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Studies on effect of carbon based nanomaterial, novel plant growth promoting agents on growth of jasmine (*Jasminum sambac* Ait.)

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Abstract
Multi-carbon nanotubes (MWCNTs) having an average particle size of 71.81 nm with different concentration of MWCNTs (3 and 7 g/L) and graphene oxide having a diameter of 65.99 nm with different concentrations (20 and 40 mg/L), hydrogen rich water (500 ppb and 1000 ppb) and with three concentration of sodium hydrosulfide (0.5 mg, 5 mg, 50 mg) as foliar spry along with absolute control (Deionized water) were used as a foliar spray at 15 days interval during 60 days of growth period in jasmine (Jasminum sambac). This study provided some insights into the use of carbon based Nano-materials. The multi-walled carbon nanotubes (MWCNTs) with 3 g/L treated plants had maximum plant height (57.91 cm), internodal length (4.94 cm), number of leaves (170.55), plant spread E-W (46.01 cm), N-S (55.69 cm), Whereas, graphene oxide treated plant with 20 mg/L showed a promotional effect on plant growth attributes.

Keywords: Carbon nanotube, graphene oxide, jasmine, hydrogen rich water, vegetative growth

Introduction
Jasmine (*Jasminum* spp.) is a historically grown "queen flower" of the Oleaceae family that is incredibly fragrant and appreciated for its distinctive Aroma. These species are used to produce flowers and value-added products like essential oils, absolutes, and concretes (Bera *et al.* 2015) [2]. The Oleaceae family's historically regarded "queen flower," Jasmine (Jasminum spp), is incredibly fragrant and prized for its distinctive Aroma. The Indian native Jasmine sambac, sometimes referred to as Arabian Jasmine or Tuscan Jasmine, has a powerful fragrance and opens at night and closes in the morning. It is used to produce essential oils, concrete, and absolute and has a strong sweet scent. In folk medicine, flowers areused as an antispasmodic, aphrodisiac, antimicrobial, and wound healer (Arun *et al*. 2016; Hirapara *et al*. 2017) [1, 6]. It is anticipated that chemicals like graphene oxide, a powerful antibacterial agent, will enhance plant growing conditions and enhance plant development (He *et al*. 2018) [5]. By keeping the above information into account, it is necessary to investigate novel compounds in the technology used to produce *Jasminum sambac* Cv. Ramanathapuram Gundumalli. As a result, the current study proposes the use of graphene oxide, sodium hydrosulfide, hydrogen-rich water, and multiwalled carbon nanotube to examine the effects on plant growth, flower bud development, and floral quality over the growing season.

Materials and Methods
The present study was conducted during 2021-2022 at Instructional farm, madanapuram, college of horticulture, mojerla, sri Konda laxman Telangana state Horticultural University. The experiment was laid out in Randomized Block design with three replications and ten treatments. comprising of Multi-Walled Carbon Nano tubes (MWCNTs), Graphene oxide, Sodium hydrosulfide and Hydrogen Rich Water (HRW) sprayed 15 days intervals from the date planting up to 60 days of growth period to study the influence of the treatments on growth, yield, quality, and shelf life of Jasmine (Jasmine sambac Ait.) Cv. Ramanathapuram Gundumalli.

As per the treatment details, one spray of each treatment was taken with hand operated pump pressure sprayer om whole established plant after planting. The required concentration of Multi walled Carbon Nano Tube (MWCNTs) which was synthesized by super growth method, and graphene oxide and Sodium Hydrosulfide procured from Sigma Aldrich Chemicals, India, and Hydrogen Rich water prepared with two concentrations (500 ppb and 1000 ppb)by using

Wellon molecular Hydrogen Generator about 2 litre of solution of each treatments was sprayed per plant at the time of application at fifteen days intervals from date of First application to 60 days growth period on established plants of one year old. The observation were recorded from nine plants in each treatment on Plant height, Number of nodes Inter nodal length, Number of leaves per plant, Plant spread E-W, The data was collected at fifteen days intervals from date of First application to 60 days growth period.

Results and Discussion

Effect on Growth Parameters

The data presented in in significant difference in growth parameters due to chemical sprays.

