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Studies on effect of nano urea on growth on French basil (*Ocimum basilicum* L.) cultivars under southern Telangana conditions

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Abstract
The present investigation entitled "Studies on effect of nano urea on growth on French basil (*Ocimum basilicum* L.) cultivars under Southern Telangana conditions" was carried out during *rabi* season of the year 2021-22 at college of Horticulture, Rajendranagar. In an attempt to achieve the objective of effect of nano urea on growth on French basil (*Ocimum basilicum* L.). The field experiment was laid out in factorial randomized block design with 3 replications and eight treatment combinations. The different varieties (2 varieties) are V_1 (CIM-Saumya), V_2 (CIM-Sharada) and fertilizers (4 levels) F_1 - 75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT), F_2 - 50% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT), F_3 - 25% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) and F_4 - 100% RDF (Control). Between varieties, at 45, 60 and 75 DAP (Days after planting), highest plant height (43.64 cm, 54.65 cm, 68.58 cm), highest number of branches per plant (12.72, 17.40, 22.65), highest number of leaves per plant (555.3, 655.3, 755.5), highest plant spread N-S (47.90 cm, 51.04 cm, 54.80 cm) and E-W (45.69 cm, 48.88 cm, 52.92 cm) was observed in variety V_1 (CIM-Saumya).
Among different fertilizer levels, highest plant height (49.12 cm, 59.54 cm, 75.46 cm), highest number of branches per plant (14.11, 19.99, 24.35), highest number of leaves per plant (591.1, 691.1, 791.2), highest plant spread N-S (49.88 cm, 53.02 cm, 57.00 cm) and E-W (47.63 cm, 50.69 cm, 54.88 cm) was observed in F_1 - 75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) respectively. The interaction between the two factors was found to be non-significant.

Keywords: *Ocimum basilicum*, soil application, phenylpropanoids, monoterpenes, sesquiterpenes

Introduction
Basil is an important essential oil crop with around 350 tonnes of essential oil being produced throughout the world annually. The Sweet basil (*Ocimum basilicum*), is a low growing annual herb 30-100 cm long. Stem is square, has slightly hairy appearance, leaves are ovate, entire to slightly toothed leaves. Flowers are whitish-pink, appear along the leaf axils in verticillasters. Fruit consists of 4 nut lets: seeds are small, black and mucilaginous (Kumar *et al*., 2019) [3]. The herb is a source of phenylpropanoids, monoterpenes, sesquiterpenes, and essential oils such eugenol, limonene, linalool, and rosmarinic acid. The herb is known for its potential use in the food, pharmaceutical, and cosmetic industries (Wei and Shibamoto, 2010) [9]. Linalool and methyl chavicol estragole, which are the two main components of Babui Tulsi's essential oil, are joined by 1, 8cineole, eugenol, limonene, ocimene, geraniol, cis3hexenol, citronellol, alphaterpineol, camphor, methyl eugenol, and methyl Methyl cinnamate has been found to be a significant component in various chemovars. The basils are able to remove the negative ions that are present in the air and thereby purify it. Because of these unique abilities of basils, humans can withstand a number of bacterial infections. High fevers can be lowered with tea made from basil leaves and black pepper. Antioxidants found in basil in sufficient amounts may support long life and good health. Basil is distinctive due to a variety of morphophysiological characteristics, the colour of the flowers, leaves, and stems, as well as chemical constituents in the essential oil.

Material and Methods
The current experiment was carried at the PG student research farm, College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, Hyderabad. The area is characterized by a Semi-arid tropical zone with average rainfall and average maximum and minimum temperatures 30.6 ºC and 17.3 ºC respectively.

The land used for the experimental layout was uniform with gentle slope and sandy loam in texture. Representative soil samples were collected from different locations (15-20) at a depth of 15-22 cm and analyzed for physico chemical properties. The experiment was carried out with the French Basil varieties CIM-Saumya and CIM-Sharadha which were procured from the Central Institute of Medicinal and Aromatic Plants, Boduppal, Hyderabad Center.

