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Effect of different treatment combination of urea and nano-urea on growth and flowering of calendula (*Calendula officinalis*)

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Abstract
An Experiment was carried out during rabi 2023-2024 at Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P) India. To study the effect of different treatment combination of urea and nano-urea on growth and flowering of calendula, CV calypso. The experiment was laid out in Randomized Block Design, replicated 3 times with 12 treatments with different combinations. The characters of growth, flowering and yield are noted. Based on above characters it is concluded that treatment combination T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays)) showed best results of Plant height (10.60 (20 days), 14.41 (40 days), 18.08 (60 days), Plant spread (6.26) 20 days (17.38) 40 days (30.52) 60 days), Number of branches per plant (3.4 (20 days), 8.06 (40 days), 20.26 (60 days), Number of leaves per plant (10.93 (20 days), 26.36 (40 days), 60.35 (60 days), Days to 1st flowering (37.6), Flower weight (5.20g), Flower diameter (6.08 cm), Number of flowers per plant (41.33), Yield per plant (202.24g), Yield per plot (202.24 kg), Flower Yield t/ha (22.60), Importance of conducting this experiment is defined that nano-urea can lead to increased productivity of calendula flowers, thus enhancing the medicinal value and also have considerable interest for potential health benefits.

Keywords: Treatment combination, urea, nano-urea, flowering, calendula, *Calendula officinalis*

Introduction
Calendula officinalis L is an annual aromatic herb belongs to the Asteraceae family. While the biennial form grows wild in the Southern, Eastern and Central Europe Van *et al*., (2004) [13], the annual form is more widely cultivated Gilman *et al*., 1999 [7]. This medicinal plant contains sesquiterpenes, glycosides, saponins, xanthophylls, triol triterpenes, flavonoids and volatiles Della Loggia *et al*., (1994) [4].

Limited water supply is major environmental constraint in productivity of crop and medicinal plants. Although, micronutrient elements are needed in relatively very small quantities for adequate plant growth and production, their deficiency may cause great disturbance in the physiological and metabolic processes involved in the plant. Thus, the application of micronutrients fertilizer in the cultivation zone may not be meeting the crop requirement for root growth and nutrient use. The alternative approach is to apply these micronutrients as foliar sprays.

The importance of pot marigold as a multipurpose plant (flower, seed, essential oil as economic production and end season water deficit condition on *Calendula officinalis* shows the importance of this effect that is the main objective of present study. Nitrogen is a major structural part of the cell cytoplasm, important constituent of amino-acids, proteins, purines and pyrimidines and acts as a biological catalyst phosphorus is an essential constituent of majority of enzymes, which are of great importance in carbohydrate and fat metabolism. It stimulates root growth, flowering and helps in fruiting. Nitrogen and phosphorus are essential nutrients for any plant growth. These nutrients are sometime deficient in soil which fulfilled by application of fertilizers based on soil analysis and crop requirement. Appropriate manure and fertilizers are very important for well growth of calendula. Nitrogen, Phosphorus and Potassium are required

maximum quantities by the plant. These nutrients are often deficient. The deficient is corrected by application of fertilizers based on soil analysis and crop requirement. So, keeping these things in mind proper manuring and fertilization are very important for calendula. Deficiencies of different nutrient result in poor growth and flowering. Each of essential nutrients has a definite and very specific function to perform in the growth and development of plant. Calendula has no serious insect or disease problems. This plant has few pests, but may have problems with aphids, powdery mildew and occasionally cucumber mosaic virus. Plants may languish in prolonged hot summer weather but typically recover when cooler weather returns. Slugs and snails may feed on the plants, especially when they are young. Keep the ground clear of debris to minimize slug and snail damage. Aphids and whiteflies can sometimes be a problem. To control them, spray them with water or treat them with insecticidal soap. With foliar Mn applications, for optimum response, two or three applications are often required. Although foliar Mn application can supply sufficient Mn to overcome Mn deficiency, this strategy is expensive and often impractical for farmers on marginal lands. Moreover, foliar Mn sprays are only effective for a limited time period since Mn is very little mobile in the plant and does not remobilize from older leaves to Mn deficient young leaves.

