. 2nd colour coordinate "b*" represents the yellow-blue axis,

positive values indicate yellow colour and negative values indicate blue colour (Devici *et al.*, 2018) [6].

Air Pollution Tolerance Index (APTI)

Estimation of different biochemical parameters, such as ascorbic acid, total chlorophyll content, relative water content, and leaf pH, was carried out according to standard procedures. APTI of samples was calculated by the following formula proposed by Singh and Rao (1983) [25] and expressed in numbers.

$$APTI = \frac{A(T + P) + R}{10}$$

Where: A= Ascorbic acid contents in mg/g of leaves, T = Total chlorophyll in mg/g fresh weight, P = pH of leaf extract, R = Relative Water Content (%)

Results and Discussion

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 Table1 and depicted in Fig 1a, b. 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). The interaction effect on the Relative Water Content of a leaf was found to be insignificant. The variation in relative water content (RWC) of leaves observed in the 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) [27], 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) [26] and Rameshkumar *et al.* (2019) [22] 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.

Total Chlorophyll content (mg g⁻¹)

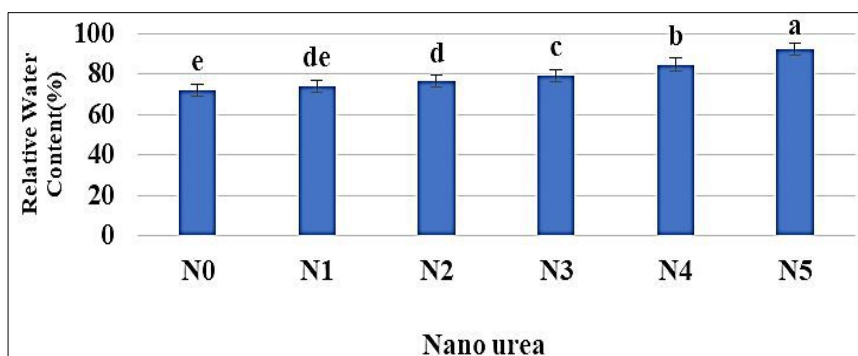
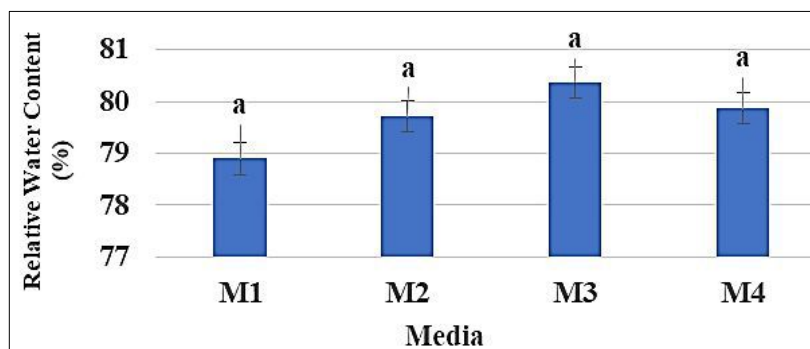
Total Chlorophyll content (mg g⁻¹) of leaves as influenced by nano urea levels and media composition at 125 days after planting is presented in Table 2 and depicted in Fig 2a, b. Among the different levels of nano urea, maximum Total Chlorophyll content (2.491 mg g⁻¹) of a leaf was recorded with nano 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) [18, 4, 10].

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) [7] 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*.

Table 1: Effect of nano urea levels and composition of potting media on RWC (Relative Water Content, %) of a leaf 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	71.47	73.24	75.99	78.89	83.75	90.05	78.9 ^b
M ₂	72.79	73.74	75.32	79.30	84.04	93.10	79.71 ^a
M ₃	72.02	74.48	77.35	79.80	85.34 ^c	93.26	80.37 ^a
M ₄	71.92	74.44	76.58	78.86	85.16 ^c	92.26	79.87 ^a
Mean	72.05 ^e	73.97 ^{de}	76.31 ^d	79.21 ^c	84.57 ^b	92.17 ^a	
	S.E.M			C.D. 1%			
N	0.42			1.19			
M	0.34			0.97			
N*M	0.84			2.38			

**Fig 1a:** Effect of nano urea levels on Relative Water Content (%) of a leaf at 125 DAP in *Philodendron scandens***Fig 1b:** Effect of composition of potting media on Relative Water Content (%) of a leaf 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 2: 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						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	MEAN
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			