Plant height

The results indicated in Table 1 Multi-walled carbon nanotube (MWCNTs) at 3g/lit as a foliar spray of T1 recorded significantly maximum mean of plant height at 15 days (21.83 cm), at 30 days (36.15 cm) at 45 days (47.27 cm), at 60 days (57.91 cm) whereas, the treatment control T0 recorded minimum mean of plant height at 15 days (14.40 cm), at 30 days (21.53 cm) at 45 days (27.66 cm), at 60 days (32.75 cm) This observation could be explained by the mechanism of thigmomorphogenesis when auxin activity increases and plant growth increases, which stimulates the growth of the plant's stems. This result is similar with what Smirnova *et al*. (2011) [9] reported in Onobrychis.

Internodal length

The maximum mean of internodal length was observed Multi-walled carbon nanotube (MWCNTs) at 3g/lit as a foliar spray extension growth in inter nodal length at 15 days (3.82 cm), 30 days (4.03 cm), 45 days (4.46 cm) and 60 days (4.94 cm) whereas, the treatment control T0 recorded minimum mean of nodes per primary shoot at 15 days (3.15), at 30 days (3.9) at 45 days (3.47), at 60 days (4.14). Since arginine is a significant source of nitrogen storage in the plant metabolome and is thought to play a role in synthesis and plant growth, an increase in nitric oxide accounts for an increase in chlorophyll content. Additionally, glutathione synthase and reductase as well as MWCNTs have an impact on the gene expression of arginine. This research contradicts the agricultural outcomes given by Mukherjee *et al*. (2016) [8].

Number of leaves per plant

The plant was observed Multi-walled carbon nanotube (MWCNTs) at 3g/lit as a foliar spray produced maximum number of leaves per plant at 15 days (47.58), 30 days (88.26), 45 days (141.25) and 60 days (170.55) whereas, the treatment control T0 recorded minimum mean of nodes per primary shoot at 15 days (36.93), at 30 days (72.06) at 45 days (122.58), at 60 days (124.82). The combined morphological and physiological study showed that MWCNTs considerably increased plant growth and biomass compared to control after roughly 5–10 days of exposure in our experiment. Plants treated with MWCNTs demonstrated beneficial benefits that were dosage dependent on the quantity and size of leaves. In the case of garlic, Srivastava *et al.* (2014) [10]

Plant spread

The plant spread in E-W direction was observed Multi-walled carbon nanotube (MWCNTs) at 3g/lit as a foliar spray recorded highest plant spread (E-W) at15 days (19.19 cm), T9 at 30 days (30.76 cm), T1 at 45 days (38.91 cm) T1 at 60 days (46.01 cm). This implies that MWCNT application increased the amount of carbohydrates accumulated in leaves, which may have increased photosynthetic activities by extending the range of light wavelengths that activate a plant photosynthetic system. Normally, plants absorb about 10% of full sunlight, but the applied MWCNTs passively transport and irreversibly localise within the lipid envelope of plant chloroplasts, promoting over three-fold higher photosynthetic activity. These are similar to the results reached by Giraldo *et al.* (2014) [4] and ultimately lead to an expansion of plant dispersion. More directly correlated with photosynthetic efficiency is plant spread.

Table 2: Effect of Carbon Based Nanomaterial, Sodium Hydrosulfide (NaHS) and Hydrogen Rich Water on plant height (cm) of Jasmine (*Jasminum Sambac* Ait.) *Cv*. Ramanathapuram Gundumalli