Materials and Methods

A Field experiment was carried out at the Horticulture Research Farm, Department of Horticulture, SHUATS, Prayagraj, U.P. in the months of November 2023 to January**,** 2024. The experiment was conducted on calendula cv. Calypso in Randomized Block Design with three replications using 12 treatment combinations. Treatments are applied at 30 Days after Transplanting, 45 Days After Transplanting. Treatment combinations are: T_0 Control T_1 75% N through Urea + Nano-urea @ 2 ml/L (2 sprays) , T_2 75% N through Urea + Nano-urea @ 2 ml/L (3 sprays), T_3 50% N through Urea + Nano-urea @ 2 ml/L (2 sprays), T_4 50% N through Urea + Nano-urea @ 2 ml/L (3 sprays), T_5 75% N through Urea + Nano-urea @ 4 ml/L (2 sprays), T_6 75% N through Urea + Nano-urea @ 4 ml/L (3 sprays), T_7 50% N through Urea + Nano-urea @ 4 ml/L (2 sprays), T_8 50% N through Urea + Nano-urea @ 4 ml/L (3 sprays), T_9 Nano-urea 2 ml/L (2 sprays), T_{10} Nano-urea 2 ml/L (3 sprays), T_{11} Nano-urea 4 ml/L (2 sprays), T_{12} Nano-urea 4 ml/L (3 sprays).

Results and Discussion

The Maximum plant height was recorded in treatment T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) (10.60, 14.41, 18.08 cm) Plant height, at 20, 40 and 60 Days respectively in twelve treatments followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with (9.59,14.15 and 17.71 cm), whereas minimum plant height (9.23, 11.48 and 14.65 cm) was recorded in Control. The plant height significantly influenced with application of Treatment combination; Nano urea is a Treatment combination essential to plant growth. In plants, it involves in the structure of photosynthetic proteins and enzymes. Excessive accumulation of Nano urea in plant tissues can change various processes, such as enzyme activity, translocation and utilization of other mineral elements Ducic and Polle, (2007) [5], Similar results were finding Mn (0.30%) by Abou-Sreea *et al.*, (2016) [2] in Calendula plants.

The maximum Plant spread (cm^2) was observed T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded maximum (10.93, 26.36 and 60.35). Number of leaves/Plant, at 20, 40 and 60 Days respectively in twelve treatments followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with (10.53, 25.44 and 59.13 leaves/plant) at 20, 40 and 60 days respectively, whereas minimum Number of leaves/plant (8.33, 24.09 and 52.70) was recorded in treatment Control. Nano urea plays a key role in photosynthesis, as the photosystem II-water oxidizing system has an absolute Nano requirement. Urea Enhance the photosynthetic efficiency and dry matter production, provide resistance to biotic stress by increasing plant resistance to various diseases and reducing the need for fungicides, contribute to abiotic stress tolerance, particularly drought and heat, resulting in increased photosynthesis and translocation of food material which might be enhanced the Number of leaves, leaves length and higher crop yield. The above result was confirmed by Alloway BJ. (2008) [1].

The maximum Number of branches per plant (cm) was observed with treatment T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded maximum (6.26, 17.38 and 30.52 cm) Plant spread, at 20, 40 and 60 Days respectively in twelve treatments ,followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with (5.64, 17.32 and 30.36 cm), whereas minimum plant spread (4.6, 14.42 and 24.98 cm) was recorded in treatment T_0 (Control). The plant sprayed significantly influenced with application of Treatment combination, Nano urea is an essential plant mineral nutrient, playing a key role in several physiological processes, it encourages, cell multiplication, cell division and cell differentiation resulting in increased photosynthesis and translocation of food material which enhanced the plant spread and is also improved root system of plants resulting in absorption of more water and nutrients and its utilization (Alloway 2008) [1]. Urea is reported to activate over 35 enzymes, several of which catalyse different steps of the lignin and phytoalexins biosynthesis. Similar results were finding by Abou-Sreea *et al.*, (2016) [2] in Calendula plants.

The maximum Number of leaves was observed with T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded maximum (3.4, 8.06 and 20.26) Number of Branches/Plant, at 20, 40 and 60 Days respectively in twelve treatments , followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with (2.8, 7.66 and 18.93 branches/plant) at 20, 40 and 60 days respectively, whereas minimum Number of branches/plant (1.53, 6 and 15.93) was recorded in treatment T_0 (Control). Increased the number of Branches be due to Treatment combinations like Nano urea activates some of enzyme systems and has an important role in cell division and cell lengthening resulting in increased photosynthesis and translocation of food material which enhanced the Number of Primary Branches. Teixeira *et al.*, (2020) also reported that the foliar application of Urea increased the stem height in common bean.

The minimum Days to 1st flowering was observed with T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded minimum (37.06 days) for first flower bud emergence, after transplanting in twelve treatments, followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with (37.66 days), whereas maximum days taken for first flower bud emergence (40.53 days) was recorded in treatment T_0 (Control). Treatment combination like Urea is used in plants as a major contributor to various biological systems including photosynthesis, respiration, and nitrogen assimilation. Urea is also involved in pollen germination, pollen tube growth, root cell elongation and resistance to root pathogens, which may be enhanced to flower earlier Jadhav (2004) [9] in Gerbera.

