RESEARCH | Egyptian Journal of Agricultural Research | Soil, Water and Environment

Using camel and duck manure tea for improving the quality and marketability of Egyptian Balady lime (*Citrus aurantifolia* L.) fruits

Omaima Abdel Monsef *[1]; *Ahmed H.A. Mansour*[2] *and Ahmed A. Ahmed*[3]; *Shimaa H. Gaber*[3]

Address:

[1]*Soil Improvement and Conservation Research Department, Soil, Water and Environment Research Institute (SWERI), Agricultural Research Center, Giza, Egypt.*

[2]*Fruit Handling Research Department, Horticulture Research Institute, Agricultural Research Center, Giza, Egypt*

[3]*Central Laboratory of Organic Agriculture, Agricultural Research Center, Giza, Egypt*

*Corresponding author: ***Omaima Abdel Monsef,*** email: omaimaabdelmonsef@yahoo.com

Received: 22-10-2024**; Accepted:** 7-02-2025**; Published:** 14-02-2025 **DOI:** 10.21608/EJAR.2025.330388.1604

ABSTRACT

This experiment was established to assess the impact of foliar spraying of camel and duck manure tea on the yield, fruits quality and marketability of Egyptian Balady lime (*Citrus aurantifolia* L.) trees under sandy calcareous soil conditions during two consecutive years, 2022 and 2023. The camel manure tea (CMT) and duck manure tea (DMT) were sprayed at two concentrations of 50% and 100% for each of them with treatments being applied three times, first at full blooming and at one-month intervals. Data analysis demonstrated that fruits' physical and chemical characteristics increased significantly ($p < 0.05$) as a result of foliar spraying with camel manure tea (CMT) or duck manure tea (DMT) compared with control (water spray) at harvest time during both seasons of study. Although DMT 100% treatment was recorded as the highest values in the most evaluated characteristics, total flavonoid content was the highest value in the CMT 100% treatment. During the cold marketing period, treatment foliar sprayed with CMT 100% had the longest period of cold marketing. According to this study, the productivity, quality, and marketability of Balady lime fruits are positively impacted by foliar spraying of manure tea.

Keywords: *Citrus aurantifolia* L., Foliar spraying, Camel and duck manure tea, Sandy calcareous soil

INTRODUCTION

Citrus fruits are among the most widely cultivated fruits worldwide. With 161.8 million tons produced on more than 10.2 million hectares, citrus fruits ranked as the second most produced fruit globally in 2021 (FAO, 2023).

One of the most significant citrus fruit species cultivated in Egypt and around the world is the lime (*Citrus aurantifolia* L.). Following the commercial juice extraction process, the pulp remains a valuable source of citric acid, pectin, and citrus oil. Lemon by-products are extensively utilized in the culinary, cosmetics, and medicinal sectors (Ye, 2017). In the recent period, Egypt has been interested in expanding the cultivation of citrus orchards as a result of the increased demand for them, whether for local consumption or export, and to open new international marketing outlets (Kimball, 2012).

Most of the area in Egypt planted with citrus is in desert reclaimed lands, which account for 75% of the total area. Most of these reclaimed lands are sandy and calcareous soil, which faces numerous challenges due to its rugged physical and chemical nature (FAO, 2016; Aboukila *et al.*, 2018; Al-Saeedi, 2022). On the other hand, coinciding with the insane rise in the prices of chemical fertilizers, their negative impact on the environment and human health, and their rapid loss in the soil through washing, volatilization, and stabilization (Zaib *et al.*, 2023).

So, find a strategy to overcome these previous conditions and achieve increased growth, productivity, and good nutritional status for trees while increasing the quantity and quality of the fruits. Organic application, one of the modern methods and techniques used by researchers, is intended to provide the plants with nutrients necessary to increase production and improve growth by reducing the constraints that reduce the existence of the elements in the soil (Shahrajabian *et al.*, 2022).

Manure tea is defined as the liquid extract of manure as camel, horse, sheep, poultry, and even human excrement. After partially dried, or a solution made by soaking manure in water to facilitate the decomposition process and promote the release of nutrients for plant use. This fertilizer is simple to prepare, is very sustainable in terms of availability, is cost effective, and can release nutrients to crops very quickly (Ibijola, 2011; Azeez *et al.*, 2014). It is best to apply manure tea as foliar fertilizer because plants can absorb nutrients about 20 times faster through the leaves. Manure tea helps to overcome temporary shortage of nutrient. It

Provides plants suffering from nutrient deficiency and enhances growth. There is no overdose in the use of manure tea, and it can be applied freely (Shahrajabian *et al.*, 2022). Poultry manure as duck manure has long been recognized as a good source of plant nutrients and provides all necessary elements such as nitrogen, phosphorus and potassium, including micronutrients. In this regard, a number of workers examined the important function that poultry manures have in changing the characteristics of the soil and improving the growth, yield, and quality of citrus (Fikry *et al.*, 2020; Adeyemi and Akhiwu, 2022; Hazarika *et al.*, 2024). In addition, it is cheaper to make mineral nitrogen fertilizers. (Granatstein, 2003).

Camel manure contains valuable nitrogen and other minerals, which may be due to camel feeding, and the storage method. Camel manure is high in nitrogen, ammonia, and carbon, among other important elements. Therefore, it is used as a natural fertilizer (Sabouni *et al.,* 2018). Camels' manures are better for cropping and farming. Furthermore, camel manure has almost the same value as cow manure (Irshad *et al.*, 2013).

Therefore, this study aimed to evaluate and compare camel manure with duck manure tea under sandy calcareous soil conditions on the yield, quality and marketability, extending their shelf life and reducing fruit losses of Egyptian Balady lime (*C. aurantifolia* L.) trees, as one of the most important types of citrus fruits, and even fruits in general.

MATERIALS AND METHODS

Experimental site and Plant Materials:

The current study was carried out at the Experimental Farm of Arab El-Awammer Research Station (latitude 27°, 03’ N, longitude 31°, 01’ E and 71 m above sea level), Agricultural Research Center (ARC), Assiut Governorate, Egypt during 2022 and 2023 seasons on trees ofBaladyLime (*C. aurantifolia* L.). Lime trees were 16 years old, planted 4 × 4 m in sandy calcareous soil and irrigated with drip irrigation (Each tree row had a single drip-line, with two drippers (16 L h^{-1}) per tree.). Soil samples were collected from the field experimental surface layer (0-60 cm depth) and air dried at and passed through a 1 mm sieve. The standard methods reported by (Klute, 1986 and Jackson, 1973) measured the physico-chemical soil characters. The obtained data are presented in (Table 1).

Table 1. Physico-chemical soil characters.

Soil Properties	Values
Particle size distribution (%):	
Sand	93.34
Silt	4.37
Clay	2.29
Soil texture	Sandy
Saturation percent (%)	26
Total $CaCO_3$ (g kg^{-1} soil)	320
Organic matter (g kg^{-1} soil)	210
EC (dS m^{-1})	0.66
pH	8.8
Soluble cations ($mmol_c$ L^{-1}):	
Ca^{++}	2.70
Mg^{++}	1.85
Na^{+}	1.41
K^{+}	0.36
Soluble anions ($mmol_c$ L^{-1}) :	
CO_3^{-} HCO_3^{-}	3.07
Cl^{-}	2.68
SO_4^{--}	0.55
Macronutrients (mgkg^{-1} soil):	
Available N	30.0
Available P	6.29
Available K	50.3

*Each value represents the mean of three replicates

Experimental design:

Thirty lime trees (Two trees per replicate, for three replicates per treatment) of nearly similar size and shape were selected and distributed in a randomized complete block design, received the recommended agriculture practices. Experimental trees were grouped under Five treatments including water as control as well as four foliar spray treatments with manure tea, which are: camel manure tea 100 % (CMT 100 %), camel manure tea 50 % (CMT 50 %), duck manure tea 100 % (DMT 100 %) and duck manure tea 50 % (DMT 50%). Treatments were applied (by 3 L/tree) in early morning three times, after the full bloom stage, after month and after two months.

Preparation of manure tea:

Dried camel and duck manure chemical properties (Table 2) were obtained by the standard methods reported by (Jackson, 1973). Each manure was mixed with tap water in a bucket at ratio 1:10 (100%) w/v (manure: water). Manure teas were prepared in the laboratory at room temperature (25˚ C) with continuous aeration by air pumping for three days. After that, the resulting manure tea was filtered through cotton cloth. The filtrate was diluted one time to obtain concentration (50%). The foliage of the trees was sprayed with each concentration of manure tea by using a hand sprayer.