Treatments	Plant Height (Cm)				
	0 Days	**15 Days**	**30 Days**	**45 Days**	**60 Days**
T0 (control) Deionized water (1 liter)	10.19±0.1a	14.4±0.14e	21.53±0.15f	27.66±0.21h	32.75±0.19g
T1 -Multi-walled carbon nanotube (3 g/liter of water)	9.49±0.11a	21.83±0.1a	36.15±0.16a	47.27±0.1a	57.91±0.16a
T2-Multi-walled carbon nanotube (7 g/liter of water)	8.22±0.13b	19.39±0.16b	32.71±0.22b	43.11±0.32c	53.26±0.35c
T3-Graphene oxide (20 mg/liter of water)	8.28±0.07b	17.46±0.1c	30.31±0.09cd	39.23±0.08d	47.95±0.08d
T4- Graphene oxide (40 mg/liter of water)	7.75±0.36b	16.83±0.37cd	28.96±0.36d	37.37±0.37e	45.59±0.37e
T5-Sodium Hydrosulfide (0.5 mg/liter of water)	9.37±0.15a	15.57±0.21de	25.40±0.2e	33.52±0.2g	41.45±0.19f
T6-Sodium Hydrosulfide (5 mg/liter of water)	8.15±0.77b	15.77±0.59de	25.83±0.75e	35.45±0.76f	44.38±0.77e
T7-Sodium Hydrosulfide (50 mg/liter of water)	9.49±0.14a	17.61±0.14c	28.96±0.16d	39.12±0.2d	48.94±0.2d
T8-Hydrogen rich water (500 ppb)	9.45±0.17a	19.29±1.52b	31.34±1.54bc	42.40±1.57c	52.59±1.61c
T9-Hydrogen rich water (1000 ppb)	10.10±0.32a	21.62±0.05a	34.90±0.15a	45.55±0.14b	55.99±0.21b
Mean	9.049	17.976	29.609	39.069	48.081
S.Em±	0.311	0.522	0.532	0.541	0.559
C.D at 5% level	0.924	1.551	1.58	1.606	1.662

Results expressed as Means±SE

Table 2: Effect of Carbon Based Nanomaterial, Sodium Hydrosulfide (NaHS) and Hydrogen Rich Water on Inter nodal length (cm) of Jasmine (*Jasminum Sambac* Ait.) *Cv*. Ramanathapuram Gundumalli

Treatments	**Inter Nodal Length (Cm)**				
	0 Days	**15 Days**	**30 Days**	**45 Days**	**60 Days**
T0 (control) Deionized water (1 liter)	2.54±0.07	3.15±0.01j	3.49±0.01i	3.74±0.02i	4.14±0.01i
T1 -Multi-walled carbon nanotube (3 g/liter of water)	2.34±0.01	3.82±0.01a	4.03±0.01a	4.46±0.01a	4.94±0.03a
T2-Multi-walled carbon nanotube (7 g/liter of water)	2.19±0.08	3.63±0.01c	3.85±0.01c	4.06±0.01c	4.51±0.03c
T3-Graphene oxide (20 mg/liter of water)	2.29±0.18	3.55±0.01e	3.79±0.01d	3.98±0.01d	4.35±0.03d
T4- Graphene oxide (40 mg/liter of water)	2.24±0.1	3.52±0.02f	3.77±0.01e	3.92±0.02ef	4.26±0.02f
T5-Sodium Hydrosulfide (0.5 mg/liter of water)	2.40±0.13	3.29±0.01i	3.60±0.01h	3.83±0.01h	4.19±0.01h
T6-Sodium Hydrosulfide (5 mg/liter of water)	2.37±0.07	3.37±0.01h	3.67±0.01g	3.87±0.01g	4.23±0.01g
T7-Sodium Hydrosulfide (50 mg/liter of water)	2.31±0.03	3.41±0.01g	3.72±0.01f	3.9±0.02fg	4.27±0.01ef
T8-Hydrogen rich water (500 ppb)	2.26±0.12	3.58±0.01d	3.78±0.01e	3.93±0.01e	4.30±0.02e
T9-Hydrogen rich water (1000 ppb)	2.37±0.13	3.72±0.01b	3.95±0.01b	4.2±0.01b	4.58±0.03b
Mean	2.331	3.505	3.765	3.990	4.376
S.Em±	0.103	0.004	0.003	0.008	0.008
C.D at 5% level	NS	0.012	0.009	0.025	0.025

Results expressed as Means±SE

Table 3: Effect of Carbon Based Nanomaterial, Sodium Hydrosulfide (NaHS) and Hydrogen RichWater on Number of leaves in Jasmine (*Jasminum Sambac* Ait.) *Cv*. Ramanathapuram undumalli