The maximum Flower weight (g) was observed with T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded maximum (5.20 g) fresh weight of flower, after transplanting in

twelve treatments, followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with (4.94 g), whereas minimum fresh weight of flower (3.95 g) was recorded in treatment T_0 (Control).Urea is used in plants as a major contributor to various biological systems including photosynthesis, respiration, and nitrogen assimilation. Urea is also involved in pollen germination, pollen tube growth, root cell elongation and resistance to root pathogens, which may be promotes the flower size and weight of the flower Hardeep Kumar *et al.,* (2003) in tuberose.

The maximum Flower diameter was observed with T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded maximum (6.08 cm) flower diameter, after transplanting in twelve treatments, followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with 5.72 cm), whereas minimum flower diameter (5.20 cm) was recorded in treatment T_0 (Control). Treatment plays an important role in the representation of critical auxins that increase cell division and increase the content chlorophyll in the leaf, Urea is used in plant as photosynthesis this might be due to more production of food material which subsequently increased in the quality parameters like flower stalk length, flower diameter. The above results also reported by Dehnavy (2009), Hardeep Kumar *et al.,* (2003) in tuberose.

The maximum Number of flowers per plant was observed T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded maximum (39.87) number of flowers/plant, after transplanting in twelve treatments, followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with (38.66 flowers/plant), whereas minimum number of flowers/plant (27.66) was recorded in treatment T_0 (Control). Application of Urea relieved the plants from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of the flower growth which may in turn increase the flower production and ultimately flower yield. Pal *et al.,* (2016) [11] in Gerbera.

The maximum Yield per plant was observed with treatment T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded maximum (202.24 g) flower yield/plant, after transplanting in twelve treatments, followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays)) with (189.73 g), whereas minimum flower yield/plant (122.64 g) was recorded in treatment T_0 (Control). Application of urea is used in plants as a major contributor to various biological systems relieved the plants from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of the flower growth which may in turn increase the flower production and ultimately flower yield. Zahedi (2016) [14], Pal *et al.,* (2016) [11] in Gerbera.

The maximum Yield per plot was observed with T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded maximum (1.26 kg) flower yield/plot, after transplanting in twelve treatments, followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with (1.20 kg), whereas minimum flower yield/plot (0.72 Kg) was recorded in treatment T_0 (Control + RDF). Application of Urea is used in plants as a major contributor to various biological systems relieved the plants from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of the flower growth which may in turn increase the flower production and ultimately flower yield. Zahedi (2016) [14] and Pal *et al.,* (2016) [11] in Gerbera

The maximum Flower Yield T/ha was observed with treatment T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) recorded maximum (22.49 tonnes) flower yield/ha, after transplanting in twelve treatments, followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (3 sprays) with (21.37 tonnes), whereas minimum flower yield/ha (14.17 tonnes) was recorded in treatment T_0 (Control). Application of Urea is used in plants as a major contributor to various biological systems relieved the plants from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of the flower growth which may in turn increase the flower production and ultimately flower yield. Zahedi (2016) [14] and Pal *et al.,* (2016) [11] in Gerbera.

In terms of Economics, Maximum Gross return (678000.00), net returns (414446.995.00) and cost benefit ratio (1:2.57) respectively was found in treatment T_7 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) followed by T_8 (50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) with (633000.00) Gross return, (263554.12) Net return and (1:2.40) Cost benefit ratio, whereas minimum Gross return (423000.00), Net return (159553.5) and Cost benefit ratio (1:1.60) was recorded in treatment T_0 (Control).

Table 1: Effect of different treatment combination of urea and nano-urea on vegetative parameters of calendula

Symbols	Treatment Combination	Plant height (90 DAT)	Plant spread 90 DAT	Number of branches per plant (90 DAT)	Number of leaves per plant (90 DAT)	Days to first flowering
T_0	Control (100% RDF)	14.65	24.98	15.93	52.70	40.53
T_1	75% N through Urea + Nano-urea @ 2 ml/L (2 sprays)	17.81	26.65	16.6	52.94	40.3
T_2	75% N through Urea + Nano-urea @ 2 ml/L (3 sprays)	16.41	27.56	17.16	53.29	40.66
T_3	50% N through Urea + Nano-urea @ 2 ml/L (2 sprays)	15.13	25.84	17.43	55.01	41
T_4	50% N through Urea + Nano-urea @ 2 ml/L (3 sprays)	16.19	26.47	16.53	52.18	39.46
T_5	75% N through Urea + Nano-urea @ 4 ml/L (2 sprays)	16.81	26.54	18.18	54.54	41
T_6	75% N through Urea + Nano-urea @ 4 ml/L (3 sprays)	16.06	27.32	18.56	54.34	40.2
T_7	50% N through Urea + Nano-urea @ 4 ml/L (2 sprays)	18.08	30.52	20.26	60.35	37.6
T_8	50% N through Urea + Nano-urea @ 4 ml/L (3 sprays)	17.71	30.36	18.93	59.13	37.66
T_9	Nano-urea 2 ml/L (2 sprays)	16.57	29.59	18.7	58.38	38.33
T_{10}	Nano-urea 2 ml/L (3 sprays)	15.31	28.58	17.33	56.6	40.53
T_{11}	Nano-urea 4 ml/L (2 sprays)	15.09	27.43	17.13	56.92	40.38
T_{12}	Nano-urea 4 ml/L (3 sprays)	17.39	27.68	17.96	54.46	40.4
	F-Test	S	S	S	S	S
	S.Ed.	0.36	0.21	0.14	0.21	0.17
	CD at 0.5%	1.07	0.61	0.42	0.61	0.52
	CV	3.88	0.65	1.42	0.65	0.78

