Biological Forum – An International Journal **15(12): 480-484(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Influence of Foliar Application of Plant Growth Regulators and Nutrients on Physico Chemical and Post Harvest Traits of Acid Lime (*Citrus aurantifolia* Swingle)

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(Received: 22 September 2023; Revised: 28 October 2023; Accepted: 27 November 2023; Published: 15 December 2023)
(Published by Research Trend)

ABSTRACT: A field trial was conducted to assess the effectiveness of different combinations plant growth regulators (2,4-D and NAA) and nutrients (Boric acid and Urea) on qualitative and yield parameters of eight year old Acid lime plants during 2019-20 and 2020-21 at Agro techno park of Krishi Vigyan Kendra, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.). The experiment was laid out in randomized block design with 25 different treatment combinations along with control. The treatments consisted of foliar application of growth regulators *viz*., NAA, and 2,4-D and nutrients such as boric acid and Urea. Results have indicated that the foliar spray of T_{19}-Urea 2%+2,4-D 15ppm + NAA 20ppm + Boron 0.5% was found superior with respect to quality parameters like fruit volume at harvest (39.54), juice content (51.29) ml and TSS (7.49) Brix) and acidity percentage (8.04) and TSS: Acid ratio (1.11). The plant growth regulators and nutrients are very much essential for growth and development of acid lime. The study denotes that post harvest parameters like physiological weight loss after 5, 10 and 15 days of storage were found to be reduced by application of Urea 2%+2, 4D 15ppm+NAA 20ppm+Boron 0.5% and specific gravity after 5, 10 and 15 days of storage was found to be increased when compared to control.

Keywords: Acid lime, urea, boric acid, 2,4-D, physico chemical, growth regulators, post harvest.

INTRODUCTION

Acid lime serves as the rich source of vitamin C, vitamin B and also trace amount of vitamin A, folate, minerals and dietary fibers (Thirugnanavel *et al.*, 2007). It contains many phytochemicals like flavonoids, phenolic acids, carotenoids and amino acids. Besides being consumed as fresh fruit, a large number of products and by-products like squash, pickles, jam, candies, jelly and marmalades are prepared and sold at a premium price (Ahmed *et al.,* 2007). Plant growth regulator plays a major role in acid lime cultivation. Deficiency of soil nutrients is the major factor among the several factors that causes significant reduction in yield and quality of acid lime which results in loss of economic yield. Plant growth regulators are the compound which are used in very low concentration but have higher effects on plant physiology. Auxin compounds like Naphthalene Acetic Acid (NAA) and 2, 4- Dichlorophenoxyacetic acid plays a vital role in enhancing qualitative traits and Nitrogen (N) increases juice content, TSS per box and per acre, and acid content. Foliar application of 2,4-D seems to be effective in improving juice quality by increasing juice volume, Total soluble solids, acidity and ascorbic acid content (Pooja *et al.*, 2020). Boron has a major role in enhancing cell division, biosynthesis of carbohydrates and proteins, pollination and fertilization of the flowers, movement of sugars and fungi control. Hence, the combination of both these growth-promoting substances (micronutrients and PGR) in an optimum amount can positively and significantly influence the physiological activities of the plant.

MATERIAL AND METHODS

An experiment was laid out in randomized block design with 24 different treatment combinations in three replications along with control during 2019-2020 and 2020-2021 under the agro-climatic conditions of Gwalior region. Eight years old uniform trees of Acid lime (*Citrus aurantifolia* Swingle*)* were selected for this study and consisted of foliar spray of Urea, Boron, 2,4-D, NAA, and control (water spray) Foliar application was applied two times at pre flowering and at pea size of fruits. Following treatment combinations were used, T_0 – Control (Water spray), T_1- Urea 1% + Boron 0.5%, T_2-Urea 1% + Boron 1%, T_3 -Urea 2% + Boron 0.5%, T_4-Urea 2% + Boron 1%, T_5-2,4-D 15ppm + NAA 10ppm, T_6-2,4-D 15ppm + NAA 20ppm, T_7-2,4-D 30ppm + NAA 10ppm, T_8-2,4-D 30ppm + NAA 20ppm, T_9-Urea 1% + 2,4-D 15ppm + NAA 10ppm + Boron 0.5%, T_{10}-Urea 1% + 2,4-D 15ppm + NAA 10ppm + Boron 1%, T_{11}-Urea 1% + 2,4-D 15ppm + NAA 20ppm + Boron 0.5%, T_{12}-Urea1% + 2,4-D 15ppm + NAA 20ppm + Boron 1%, T_{13}-Urea 1% + 2,4-D 30ppm + NAA 10ppm + Boron 0.5%, T_{14}-Urea 1% +

