

EFFECT OF TRIACONTANOL, NANO-ZINC, AND LIQUID ORGANIC FERTILIZER ON QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF LOCAL LEMON FRUITS

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ABSTRACT

The experiment was conducted during 2023 and 2024 growing seasons in a private orchard in Alexandria area in Babylon Governorate. study included three factors, first was spraying growth regulator triacontanol at three levels: no spraying (T₀), spraying 10 mg.l⁻¹ (T₁), spraying 20 mg L⁻¹ (T₂): second factor is spraying Nano-zinc at three levels (0, 50, 100 mg L⁻¹), as Z₀, Z₁, and Z₂ respectively and third factor is adding liquid organic fertilizer at three levels (0, 50 , 100 ml Tree⁻¹) is represented by symbols O₀, O₁, O₂ respectively. Spraying and adding process is carried out five times in spring season and three times in autumn season with an interval of 20 days between one spray and another. This is also case for addition and for two growing seasons. Coefficients were repeated three times in RCBD factorial experiment so trees number included in experiment was 81 trees. Experimental results showed that spraying triacontanol at 20 mg L⁻¹ and spraying Nano zinc at 100 mg L⁻¹ and adding liquid organic fertilizer at 100 ml L⁻¹ as an interaction treatment (T₂Z₂O₂) gave best results in average fruit weight trait (92.00, 89.88) g , total tree yield (9.893, 12.000) kg tree⁻¹, total fruits acidity (4.75, 4.87) %, vitamin C fruit content (45.45,46.25) mg 100 ml⁻¹, GA₃ leaves content (161.64) and IAA (39.24) µg g⁻¹ FW for two growth seasons respectively compared to control treatment that gave lowest values.

Key words: citrus, growth, Nano-zinc, Triacontanol

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INTRODUCTION

Citrus can be considered one of largest fruit crops, as it is grown in more than 140 countries around world and has an agricultural history of more than 4.000 years (Xu et al, 2018). Citrus represents a comprehensive term for fruits that belong to Rutaceae family. Globally lemons, oranges, and tangerines are considered most widely traded horticultural products. Among all types citrus fruits are highly appreciated due to their rich nutritional content and are also considered a good source of vitamins, minerals, pectin, and fiber necessary for normal functioning body human (Hussain et al, 2021). Climatic conditions

affect citrus fruits growth, as Mediterranean climate is considered suitable for growth and production. Citrus where vegetative growth generally begins at 12.8° and growth increases continuously with increasing temperatures up to 35° and declines when it rises to more than 35°, which affects citrus production and its fluctuation and thus an annual loss in crop, Water shortage also has an effect in weakening Growth, flowering and citrus productivity (Abobatta, 2021). Triacontanol is a non-toxic internal growth regulator that works to enhance various metabolic activity in plants, leading to improved growth and development (Pang et al, 2020; Bhandari et al, 2021). It is a

long-chain saturated primary alcohol containing 30 carbon atoms $\text{CH}_3(\text{CH}_2)_{28}\text{CH}_2\text{OH}$ It was identified for first time in Alfalfa plant (Rise et al, 1977), positive role of growth regulator triacontanol when applied foliar is represented by growth and plant production and metabolic process control including division, elongation cell, photosynthesis and enzymatic activity (Perveen et al, 2011; Sarwar et al, 2019). Recently, it has been considered one of plant genetic materials that has It has an impact on many chemical, physical and biological processes in different crops growth (Karam et al, 2017). Despite few studies that have regulator changed importance in various fruit trees growth, they have documented improvements that have occurred through this regulator (Verma et al, 2022). (EL-Beltagi et al, 2022) explained in an experiment conducted on mango trees "Kesar" in which various treatments were used including triacontanol at 750 mg L^{-1} sprayed on trees where they observed superiority of triacontanol in several characteristics including fruits number, fruit weight, and tree total yield, vitamin C fruits content was superior to control treatment that gave lowest values. (EL-Beltagi, 2022) confirmed in an experiment on strawberry transplants in which three concentrations of triacontanol were used: 0, 0.5, and 1 ppm, It was found that 1 ppm gave highest values for one fruit weight, fruits number, tree total yield and highest vitamin C content for both growing seasons superior to control treatment which gave lowest. Recently, it has been noted that there is great interest by researchers in nano-zinc use in terms of its positive effect on plant through its absorption and spread within high-end plants, which is reflected positively in increasing vegetative growth and increasing productivity while improving product quality and fruit lifespan and reducing loss rate which is first step towards wider participation for zinc nanoparticles in agriculture (Helena et al, 2018; Seyed Morteza et al, 2020). It has also been noted that foliar feeding is an effective and good method in cases where root system is inefficient in absorbing nutrients from soil (Czyowska and Barbasz, 2022). (Mosa et al,