Results and Discussion

1. Plant height (cm)

Plant height is a crucial aspect of the vegetative phase and indirectly affects the yield components. The data pertaining to plant height at 45, 60 and 75 DAP as influenced by the varieties, fertilizers and their interaction effects are presented in the Table 1. The results showed that there was a significant difference observed between the varieties on plant height at 45 DAP. Highest plant height (43.64 cm) was observed in the variety V_1 (CIM-Saumya), over the variety V_2 (CIM-Sharada) (41.80 cm). Among the treatments significantly maximum plant height (49.12cm) was recorded in fertilizer level F_1 (75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT)) and minimum plant height (33.27 cm) was observed in fertilizer level F_3 (25% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT). Varieties showed significant difference on plant height at 60 DAP. Significantly maximum plant height (54.65 cm) was recorded in variety V_1 (CIM-Saumya), over the variety V_2 (CIM-Sharada) (52.06cm). Among the treatments at 60 DAP maximum plant height (59.54 cm) was observed in fertilizer level F_1 (75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) and minimum plant height (43.88cm) was observed in fertilizer level F_3 (25% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT). Varieties showed significant difference on plant height at 75 DAP. Significantly maximum plant height (68.58 cm) was recorded in variety V_1 (CIM-Saumya), over the variety V_2 (CIM-Sharada) (66.00cm). The effect of fertilizer levels showed significant difference among the treatments. Significantly maximum plant height (75.46cm) was observed in fertilizer level F_1 (75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) and minimum plant height (55.52 cm) was observed in fertilizer level F_3 (25% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT). This might be because to nano fertilizers longer-lasting ability to release nutrients. This helps to maintain the plant's nutrition supply, which helps to increase plant height (Subramaniain and Sharmila, 2009) [7]. Nitrogen is an important component of protoplasm, and its beneficial effect on leaf chlorophyll content may have increased the synthesis of carbohydrates, amino acids, and other compounds, which produced phytohormones such as auxins, gibberellins, cytokinins, and ethylene, resulting in increased plant growth (Hale and Orcutt, 1987) [1].

2. Number of branches per plant

Number of branches per plant were collected at 45, 60, and 75 days after planting and are the date presented in Table 2. The results showed significant difference on this parameter at 45 DAP. Significantly more number of branches per plant (12.72) was recorded in variety V_1 (CIM-Saumya), than variety V_2 (CIM-Sharada) (12.32). All fertilizer levels differed significantly among treatments at 45 DAP. Significantly more number of branches per plant (14.11) was recorded in fertilizer level F_1 (75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) and less number of branches per plant (10.43) was recorded in fertilizer level F3 (25% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT). At 60 DAP significantly more number of branches per plant (17.40) was observed in variety V_1 (CIM-Saumya), over the variety V_2 (CIM-Sharada) (16.59). Among treatments at 60 DAP, significantly more number of branches per plant (19.99) was recorded in fertilizer level F1 (75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) and less number of branches per plant (14.02) was recorded in fertilizer level F3 (25% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT). At 75 DAP maximum number of branches per plant (22.65) was recorded in variety V_1 (CIM-Saumya), than variety V_2 (CIM-Sharada) (21.67). Among treatments at 75 DAP significantly more number of branches per plant (24.35) was observed in fertilizer level F1 (75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) and less number of branches per plant (19.69) was observed in fertilizer level F3 (25% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT). The reason why plants have the most branches per plant may be because they received enough nitrogen through nano urea at a critical stage, which would have maintained a constant supply of nitrogen, stimulated cell elongation and meristematic activity in plants, and ultimately resulted in more branches. These findings were similar to the results of Jassim *et al*. (2019) [2].

3. Number of leaves per plant

The data pertaining to number of leaves per plant recorded at 45, 60 and 75 DAP are presented in Table 3. The results revealed a significant difference in the number of leaves per plant between treatments at 45 DAP. Significantly maximum number of leaves per plant (555.3) were recorded in variety V1 (CIM-Saumya), while it was minimum in variety V2 (CIM-Sharada) (551.1). All fertilizer level treatments had significant influence on number of leaves per plant at 45 DAP. Significantly maximum number of leaves per plant (591.1) was recorded in fertilizer level F_1 (75% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT) and minimum number of leaves per plant (466.1) were observed in fertilizer level F_3 (25% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT). Significant difference in the number of leaves per plant between treatments at 60 DAP with maximum number of leaves per plant (655.3) were recorded in variety V1 (CIM-Saumya), over the variety V2 (CIM-Sharada) (651.1). Between treatments significantly more number of leaves per plant (691.1) was observed in fertilizer level F_1 (75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) and less number of leaves per plant (566.0) were recorded in fertilizer level F3 (75% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT). At 75 DAP significantly maximum number of leaves per plant (755.5) was recorded in variety V1 (CIM-Saumya), over the variety V2 (CIM-Sharada) (751.0). Between treatments significantly more number of leaves per plant (791.2) was recorded in fertilizer level F1 (75% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT) and less number of leaves per plant (665.9) were observed in fertilizer level F3 (25% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT). The increase in leaf count may result from the nutrients delivered by foliar spraying reaching the cells more quickly through stomata or cuts and scrapes in the leaves, which helps to maintain the continuity and speed of delivery of nutrients necessary for plant metabolic activities. These findings were in strong agreement with those of Rajaseker *et al*. (2017) [6].