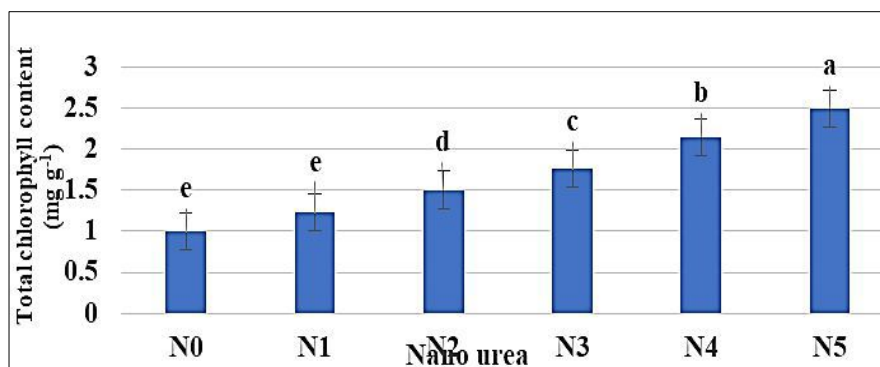


Fig 2a: Effect of nano urea levels on Total chlorophyll content (mg g⁻¹) in leaves at 125 DAP in *Philodendron scandens*

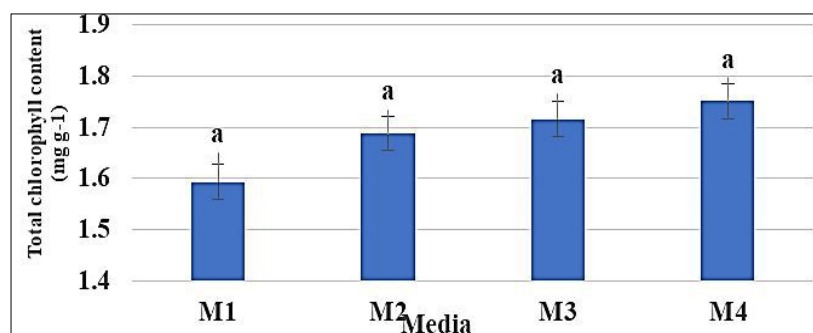


Fig 2b: Effect of composition of potting media on Total chlorophyll content in leaves at 125 DAP in *Philodendron scandens*

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)

Ascorbic acid content (mg g⁻¹)

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 3 and depicted in Fig 3a, b. 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). The composition of potting media and the interaction effect of nano urea levels with media composition on Ascorbic acid in the 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) [9, 14]. Chiesa *et al.* (2009) [5] reported that high N (150 kg ha⁻¹) increased ascorbic acid content in lettuce. Variation in the accumulation of ascorbic acid content at different rates of N applications, altered with the findings of Mahlangu *et al.* (2016) [15]. In this experiment application of nano urea increased the ascorbic acid, which might be due to the timely release and high nitrogen use efficiency of nano urea.

Leaf pH

Leaf pH as influenced by nano urea levels and media composition at 125 days after planting is presented in Table 4 and depicted in Fig 4a, b. 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). The 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 by Prajapati and Tripathi (2008) [19], 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) [26], 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*.

Table 3: 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			

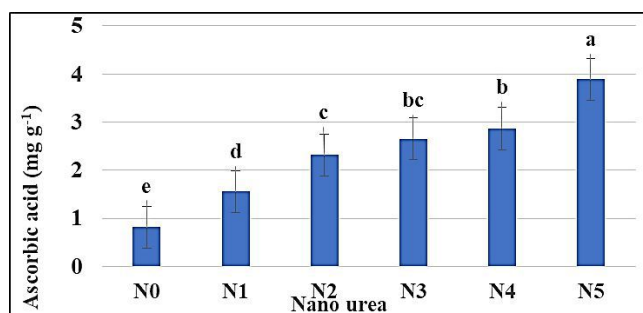


Fig 3a: Effect of nano urea levels on Ascorbic acid content (mg g⁻¹) in leaves of (mg g⁻¹) *Philodendron scandens* at 125 DAP

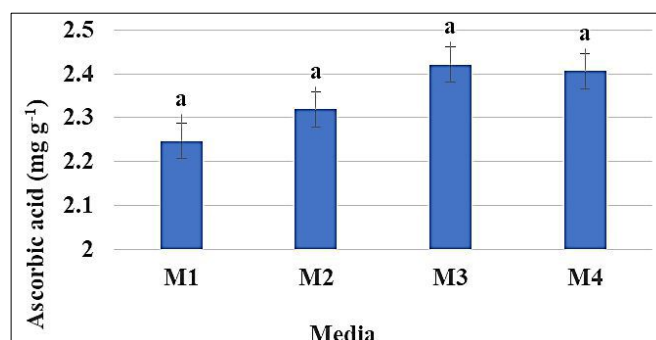


Fig 3b: Effect of composition of potting media on Ascorbic acid in content in leaves of *Philodendron scandens* at 125 DAP

