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Foliar Impact of Urea and Nano Urea Application on Growth and Yield Attributes of Acid Lime (*Citrus aurantifolia* Swingle.) Cv. Kagzi

Vishwadeep Balyan[1], Prerak Bhatnagar[1], Rahul Chopra[2], Jitendra Singh[1], Anju S. Vijayan[3] **10.18805/ag.D-5819**

ABSTRACT

Background: Acid lime being the nutrient exhaustive fruit crop and requires regular annual application of macro and micronutrients and there was a need to study the response of foliar application of Urea and Nano urea as a source of nitrogen to assess its impact on Kagzi lime trees. The reason to undertake this research was based on response of foliar Urea and Nano urea on nutrient supplementation, rapid nutrient uptake, improved nitrogen utilization along with enhanced nutrient mobility and its effect on growth and yield attributes in acid lime cv. Kagzi plants.

Methods: A field experiment was conducted at the Fruit Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar during June 2022 to December 2022 in established Kagzi lime orchard of 14 years age. The experiment was laid out in Randomized Block Design with three replications. The experiment consisted of foliar application of nine treatments comprising Urea and Nano urea.

Result: On the basis of results obtained in the present investigation, the foliar application of T_4 treatment (Urea @ 2.0%) was found beneficial in the improvement of growth and yield attributes in acid lime cv. Kagzi. The foliar feeding response through T_4 treatment (Urea @ 2.0%) resulted in enhancement of plant height (m), plant spread [E-W and N-S (m)], canopy volume (m^3), number of fruits $plant^{-1}$, yield $plant^{-1}$ (kg) and estimated yield (kg/ha) in acid lime cv. Kagzi trees.The overall maximum percentage increase in growth attributes viz. plant height (6.46%), E-W plant spread (6.09%), N-S plant spread (6.27%) and canopy volume (20.34%) were found in T_4 treatment consisting (Urea @ 2.0%). The application of T_4 treatment (Urea @ 2%) resulted in enhancement of number of fruits $plant^{-1}$ (480.33), fruit weight (67.90 g), yield $plant^{-1}$ (27.87) and estimated yield (77.21 q/ha).

Key words: Acid lime, *Citrus aurantifolia*, Nano urea, Urea.

INTRODUCTION

Acid lime (*Citrus aurantifolia* Swingle.) is an important sub-tropical fruit crop of the world. It is the third most important citrus crop in India next to mandarin and sweet oranges. India is the largest producer of acid lime in the world with production 37.17 lakh metric tonnes and area 3.17 lakh hectares as per National Horticulture Board data of duration 2019-20. Most of the Indian agricultural lands are deprived of some of the most essential nutrients for growth and development of crop plants due to lesser incorporation of mineral nutrient inputs. One of the major essential and vital elements for growth of plants is nitrogen. Nitrogen enhances the fruit quality along with the production of crops. As an integral part of chlorophyll, it increases the photosynthetic activity which regulates source- sink ratio and ultimately yield and production of fruit crops. Nano fertilizers are emerging novel technology in Indian market to compensate bulk use of traditional fertilizers. Nano-fertilizer facilitates slow and steady release of nutrients, also augments nutrient use efficiency by reducing loss of nutrients. Nano fertilizers have higher surface area and less particle size than the pore size of roots and leaves of the plant which can increase better penetration and absorption into the plant and can improve uptake and nutrient use efficiency of the fertilizer. Foliar spray of urea is a tested technique that enables the direct application of nitrogen to plant leaves, bypassing soil uptake. It can provide a targeted and efficient means of nutrient delivery, particularly during critical growth stages or periods of deficiency.

[1]Department of Fruit Science, College of Horticulture and Forestry, (Agriculture University, Kota), Jhalawar, Jhalrapatan-326 023, Rajasthan, India.
[2]Department of Natural Resource Management, College of Horticulture and Forestry, (Agriculture University, Kota), Jhalawar, Jhalrapatan-326 023, Rajasthan, India.
[3]Department of Forest Product Utilization, College of Horticulture and Forestry, (Agriculture University, Kota), Jhalawar, Jhalrapatan-326 023, Rajasthan, India.