2,4-D 30ppm + NAA 10ppm + Boron 1%, T_{15}-Urea 1% + 2,4-D 30ppm + NAA 20ppm + Boron 0.5%, T_{16}-Urea 1%+2,4-D 30ppm + NAA 20ppm + Boron 1%, T_{17}-Urea 2%+2,4-D 15 ppm + NAA 10ppm + Boron 0.5%, T_{18}-Urea 2%+2,4-D 15ppm + NAA 10ppm + Boron 1%, T_{19}-Urea 2%+2,4-D 15ppm + NAA 20ppm + Boron 0.5%, T_{20}-Urea 2%+2,4-D 15ppm + NAA 20ppm + Boron 1%, T_{21}-Urea 2% +2,4-D 30ppm + NAA 10ppm + Boron 0.5%, T_{22}-Urea 2%+2,4-D 30ppm + NAA 10ppm + Boron 1%, T_{23}-Urea 2%+2,4-D 30ppm + NAA 20ppm + Boron 0.5%, T_{24}-Urea 2%+2,4-D 30ppm + NAA 20ppm + Boron 1%.

RESULTA ND DISCUSSION

Physico chemical parameters

Fruit Volume at harvest (ml). The maximum fruit volume at harvest (39.54) was recorded under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which was significantly superior to all the treatments under study. The minimum fruit volume at harvest (32.25) was recorded under Control. These findings suggest that volume of the fruit is increased due to augmentation of the native supply of hormonesand the findings are in line with the observation by Bhatt *et al.* (2017); Chouhan *et al.* (2018). Similar results were obtained Jagtap *et al.* (2013); Debaje *et al.* (2011); Shinde *et al.* (2008) in acid lime and Choudhary *et al.* (2013) in Nagpur mandarin.

Juice percentage. All the treatments were statistically at par with each other. The maximum juice percentage in fruits at harvest (51.87 %) was recorded under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which was significantly superior to all the treatments under study. The minimum juice percentage in fruits at harvest (38.58%) was recorded under Control. These findings are in line with the observation by Ingle *et al.* (2001); Chouhan *et al.* (2018).

Total soluble solids (°Brix). The maximum total soluble solids (°Brix) at harvest (7.49) were taken under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which was significantly superior to all the treatments under study (7.39). The minimum total soluble solids (°Brix) at harvest (6.26) was recorded under Control. The present findings are close to those of Yadav *et al.* (2005); Iqbal *et al.* (2012) ; Golnar *et al.* (2015).

Acidity percentage. The maximum acidity (%) at harvest (8.04) was recorded under Control.T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% showed the minimum acidity (%) at harvest (6.49) were taken under the treatment which was significantly superior to all the treatments under study except T_{18} - Urea 2%+2,4-D 15ppm + NAA10 ppm+Boron 1% (6.70). The decrease in acidity of fruits may be associated with the fact that under the influence of growth regulators, acids by reactions involving reverse glycolytic pathways might have either been converted into sugars and their derivatives or might have been used in respiration or both. Similar results were also obtained by Shinde *et al.*(2008); Ashraf *et al.* (2013); Chouhan *et al.* (2018) in citrus.

TSS : acid ratio at harvest. The maximum TSS : acid ratio at harvest at harvest (1.11) was recorded under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which was significantly superior to all the treatments under study. The minimum TSS : acid ratio at harvest(0.86) was recorded under Control. The present findings are close to those of Ashraf *et al.* (2013).

Post harvest parameters

Physiological weight loss (%) of fruits at 5,10 and 15 DAS. The minimum physiological weight loss (%) of fruits at 5 DAS (6.73) were taken under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which was significantly superior to all the treatments under study The maximum physiological weight loss (%) of fruits at 5 DAS (9.20) was recorded under Control. The minimum physiological weight loss (%) of fruits at 10 DAS(9.90) were taken under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which was significantly superior to all the treatments under study The maximum physiological weight loss (%) of fruits at 10 DAS 13.89 was recorded under Control. The minimum physiological weight loss (%) of fruits at 15 DAS(15.29) were taken under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which was significantly superior to all the treatments under study The maximum physiological weight loss (%) of fruits at 15 DAS (20.05) was recorded under Control. Findings of similar sort have been reported by Dhakad *et al.*(2020).

Specific gravity (g/cc) at 5,10 and 15 DAS. The maximum specific gravity (g/cc) at 5 DAS (1.79) was recorded under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which performed superiorly to all the treatments under study. The minimum specific gravity (g/cc) at 5 DAS (1.44) was recorded under Control. The maximum specific gravity (g/cc) at 10 DAS (1.49) was recorded under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which was significantly superior to all the treatments under study except T_{18} - Urea 2%+2,4-D 15ppm + NAA10ppm+Boron 1% (1.48). The minimum specific gravity (g/cc) at 10 DAS (1.18) was recorded under Control. The maximum specific gravity (g/cc) at 15 DAS (1.21) were taken under the treatment T_{19}-Urea 2%+2,4D 15ppm+NAA 20ppm+Boron 0.5% which was significantly superior to all the treatments under study. The minimum specific gravity (g/cc) at 15DAS (0.80) was recorded under Control. The findings are in close conformity to the reports by Mukhim *et al.* (2015); Chouhan *et al.* (2018).