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)

Table 4: Effect of nano urea levels and composition of potting media on pH of leaves at 125 days after planting in *Philodendron scandens*

Media Composition	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			

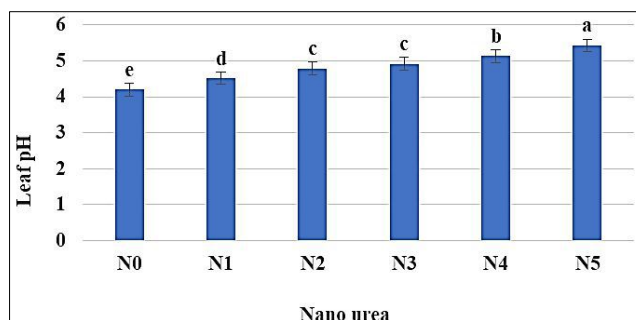


Fig 4a: Effect of nano urea levels on pH of a leaf at 125 DAP in *Philodendron scandens*

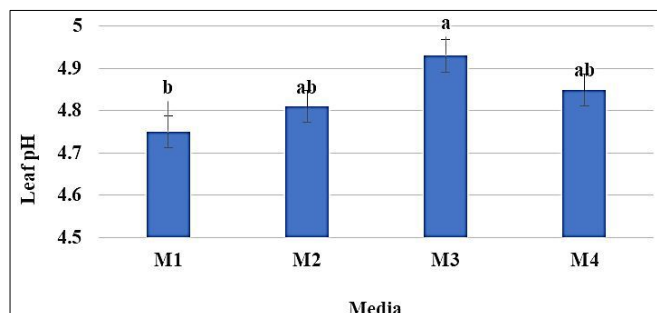


Fig 4b: Effect of composition of potting media on pH of a leaf at 125 DAP in *Philodendron scandens*

N0: Control (No sprays)	N3: Nano urea 1 ml L ⁻¹	M1: Red earth
N1: Conventional Urea 2 g L ⁻¹	N4: Nano urea 1.5 ml L ⁻¹	M2: Red earth + Cocopeat (1:1)
N2: Nano urea 0.5 ml L ⁻¹	N5: Nano urea 2 ml L ⁻¹	M3: Red earth + Cocopeat + FYM (1:1:1)

Leaf colour

The mean data pertaining to Leaf colour as influenced by nano urea levels and media composition at 125 days after planting is presented in Table 5. Among the different levels of nano urea application, highest values in terms of dark greenness (L^* : 40.2, a^* : -0.76, b^* : 25.00) was recorded with N₅ (Nano urea 2 ml L⁻¹) and light greenness (L^* : 52.3, a^* : 11.91, b^* : 25.95) was recorded with N₀ (No spray) at 125 days after planting. There was no observable effect of media on leaf colour. However, M₃ and M₄ have shown negative values for a^* , which indicates the high intensity of leaf colour, increase in greenness indicates an increase in chlorophyll content of leaves.

Leaf colour (L^* , a^* , b^*) showed distinct variation in response to different levels of nano urea application, indicating changes in leaf pigment concentration and photosynthetic status of *Philodendron scandens*. Darker green leaves, characterized by lower L^* values and more negative a^* values, were recorded under higher nano urea levels, whereas lighter green leaves were observed under the control treatment. The highest greenness intensity recorded with nano urea at 2 ml L⁻¹ (N₅) may be attributed to enhanced nitrogen availability, which plays a key role in chlorophyll biosynthesis and maintenance of chloroplast structure. Increased nitrogen supply leads to greater chlorophyll accumulation, resulting in darker green leaves with reduced lightness (L^*) and negative a^* values. Similar observations were reported by Wang *et al.* (2019) [28] and Umnajkitikorn *et al.* (2021) [27], who demonstrated a strong positive relationship between nitrogen nutrition and leaf greenness indices in ornamental foliage plants.