Corresponding Author: Vishwadeep Balyan, Department of Fruit Science, College of Horticulture and Forestry, (Agriculture University, Kota), Jhalawar, Jhalrapatan-326 023, Rajasthan, India. Email: balyanvishwadeep@gmail.com

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MATERIALS AND METHODS

The present investigation entitled "Foliar impact of Urea and Nano urea on growth and yield attributes of Acid lime (*Citrus aurantifolia* Swingle.) cv. Kagzi" was carried out from June 2022 to December 2022. The experiment was carried out on 14 year old acid lime (*Citrus aurantifolia* Swingle.) cv. Kagzi trees. The experiment was conducted during June, 2022 to December, 2022. A plantation of fifty four acid lime plants spaced at a distance of 6m x 6m under square system were selected for the purpose at the established Kagzi lime orchard of College of Horticulture and Forestry, Jhalawar under (Agriculture University, Kota) for research experimentation. The experiment consisted of nine treatments *viz*. Control, Urea levels (0.5, 1.0, 1.5 and 2.0%) and Nano urea levels (500, 1000, 1500 and 2000 ppm). Two sprays of each treatment were given; first spray of respective treatments was applied on 7thJuly 2022 while the second spray of different treatments was done on 30 days after the first spray. The soil texture was primarily clay loam in nature and heavy clay textural class.

Details of the treatment

T_0: Control (water spray).
T_1: (Urea @ 0.5%).
T_2: (Urea @ 1%).
T_3: (Urea @ 1.5%).
T_4: (Urea @ 2%).
T_5: (Nano urea @ 500 ppm).
T_6: (Nano urea @ 1000 ppm).
T_7: (Nano urea @ 1500 ppm).
T_8: (Nano urea @ 2000 ppm).

Plant height (m)

The height of plants was recorded from the surface of soil to the apex of the longest shoot of the plant with the help of measuring tape using ladder. Growth parameters were recorded initially and subsequently after two months interval *i.e*. September and December 2022 months. The average gain in plant height was calculated on the basis of cumulative increase in initial value.

Canopy volume (m^3)

The canopy volume of plants was calculated using formula as suggested by Westwood (1963) and recorded in cubic meter at every two months interval. The average increase in canopy volume was computed on the basis of recorded values of plant height and plant spread as per the given formula:

$$\text{Canopy volume} = 4/3\ \pi\ a^2b$$

Where:
a= Half of the plant height.
b= Average of East-West and North-South plant spread.

Plant spread (m)

(a) East-West

(b) North-South

The canopy spread orientation (East-West and North-South spread) of the acid lime cv. Kagzi plants was recorded using measuring tape. The average increase in each direction was calculated on the basis of cumulative increase in initial value. Growth parameters were recorded initially (July) and were then recorded after two months interval *i.e*. September and December months.

Number of fruits per plant

The number of fruits per plant treatment wise was calculated manually by collecting the harvested fruits through five pickings in crates.

Average fruit weight (g)

Randomly selected four fruits in each treatment replication wise during harvesting were weighed with the help of Sartorius electronic balance model no. BS 224 S and mean weight of fruit was calculated.

Yield per plant (kg)

The yield per plant of harvested fruits treatment wise were weighted on electronic balance and was computed

Estimated yield (q/ha)

The estimated yield (q/ha) of acid lime cv. Kagzi fruits were done by multiplying yield plant^{-1} with number of acid lime plants in one hectare area and calculation was done treatment wise accordingly.

RESULTS AND DISCUSSION

Growth attributes

The results on vegetative growth attributes such as plant height, plant spread and canopy volume indicated that foliar application of treatment consisting Urea and Nano urea had a significant influence in these parameters. It is evident from the results presented in (Table 1). That the foliar application of Urea and Nano urea at different concentration under varying treatments has significant effect on augmentation in plant growth attributes *viz*. plant height, East- West spread (m), North- South spread (m) and canopy volume (m^3) of acid lime cv. Kagzi trees.

The Kagzi lime trees sprayed with T_4 treatment (Urea @ 2%) exhibited maximum percent increase (6.78%) in plant height as compared to control; while minimum per cent increase in plant height (3.60%) was noted under control and was found at par with treatment T_1.

The maximum per cent increase (6.21%) of East - West spread in acid lime cv. Kagzi trees were recorded in T_4 treatment consisting (Urea @ 2%) while minimum percent increase in E- W spread with value (2.53%) was measured in T_0 (control) treatment. Likewise, the overall maximum per cent increase (6.27%) in North- South spread of acid lime cv. Kagzi trees was recorded in T_4 treatment (Urea @ 2%) and was found significantly higher over other treatments.

The maximum augmentation in canopy volume (20.38%) of acid lime cv. Kagzi trees was estimated in T_4 treatment having equivalent performance with T_3 treatment

(Urea @ 1.5%) with value (18.39%), whereas minimum per cent increase (8.62%) in canopy volume of acid lime plants was obtained in T_0 (control) treatment and was found at par with T_1 treatment (urea @ 0.5%) with value (11.97%). The relative better response of T_4 treatment (Urea @ 2.0%) in acid lime cv. Kagzi trees for enhancement in growth attributes could be attributed to better cellular uptake of Urea including passive diffusion and active transport mechanisms. Passive diffusion occurs when urea moves from higher concentration (foliar spray solution) to an area of lower concentration (leaf cells). Active transport involves the use specific carrier protein to transfer urea across cell membranes.