2021) found in a study on peach trees in which nano-zinc three concentrations were used, 2.5, 5 and 7.5 mg L^{-1} , sprayed on trees, It was noted that nano-zinc high concentrations had a significant effect and gave highest values in fruit weight characteristic, per unit and total tree yield as well as an increase in vitamin C fruits content and a reduction in acidity percentage compared to control treatment and other treatments rest. (Shaaban, 2024) explained in a study in which nano-zinc was used sprayed on "Thompson" grapes at 1,2 PPM where they noticed that second concentration had a significant effect on total yield weight, length and bunch thickness, and gave lowest acidity percentage compared to treatments rest . It is not hidden from those working in agricultural field large amounts importance of organic matter and its influential role in improving vegetative characteristics and different types yields whether added or sprayed on plants (AL-Hadethi, 2019). All types' organic fertilizers are considered a basic and important source in supplying plants with major and minor elements. In addition to improving chemical, physical and soil biological properties, it is considered one of best good alternatives for various nutrients during plant growth different stages because it contains organic acids such as fulvic, humic, amino acids and others (AL-hayani and AL-Hadethi, 2023). (EL-Degnawy et al, 2019) observed in an experiment on orange trees in which humic liquid organic fertilizer was added to trees soil at 150 ml Tree^{-1} , which led to a significant improvement in tree's total yield quality and weight, size and one fruit shape, as well as an increase in fruits content were rich in vitamin C and their acidity was reduced for both growing seasons superior to control treatment that gave lowest values. (Dewa et al, 2024) showed that when adding liquid organic fertilizer to orange trees soil at 5, 10 and 15 ml L^{-1} , he noted that 15 ml L^{-1} gave highest values in one fruit weight terms and tree fruits number, outperforming on control treatment that gave lowest.

MATERIALS AND METHODS

Experiment was carried out in one of orchards located in Alexandria city in Babylon Governorate (45 km south of Baghdad) for

2023/2024 growing seasons to study effect of spraying with growth regulator triacontanol, nano-zinc and adding liquid organic fertilizer on quantitative and qualitative local lemon fruits characteristics. 81 homogeneous trees were selected with vegetative growth free of insect infestations and diseases as much as possible at 7 years, study included spraying triacontanol at three levels: no spraying (T_0), spraying 10 mg L⁻¹ (T_1), spraying 20 mg.L⁻¹ (T_2), second factor (0, 50, 100) mg L⁻¹ of nano-zinc (Z_0 , Z_1 , Z_2) third factor is adding liquid organic fertilizer (proteon) at (0, 50, 100) ml Tree⁻¹ (O_0 , O_1 , O_2) spraying and addition process was carried out five times in spring season and three times in autumn season for two growing seasons and period between one spraying and next was 20 days same was true for addition , experiment was within a completely randomized block design (RCBD) , results of study were analyzed statistically and averages were compared according to L.S.D. level. 0.05 according to (ELsahookie and Wuhaib, 1990), following parameters were determined: Fruits number, Fruit weight (g), One tree yield (kg), Fruits total acidity (%): 10 ml of lemon juice was taken and volume was completed to 100 ml with distilled water, Then mixture 10 ml was taken and triturated against 0.1 NaOH in phenolphthalein dye presence (reagent), then total acidity was calculated on basis that citric acid is dominant acid (g 100 ml⁻¹ Juice). was determined using an (AOAC, 2005) method, Vitamin C (mg 100 ml⁻¹): Vitamin C amount (100 mg⁻¹ fresh weight) was estimated using oxalic acid (2%) as a preservative solution and coloring using dye Indophenol 2.6 Dichlorophenol, ascorbic acid alone is able to reduce this dye, as it turns from blue in basic medium to pink in acidic medium. (Ranganna, 1977), Leaves (IAA and GA₃) content were assayed according to (Unyayar et al, 1996).