Table 2. Chemical properties of camel and duck manure:

Manure type	PH (1:10)	EC (dS m^{-1}) (1:10)	Organic matter (g/kg)	Organic carbon (g/kg)	Macronutrients (mg/g)			C/N ratio
					N	P	K	
Camel	9.20	5.33	786.5	405.9	13.40	4.00	9.60	30.38
Duck	8.60	6.17	471.0	245.0	14.36	5.70	17.4	17.06

*Each value represents the means of three replicates

Yield Parameters:

At harvest time (mid-August), the total fruit yield per tree was recorded. Then total Yield (Ton/ha) was estimated according to the following equation:

$$\text{Yield (Ton/ha)} = \frac{yield\ per\ tree\ \times No.of\ trees\ per\ ha}{1000}$$

Sample of twenty fruits were randomly selected from each treatment to measure the following characteristics: Fruit weight (g), fruit length (mm), fruit diameter (mm), Juice weight (%) and peel weight (%).

Juice weight (JW %) and peel weight (PW %) were calculated by the following equations:

$$JW\ \% = \frac{JW}{FW} \times 100$$

Where JW is the juice weight (g); FW is the fruit weight (g)

$$PW\ \% = \frac{PW}{FW} \times 100$$

Where PW is the peel weight (g); FW is the fruit weight (g)

Leaves and fruits nutrients analysis:

Dried Leaves and fruits samples were digested using H_2SO_4 mixed with $HClO_4$ according to the method described by (Chapman and Pratt, 1961). Nitrogen content (%) was determined using micro-kjeldahl method. Total phosphorus was estimated calorimetrically using stannous chloride phosphomolybdic-sulfuric acid. Total potassium was determined using flame photometric method. These methods as explained by (Jackson, 1973).

Fruits chemical analysis:

Total soluble solids (TSS %) of fruits were determined using a hand refractometer. Titratable acidity (g of citric acid per 100 ml fruit juice) of the fruit juice was determined by titration of 5 ml juice against 0.3 N sodium hydroxide using phenolphthalein as an indicator (A.O.A.C., 1985). Ascorbic acid (V.C.) content (mg of ascorbic acid/100 g juice) was determined in fruit juice by titration with, 2,6-Dichlorophenol indophenol blue dye according to (A.O.A.C., 1985).

Total antioxidants, phenolics and flavonoids of fruits were determined spectrophotometrically. Antioxidants were evaluated using phosphomolybdenum assay as described in (Prieto *et al.*, 1999) at 695 nm. Phenolics were estimated using Folin–Ciocalteu reagent, and measured at 725 nm (Kofalvi and Nassuth, 1995). Flavonoids were estimated methods of Zou *et al.* (2004) using aluminum chloride reagent and measured at 415 nm.

Cold marketing measurements:

At harvest, at mid-August for both studied seasons, Fruit samples were selected from each replicate. Samples were directly brought to the laboratory of Assiut Agricultural Research Station, cleaned and washed by distilled water, left to dry at room temperature. Infected and all fruits with visual defects were excluded. The samples were divided into two groups: the first one included 20 fruits for each replicate/treatment for determining and measuring some analysis and the initial quality parameters at harvest. The second one was packed in non-perforated plastic bags, contains a bag with 25g calcium hydroxide. Each treatment consisted of 12 bags with three replicates and each replicate represented 250g of lime fruits. The bags were stored at (7±2°C and 65-70% relative humidity). The variables were recorded at two-week intervals during the Marketing period. Fruit weight loss (FWL %) and Fruit unmarketable (FUM %) were calculated by the following equations:

$$FWL\ \% = \frac{Wi\ - Wf}{Wi} \times 100$$

Where Wi = Initial Fruit weight; Wf = Final Fruit weight.

$$FUM\ \% = \frac{Wum}{Wi} \times 100$$

Where Wum= Weight of unmarketable Fruit; Wi = Initial Fruit weight

Statistical analysis:

All treatments of the experiment were arranged in a randomized complete block design with three replicates. The data were analyzed using the one-way ANOVA statistically analyzed by Statistics 8.1 software (Analytical Software, 2005). Means were compared for significant differences using Tukey test at $p \leq 0.05$. Data were presented as means ± standard deviations.

RESULTS

Fruit biomass:

Fruit weight and Yield: The perusal of data concerning fruit yield of Balady lime yield expressed as Fruit weight (g) (A), Yield (kg/tree) (B) and Yield (Ton/ha) (C) (Fig. 1) as affected by foliar spraying of camel and duck manure tea indicated that both concentrations of camel and duck manure tea a significant influence on Fruit weight, Yield (kg/ tree) and Yield (Ton/ha). However, observed increased, Fruit weight, Yield (kg/tree), and Yield (Ton/ ha) with increasing the concentration used from 50 to 100 %. DMT 100% had the highest significant values of yield during the two seasons compared with control and other treatments, Followed by CMT 100%.

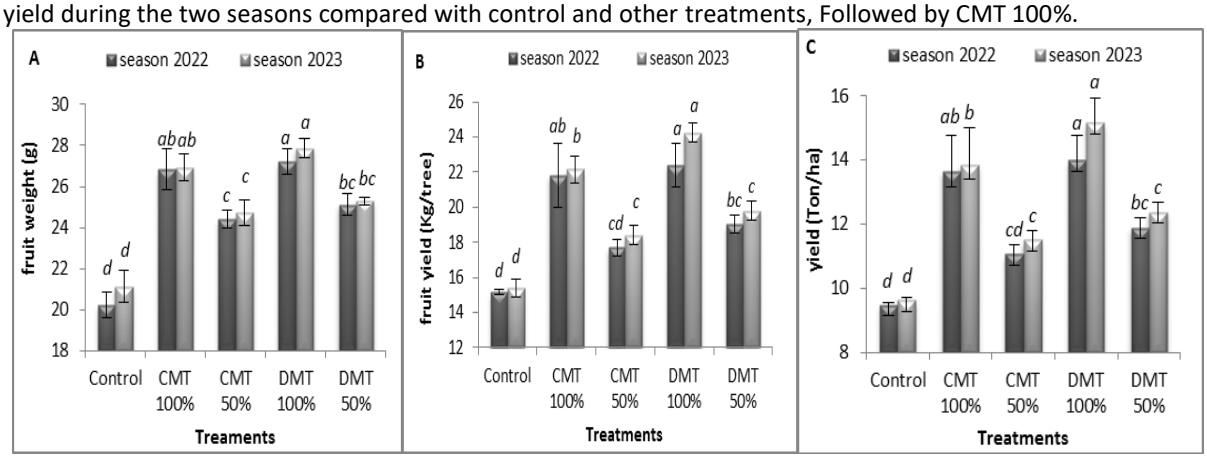


Fig. 1. Effect of foliar spraying with camel and duck manure tea on Fruit weight (g) (A), Yield (kg/tree) (B) and Yield (Ton/ha) (C) of Balady lime fruits under sandy calcareous soil conditions during 2022 and 2023 seasons. CMT: camel manure tea; DMT: duck manure tea. The different upper letters are significantly different ($p < 0.05$) according to the Tukey test.

Fruit length and diameter (mm):

Foliar spraying with camel and duck manure tea significantly affected the fruit length, diameter during two study seasons (Fig. 2) comparing to control, all foliar spraying with camel, and duck manure tea treatments recorded the greatest value of fruit length and diameter. Fruit length values were highest in the two seasons for lime trees treated with DMT 100% (39.13 and 38.23 mm) or CMT 100% (38.23 and 37.60mm), respectively. Also, in both seasons, the maximum fruit diameters were observed by administrations with DMT 100% or CMT 100% (38.40 and 37.87mm) and (37.73 and 37.13mm), respectively. On the other hand, during the two trial seasons, untreated trees produce the smallest fruits in terms of both diameter and length

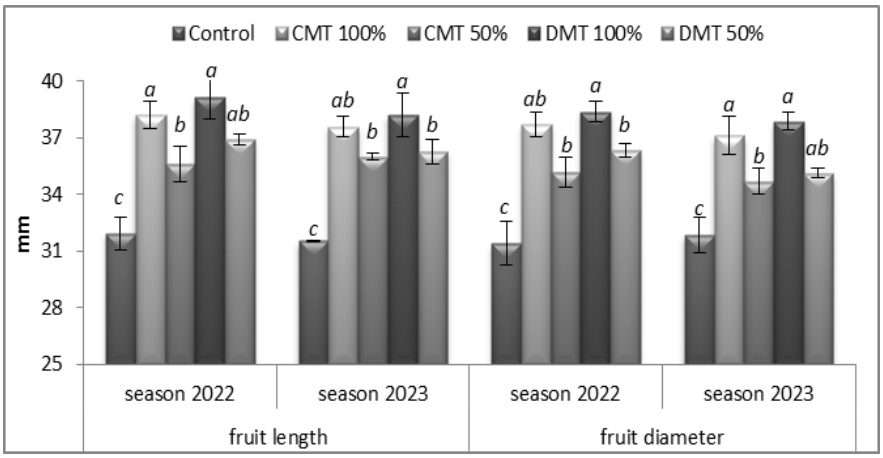


Fig. 2. Effect of foliar spraying with camel and duck manure tea on Fruit length and fruit diameter (mm) of Balady lime fruits under sandy calcareous soil conditions during 2022 and 2023 seasons. CMT: camel manure tea; DMT: duck manure tea. The different upper letters are significantly different ($p < 0.05$) according to the Tukey test.