The probable reason for augmentation in plant height, canopy spread and canopy volume in acid lime cv. Kagzi trees under T_4 treatment (Urea @2.0%) could be attributes to essential role of nitrogen as nutrient and being a constituent of many plant compounds including proteins, chlorophyll and nucleic acids. The foliar application of urea in acid lime plants might stimulated key physiological processes such as photosynthesis, respiration, protein synthesis along with increased phytohormone modulation and enzymatic activity which further lead to enhanced growth attributes like plant height, canopy spread (E-W and N-S) and canopy volume of acid lime cv. Kagzi trees.

These results are in accordance with the earlier findings of Rathore and Chandra (2003) in acid lime, Prasad *et al*. (2015) in Kinnow, Chouhan *et al*. (2018) in acid lime, Reetika *et al*. (2018) in Kinnow mandarin, Yadav *et al*. (2020) in acid lime cv. Kagzi and Kumar *et al*. (2020) in Kinnow mandarin.

Effect of foliar urea and nano urea application on yield attributes

The important yield attributing aspect *i.e*. number of fruits per plant in acid lime cv. Kagzi trees got significantly influenced by foliar application of treatments consisting Urea and Nano urea. The foliar application of different treatments comprising Urea and Nano urea augmented the significant increase in number of fruits per plant in different treatments. (Table 2). Application of (Urea @ 2%) had significant effect on number of fruits/plant and maximum number of fruits/ plant (480.33). The results of present research have indicated that application of (Urea @ 2%) was found better in obtaining maximum number of fruits/plant in acid lime cv. Kagzi trees as compared to nano urea treatments in varying concentrations. The foliar feeding of Urea @ 2% also showed better response in improving the yield/plant of acid lime cv. Kagzi.

The relative higher number of fruits per plant and yield (q/ha) in Kagzi lime plant might be due to better availability of nitrogen to the acid lime plant through application of urea (2%) and also quick absorption by the acid lime leaves and transportation to different plant parts including the developing fruits which might led to increased nitrogen availability in the reproductive structure and promoted their growth facilitating increase in acid lime fruit yield. The better availability to Kagzi lime trees through T_4 treatment might be due to positive effect in acid lime trees such as

Table 1: Effect of Urea and Nano urea on percentage increase in growth attributes *viz*. plant height (m), East-West plant spread (m), North-South plant spread (m), canopy volume (m^3) in acid lime (*Citrus aurantifolia* Swingle.) cv. Kagzi trees.

Treatments	Initial plant height (m)	Plant height (m) December 2022	Initial E-W spread (m)	E-W spread (m) December 2022	Initial N-S spread (m)	N-S spread (m) December 2022	Initial canopy volume spread (m^3)	Canopy volume (m^3) December 2022
T_0	3.81	3.95 (3.60%)	3.93	4.03 (2.53%)	3.46	3.55 (2.70%)	48.70	52.90 (8.62%)
T_1	4.11	4.27 (4.06%)	3.20	3.30 (3.23%)	3.43	3.57 (3.99%)	58.45	65.45 (11.97%)
T_2	4.23	4.42 (4.57%)	3.46	3.60 (4.24%)	3.19	3.33 (4.49%)	62.11	70.76 (13.92%)
T_3	3.91	4.15 (5.96%)	3.38	3.57 (5.73%)	3.35	3.53 (5.27%)	53.98	63.91 (18.39%)
T_4	4.23	4.52 (6.78%)	3.28	3.48 (6.21%)	3.56	3.78 (6.27%)	67.02	80.68 (20.38%)
T_5	3.57	3.72 (4.10%)	3.66	3.78 (3.37%)	3.39	3.49 (2.95%)	47.17	52.52 (11.35%)
T_6	3.71	3.87 (4.22%)	3.43	3.57 (4.09%)	3.73	3.85 (3.31%)	51.72	58.02 (12.17%)
T_7	4.10	4.28 (4.48%)	3.79	3.96 (4.48%)	4.07	4.24 (4.10%)	69.10	78.46 (13.55%)
T_8	4.28	4.48 (4.75%)	3.17	3.32 (4.52%)	3.2	3.36 (5.00%)	60.99	70.04 (14.84%)
SEm (±)	0.05	0.04 (0.39)	0.05	0.04 (0.37)	0.05	0.05 (0.53)	1.68	2.03 (0.78)
CD 5%	0.13	0.14 (1.19)	0.15	0.12 (1.12)	0.17	0.17 (1.61)	5.04	6.10 (2.36)

*Values in bracket show the per cent increase from initial (July 2022 month) to final (December 2022 month) for improved plant growth characters.
Where: T_0 (water spray), T_1 (Urea @ 0.5%), T_2 (Urea @ 1.0%), T_3 (Urea @ 1.5%), T_4 (Urea @ 2%), T_5 (Nano urea @ 500 ppm), T_6 (Nano urea @1000 ppm), T_7 (Nano urea @ 1500 ppm) and T_8 (Nano urea 2000 ppm) are applied foliar treatments.