Table 1: Physico chemical quality parameters in Acid Lime.

Treatment	Fruit Volume at harvest (ml)	Juice percentage	Total soluble solids (°Brix)	Acidity percentage	TSS : acid ratio at harvest
T_0 – Control (Water spray)	32.25	38.58	6.26	8.04	0.86
T_1- Urea 1% + Boron 0.5%	33.35	41.49	6.44	7.94	0.87
T_2-Urea 1% + Boron 1%	36.41	42.17	6.63	7.81	0.88
T_3 -Urea 2% + Boron 0.5%	36.00	42.19	6.69	7.69	0.89
T_4-Urea 2% + Boron 1%	32.82	44.19	6.67	7.64	0.89
T_5-2,4-D 15ppm + NAA 10ppm	34.70	48.78	6.79	7.53	0.90
T_6-2,4-D 15ppm + NAA 20ppm	33.61	47.40	6.85	7.50	0.91
T_7-2,4-D 30ppm + NAA 10ppm	34.27	42.17	6.79	7.72	0.91
T_8-2,4-D 30ppm + NAA 20ppm	36.75	45.83	6.90	7.70	0.92
T_9-Urea 1% + 2,4-D 15ppm + NAA 10ppm + Boron 0.5%	36.49	48.08	6.86	7.61	0.93
T_{10}-Urea 1% + 2,4-D 15ppm + NAA 10ppm + Boron 1%	36.21	49.25	6.82	7.54	0.93
T_{11}-Urea1% + 2,4-D 15ppm + NAA 20ppm + Boron 0.5%	35.30	44.52	6.88	7.36	0.93
T_{12}-Urea1% + 2,4-D 15ppm + NAA 20ppm + Boron 1%	35.99	44.29	6.98	7.29	0.95
T_{13}-Urea 1% + 2,4-D 30ppm + NAA 10ppm + Boron 0.5%	35.51	42.24	6.95	7.23	0.96
T_{14}-Urea 1% + 2,4-D 30ppm + NAA 10ppm + Boron 1%	35.60	43.33	7.08	7.18	0.97
T_{15}-Urea 1% + 2,4-D 30ppm + NAA 20ppm + Boron 0.5%	37.10	47.54	7.05	7.16	0.97
T_{16}-Urea 1%+2,4-D 30ppm + NAA 20ppm + Boron 1%	37.33	46.58	7.13	7.13	0.99
T_{17}-Urea 2%+2,4-D 15 ppm + NAA 10ppm + Boron 0.5%	33.48	46.90	7.24	6.73	0.99
T_{18}-Urea 2%+2,4-D 15ppm + NAA 10ppm + Boron 1%	38.47	50.72	7.39	6.70	1.09
T_{19}-Urea 2%+2,4-D 15ppm + NAA 20ppm + Boron 0.5%	39.54	51.87	7.49	6.49	1.11
T_{20}-Urea 2%+2,4-D 15ppm + NAA 20ppm + Boron 1%	36.64	47.92	7.28	6.85	1.04
T_{21}-Urea 2% +2,4-D 30ppm + NAA 10ppm + Boron 0.5%	35.58	49.15	7.24	6.93	1.02
T_{22}-Urea 2%+2,4-D 30ppm + NAA 10ppm + Boron 1%	37.16	46.06	7.09	7.00	1.01
T_{23}-Urea 2%+2,4-D 30ppm + NAA 20ppm + Boron 0.5%	37.32	46.81	7.02	6.84	1.00
T_{24}-Urea 2%+2,4-D 30ppm + NAA 20ppm + Boron 1%	33.90	44.88	7.00	6.88	1.00
SE(m)±	**0.91**	**1.45**	**0.09**	**0.13**	**0.02**
CD(5%)	**2.56**	**4.09**	**0.27**	**0.37**	**0.06**

Table 2: Post harvest parameters in Acid Lime.