Treatments	**Leaves (No.)**				
	0 Days	**15 Days**	**30 Days**	**45 Days**	**60 Days**
T0 (control) Deionized water (1 liter)	8.83±0.41h	36.93±0.23f	72.06±0.31g	122.58±0.45h	124.82±0.3i
T1 -Multi-walled carbon nanotube (3 g/liter of water)	14.96±0.4a	47.58±0.51a	88.26±0.23a	141.25±0.16a	170.55±1.17a
T2-Multi-walled carbon nanotube (7 g/liter of water)	13.38±0.14b	43.33±0.25c	80.08±0.06d	133.38±0.12d	164.35±0.58b
T3-Graphene oxide (20 mg/liter of water)	12.89±0.06bc	42.75±0.28c	80.24±0.34d	132.77±0.46de	151.8±0.26d
T4- Graphene oxide (40 mg/liter of water)	10.49±0.08e	41.63±0.09d	78.02±0.22e	130.17±0.24f	138.86±1.17f
T5-Sodium Hydrosulfide (0.5 mg/liter of water)	9.48±0.04g	39.96±0.12e	75.86±0.91f	126.56±0.68g	129.84±0.36h
T6-Sodium Hydrosulfide (5 mg/liter of water)	9.72±0.13fg	41.77±0.15d	78.55±0.2e	130.09±0.17f	133.99±0.32g
T7-Sodium Hydrosulfide (50 mg/liter of water)	10.07±0.03ef	43.16±0.23c	79.84±0.12d	132.16±0.24e	135.89±0.4g
T8-Hydrogen rich water (500 ppb)	11.29±0.04d	45.91±0.13b	83.72±0.04c	137.17±0.15c	144.91±0.35e
T9-Hydrogen rich water (1000 ppb)	12.63±0.04c	46.52±0.28b	85.05±0.51b	139.54±0.33b	158.95±0.32c
Mean	11.374	42.953	80.167	132.567	145.396
S.Em±	0.180	0.258	0.379	0.342	0.647
C.D at 5% level	0.535	0.766	1.126	1.017	1.921

Results expressed as Means±SE

Table 3: Effect of Carbon Based Nanomaterial, Sodium Hydrosulfide (NaHS) and Hydrogen Rich Water on plant spread E-W (cm) in Jasmine (*Jasminum Sambac* Ait.) *Cv*. Ramanathapuram Gundumalli

Treatments		**Plant Spread E-W (Cm)**			
	0 Days	**15 Days**	**30 Days**	**45 Days**	**60 Days**
T0 (control) Deionized water (1 liter)	8.46±0.79d	12.26±0.45g	17.99±0.43h	21.48±0.7e	23.99±0.4g
T1 -Multi-walled carbon nanotube (3 g/liter of water)	11.82±0.43a	19.91±0.37a	30.76±0.07a	38.91±0.3a	46.01±0.47a
T2-Multi-walled carbon nanotube (7 g/liter of water)	10.52±0.64abc	18.53±0.26bc	29.36±0.44bc	37.18±0.37ab	41.92±0.48c
T3-Graphene oxide (20 mg/liter of water)	11.16±0.86ab	17.17±0.64de	28.31±0.28cd	34.33±0.27bc	37.36±0.57d
T4- Graphene oxide (40 mg/liter of water)	10.99±0.34ab	17.82±0.44bcd	27.2±0.67de	28.77±2.7d	36.14±0.4e
T5-Sodium Hydrosulfide (0.5 mg/liter of water)	11.60±0.69a	15.81±0.34f	25±0.38g	28.67±0.57d	33.37±0.37f
T6-Sodium Hydrosulfide (5 mg/liter of water)	11.49±0.77a	16.53±0.3ef	25.16±0.61g	30.47±0.27cd	33.60±0.54f
T7-Sodium Hydrosulfide (50 mg/liter of water)	11.18±0.2ab	17.07±0.54de	26.01±0.43fg	30.89±0.5cd	35.16±0.34e
T8-Hydrogen rich water (500 ppb)	8.82±0.15cd	17.59±0.26cde	26.86±0.2ef	30.71±3.72cd	37.44±0.66d
T9-Hydrogen rich water (1000 ppb)	9.60±0.72bcd	18.88±0.19ab	30.5±0.42ab	37.64±0.38ab	43.59±0.23b
Mean	10.56	17.16	26.71	31.904	36.86
S.Em±	0.63	0.38	0.39	1.493	0.37
C.D at 5% level	1.86	1.13	1.17	4.435	1.09

Results expressed as Means±SE

Conclusion

From this investigation it has been concluded that application of novel chemical such as MWCNT had profound effect on plant growth in jasmine. The results have confirmed the advantages of the MWCNT for jasmine plant growth promotion.

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