In contrast, the lighter green colour observed in the control treatment reflects reduced chlorophyll concentration due to limited nitrogen availability, as indicated by higher L^* values and positive a^* values. Such changes in leaf colour

are commonly associated with nitrogen deficiency and reduced photosynthetic efficiency. Potting media composition did not exert a significant influence on leaf colour parameters. However, media combinations containing coco peat and FYM (M₃ and M₄) exhibited relatively more negative a^* values, suggesting improved greenness intensity, possibly due to better nutrient availability and moisture retention. These results indicate that while nano urea application played a dominant role in determining leaf colour, organically enriched media provided supportive conditions for chlorophyll development. Overall, the increase in leaf greenness under higher nano urea levels reflects enhanced chlorophyll content and improved physiological performance, which may contribute to greater photosynthetic capacity and stress tolerance in *Philodendron scandens*.

APTI (Air Pollution Tolerance Index)

The mean data pertaining to APTI (Air Pollution Tolerance Index) as influenced by nano urea levels and media composition at 125 days after planting is presented in Table 5 and depicted in Fig 5a, 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). The 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) [19], 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) [21] and Kaur and Nagpal (2017) [13] 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) [24] and Begum and Harikrishna (2010) [3], 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) [26] and Rameshkumar *et al.* (2019) [22]. 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.

Table 5: 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 Composition	Nano Urea Levels						
	N ₀	N ₁	N ₂	N ₃	N ₄	N ₅	Mean
M ₁	7.49	8.20	9.0	9.61	10.34	11.75	9.4 ^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			

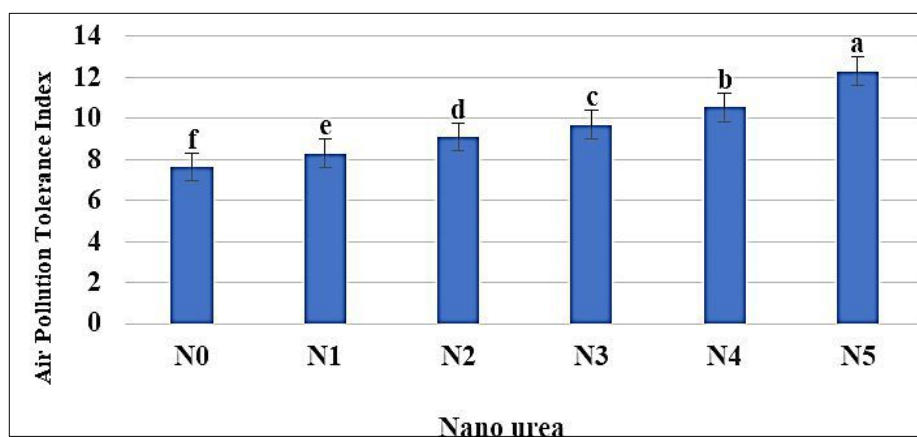


Fig 5a: Effect of nano urea levels on APTI at 125 DAP in *Philodendron scandens*

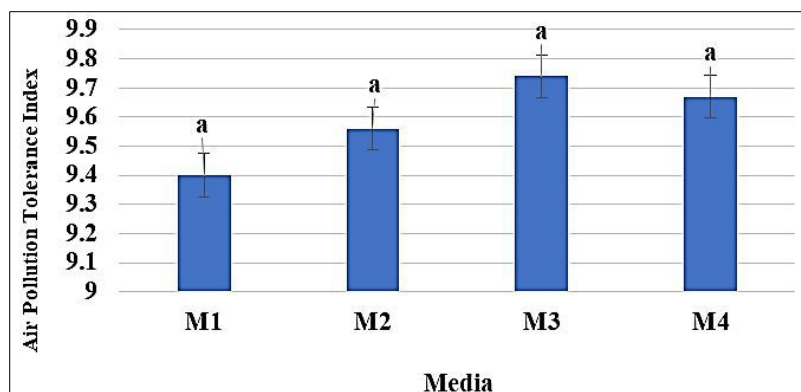


Fig 5b: Effect of composition of potting media on APTI at 125 DAP in *Philodendron scandens*

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)

Conclusion

The study revealed that nano urea application significantly enhanced physiological and biochemical parameters associated with air pollution tolerance in *Philodendron scandens*. Foliar application of nano urea at 2 ml L⁻¹ consistently resulted in higher relative water content, leaf pH, chlorophyll content and leaf greenness, leading to a marked improvement in Air Pollution Tolerance Index (APTI). These responses indicate improved nitrogen use efficiency, photosynthetic capacity and physiological stability.

Potting media containing coco peat and FYM performed better than red earth alone by supporting improved water retention and nutrient availability, though their effects were largely independent of nano urea levels. Overall, the results confirm that *Philodendron scandens* exhibits enhanced pollution tolerance under optimal nano urea nutrition, highlighting its suitability for urban and vertical landscaping applications.

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