RESULTS AND DISCUSSION

Fruits quantitative traits: Fruits number, fruit weight, total tree yield: tables (1,2,3) show that study factors had a moral impact on

studied traits where it was noted that spraying with triacontanol (T_2) was morally affected in fruits number characteristic gave (119.24, 140.67) fruit, fruit weight (71.67, 72.14) g and total tree yield (8.474, 10.080) kg-tree⁻¹. As for spraying with nano-zinc effect it was noted that (Z_2) exceeded morally and gave highest values giving (120.02, 143.45) fruits to fruits number traits, (65.56, 65.89) g for fruit weight and (7.769, 9.218) kg tree⁻¹ total tree yield is superior to rest treatment for two growth season. As for liquid organic fertilizer effect (Proteon) it was noted that (O_2) gave best values in fruit weight of (78.00, 76.36) g and (8.911, 10.661) kg tree⁻¹. As for twice interaction effect it was noted that (T_2O_2) excelled as fruit weight (88.33, 85.98) g and total tree yield (9.795, 11.610) kg tree⁻¹. As for triple interaction ($T_2Z_2O_2$) It excelled in fruit weight (92.00, 89.88) g and total tree yield (9.893, 12.000) kg tree⁻¹ is superior to interactions rest for two growth season. Increase in one tree yield (Table 3) can be attributed to role played by growth regulator triacontanol in increasing photosynthesis efficiency process by increasing leaf area, chlorophyll and increasing nitrogen and carbohydrates manufactured in plant tissues. It was also found that it contributes to transfer and sugars accumulation in reproductive organs , increasing flower buds, flowers number and completing fruit set process all of which were positively reflected in increasing fruit formed amount on tree (table,1) (Khandaker et al, 2013; Bhatla and Lal, 2018) these results are consistent with what. (Gaikwad et al, 2022) found when spraying triacontanol on mango trees. As for reason for increase in indicators of above-mentioned yield traits when spraying with nano-zinc element it may be due to its positive effect on plant through its absorption and assimilation within plant which is positively reflected in improving vegetative growth, flower growth and fruit set which affects increasing productivity and improving product quality (Seyed Morteza, 2020; Gommez et al, 2021).

Table 1. Effect of spraying Triaccontanol, Nano- zinc, adding liquid organic fertilizer, and interference in fruits number (fruit tree⁻¹) for 2023/2024 of local lemon trees

Triaccontanol (T)	Nano-Zinc (Z)	Organic fertilizer (O)			T × Z	Organic fertilizer (O)			T × Z
		O ₀	O ₁	O ₂		O ₀	O ₁	O ₂	
T ₀	z ₀	132.67	117.33	118.67	122.89	134.05	136.54	140.18	136.92
	z ₁	119.33	115.00	117.50	117.28	126.23	117.64	160.05	134.64
	z ₂	131.50	113.67	120.00	121.72	166.14	160.07	155.83	160.68
T ₁	z ₀	119.00	117.50	115.33	117.28	121.34	98.47	140.96	120.26
	z ₁	117.00	115.00	112.50	114.83	139.50	106.46	131.45	125.80
	z ₂	130.33	114.33	115.33	120.00	150.25	109.14	133.23	130.87
T ₂	z ₀	119.67	124.00	109.00	117.56	150.00	148.51	132.40	143.64
	z ₁	125.33	123.50	116.67	121.83	141.91	137.56	139.26	139.58
	z ₂	124.50	123.00	107.50	118.33	147.49	135.40	133.51	138.80
LSD 5%			2.014		1.163		6.592		3.806
		T × O			T		T × O		T
T ₀		127.83	115.33	118.72	120.63	142.14	138.08	152.02	144.08
T ₁		122.11	115.61	114.39	117.37	137.03	104.69	135.21	125.64
T ₂		123.17	123.50	111.06	119.24	146.47	140.49	135.06	140.67
LSD 5%			1.163		0.671		3.806		2.197
		Z × O			Z		Z × O		Z
	Z ₀	123.78	119.61	114.33	119.24	135.13	127.84	137.85	133.61
	Z ₁	120.56	117.83	115.56	117.98	135.88	120.55	143.59	133.34
	Z ₂	128.78	117.00	114.28	120.02	154.63	134.87	140.86	143.45
LSD 5%			1.163		0.671		3.806		2.197
O		124.37	118.15	114.72		141.88	127.75	140.76	
LSD 5%			0.671				2.197		