Table 2: Effect of urea and nano urea on yield attributes of acid lime (*Citrus aurantifolia* Swingle.) cv. Kagzi.

Treatments	Number of fruits plant	Fruit weight (g)	Yield/plant (Kg)	Estimated yield (q/ha)
T_0	442.00	40.89	17.71	49.07
T_1	451.00	44.73	20.20	55.96
T_2	456.00	48.09	21.09	58.43
T_3	462.00	51.46	23.58	65.31
T_4	480.33	67.90	27.87	77.21
T_5	454.66	40.56	18.22	50.62
T_6	456.66	45.85	20.43	56.59
T_7	467.66	48.42	22.35	61.92
T_8	469.33	52.68	24.85	68.85
SEm (±)	1.87	1.41	0.63	175.97
CD 5%	5.62	4.25	1.90	527.56

Where: T_0 (water spray), T_1 (urea @ 0.5%), T_2 (urea @ 1.0%), T_3 (urea @ 1.5 %), T_4 (urea @ 2 %), T_5 (Nano urea @ 500 ppm), T_6 (Nano urea @ 1000 ppm), T_7 (Nano urea @ 1500 ppm) and T_8 (Nano urea @2000 ppm) are applied foliar treatments.

increased chlorophyll content enhanced photosynthesis and improved physiological processes this contributing higher yield as compared to other treatments including control. The results of present investigations are supported by the previous findings of Yadav *et al*. (2020) in acid lime and Senjam and Singh (2021) in Assam Lemon.

The higher yield (kg/plant) was obtained in T_4 treatments in acid lime cv. Kagzi over other treatments. The foliar application of (Urea @ 2%) exhibited better response in improving the yield/plant as compared with other treatments. The relatively better yield may be due to consolidated effect of better cell division, cell differentiation and thereby causing enhanced fruit weight of acid lime cv. Kagzi caused by foliar application of Urea @ 2%. The higher yield observed in T_4 treatment could be ascribed to the better foliar response of Urea @ 2% which favored increment of chlorophyll production and photosynthetic processes and perhaps it lead to increased yield of acid lime cv. Kagzi trees. The present results are in conformity with findings of El-Otmani *et al*. (2004), El-Tenany *et al*. (2009), Al-Obeed *et al*. (2018), Davarpanah *et al*. (2017), Rokaya *et al*. (2019), Abdallah (2020), Dal and Gubbuck (2018) in Washington naval orange.

The maximum fruit weight (67.90 g) was recorded in cv. Kagzi lime was recorded in T_4 treatment (Urea @ 2%) and minimum fruit weight (40.89 g) was recorded in T_0 treatment. The increase in fruit weight with T_4 treatment (Urea @ 2%) could be attributed to enhanced nitrogen availability as urea is a rich source of nitrogen and being a critical nutrient of protein, enzymes and chlorophyll involved in various bio-chemical processes within the plant. The foliar application of urea through T_4 treatment (Urea @ 2%) might trigger the photosynthetic rate which in turn facilitated higher production of carbohydrates ultimately leading to higher fruit weight. The results of present findings are in consonance with those reported by Dudi *et al*. (2004), El-Tanany *et al*. (2009), Katiyar *et al*. (2010) in ber, Debaje *et al*. (2011) in acid lime, Jat and Laxmidas (2014) in guava, Prasad *et al*. (2015) and Al-Obeed *et al*. (2018) in Kinnow mandarin.

CONCLUSION

On the basis of result obtained in the present investigation, it may be concluded that the T_4 treatment consisting (Urea @ 2.0%) was found better in improvement of growth and yield attributes of acid lime cv. Kagzi in Vertisols of Jhalawar district. In addition to recommended soil application doses of macro-nutrients, balanced nitrogen nutrition through foliar application of Urea @ 2.0% in acid lime cv. Kagzi trees can help in optimizing growth and yield attributes of acid lime plants and also ensuring nutrient balance in plants to produce fruits with desired nutritional qualities. Adequate nitrogen nutrition contributes to nitrogen accumulation in citrus ensuring that foliar application of Urea should be used for improved nitrogen uptake, osmotic regulation and overall plant metabolism in acid lime cv. Kagzi trees.

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Conflict of interest

The authors declare that they have no conflicts of interest regarding the research presented in this paper.

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