	Physiological weight loss (DAS)*			Specific Gravity (DAS)		
	5	**10**	**15**	**5**	**10**	**15**
T_0 – Control (Water spray)	8.96	13.89	20.05	1.44	1.18	0.80
T_1- Urea 1% + Boron 0.5%	8.80	13.59	19.60	1.46	1.21	0.93
T_2-Urea 1% + Boron 1%	8.57	13.47	19.10	1.48	1.25	0.94
T_3 -Urea 2% + Boron 0.5%	8.49	13.03	18.84	1.50	1.26	0.95
T_4-Urea 2% + Boron 1%	8.42	12.79	18.78	1.51	1.28	0.97
T_5-2,4-D 15ppm + NAA 10ppm	8.40	12.53	18.63	1.53	1.29	0.99
T_6-2,4-D 15ppm + NAA 20ppm	8.28	12.47	18.58	1.55	1.30	0.99
T_7-2,4-D 30ppm + NAA 10ppm	8.24	12.30	18.49	1.55	1.33	1.00
T_8-2,4-D 30ppm + NAA 20ppm	8.21	12.18	18.44	1.55	1.33	1.02
T_9-Urea 1% + 2,4-D 15ppm + NAA 10ppm + Boron 0.5%	8.09	12.11	18.31	1.57	1.34	1.04
T_{10}-Urea 1% + 2,4-D 15ppm + NAA 10ppm + Boron 1%	8.01	11.85	18.15	1.59	1.35	1.04
T_{11}-Urea1% + 2,4-D 15ppm + NAA 20ppm + Boron	7.98	11.83	17.78	1.60	1.35	1.06

0.5%						
T_{12}-Urea1% + 2,4-D 15ppm + NAA 20ppm + Boron 1%	7.93	11.65	17.24	1.61	1.36	1.08
T_{13}-Urea 1% + 2,4-D 30ppm + NAA 10ppm + Boron 0.5%	7.91	11.50	17.13	1.61	1.38	1.13
T_{14}-Urea 1% + 2,4-D 30ppm + NAA 10ppm + Boron 1%	7.81	11.39	16.98	1.64	1.39	1.14
T_{15}-Urea 1% + 2,4-D 30ppm + NAA 20ppm + Boron 0.5%	7.73	11.35	16.97	1.64	1.39	1.15
T_{16}-Urea 1%+2,4-D 30ppm + NAA 20ppm + Boron 1%	7.56	11.32	16.89	1.65	1.40	1.16
T_{17}-Urea 2%+2,4-D 15 ppm + NAA 10ppm + Boron 0.5%	7.41	10.67	16.74	1.65	1.42	1.17
T_{18}-Urea 2%+2,4-D 15ppm + NAA 10ppm + Boron 1%	6.79	10.31	15.83	1.74	1.48	1.20
T_{19}-Urea 2%+2,4-D 15ppm + NAA 20ppm + Boron 0.5%	6.73	9.90	15.29	1.79	1.49	1.21
T_{20}-Urea 2%+2,4-D 15ppm + NAA 20ppm + Boron 1%	6.97	10.20	16.09	1.73	1.47	1.19
T_{21}-Urea 2% +2,4-D 30ppm + NAA 10ppm + Boron 0.5%	7.14	10.57	16.34	1.72	1.46	1.20
T_{22}-Urea 2%+2,4-D 30ppm + NAA 10ppm + Boron 1%	7.52	10.67	16.44	1.69	1.44	1.19
T_{23}-Urea 2%+2,4-D 30ppm + NAA 20ppm + Boron 0.5%	7.61	10.75	16.50	1.68	1.44	1.19
T_{24}-Urea 2%+2,4-D 30ppm + NAA 20ppm + Boron 1%	7.62	10.82	16.55	1.67	1.42	1.18
SE.m.±	**0.24**	**0.33**	**0.56**	**0.04**	**0.03**	**0.03**
CD at 5%	**0.70**	**0.94**	**1.60**	**0.11**	**0.08**	**0.09**

(DAS)*Days after storage

CONCLUSIONS

On the basis of results obtained in present investigation it is concluded that foliar application of T_{19}-Urea 2%+2,4-D 15ppm + NAA 20ppm + Boron 0.5% was found to be significantly superior to all the treatments under study and resulted in increase in fruit volume, juice percentage, TSS Brix, and TSS: Acid ratio and specific gravity whereas reduced the acidity percentage, physiological weight loss as compared to control. Hence this treatment combination seems to be useful or improving the quality and post harvest parameters of acid lime for consumption of its by products like squash, marmalades, pickles and help farmers to get a higher price for their produce thereby increasing their income.

Acknowledgement. The authors wish to express their gratitude and acknowledgement to the Department of Horticulture, (RVSKVV), College of Agriculture and Krishi Vigyan Kendra (RVSKVV) Gwalior (Madhya Pradesh) for providing all the facilities to conduct this research experiment.

Conflict of Interest. None.

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How to cite this article: Shrikunwar, Karan Vir Singh, Khusboo Namdev and Rajesh Lekhi (2023). Influence of Foliar Application of Plant Growth Regulators and Nutrients on Physico Chemical and Post Harvest Traits of Acid Lime (*Citrus aurantifolia* Swingle)**.** *Biological Forum – An International Journal, 15*(12): 480-484.