Juice weight (JW %) and peel weight (PW %):

Data in (Fig. 3 (A and B) shows that conducted treatments significantly increased the parameters considered. The highest weight of juice (53.8 and 53.97%) was achieved with spraying trees DMT 100% followed CMT 100% (53.27 and53.83%) and the differences between them were no significant in 2022 and 2023seasons, respectively. Untreated showed the least values in this respect in the two seasons. Regarding peel weight percent, foliar application with CMT 100% was superior in this respect and resulted in the highest peel weight of 18.85 and 19.26% as compared with control trees which showed the lowest values (16.25and 16.84%) in the first and second season, respectively.

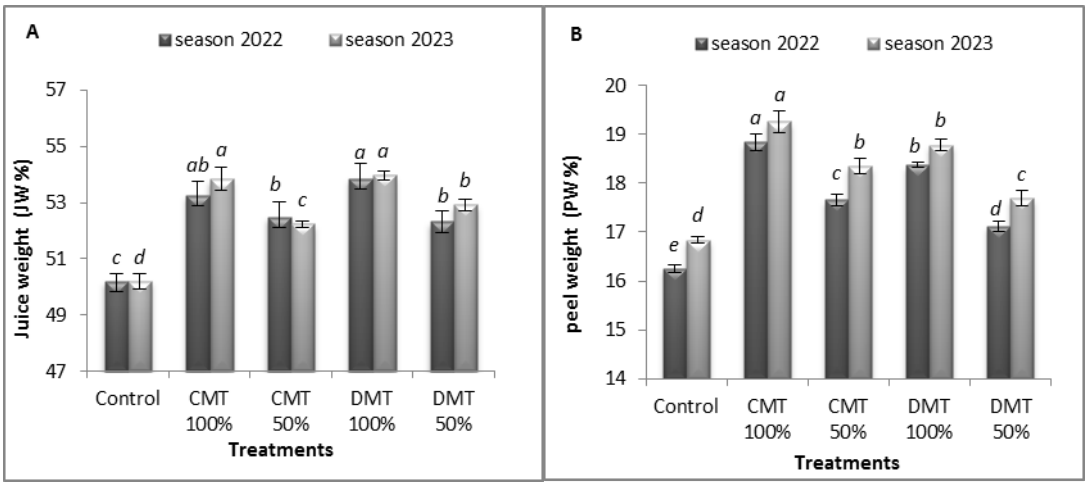


Fig. 3. Effect of foliar spraying with camel and duck manure tea on Juice weight (JW %)(A) and peel weight (PW %) (B) of Balady lime fruits under sandy calcareous soil conditions during 2022 and 2023 seasons. CMT: camel manure tea; DMT: duck manure tea. The different upper letters are significantly different ($p < 0.05$) according to the Tukey test.

Leaves and fruits nutrients content:

The nutrients content (Total N, P and K) of leaves and fruits Balady lime as an effect of foliar spraying with camel and duck manure tea in sandy calcareous soil are illustrated in (Table 3). Data observed that the total NPK concentrations in leaves were higher than in fruits of lime. All treatments resulted in an increase in NPK content in leaves and fruits compared to the control in 2022 and 2023 seasons. The highest level of NPK in lime leaves and fruits was realized in DMT 100 % treatment with average values in seasons of 12.46, 1.66 and 18.23 mg/g in leaves and 5.97, 1.34 and 13.90 mg/g in fruits, respectively. Treatments can be arranged in descending order of increasing NPK concentrations in leaves and fruits of lime as follows: DMT 100% > CMT 50% > DMT 50% > CMT control.

Table 3. Leaves and fruits macronutrients content of Balady lime under the effect of foliar spraying with camel and duck manure tea under sandy calcareous soil conditions during 2022 and 2023 seasons.

Treatments	N (mg/g)				P (mg/g)			
	2022 season		2023 season		2022 season		2023 season	
	Leaves (±SD)	Fruits (±SD)	Leaves (±SD)	Fruits (±SD)	Leaves (±SD)	Fruits (±SD)	Leaves (±SD)	Fruits (±SD)
Control	9.45 ± 0.00^{c}	4.45 ± 0.08^{c}	10.40 ± 0.32^{c}	5.00 ± 0.04^{c}	1.36 ± 0.00^{d}	1.06 ± 0.06^{d}	1.41 ± 0.02^{d}	1.12 ± 0.03^{c}
CMT 100 %	11.97 ± 0.12^{a}	5.04 ± 0.13^{ab}	12.81 ± 0.12^{a}	6.62 ± 0.00^{a}	1.56 ± 0.03^{ab}	1.27 ± 0.02^{b}	1.66 ± 0.01^{ab}	1.34 ± 0.05^{a}
CMT 50 %	10.71 ± 0.00^{b}	4.73 ± 0.05^{bc}	11.55 ± 0.22^{b}	5.67 ± 0.21^{b}	1.42 ± 0.02^{cd}	1.13 ± 0.00^{cd}	1.54 ± 0.04^{c}	1.19 ± 0.02^{bc}
DMT 100 %	12.12 ± 0.15^{a}	5.16 ± 0.12^{a}	12.97 ± 0.19^{a}	6.78 ± 0.15^{a}	1.63 ± 0.09^{a}	1.30 ± 0.10^{a}	1.69 ± 0.06^{a}	1.37 ± 0.01^{a}
DMT 50 %	11.03 ± 0.32^{b}	4.89 ± 0.18^{ab}	11.90 ± 0.10^{b}	5.83 ± 0.16^{b}	1.49 ± 0.04^{bc}	1.16 ± 0.02^{c}	1.58 ± 0.04^{bc}	1.23 ± 0.02^{b}
P values	0.00***	0.0001***	0.00***	0.00***	0.0011**	0.00***	0.0023**	0.0001***
Tukey values	0.37	0.27	0.64	0.25	0.14	0.08	0.16	0.09

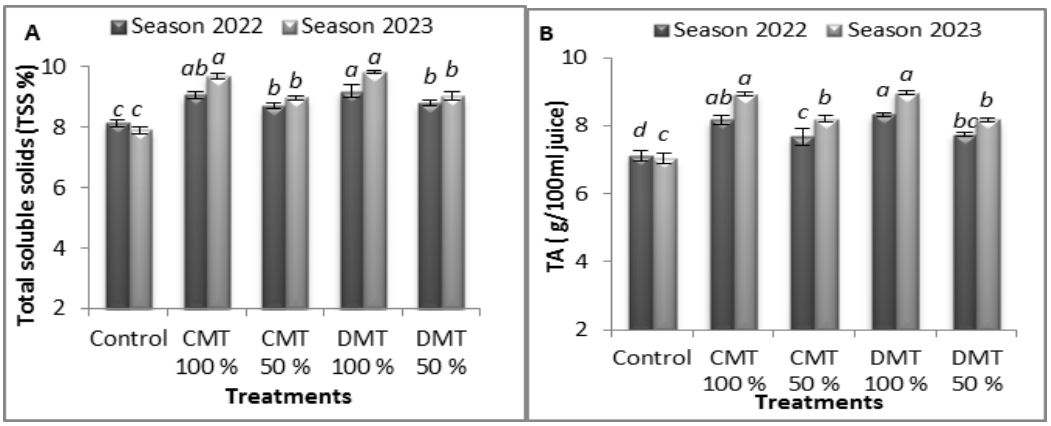
Treatments	K (mg/g)			
	2022 season		2023 season	
	Leaves (±SD)	Fruits (±SD)	Leaves (±SD)	Fruits (±SD)
Control	14.69 ± 0.32^{c}	11.11 ± 0.52^{c}	15.90 ± 0.65^{d}	12.32 ± 0.17^{d}
CMT 100 %	16.96 ± 0.19^{a}	13.50 ± 0.09^{a}	18.95 ± 0.22^{ab}	14.05 ± 0.10^{ab}
CMT 50 %	15.94 ± 0.21^{b}	12.49 ± 0.36^{b}	17.74 ± 0.20^{c}	13.59 ± 0.22^{c}
DMT 100 %	17.13 ± 0.14^{a}	13.63 ± 0.09^{a}	19.16 ± 0.52^{a}	14.16 ± 0.19^{a}
DMT 50 %	16.11 ± 0.44^{b}	12.61 ± 0.15^{b}	17.93 ± 0.45^{bc}	13.72 ± 0.07^{bc}
P values	0.0001***	0.00***	0.0003***	0.00***
Tukey values	0.88	0.76	1.37	0.50