4. Plant spread (cm^2)

The data pertaining to plant spread were recorded at 45, 60 and 75 days after planting which are presented in Table 4 and 5. Varieties show significant difference on plant spread (N-S and E-W) at 45 DAP. Significantly maximum plant spread (N-S and E-W) of 47.90 cm and 45.69 cm was observed in variety V_1 (CIM-Saumya), than variety V_2 (CIM-Sharada) on plant spread (N-S and E-W) of 46.93 cm and 44.85 cm. Treatments showed significant difference on plant spread (N-S and E-W) at 45 DAP. While maximum plant spread (N-S and E-W) of 49.88 cm and 47.63 cm was recorded in fertilizer level F1 (75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) and minimum plant spread (N-S and E-W) of 44.69 cm and 42.57 cm was recorded in fertilizer level F3 (25% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT). At 60 DAP, significantly maximum plant spread (N-S and E-W) of 51.04 cm and 48.88 cm was observed in variety V1 (CIM-Saumya), than variety V2 (CIM-Sharada on plant spread (N-S and E-W) of 50.18 cm and 47.87 cm. Between treatments at 60 DAP, significantly maximum plant spread (N-S and E-W) of 53.02 cm and 50.69 cm was recorded in fertilizer level F1 (75% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT) and minimum plant spread (N-S and E-W) of 47.89 cm and 47.55 cm was recorded in fertilizer level F3 (25% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT). At 75 DAP, the maximum plant spread (N-S and E-W) of 54.80 cm and 52.92 cm was observed in variety V1 (CIM-Saumya), over the variety V2 (CIM-Sharada) on plant spread (N-S and E-W) of 54.12 cm and 51.09cm and between treatments plant spread (N-S and E-W) at 75 DAP, maximum plant spread (N-S and E-W) of 57.00cm and 54.88cm was recorded in fertilizer level F1 (75% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT) and minimum plant spread (N-S and E-W) of 51.58 cm and 49.65cm was recorded in fertilizer level F3 (25% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT). The enhanced plant spread (N-S and E-W) may be the result of the vigorous nature of plant growth at this level, as indicated by the greater number of branches and leaves. These findings agree with those of Muniramappa *et al*. (1997) [5] in kalmegh, Lokesh and Gangadharappa (2007) [4] in makoi, and Sumathi *et al*. (2012) [8].

Table 1: Effect of combination of different levels of soil application of nitrogen and nano urea on plant height (cm) of french basil (*Ocimum basilicum* L.) cultivars

Plant height (cm)															
Varieties (V)	**Fertilizers (F)**														
	45 DAP					**60 DAP**					**75 DAP**				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
V_1	50.40	45.30	34.37	44.44	43.64	61.87	56.10	45.65	54.97	54.65	76.61	71.48	57.77	68.47	68.58
V_2	47.84	44.77	32.16	42.44	41.80	57.20	55.17	42.12	53.75	52.06	74.30	69.57	53.26	66.87	66.00
MEAN	49.12	45.04	33.27	43.44		59.54	55.63	43.88	54.36		75.46	70.53	55.52	67.67	
Factors	**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**	
V	0.60			1.81		0.85			2.58		0.85			2.57	
F	0.80			2.57		1.20			3.65		1.20			3.63	
V*F	1.20			NS		1.70			NS		1.69			NS	

Table 2: Effect of combination of different levels of soil application of nitrogen and nano urea on number of branches per plant of French basil (*Ocimum basilicum* L.) cultivars

Number of branches per plant															
Varieties (V)	**Fertilizers (F)**														
	45 DAP					**60 DAP**					**75 DAP**				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
V1	14.14	13.53	10.47	12.73	12.72	20.50	18.13	14.61	16.34	17.40	24.87	22.73	20.60	22.39	22.65
V2	14.07	13.27	10.40	11.53	12.32	19.48	17.67	13.42	15.78	16.59	23.83	22.67	18.79	21.40	21.67
MEAN	14.11	13.40	10.43	12.13		19.99	17.90	14.02	16.06		24.35	22.70	19.69	21.90	
Factors	**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**	
V	0.08			0.24		0.20			0.62		0.22			0.68	
F	0.11			0.34		0.29			0.87		0.31			0.96	
V*F	0.16			NS		0.41			NS		0.45			NS	

Table 3: Effect of combination of different levels of soil application of nitrogen and nano urea on number of leaves per plant of French basil (*Ocimum basilicum* L.) cultivars