Table 2. Effect of spraying Triaccontanol, Nano- zinc, adding liquid organic fertilizer, and interference in Fruit weight (g) for 2023 / 2024 of local lemon trees

Triaccontanol (T)	Nano-Zinc (Z)	Organic fertilizer (O)			T × Z	Organic fertilizer (O)			T × Z
		O ₀	O ₁	O ₂		O ₀	O ₁	O ₂	
T ₀	z ₀	35.00	42.00	66.00	47.67	38.12	44.00	64.20	48.77
	z ₁	46.00	55.00	58.00	53.00	47.50	58.14	60.18	55.27
	z ₂	34.00	45.00	67.00	48.67	36.80	45.48	64.13	48.80
T ₁	z ₀	46.00	72.00	77.00	65.00	47.22	70.88	72.90	63.67
	z ₁	48.00	76.00	86.00	70.00	52.90	74.20	83.68	70.26
	z ₂	51.00	81.00	83.00	71.67	52.82	79.14	84.20	72.05
T ₂	z ₀	54.00	57.00	90.00	67.00	55.20	60.60	85.80	67.20
	z ₁	59.00	73.00	83.00	71.67	60.74	74.22	82.26	72.41
	z ₂	61.00	76.00	92.00	76.33	61.78	78.80	89.88	76.82
LSD 5%			1.891		1.092		2.162		1.248
		T × O			T		T × O		T
T ₀		38.33	47.33	63.67	49.78	40.81	49.21	62.84	50.95
T ₁		48.33	76.33	82.00	68.89	50.98	74.74	80.26	68.66
T ₂		58.00	68.67	88.33	71.67	59.24	71.21	85.98	72.14
LSD 5%			1.092		0.630		1.248		0.721
		Z × O			Z		Z × O		Z
	Z ₀	45.00	57.00	77.67	59.89	46.85	58.49	74.30	59.88
	Z ₁	51.00	68.00	75.67	64.89	53.71	68.85	75.37	65.98
	Z ₂	48.67	67.33	80.67	65.56	50.47	67.81	79.40	65.89
LSD 5%			1.092		0.630		1.248		0.721
O		48.22	64.11	78.00		50.34	65.05	76.36	
LSD 5%			0.630				0.721		

these results are consistent with what (Abd EL-wahed et al, 2024) found when spraying pomegranate trees with nano-zinc. As for role played by liquid organic fertilizer it may be due to its compounds rich content in polysaccharides and its high nitrogen concentration and potassium as it helps increase leaves mineral content and hormones or it is due to increased these elements

concentration in soil solution and thus increasing their readiness and amount absorbed by plant which is reflected in nutritional trees status through carbohydrates accumulation well (AL-Mawsili et al, 2019) these results are consistent with what (Dewa et al;2024) found when adding liquid organic fertilizer to orange trees soil.

Table 3. Effect of spraying Triacontanol, Nano- zinc, adding liquid organic fertilizer, and interference in tree yield (kg) for 2023/2024 of local lemon trees