CMT: camel manure tea; DMT: duck manure tea. Data are means ± SDs (n=3). Means for each parameter with different letters are significantly different from each other ($p < 0.05$) according to the Tukey test. *P < 0.05; **P < 0.01; ***P <0.001

Fruits chemical quality:

Total soluble solids (TSS) and titratable acidity (TA) Data presented in (Fig. 4 (A and B)) showed significant increases in both TSS and TA in response to application of foliar spraying with camel and duck manure tea in the two seasons. The highest TSS and TA (9.20 – 9.83 % and 8.33 - 8.97g /100 ml juice in 2022 and 2023 seasons, respectively) were achieved with spraying trees with DMT 100% followed by CMT 100% (9.07 - 9.70 % and 8.17 - 8.93g /100 ml juice in 2022 and 2023 seasons, respectively) and the differences between them weren't significant in both seasons. Control showed the least value in this respect in both seasons.

The response of total antioxidant, Vitamin C, total phenolics and total flavonoids to foliar spraying with camel and duck manure tea in two seasons was investigated (Fig. 4C, D, E and F, respectively). The total antioxidant content, Vitamin C and total phenolics of lime fruits were found to be higher in DMT 100% treatment in both seasons recording 100.69 - 117.93 mg/g DW, 62.07 – 63.03 mg/100ml juice and 26.89 – 27.51 mg/g DW in 2022 and 2023 seasons, respectively. In contrast, the total flavonoids in lime fruits were higher in CMT 100% treatment (70.50 – 78.93 mg/g DW in 2022 and 2023, respectively) than DMT 100% (61.79 – 76.57 mg/g DW in 2022 and 2023, respectively) followed by CMT 50% and then DMT 50%.



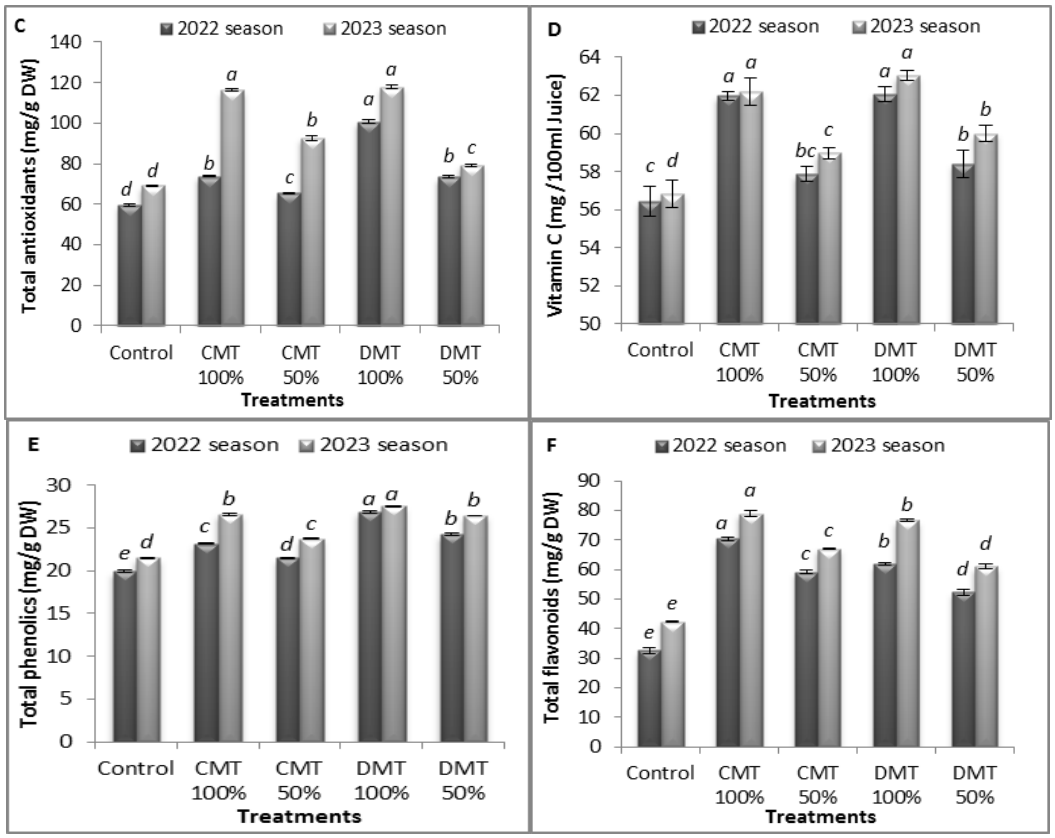


Fig. 4. Effect of foliar spraying with camel and duck manure tea on total soluble solids (TSS %) (A), titratable acidity (TA) (g/100ml juice) (B), total antioxidants (mg/g DW) (C), Vitamin C (mg/100ml juice) (D), total phenolics (mg/g DW) (E) and total flavonoids (mg/g DW) (F) of Balady lime fruits under sandy calcareous soil conditions during 2022 and 2023 seasons. CMT: camel manure tea; DMT: duck manure tea. The different upper letters are significantly different ($p < 0.05$) according to the Tukey test.

Physical characteristics of Balady lime during cold marketing in 2022 and 2023 seasons:

Results of fruit weight loss (FWL %), fruit unmarketable (FUM %) and weight juice (JW %) were shown in (Fig. 5) and (Table 4). Data revealed that Fruit weight loss and fruit unmarketable increased gradually as cold marketing period advanced. While descend trend in juice weight was observed with the advancement of cold marketing period in the both seasons. Our results indicate that the maximum Fruit weight loss, unmarketable fruit and minimum juice weight of Balady lime fruits were observed at the end of the cold marketing period in the first and second seasons.

In addition, statistical data also demonstrate that all foliar spraying with camel and duck manure treatments were significantly effective in reducing weight loss and unmarketable fruit with significantly high in juice percentage of Balady lime as compared to control in both seasons. The lowest weight loss values during the different marketing periods were with the CMT 100% treatment, followed by the DMT 100 % treatment. In addition, the highest weight loss was with the control (4.38 and 3.53%) and the lowest weight loss was with the CMT 100% treatment (1.11 and 1.25%), at the end of the storage period after 8weeks in 2022 and 2023 seasons. Data declares that, in 4 weeks no un-marketable fruit was detected during two seasons. However, in 6 weeks, no un-marketable fruit was observed with CMT 100% treatment.

Control treatment recorded the maximum percentage of un-marketable fruits, which were 20.52 and 19.93 % during the 2022 and 2023 seasons, respectively, at 6 weeks. Moreover, a similar trend was observed at 8weeks, where control treatment showed the highest un-marketable fruit percentage in both seasons (48.67 and 41.00%). Treatment of CMT 100 % showed the highest reduction percentage in un-marketable fruit percentage over other foliar spraying treatments, which were 20.67 and 17.33% in 1st and 2nd seasons, respectively at 8 weeks. In both seasons, the control recorded less percentages of juice weight at all assessment days than other treatments. While foliar spray treatments gave the highest juice weight values and values tended to be statistically equal between foliar spraying treatments in most cases.

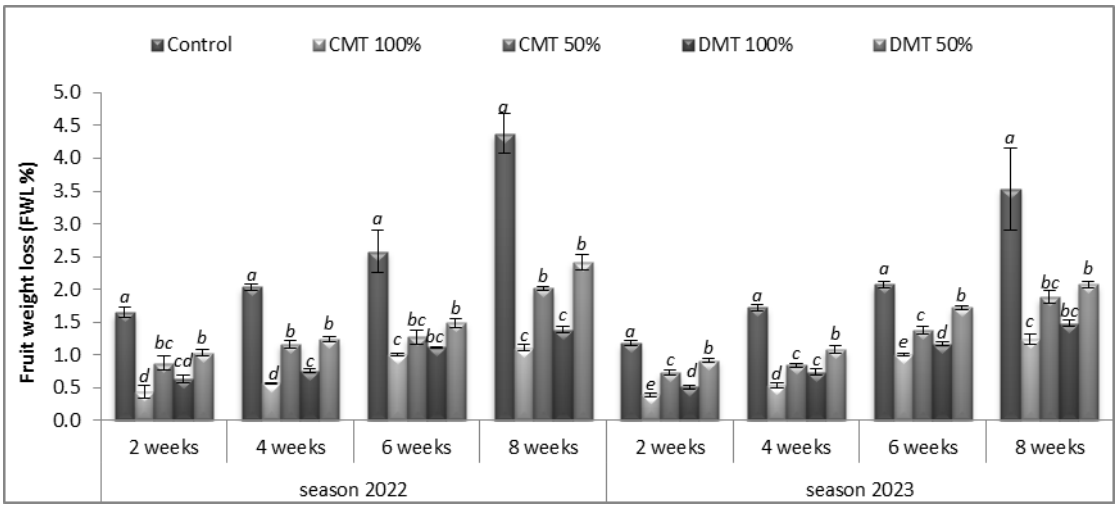


Fig. 5. Effect of foliar spraying with camel and duck manure tea on Fruit weight loss (FWL %) of Balady lime fruits under sandy calcareous soil conditions during 2022 and 2023 seasons. CMT: camel manure tea; DMT: duck manure tea. The different upper letters are significantly different ($p < 0.05$) according to the Tukey test.