Table 2: Effect of different treatment combination of urea and nano-urea on vegetative parameters of calendula

Symbols	Treatment Combination	Flower weight	Flower diameter	Number of flowers/plants	Yield/plant	Yield/plot	Flower Yield t/ha
T_0	Control (100% RDF)	3.95	5.07	27.66	122.64	0.72	14.17
T_1	75% N through Urea + Nano-urea @ 2 ml/L (2 sprays)	4.28	5.48	32.53	141.08	0.85	15.73
T_2	75% N through Urea + Nano-urea @ 2 ml/L (3 sprays)	4.39	5.06	30.46	137.25	0.84	15.74
T_3	50% N through Urea + Nano-urea @ 2 ml/L (2 sprays)	4.52	5.34	29.26	128.69	0.75	14.47
T_4	50% N through Urea + Nano-urea @ 2 ml/L (3 sprays)	4.71	5.75	35.93	152.28	0.95	16.73
T_5	75% N through Urea + Nano-urea @ 4 ml/L (2 sprays)	4.11	5.95	36.3	157.63	0.93	17.87
T_6	75% N through Urea + Nano-urea @ 4 ml/L (3 sprays)	4.35	5.46	35.73	146.68	0.88	16.36
T_7	50% N through Urea + Nano-urea @ 4 ml/L (2 sprays)	5.20	6.08	41.33	202.24	1.26	22.60
T_8	50% N through Urea + Nano-urea @ 4 ml/L (3 sprays)	4.94	5.72	38.66	189.73	1.20	21.11
T_9	Nano-urea 2 ml/L (2 sprays)	4.98	5.79	36.73	179.43	1.01	20.29
T_{10}	Nano-urea 2 ml/L (3 sprays)	4.59	5.45	36	153.98	1.12	19.17
T_{11}	Nano-urea 4 ml/L (2 sprays)	4.48	5.76	35.33	156.53	1.09	18.52
T_{12}	Nano-urea 4 ml/L (3 sprays)	4.53	5.23	33.2	140.76	1.15	19.74
	F-Test	S	S	S	S	S	S
	S.Ed.	0.05	0.06	0.23	1.83	0.03	0.39
	CD at 0.5%	0.15	0.17	0.68	5.36	0.08	1.16
	CV	2.05	1.87	1.18	2.06	5.38	3.84

Table 3: Effect of different treatment combination of urea and nano-urea on Benefit Cost Ratio

Treatments	Yield	Selling rate	Gross return	Cost of cultivation	Net return	Cost benefit Ratio
T_0	14.1	30000	423000	263446.5	159553.5	1.60
T_1	15.7	30000	471000	263601.81	207398.19	1.78
T_2	15.7	30000	471000	263602.93	207397.07	1.78
T_3	14.4	30000	432000	263553.005	168446.995	1.63
T_4	16.7	30000	501000	263554.125	237445.875	1.90
T_5	17.8	30000	534000	263601.81	270398.19	2.02
T_6	16.3	30000	489000	263602.93	225397.07	1.85
T_7	22.6	30000	678000	263553.005	414446.995	2.57
T_8	21.1	30000	633000	263554.125	369445.875	2.40
T_9	20.2	30000	606000	263455.38	342544.62	2.30
T_{10}	19.1	30000	573000	263456.5	309543.5	2.17
T_{11}	18.5	30000	555000	263464.16	291535.84	2.10
T_{12}	19.7	30000	591000	263472.04	327527.96	2.24

Conclusion

From the present investigation, it is concluded that treatment combination T_7- 50% N through Urea + Nano-urea @ 4 ml/L (2 sprays) is superior among all other treatments in terms of plant height, plant spread, Number of branches per plant, Number of leaves per plant, Days to first flowering, Flower diameter, Number of flowers per plant, Yield per plant, Yield per plot, Flower yield t/ha in Calendula.

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