Number of leaves per plant															
Varieties (V)	**Fertilizers (F)**														
	45 DAP					**60 DAP**					**75 DAP**				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
V1	595.3	581.3	468.1	576.7	555.3	695.3	681.3	568.0	676.7	655.3	795.5	781.7	668.1	776.7	755.5
V2	586.8	579.3	464.0	574.3	551.1	686.8	679.3	564.0	674.3	651.1	786.8	779.3	663.6	774.3	751.0
MEAN	591.1	580.3	466.1	575.5		691.1	680.3	566.0	675.5		791.2	780.5	665.9	775.5	
Factors	**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**	
V	1.22			3.71		1.22			3.69		1.21			3.68	
F	1.73			5.24		1.72			5.22		1.71			5.20	
V*F	2.44			NS		2.44			NS		2.42			NS	

Table 4: Effect of combination of different levels of soil application of nitrogen and nano urea on plant spread (N-S) of French basil (*Ocimum basilicum* L.) cultivars

Plant spread (N-S) (cm)															
Varieties (V)	**Fertilizers (F)**														
	45 DAP					**60 DAP**					**75 DAP**				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
V1	50.17	49.02	45.35	47.05	47.90	53.14	52.14	48.51	50.38	51.04	57.02	56.07	52.03	54.06	54.80
V2	49.59	48.07	44.03	46.02	46.93	52.91	51.51	47.26	49.06	50.18	56.99	55.16	51.13	53.21	54.12
MEAN	49.88	48.55	44.69	46.54		53.02	51.83	47.89	49.72		57.00	55.62	51.58	53.64	
FACTORS	**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**	
V	0.14			0.44		0.15			0.46		0.08			0.25	
F	0.20			0.62		0.21			0.65		0.12			0.35	
V*F	0.29			NS		0.30			NS		0.17			NS	

Table 5: Effect of combination of different levels of soil application of nitrogen and nano urea on plant spread (E-W) of French basil (*Ocimum basilicum* L.) cultivars

Plant spread (E-W) (cm)															
Varieties (V)	**Fertilizers (F)**														
	45 DAP					**60 DAP**					**75 DAP**				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
V1	48.02	46.68	43.04	45.02	45.69	51.04	50.12	46.29	48.07	48.88	55.40	54.08	50.18	52.03	52.92
V2	47.24	46.04	42.10	44.04	44.85	50.34	49.02	45.08	47.03	47.87	54.37	53.03	49.11	51.09	51.90
MEAN	47.63	46.36	42.57	44.53		50.69	49.57	45.68	47.55		54.88	53.56	49.65	51.56	
FACTORS	**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**		**S.E.M±**			**CD at 5%**	
V	0.26			0.79		0.13			0.39		0.20			0.60	
F	0.37			1.12		0.18			0.55		0.28			0.84	
V*F	0.52			NS		0.25			NS		0.39			NS	

V_1: CIM-Saumya
V_2: CIM-Sharada

F_1: 75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT)
F_2: 50% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT)
F_3: 25% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT)
F_4: 100% RDF (Control)

Conclusion

On the basis of results observed from the experiment it was concluded that between the varieties, at 45, 60 and 75 DAP, highest plant height (43.64cm, 54.65cm, 68.58cm), highest number of branches per plant (12.72, 17.40, 22.65), maximum number of leaves per plant (555.3, 655.3, 755.5), highest plant spread (N-S) (47.90cm, 51.04cm, 54.80cm) and (E-W) (45.69 cm, 48.88cm, 52.92cm) was observed in variety V1- CIM-Saumya. Among different fertilizer levels, highest plant height (49.12cm, 59.54cm, 75.46cm), highest number of branches per plant (14.11, 19.99 and 24.35), maximum number of leaves per plant (591.1, 691.1, 791.2), plant spread (N-S) (49.88cm, 53.02cm and 57.00cm) and (E-W) (47.63 cm, 50.69 cm, 54.88 cm) were observed in fertilizer level F_1 75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT) at 45, 60 and 75 DAP respectively. Among the different levels of fertilizers, (75% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT) was observed superior for growth, herbage and oil yield. Based on the findings it may be concluded that variety V_1 (CIM-Saumya) with (75% RDN + Nano Urea @ 2 ml/l (2 sprays at 30, 60 DAT)) produced higher growth, herbage and oil yield per hectare. So, it was concluded that variety V_1 (CIM-Saumya) and fertilizer level F_1 (75% RDN + Nano Urea @ 2ml/l (2 sprays at 30, 60 DAT) is most profitable for the cultivation.

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