Table 4. Fruit un-marketable (FUM %) and Juice weight (JW %) of Balady lime fruits under the effect of foliar spraying with camel and duck manure tea under sandy calcareous soil conditions during cold marketing in 2022 and 2023 seasons.

Treatments	Fruit un-marketable (FUM %)							
	Season 2022				Season 2023			
	2 weeks (± SD)	4 weeks (± SD)	6 weeks (± SD)	8 weeks (± SD)	2 weeks (± SD)	4 weeks (± SD)	6 weeks (± SD)	8 weeks (± SD)
Control	0.00 ± 0.00	0.00 ± 0.00	20.52 ± 0.50^{a}	48.67 ± 3.25^{a}	0.00 ± 0.00	0.00 ± 0.00	19.93 ± 1.37^{a}	41.00 ± 2.65^{a}
CMT 100 %	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00^{c}	20.67 ± 1.15^{c}	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00^{c}	17.33 ± 6.43^{c}
CMT 50 %	0.00 ± 0.00	0.00 ± 0.00	10.12 ± 1.24^{abc}	30.07 ± 1.10^{bc}	0.00 ± 0.00	0.00 ± 0.00	7.03 ± 6.17^{bc}	30.67 ± 2.08^{ab}
DMT 100 %	0.00 ± 0.00	0.00 ± 0.00	6.62 ± 5.73^{bc}	28.67 ± 6.51^{bc}	0.00 ± 0.00	0.00 ± 0.00	3.77 ± 6.54^{bc}	23.73 ± 3.10^{bc}
DMT 50 %	0.00 ± 0.00	0.00 ± 0.00	14.34 ± 4.93^{ab}	36.30 ± 5.48^{b}	0.00 ± 0.00	0.00 ± 0.00	13.61 ± 5.42^{ab}	34.00 ± 3.61^{ab}
P values	-	-	0.002**	0.0004***	-	-	0.003**	0.0012**
Tukey values	-	-	10.80	11.78	-	-	12.06	12.03
Treatments	Juice weight (JW %)							
	Season 2022				Season 2023			
	2 weeks (± SD)	4 weeks (± SD)	6 weeks(± SD)	8 weeks (± SD)	2 weeks (± SD)	4 weeks (± SD)	6 weeks (± SD)	8 weeks (± SD)
Control	49.97 ± 0.06^{c}	49.63 ± 0.55^{c}	48.97 ± 0.90^{b}	48.13 ± 0.70^{b}	50.13 ± 0.31^{c}	49.67 ± 0.61^{b}	49.10 ± 0.66^{b}	48.30 ± 0.62^{b}
CMT 100 %	53.20 ± 0.50^{a}	53.00 ± 0.40^{ab}	52.47 ± 0.61^{a}	51.93 ± 0.61^{a}	53.77 ± 0.50^{a}	53.53 ± 0.68^{a}	52.97 ± 0.35^{a}	52.40 ± 0.53^{a}
CMT 50 %	52.20 ± 0.44^{b}	51.67 ± 0.58^{b}	51.47 ± 0.50^{a}	50.90 ± 0.56^{a}	52.23 ± 0.12^{b}	51.90 ± 0.53^{a}	51.53 ± 0.68^{a}	50.87 ± 0.51^{a}
DMT 100 %	53.77 ± 0.57^{a}	53.10 ± 0.62^{a}	52.57 ± 0.67^{a}	52.07 ± 0.31^{a}	53.20 ± 0.72^{ab}	52.87 ± 1.03^{a}	52.53 ± 0.50^{a}	51.87 ± 0.51^{a}
DMT 50 %	52.13 ± 0.30^{b}	51.97 ± 0.06^{ab}	51.93 ± 0.35^{a}	51.40 ± 0.62^{a}	52.70 ± 0.61^{ab}	52.37 ± 0.64^{a}	51.70 ± 0.30^{a}	51.07 ± 0.85^{a}
P values	0.00***	0.0001***	0.001**	0.0003***	0.00***	0.0022**	0.0002***	0.0003***
Tukey values	0.91	1.37	1.91	1.77	1.12	2.13	1.53	1.69

CMT: camel manure tea; DMT: duck manure tea. Data are means ± SDs (n=3). Means for each parameter with different letters are significantly different from each other ($p < 0.05$) according to the Tukey test. NS: not significant; *P < 0.05; **P < 0.01; ***P < 0.001.

Chemical characteristics of Balady lime during cold marketing in 2022 and 2023 seasons:

Changes in total soluble solids (TSS), titratable acidity (TA) and ascorbic acid of Balady lime after cold marketing period are shown in (Table 5). Results illustrate that, significant declining in TA contents and ascorbic acid were noticed with prolonging of cold marketing period in the both seasons. While significant rising trend in TSS were observed with the advancement of marketing period in the first and second seasons.

In addition, also results reveal that all foliar spraying treatments of Balady lime fruits significantly increased TA and ascorbic acid content as compared to water control or in both seasons.

Our data also clearly indicates that foliar spraying treatment of Balady lime with DMT 100 % or CMT 100 % showed the significant highest of TSS, TA and ascorbic acid content, with no significant differences between them. Conversely, untreated fruits showed the minimum value TSS, which was 8.27, 8.40, 8.60 and 8.80 % in 1st seasons and 7.93, 8.03, 8.20 and 8.53% in 2nd seasons at 2, 4, 6 and 8 weeks, respectively. Also, the lowest TA value was recorded when Balady lime trees sprayed with water (control) (6.97, 6.80, 6.40 and 6.70 g/100ml juice at 2, 4,6 and 8 weeks, respectively, during 2022 season and 6.80, 6.60,6.40 and 6.47g/100 ml juice at 2, 4,6 and 8 weeks, respectively, during 2023 season). So too, the lowest content of vitamin C was observed at control treatment overall sampling time (55.10,52.63,51.13and 48.50 mg/100ml juice during 2022 season and 55.37, 54.17, 52.50 and 49.83 mg/100ml juice during 2023 season at 2, 4, 6 and 8 weeks, respectively).

Table 5. Total soluble solids (TSS%), Titratable acidity (TA) (g /100 ml juice) and vitamin C content (mg /100 ml juice) of Balady lime fruits under the effect of foliar spraying with camel and duck manure tea under sandy calcareous soil conditions during cold Marketing in 2022 and 2023 seasons.