Triacontanol (T)	Nano-Zinc (Z)	Organic fertilizer (O)			T × Z	Organic fertilizer (O)			T × Z
		O ₀	O ₁	O ₂		O ₀	O ₁	O ₂	
T ₀	z ₀	4.643	4.927	7.382	5.801	5.110	6.004	9.000	6.705
	z ₁	7.875	6.325	6.815	7.005	5.996	6.840	9.632	7.489
	z ₂	4.471	5.115	8.040	5.875	6.114	7.280	9.994	7.796
T ₁	z ₀	5.474	8.460	8.880	7.605	5.730	6.980	10.276	7.662
	z ₁	5.616	8.740	9.675	8.010	7.380	7.900	11.000	8.760
	z ₂	6.646	9.243	9.572	8.487	7.940	8.638	11.218	9.265
T ₂	z ₀	6.462	7.068	9.810	7.780	8.280	9.000	11.360	9.547
	z ₁	7.394	9.015	9.683	8.697	8.620	10.210	11.470	10.100
	z ₂	7.594	9.348	9.893	8.945	9.112	10.670	12.000	10.594
LSD 5%			0.622		0.359		0.383		0.221
T × O					T		T × O		T
T ₀		5.663	5.456	7.562	6.227	5.740	6.708	9.542	7.330
T ₁		5.912	8.814	9.376	8.034	7.017	7.839	10.831	8.562
T ₂		7.150	8.477	9.795	8.474	8.671	9.960	11.610	10.080
LSD 5%			0.359		0.207		0.221		0.128
Z × O					Z		Z × O		Z
Z ₀		5.526	6.818	8.841	7.062	6.373	7.328	10.212	7.971
Z ₁		6.962	8.027	8.724	7.904	7.332	8.317	10.701	8.783
Z ₂		6.237	7.902	9.168	7.769	7.722	8.863	11.071	9.218
LSD 5%			0.359		0.207		0.221		0.128
O		6.242	7.582	8.911		7.142	8.169	10.661	
LSD 5%			0.207				0.128		

Fruits qualitative traits: Total acidity, vitamin C fruits content shows tables (4,5) that study factors had a positive effect on studied qualities as it was noted that spraying with triacontanol (T₂) is morally outperformed in total acidity attribute gave (4.83, 4.92)% and vitamin C (40.55,41.59) mg.100.ml⁻¹ for two growth seasons and moral difference from control treatment Which gave least, but nano-zinc element it was observed that (Z₂) gave highest value to total acidity (4.71, 4.80) % vitamin C (39.35, 40.17) mg 100 ml⁻¹ for two growth seasons superior to control treatment that gave least, Liquid organic fertilizer had no

moral effect on total acidity, While morally (O₂) affected vitamin C fruits content it amounted to (38.59, 39.46) mg 100 ml⁻¹ for two growth season superior to other treatments. As for twice interaction effect it was noted that treatment (T₂Z₂) gave highest value (5.05, 5.15) % for two growth season in fruits total acidity and (43.56, 44.27) mg 100 ml⁻¹ vitamin C attribute superior to rest of interference and. As for triple interference it was noted that (T₂Z₂O₂) has excelled morally and gave highest values in total acidity attribute (5.09, 5.20) % and vitamin C (45.45, 46.25) mg 100 ml⁻¹ outperforming rest of interference for two growth seasons.

Table 4. Effect of spraying Triacontanol, Nano- zinc, adding liquid organic fertilizer, and interference in total fruits acidity (%) for 2023/2024 of local lemon trees

Triacontanol (T)	Nano-Zinc (Z)	Organic fertilizer (O)			T × Z	Organic fertilizer (O)			T × Z
		O ₀	O ₁	O ₂		O ₀	O ₁	O ₂	
T ₀	z ₀	4.11	4.14	4.22	4.16	4.19	4.26	4.31	4.25
	z ₁	4.15	4.24	4.21	4.20	4.33	4.34	4.38	4.35
	z ₂	4.33	4.27	4.27	4.29	4.45	4.40	4.39	4.41
T ₁	z ₀	4.42	4.44	4.51	4.46	4.45	4.48	4.54	4.49
	z ₁	4.61	4.55	4.52	4.56	4.66	4.58	4.54	4.59
	z ₂	4.78	4.78	4.81	4.79	4.84	4.88	4.75	4.82
T ₂	z ₀	4.52	4.66	4.70	4.63	4.69	4.73	4.64	4.69
	z ₁	4.88	4.81	4.75	4.81	4.98	4.92	4.87	4.92
	z ₂	5.03	5.03	5.09	5.05	5.11	5.14	5.20	5.15
LSD 5%			0.30		0.17		0.24		0.14
T × O					T		T × O		T
	T ₀	4.20	4.22	4.23	4.22	4.32	4.33	4.36	4.34
	T ₁	4.60	4.59	4.61	4.60	4.65	4.65	4.61	4.64
	T ₂	4.81	4.83	4.85	4.83	4.93	4.93	4.90	4.92
LSD 5%			0.17		0.10		0.14		0.08
Z × O					Z		Z × O		Z
	Z ₀	4.35	4.41	4.48	4.41	4.44	4.49	4.50	4.48
	Z ₁	4.55	4.53	4.49	4.52	4.66	4.61	4.60	4.62
	Z ₂	4.71	4.69	4.72	4.71	4.80	4.81	4.78	4.80
LSD 5%			0.17		0.10		0.14		0.08
O		4.54	4.54	4.56		4.63	4.64	4.63	
LSD 5%			N.S				N.S		