Treatments	Total soluble solids (TSS %)							
	Season 2022				Season 2023			
	2 weeks (± SD)	4 weeks (± SD)	6 weeks (± SD)	8 weeks (± SD)	2 weeks (± SD)	4 weeks (± SD)	6 weeks (± SD)	8 weeks (± SD)
Control	8.27 ± 0.15^{c}	8.40 ± 0.10^{c}	8.60 ± 0.10^{c}	8.80 ± 0.10^{c}	7.93 ± 0.15^{c}	8.03 ± 0.15^{c}	8.20 ± 0.10^{c}	8.53 ± 0.15^{c}
CMT 100 %	9.13 ± 0.15^{ab}	9.27 ± 0.15^{a}	9.30 ± 0.20^{ab}	9.33 ± 0.15^{ab}	9.70 ± 0.10^{a}	9.80 ± 0.10^{a}	9.90 ± 0.10^{a}	9.97 ± 0.15^{a}
CMT 50 %	8.80 ± 0.10^{b}	8.87 ± 0.06^{b}	9.00 ± 0.10^{bc}	9.28 ± 0.07^{b}	9.07 ± 0.12^{b}	9.17 ± 0.15^{b}	9.30 ± 0.10^{b}	9.37 ± 0.15^{b}
DMT 100 %	9.23 ± 0.15^{a}	9.27 ± 0.12^{a}	9.43 ± 0.15^{a}	9.60 ± 0.10^{a}	9.90 ± 0.10^{a}	10.00 ± 0.10^{a}	10.07 ± 0.21^{a}	10.10 ± 0.17^{a}
DMT 50 %	8.90 ± 0.10^{ab}	8.97 ± 0.06^{ab}	9.17 ± 0.15^{ab}	9.40 ± 0.10^{ab}	9.10 ± 0.10^{b}	9.17 ± 0.15^{b}	9.27 ± 0.21^{b}	9.50 ± 0.10^{b}
P values	0.0004***	0.0001***	0.0009***	0.0001***	0.00***	0.00***	0.00***	0.00***
Tukey values	0.42	0.31	0.40	0.29	0.35	0.39	0.44	0.42
Treatments	Titratable acidity (TA) (g /100 ml juice)							
	Season 2022				Season 2023			
	2 weeks (± SD)	4 weeks (± SD)	6 weeks (± SD)	8 weeks (± SD)	2 weeks (± SD)	4 weeks (± SD)	6 weeks (± SD)	8 weeks (± SD)
Control	6.97 ± 0.15^{c}	6.80 ± 0.10^{c}	6.40 ± 0.10^{c}	6.70 ± 0.10^{c}	6.80 ± 0.10^{c}	6.60 ± 0.10^{c}	6.40 ± 0.10^{c}	6.47 ± 0.15^{c}
CMT 100 %	8.10 ± 0.10^{a}	7.97 ± 0.06^{a}	7.80 ± 0.10^{a}	7.90 ± 0.10^{a}	8.80 ± 0.10^{a}	8.67 ± 0.15^{a}	8.60 ± 0.10^{a}	8.60 ± 0.10^{a}
CMT 50 %	7.57 ± 0.12^{b}	7.43 ± 0.06^{b}	7.20 ± 0.10^{b}	7.33 ± 0.21^{b}	8.07 ± 0.15^{b}	7.87 ± 0.15^{b}	7.70 ± 0.10^{b}	7.80 ± 0.10^{b}
DMT 100 %	8.20 ± 0.10^{a}	8.10 ± 0.10^{a}	7.90 ± 0.10^{a}	8.03 ± 0.06^{a}	8.90 ± 0.10^{a}	8.80 ± 0.10^{a}	8.70 ± 0.10^{a}	8.70 ± 0.10^{a}
DMT 50 %	7.60 ± 0.10^{b}	7.40 ± 0.10^{b}	7.27 ± 0.15^{b}	7.30 ± 0.10^{b}	8.03 ± 0.06^{b}	7.90 ± 0.10^{b}	7.70 ± 0.10^{b}	7.80 ± 0.10^{b}
P values	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Tukey values	0.36	0.26	0.32	0.24	0.29	0.33	0.23	0.35
Treatments	Vitamin C content (mg /100 ml juice)							
	Season 2022				Season 2023			
	2 weeks (± SD)	4 weeks (± SD)	6 weeks (± SD)	8 weeks (± SD)	2 weeks (± SD)	4 weeks (± SD)	6 weeks (± SD)	8 weeks (± SD)
Control	55.10 ± 0.56^{c}	52.63 ± 0.75^{c}	51.13 ± 1.10^{c}	48.50 ± 0.56^{c}	55.37 ± 1.18^{c}	54.17 ± 0.38^{c}	52.50 ± 1.23^{c}	49.83 ± 0.55^{d}
CMT 100 %	61.23 ± 1.07^{a}	60.83 ± 1.00^{a}	59.87 ± 1.00^{a}	58.00 ± 0.66^{a}	61.93 ± 1.68^{a}	61.20 ± 0.69^{a}	60.23 ± 0.98^{a}	58.43 ± 1.03^{a}
CMT 50 %	57.73 ± 0.50^{b}	57.00 ± 0.92^{b}	55.73 ± 0.64^{b}	53.47 ± 0.50^{b}	59.50 ± 0.44^{ab}	58.27 ± 1.36^{ab}	57.13 ± 0.91^{ab}	55.00 ± 0.82^{bc}
DMT 100 %	61.30 ± 0.95^{a}	60.63 ± 1.02^{a}	60.13 ± 0.21^{a}	58.40 ± 1.21^{a}	61.13 ± 0.32^{ab}	60.47 ± 1.31^{ab}	59.30 ± 1.47^{ab}	57.50 ± 0.82^{ab}
DMT 50 %	57.43 ± 0.40^{b}	56.40 ± 0.53^{b}	55.50 ± 1.04^{b}	53.60 ± 0.62^{b}	58.20 ± 1.04^{bc}	57.33 ± 1.23^{bc}	56.10 ± 1.01^{b}	54.60 ± 0.96^{c}
P values	0.00***	0.00***	0.00***	0.00***	0.0004***	0.0005***	0.0005***	0.00***
Tukey values	2.26	2.67	2.53	2.14	2.95	3.25	3.51	2.61

CMT: camel manure tea; DMT: duck manure tea. Data are mean ± SD (n=3). Means for each parameter with different letters are significantly different from each other ($p < 0.05$) according to the Tukey test. *P < 0.05; **P < 0.01; ***P < 0.001.

DISCUSSION

Citrus fruit production is influenced by genetic, climatic, and horticultural factors (Cabezas-Gutierrez and Rodríguez, 2010). Fertilization is regarded as one of the most critical aspects, an essential method for improving plant nutrient accessibility, and increasing plant yields in modern agriculture; in although of this, the widespread use of chemical fertilizers has resulted in a variety of ecological and biological difficulties (Meier *et al.*, 2001). As a result, using chemical fertilizers wisely or using natural fertilizers more intensively would be more beneficial (Grzebisz *et al.*, 2008). Fertilization is an important aspect of citrus crop management. However, little information is available about the fertilization strategy for citrus plant development (Ma *et al.*, 2022).

The application of organic manures, particularly through tea sources, has been shown to enhance fruit crops' yield and quality. This shift from solid to liquid form is therefore thought to be the cause of the increase in the release of most nutrients when applied to fruit crops at the right time and concentration. The use of tea made from all organic manures accomplished many significant goals. This is explained by the fact that organic manures tea has a higher concentration of all nutrients and that these nutrients are also more readily available. Improving growth, yield, and fruit quality (Ibrahim *et al.*, 2015). Additionally, it has some compounds that shield the plant from harmful substances, diseases, and pests.

During our research, we looked at how foliar spraying camel and duck manure tea in two concentrations affected the growth and productivity of limes (*C. aurantifolia* L.) in newly reclaimed soils. Our findings revealed that both concentrations of camel and duck manure tea had a significant impact on the nutritional status of trees, as evidenced by an increase in nutrients in the leaves and fruits, as well as a yield, fruit quality, total content of phenolics, antioxidants, flavonoids, and marketable fruit compared with the control.

When compared to the control treatment, the significant increase in yield and its constituents can be attributed to the use of both organic fertilizers duck and camel manures in the form of tea. This is because, like other organic fertilizers, duck and camel manures offer all the nutrients required for fruit growth and quality, in addition to their high concentration of vital macro- and micronutrients (Warman, 1986; Dikinya and Mufwanzala, 2010).

Minerals like calcium, sulfur, potassium, and phosphorus are abundant in poultry manure. Moreover, it has a high nitrogen concentration between 40 and 90% (Abouelenien *et al.*, 2009; Ayeni and Adetunji, 2010). Because duck dung contains a lot of nitrogen, which promotes cell division, juice content, pulp and fruit

weights, it stands out for offering a high rate of fruit weight and yield. Many organic materials, such as proteins, vitamins, hormones, nucleic acids, chlorophyll, and other active ingredients, are primarily composed of nitrogen (Sakakibara *et al.*, 2006; Garnica *et al.*, 2010). In certain citrus species, nitrogen increased the fruit's size, peel thickness, juice content, and tree yield (El-Otmani *et al.*, 2004; Khan *et al.*, 2009).

On the other hand, a variety of factors affects fruit quality, such as total soluble solids (TSS), titratable acidity, fruit length and diameter, and juice and peel weight percentage. Comparing the spraying of organic manure tea to the control treatment, our results indicated a significant increase in each of these characteristics. According to Ibrahim *et al.* (2013), this is because applying organic fertilizer increased the production of total phenolics, flavonoids, ascorbic acid, saponin, and glutathione content.