Increase in total acidity and vitamin C fruits content (Table 4, 5) can be attributed to role that triacontanol plays in regulating internal plant growth so it facilitates many optical acting activities and increase in leaves area, chlorophyll, nitrogen, and carbohydrates that are reflected in fruits qualitative traits and improves its content from salts and vitamins including total acidity fruits content (Islam and Mohammad, 2020) these results are compatible with what (Nazir et al, 2017) found when spraying with triacontanol kiwi trees "Hayward" where a significant increase in total acidity and vitamin C fruits content. As for nano-zinc effect element in above traits it may be due to fact that nanoparticles are characterized by their small size and good chemical properties in nutrients balance terms

in plant, which are reflected positively on fruits qualitative traits (Garcia-Lopez et al, 2019; ELsheery et al, 2020; AL-Hchami and AL-Rawi, 2020) is consistent with this results with what (Mosa et al, 2021) found when spraying peach trees with nano-zinc. As for liquid organic fertilizer effect in above traits reason may be due to fact that this fertilization works method to supply plant with nutrients needed for its growth and achieve quantitative and qualitative improvement in its production, as adding ease it and its melting speed in water and its ability to free largest elements amount that are associated with soil all of them improved fruits qualitative traits (Mahawesh, 2023) These results are consistent with what (Samra et al, 2017) found when adding liquid organic fertilizer to orange trees soil.

Table 5. Effect of spraying Triacontanol, Nano- zinc, adding liquid organic fertilizer, and interference in vitamin C fruits content (mg100 ml⁻¹) for 2023/2024 of local lemon trees

Triacontanol (T)	Nano-Zinc (Z)	Organic fertilizer (O)			T × Z	Organic fertilizer (O)			T × Z
		O ₀	O ₁	O ₂		O ₀	O ₁	O ₂	
T ₀	z ₀	34.23	34.67	34.73	34.54	34.50	34.72	34.86	34.69
	z ₁	34.60	34.89	34.96	34.82	34.71	35.15	35.36	35.07
	z ₂	36.88	35.38	36.42	36.23	36.10	36.48	37.23	36.60
T ₁	z ₀	35.18	35.92	36.15	35.75	35.55	36.18	36.94	36.22
	z ₁	35.63	36.20	36.83	36.22	36.40	37.61	38.58	37.53
	z ₂	37.02	37.64	40.12	38.26	38.24	39.89	40.83	39.65
T ₂	z ₀	36.42	37.16	39.22	37.60	37.30	39.46	41.12	39.29
	z ₁	38.06	39.98	43.40	40.48	39.25	40.44	43.95	41.21
	z ₂	41.13	44.10	45.45	43.56	41.83	44.72	46.25	44.27
LSD 5%		3.21			1.85	3.54			2.04
T × O		T			T	T × O			T
T ₀		35.24	34.98	35.37	35.20	35.10	35.45	35.82	35.46
T ₁		35.94	36.59	37.70	36.74	36.73	37.89	38.78	37.80
T ₂		38.54	40.41	42.69	40.55	39.46	41.54	43.77	41.59
LSD 5%		1.85			1.07	2.04			1.18
Z × O		Z			Z	Z × O			Z
Z ₀		35.28	35.92	36.70	35.97	35.78	36.79	37.64	36.74
Z ₁		36.10	37.02	38.40	37.17	36.79	37.73	39.30	37.94
Z ₂		38.34	39.04	40.66	39.35	38.72	40.36	41.44	40.17
LSD 5%		1.85			1.07	2.04			1.18
O		36.57	37.33	38.59		37.10	38.29	39.46	
LSD 5%		1.07				1.18			

Plant hormones:==Plant hormones GA₃, IAA for growth season 2024 table (6) It was observed that study factors had a clear impact on vegetable hormones leaves content where it was found that growth regulator triacontanol directly when treatment (T₂) on GA₃ leaves content where it was given (142.79) µg g⁻¹ FW superiority on interactions rest that gave lowest value either from its impact on IAA leaves content it was noted that (T₂) did not differ morally from (T₁) but it surpassed control treatment gave (35.64) µg g⁻¹ FW. (Z₂) gave highest value to GA₃ amounted to (146.71) µg g⁻¹ FW as well as highest IAA

value amounted to (36.54) µg g⁻¹ FW superior to control treatment that gave lowest value. (O₂) effect on GA₃ gave highest value (142.37) µg g⁻¹ FW and IAA amounted to (36.18) µg g⁻¹ FW for growth season. As for interactions effect it was found that (T₂Z₂) outperformed interactions rest as it gave (153.31) µg g⁻¹ FW GA₃ while (Z₂O₂) was given highest value for IAA (38.15) µg g⁻¹ FW. As for triple interactions effect it was observed that (T₂Z₂O₂) excelled in giving highest value to GA₃ amounted to (161.64) µg g⁻¹ FW and IAA (39.24) µg g⁻¹ FW outperforming interactions rest.

Table 6. Effect of spraying Triacontanol, Nano- zinc, adding liquid organic fertilizer, and interference in GA₃ and IAA leaves content ($\mu\text{g g}^{-1}$ FW) for 2024 of local lemon trees

Triacontanol (T)	Nano-Zinc (Z)	GA ₃				IAA			
		Organic fertilizer (O)			T × Z	Organic fertilizer (O)			T × Z
		O ₀	O ₁	O ₂		O ₀	O ₁	O ₂	
T ₀	z ₀	111.74	119.83	124.22	118.60	31.47	31.86	32.18	31.84
	z ₁	122.84	127.95	140.50	130.43	31.90	35.12	36.92	34.65
	z ₂	135.62	139.40	143.46	139.49	32.88	36.48	37.28	35.55
T ₁	z ₀	118.18	121.22	122.79	120.73	32.15	33.00	33.28	32.81
	z ₁	130.45	136.82	145.94	137.74	35.82	35.48	37.14	36.15
	z ₂	150.53	143.70	147.77	147.33	34.30	37.52	37.94	36.59
T ₂	z ₀	120.22	128.39	142.49	130.37	32.26	33.41	33.70	33.12
	z ₁	137.34	144.20	152.54	144.69	34.88	36.06	38.00	36.31
	z ₂	143.71	154.58	161.64	153.31	35.14	38.04	39.24	37.47
LSD 5%		12.42			7.17	2.04			1.18
T × O					T	T × O			T
T ₀		123.40	129.06	136.06	129.51	32.08	34.49	34.59	33.72
T ₁		133.05	133.91	138.83	135.26	34.09	35.33	36.12	35.18
T ₂		133.76	142.39	152.22	142.79	34.09	35.84	36.98	35.64
LSD 5%		7.17			4.14	1.18			0.68
Z × O					Z	Z × O			Z
Z ₀		116.71	123.15	129.83	123.23	31.96	32.76	33.05	32.59
Z ₁		130.21	136.32	146.33	137.62	34.20	35.55	37.35	35.70
Z ₂		143.29	145.89	150.96	146.71	34.11	37.35	38.15	36.54
LSD 5%		7.17			4.14	1.18			0.68
O		130.07	135.12	142.37		33.42	35.22	36.18	
LSD 5%		4.14				0.68			