The percentages of N, P, and K increased significantly, as did the total content of phenolics, antioxidants, and flavonoids in the leaves compared to control, may be due to the increased content of these elements and compounds in duck and camel manure tea itself, which was reflected in their increased content in the leaf. The results indicate that spraying significantly increases tree absorption of these elements. These findings were consistent with Gao and his team who found that nutrient elements can be absorbed directly through the leaves and transported to other organs, replenishing essential nutrients more quickly and efficiently than soil fertilization (Gao *et al.*, 2018). Otálora *et al.* (2018) who stated that foliar fertilization strategies can increase nutrient use efficiency, reduce negative environmental impact, and potentially improve consumer health benefits. In same line, using the 15N tracer technique, the level of 15N in leaves was higher in grape seedlings treated with foliar fertilization than soil fertilization at the mature stage in new shoots (Sun *et al.*, 2017).

Also these results are harmonic with Ibrahim *et al.* (2015) who hypothesized that foliar application of any organic manure tea (compost, farmyard manure, and chicken manure), either in combination with seaweed extract at 10 % or Royal Jelly at 0.05%, would significantly increase total chlorophylls, N, P, and K in the leaves as opposed to not applying any at all in mango trees at Keitte.

Furthermore, we investigated the physical characteristics of fruits during cold marketing, including the percentage of unmarketable fruit, fruit weight, and juice weight. The loss in fruit weight after harvest could be attributed to water loss from the fruit, which causes shrinkage and weight loss. The decrease in fruits weight loss percentage because of organic manure application may be due to the accumulation of some elements that regulate water relations or that contribute to the maintenance of cell wall turgidity. This reduces water loss, prevents shrivelling of the fruit skin, and thus delays the decline in fruit quality. Similar results were found by Omar and Belal, (2013) and Ennab *et al*. (2019) on Washington navel orange and El-Hadidy *et al.* (2022) on Moringa oleifera seeds.

One possible explanation for the decline in acidity percentage during the marketing period is the oxidation and consumption of organic acids that occur during the fruit tissues' respiration processes. Also revealed that the fresh fruits' respiration rate increased as the marketing period progressed (Hussien *et al.*, 1998). Fruits' ascorbic acid content is known to drop during marketing, possibly as a result of the fruit's conversion to sugars or use of organic acids during respiration (Kader, 2002).

Furthermore, the quick transformation of L-ascorbic acid into dehydroascorbic acid in the presence of L-ascorbic acid oxidase may be responsible for the decrease in ascorbic acid content during marketing (Hussein *et al.*, 1998). Furthermore, as per the findings of Mapson, (1970) and Ladaniya and Singh, (1998), ascorbic acid content in citrus fruits generally decreases with increased storability because of an increase in the activity of oxidizing enzymes such as ascorbic acid oxidase, peroxidase, and catalase, which may have into dehydroascorbic acid. These findings are consistent with those of El-Fouly and El-Sayed (1997), Candir et al. (2013), Omar and Belal (2013), Ennab et al. (2019), and El-Hadidy et al. (2022).

All treatments resulted in a significant increase in shelf life and fruit quality during cold marketing, especially the camel manure tea spray treatment, which resulted in the longest marketing period. This may be due to that Flavonoids play a key role as a secondary antioxidant defence system against different biotic and abiotic stresses and act as colouring compounds in various fruiting plants, resist in ultraviolet (UV) radiation, against pathogens infection (Shi *et al.*, 2021). Flavonoids are also known to have antifungal activities and improve fruit postharvest quality (Hammerschmidt, 1999; Treutter, 2006). Which in turn is reflected in raising the nutritional value of lime fruit due to its high content of flavonoids that have the ability could exert anti-inflammatory, immunomodulatory (Yahfoufi *et al.*, 2018) and strong anticancer activities (Rodriguez-Garcia *et al.*, 2019; Abotaleb *et al.*, 2018).

CONCLUSION

Under sandy calcareous soil conditions, the impact of foliar spraying Balady lime *(C. aurantifolia* L.) with tea made from camel and duck manure was investigated. Our findings show that applying CMT or DMT in two different concentrations via foliar spraying to Balady lime trees improved the fruit's physical characteristics

(fruit weight, yield, length, diameter, peel weight percentage, and juice weight percentage) as well as its chemical characteristics (total nitrogen, phosphorus, potassium, total soluble solids, titratable acidity, total antioxidants, phenolics, flavonoids, and ascorbic acid).The fruit quality and shelf life increased significantly with all treatments during cold marketing, but the camel manure tea spray with high concentration treatment produced the longestmarketing period. Our findings demonstrated the beneficial effects of manuring tea on fruit quality, marketability, and productivity. Spraying lime trees with organic manure tea could be a practical fertilization technique for good quality fruits as well as decreasing the cost and harmfulness of chemical fertilization. Thus, extending the marketing period of fruits and increasing the farmers' income.

REFERENCES

Abotaleb, M., Samuel, S. M., Varghese, E., Varghese, S., Kubatka, P., Liskova, A. & Busselberg, D. (2018). Flavonoids in Cancer and Apoptosis. *Cancers*, 11(1), 28.

Abouelenien, F., Nakashimada, Y. & Nishio, N. (2009). Dry mesophilic fermentation of chicken manure for production of methane by repeated batch culture. *Journal of Bioscience and Bioengineering*, 107(3), 293–295.

Aboukila, E. F., Nassar, I. N., Rashad, M., Hafez, M. & Norton, J. B. (2018). Reclamation of calcareous soil and improvement of squash growth using brewers' spent grain and compost. *Journal of the Saudi Society of Agricultural Sciences*, 17(4), 390-397.

Adeyemi, O. & Akhiwu, B. (2022). Effects of poultry manure on the growth of lisbon lemon (*Citrus limon*; var. Lisbon). *Scientific Journal Biology and Life Sciences,* 2(3).

Al-Saeedi, A. H. (2022). Characterizing physical and hydraulic properties of soils in Al-Ahsa, Kingdom of Saudi Arabia. *Saudi Journal of Biological Sciences*, 29(5), 3390–3402.

Analytical software (2005). Statistix 8.1 for Windows analytical software. Tallahassee, Florida.

AOAC (1985). Official Method Analysis. Association of Official Analytical Chemists, Washington, DC., USA.

Ayeni, L. S. & Adetunji, M. T. (2010). Integrated application of poultry manure and mineral fertilizer on soil chemical properties, nutrient uptake, yield and growth components of maize. *Nature and Science*, 8, 60-67.

Azeez, J. O., Ibijola, T. O., Adetunji, M. T., Adebisi, M. A. & Oyekanmi, A. A. (2014). Chemical characterization and stability of poultry manure tea and its influence on phosphorus sorption indices of tropical soils. *Communications in Soil Science and Plant Analysis*, 45, 2680-2696.

Cabezas-Gutiérrez, M. & Rodríguez, C. A. (2010). Horticultural techniques for improving orange fruit (*Citrus sinensis* L.) size and quality. *Agronomía Colombiana*, 28(1), 55-62.

Candir, E., Kamiloglu, M., Ustun, D. & Kendir, G. T. (2013). Comparison postharvest quality of conventionally and organically grown Washington navel orange. *Journal of Applied Botany and Food Quality*, 86, 59-65.

Chapman, H. D. & Pratt, P. F. (1961). Methods of analysis for soils, plants and waters. Division of Agricultural Sciences, University of California, Riverside.

Dikinya, O. & Mufwanzala, N. (2010). Chicken manure-enhanced soil fertility and productivity: Effects of application rates. *Journal of Soil Science and Environmental Management*, 1(3), 46-54.

El-Fouly, M. M. & El-Sayed, A. A. (1997). Foliar fertilization: An environmentally friendly application of fertilizers. Dahlia Greidinger International Symposium on "Fertilization and Environment" 24-27 March, Haifa, Israel, John, 1. (ed.), 346-357.

El-Hadidy, G. A. M., Mahmoud, T. Sh. M., Shaabana, F. K. M. & Hemdan, N. A. (2022). Effect of organic fertilization with Moringa oleifera seeds cake and compost on storability of Valencia orange fruits. *Egyptian Journal of Chemistry*, 65(2), 659-667.

El-Otmani, M., Taibi, F. -Z., Lmoufid, B., Ait-Oubahou, A. & Lovatt, C. J. (2004). Improved use of foliar on clementine mandarin to manipulate cropping in a sustainable production system. *Acta Horticulturae*, 632, 167–175.

Ennab, H. A., El Shemy,M. A. & Abd El Aziz, M. H. (2019). Impact of organic and inorganic fertilizers on Washington Navel orange tree. II. Fruit quality during cold storage. *Menoufia Journal of Plant Production*, 4(5), 415 -427.

Fikry, A.M., Sayed-Ahmed, A., Mohsen, F.S. & Ibrahim, M.M. (2020). Effect of nitrogen fertilization through inorganic, organic and biofertilizers sources on vegetative growth, yield and nutritional status in murcott tangerine trees. *Plant Archives*, *20*(1).

Food and Agriculture Organization of the United Nations (FAO) (2023). Food and agriculture organizations of the United Nations. Available from: http://www.fao.org/faostat/en/#data.

Food and Agriculture Organization of the United Nations (FAO) (2016). FAO Soils Portal: Management of Calcareous Soils (accessed 01.04.16).

Gao, S. D., Yang, C. Y., Deng, X. P., Xia, Y., Shen, Z. G. & Chen, Y. H. (2018). Study on absorption and transport of K and Zn by foliar application in tobacco leaves. *Journal of Nanjing Agricultural University*, 41(2), 330-340.

Garnica, M., Houdusse, F., Zamarreño, A. M. & Garcia-Mina, J. M. (2010). The signal effect of nitrate supply enhances active forms of cytokinins and indole acetic content and reduces abscisic acid in wheat plants grown with ammonium. *Journal of Plant Physiology*, 167, 1264–1272.

Granatstein, D. (2003). Tree fruit production with organic farming methods. Wenatchee (WA): Center for Sustaining Agriculture and Natural Resources, Washington State University.

Grzebisz, W., Wrońska, M., Diatta, J. B. & Szczepaniak, W. (2008). Effect of zinc foliar application at early stage of maize growth on the patterns of nutrients and dry matter accumulation by the canopy. Part II: Nitrogen uptake and dry matter accumulation patterns. *Journal of Elementology*, 13(1), 29–40.

Hammerschmidt, R. (1999). PHYTOALEXINS: What have we learned after 60 years? *Annual Review of Phytopathology*, 37, 285-306.

Hazarika, T.K., Malsawmkimi & Ngurthankhumi, R. (2024). Biodynamics enriched organic amendments in improving leaf and soil nutrition of Khasi mandarin (*Citrus reticulata* Blanco). *Journal of Plant Nutrition*, *47*(6), 868-880.

Hussein, A. M., El-Sabrout,M. B., Zaghloul,A. E. (1998). Postharvest physical and biochemical changes of common and late types of seedy guava fruits during storage. *Alexandria Journal of Agricultural Sciences*, 43(3), 187-204.

Ibijola, T. O. (2011). Chemical characterization, stability of liquid organic fertilizer, and its influence on phosphorus sorption characteristics and uptake by maize [Z*ea mays* (L.)]. MA thesis, Federal University of Agriculture, Umudike, Abia State, Nigeria.

Ibrahim, H. I. M., Mansour, A. E. M. & Merwad, M. A. (2015). Impact of spraying some organic manure tea, seaweed extract and royal jelly on fruiting of Keitte mango trees. *International Journal of ChemTech Research*, 8(4), 2131-2141.

Ibrahim, M. H., Jaafar, H. Z. E., Karimi, E. K., Ghasemzadeh, A. (2013). Impact of organic and inorganic fertilizers application on the phytochemical and antioxidant activity of Kacip Fatimah (Labisia pumila Benth). *Molecules*, 18, 10973-10988.

Irshad, M., Eneji, A.E., Hussain, Z. & Ashraf, M. (2013). Chemical characterization of fresh and composted livestock manures. *Journal of Soil Science and Plant Nutrition*, 13(1), 115-121.

Jackson, M. L. (1973). "Soil Chemical Analysis". Prentice-Hall of India Private Limited, New Delhi.

Kader, A. A. (2002). Recommendations for maintaining postharvest quality. Post-harvest Technology Research Information Center. Department of Pomology. University of California. One Shield Ave., Davis, CA., 95616-8683.

Khan, A. S., Malik, A., Pervez, M., Saleem, B., Rajwana I., Shaheen, T., Anwar, R. (2009). Foliar application of low-biuret urea and fruit canopy position in the tree influence the leaf nitrogen status and physico-chemical characteristics of Kinnow mandarin (Citrus Reticulata Blanco). *Pakistan Journal of Botany*, 41(1), 73–85.

Kimball, D. A. (2012). Citrus processing: a complete guide. Springer Science and Business Media.

Klute, A. (1986). Methods of soil analysis. Part-1. Physical and mineralogical methods. 2nd Edition American Society of Agronomy, Madison, Wisconsin, USA.

Kofalvi, S. A. & Nassuth, A. (1995). Influence of wheat streak mosaic virus infection phenylpropanoid metabolism and the accumulation of phenolics and lignin in wheat. *Physiological and Molecular Plant Pathology*, 47, 365–377.

Ladaniya, M. S. & Singh,Sh. (1998). Post-harvest technology of Nagpur mandarin (*Citrus reticulate* Blanco). NRCC, Nagpur, Technical Bulletin-2, 44.

Ma, X., Li, F., Chen, Y., Chang, Y., Lian, X., Li, Y., Ye, L., Yin, T. & Lu, X. (2022). Effects of fertilization approaches on plant development and fertilizer use of citrus. *Plants*, 11(19), 2547.

Mapson, C. W. (1970). Vitamins in fruits. In: Biochemistry of fruits and their products. Vol 1. Hulme AC (ed.) Academic Press, New York.

Meier, U. (2001). Growth stages of mono and dicotyledonous plants. BBCH Monograph, Federal Biological Research Centre for Agriculture and Forestry, Bonn.

Omar, A. E. K. & Belal, E. A. (2013). Storability and quality improvement of Washington navel orange fruit (*Citrus sinensis* Osbeck) by safe preharvest treatments. *Biological Agriculture and Horticulture*, 30(1).

Otálora, G., Piñero M. C., López-Marín, J., Varó, P. & Del Amor, F. M. (2018). Effects of foliar nitrogen fertilization on the phenolic, mineral, and amino acid composition of escarole (*Cichorium endivia* L. var. *latifolium*). *Scientia Horticulturae*, 239(2), 87-92.

Prieto, P., Pineda, M. & Aguilar, M. (1999). Spectrophotometric Quantitation of Antioxidant Capacity through the Formation of a Phosphomolybdenum Complex: Specific Application to the Determination of Vitamin E. *Analytical Biochemistry*, 269, 337-341.

Rodríguez-García, C., Sánchez-Quesada, C. & J Gaforio, J. (2019). Dietary Flavonoids as Cancer Chemopreventive Agents: An Updated Review of Human Studies. *Antioxidants*, 8(5), 137.

Sabouni, I., Allach, M. & Ishak, E.A. (2018). Evaluation of camels, sheep and chicken manures influences growth and fruits quality of olive trees in Al Jouf region. *Saudi Arabia*, *8*(2), 32-39.

Sakakibara, H., Takei, K. & Hirose, N. (2006). Interactions between nitrogen and cytokinin in the regulation of metabolism and development. *Trends in Plant Science*, 11(9), 440-448.

Shahrajabian, M. H., Sun, W.&Cheng, Q. (2022). Foliar application of nutrients on medicinal and aromatic plants, the sustainable approaches for higher and better production. *Beni-Suef University journal of Basic and Applied Sciences*, 11:26.

Shi, M., Ali, M. M., He, Y., Ma, S., Rizwan, H. M., Yang, Q., Li, B., Lin, Z. & Chen, F. (2021). Flavonoids accumulation in fruit peel and expression profiling of related genes in purple (*Passiflora edulis* f. *edulis*) and yellow (*Passiflora edulis* f. *flavicarpa*) Passion Fruits. *Plants*, 10(11), 2240.

Sun, C. W., Chen, Z., Zhao, Y. Z., Niu, S. K. & Yang, L. L. (2017). Absorption, distribution and utilization of 15 N in Jumeigui seedlings under different fertilization methods. *Acta Agriculturae Boreali-Sinica*, 32, 260–264.

Treutter, D. (2006). Significance of flavonoids in plant resistance: a review. Environmental chemistry letters. *Environmental Chemistry Letters*, 4(3), 147-157.

Warman, P. R. (1986). The effect of fertilizer, chicken manure and dairy manure on timothy yield, tissue composition and soil fertility. *Agricultural Wastes*, 18(4), 289-298.

Yahfoufi, N., Alsadi, N., Jambi, M. & Matar, C. (2018). The Immunomodulatory and Anti-Inflammatory Role of Polyphenols. *Nutrients*, 10(11), 1618.

Ye, X. (2017). Phytochemicals in Citrus: Applications in Functional Foods, CRC Press.

Zaib, M., Zubair, H., Akbar, H., Zahra, M., Ali, U., Afzal, A. & Marium, A. (2023). Emerging trends in biofortification for microelement enrichment in crop edibles: implications for health. *Current Research in Agriculture and Farming*, 4(4), 15-24.

Zou, Y., Lu, Y. & Wei, D. (2004). Antioxidant activity of flavonoid-rich extracts of *Hypericum perforatum* L. in vitro. *Journal of Agricultural and Food Chemistry*, 52, 5032–5039.