The increase in leaves hormones content GA₃, IAA to role that triacontanol plays in increasing leaves mineral elements content and hormones through its spacious role in elongation, expansion and cells multiplication and increased root total density and its ability to increase cellular membranes permeability and water absorption and nutrients From the soil as all of these factors lead to hormones accumulation (Sarwar et al, 2019; AL-Harbi et al, 2021) these results are consistent with what (EL-Beltagi et al, 2022) is consistent with spraying strawberry with triacontanol. As for nano zinc element effect reason may be due to rapid plant response to leaves spray during different growth stages which would achieve a dietary balance that will increase hormones content (Warang et al, 2023; Salih and AL-Jeboory, 2023). These results are consistent with what found (Kareem et al, 2022) When spraying local lemon transplants with nano zinc. As for liquid organic fertilizer effect (Proteon) it may be due to its important role in

improving soil fertility and its chemical and physical properties that increase its ability to keep water which is reflected positively on growth and spread of the root total, as well as increasing nutrients readiness and increasing activity and microbiology secretions Which all works to increase hormones content (Qiu et al, 2021; Chatzistathis et al, 2021). These results are consistent with what it found (Latif and Abood, 2023) when adding liquid organic fertilizer to lemon transplants soil.

CONCLUSION

According to obtained results it can be concluded that high concentration of study factors T₂Z₂O₂ as an interaction treatment gave best results in many quantitative and qualitative lemon fruit characteristics during two growing seasons, it is possible to recommend increasing their concentration on other fruit trees and other location.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR/S DECLARATION

We confirm that all Figures and Tables in the manuscript are original to us. Additionally, any Figures and images that do not belong to us have been incorporated with the required permissions for re-publication, which are included with the manuscript.

Author/s signature on Ethical Approval Statement.

Ethical Clearance and Animal welfare

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Hussein, K, E, Alshujairy wrote the manuscript, conducted the field experiment ,prepared materials used ,performed statistical analyses and supported the field implementation

Mustafa, E, A, Al-Hadethi contributed to development of scientific methodology ,provided critical scientific review ,and performed language editing .

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تأثير الترايكونتانول والزنك النانوي والسماذ العضوي السائل في الصفات الكمية والنوعية لثمار الليمون الحامض المحلي

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المستخلص

اجريت التجربة خلال موسمي النمو 2023، 2024 في بستان خاص في الاسكندرية في محافظة بابل، تضمنت الدراسة ثلاثة عوامل الاول رش منظم النمو الترايكونتانول بثلاثة مستويات هي: بدون رش (T_0)، رش 10 ملغم لتر⁻¹ (T_1)، رش 20 ملغم لتر⁻¹ (T_2) العامل الثاني رش الزنك النانوي بثلاثة مستويات (0، 50، 100 ملغم لتر⁻¹) ويرمز لها بالرموز Z_0 و Z_1 و Z_2 على التوالي والعامل الثالث إضافة السماذ العضوي السائل بثلاثة مستويات (0، 50، 100 مل شجرة⁻¹) يرمز لها بالرموز O_0 ، O_1 ، O_2 على التوالي. تتم عملية الرش والإضافة خمسة مرات في الموسم الربيعي وثلاثة مرات في الموسم الخريفي بين رشة وأخرى 20 يوم كذلك الحال للإضافة ولموسمي النمو. تكررت المعاملات ثلاثة مرات في تجربة عامليه RCBD وبذلك يكون عدد الاشجار الداخلة في التجربة 81 شجرة. اظهرت نتائج الدراسة ان رش الترايكونتانول بتركيز 20 ملغم لتر⁻¹ ورش الزنك النانوي بتركيز 100 ملغم لتر⁻¹ وإضافة السماذ العضوي السائل بتركيز 100 مل لتر⁻¹ كمعاملة تداخلية ($T_2Z_2O_2$) اعطت افضل النتائج في صفة معدل وزن الثمرة (89.88،92.00) غم و الحاصل الكلي للشجرة (9.893 ، 12.000) كغم شجرة⁻¹ والحموضة الكلية للثمار (4.75، 4.87) % ومحتوى الثمار من فيتامين C (45.45، 46.25) ملغم 100 مل⁻¹ ومحتوى الاوراق من GA_3 (161.64) و IAA (39.24) مايكروغرام غم⁻¹ ولموسمي النمو على التوالي مقارنة بمعاملة المقارنة التي اعطت اقل القيم.

الكلمات المفتاحية: الحمضيات، النمو، الزنك النانوي، الترايكونتانول.

*البحث مستل من أطروحة دكتوراه للباحث الأول