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Effect of Different Forms of Calcium and Methods of Addition on Vegetative Growth and Nutritional Status of Fruitful Naomi Mango Trees.

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Abstract

This study was conducted during two successive 2023 & 2024 seasons, carried out on 8-year-old fruitful mango trees of the "Naomi" cultivar. In an orchard with sandy soil that received drip irrigation and was situated along a private orchard located in the International Coastal region - Kafr El-Sheikh Governorate-Egypt, trees were planted at (2 x 4 m) apart including 480 trees / feddan. The two factors in the factorial experiment were the method of addition and various forms of Ca (calcium Boron Acetate, calcium Boron pectate and Calcium nitrate). The specific and interaction effects of the two studied factors were evaluated by determining the changes (response) exhibited in the vegetative growth (Shoot length and average leaf area) as well as nutritional status (Total chlorophyll and leaf (N, P, K, Ca, Mg as percentages" %") and (Fe, Zn and Mn part per million "ppm"). The foliar spraying calcium Boron Acetate rates and Calcium nitrate Soil addition and interaction between proved to be the most effective treatment for most of the parameters examined in this study compared with water sprayed trees (control). On the contrary, the trend of response took the other way around with P concentrations that showed a progressive increase with the gradual increase in untreated "control" treatments.

Keywords: Naomi Mango, Calcium boron, Calcium nitrate, Vegetative growth and Nutritional status.

Introduction

The Indo-Burma region is said to be where mango farming first began, around 4,000 years ago **(Mukherjee, 1951)**. Because of their heterozygous state and high level of open pollination, mangoes, both farmed and wild, exhibit enormous diversity. Around two L, mangos are grown for commercial purposes in around 80 nations. . The top producers are China, Thailand, Indonesia, Pakistan, Mexico, Brazil, Bangladesh, and Nigeria, in order of precedence. Among food commodities that are traded worldwide, mangos are one of the four fruit crops with the quickest average yearly growth rates in terms of export volume, greatly surpassing growth in the main food markets. **(FAO 2020)**.

One of the most popular tropical fruits growing in the Arab Republic of Egypt is the mango. In 1825, mango trees were brought to Egypt, and since then, they have grown to become one of the most popular fruits there, ranking third in terms of production after grape and citrus crops. As stated by the **Ministry of Agriculture and Land Reclamation, (2022)**, Egypt generated roughly 326626 feddans 1280310 tons of output from under cultivation. The primary production sites are the governorates of Ismailia, Noubaria, and Sharkia. Typically, the Naomi tree is medium in stature and erect. When the leaves are young, they are reddish-brown. One embryo is present in the seed. The flesh is golden, low in fiber, and mildly flavored. The medium-sized, oval- and rectangular-shaped fruits change color when ripe. According to **Tomer *et al*., (1993)**, Naomi is a mango that is in season.

According to **(Dhillon *et al*., 2004)**, Fruit set, tree vigor, photosynthesis, plant hormones, and leaf area are among the intrinsic differences between cultivars that may have a significant impact on the variability in fruit quality and yield. Mango growers are looking for varieties that are easy to grow in challenging areas, reliable, and of superior quality. While customers seek the greatest quality fruit in the interim, distributors and traders need mango cultivars that are more resilient to handling and shipment. The best mango cultivars for various locations can be selected with the aid of evaluation studies to produce the largest yield of fruit of the highest quality. **(Naz *et al.*, 2014)**.

Nutrients are essential for the growth, development, and production of plants. Plants need a balanced amount of nutrients to grow. Sixteen different nutrients are needed by plants, and each one has a specific function. Nine of these elements have been classified as "macronutrients" due to the high levels of these elements required by their plants. The elements H, O, N, P, K, Ca, Mg, and S are among them. According to **(Marschner, 2011),** The remaining elements are known as micronutrients and include B, Cu, Fe, Mn, Mo, Zn, and Cl.

Moreover, the translocation of macronutrients depends on micronutrients for several metabolic processes in plants, such as respiration, cell wall production, chlorophyll synthesis, photosynthesis, hormone synthesis, nitrogen fixation, and enzyme activity. **(Das, 2003)**. K, Ca, and B were used to promote fruit set, fruit retention, and fruiting characteristics. When Ca and B are administered at a rate of 3.0 m/L, fruit set and pollen germination are enhanced. Even when B is abundant, a lack of it is associated with a number of disorders. This implies that these circumstances are physiological in origin and have to do with B's movement inside plant tissues. Moreover, the concentration of fruit B determines the percentage of fruit retention and fruit setting. **(Tohidloo and Souri, 2009)**.

Calcium is not considered a leachable nutrient **(Cheung, 1990)**. Many insoluble calcium such as calcium carbonate soils contain high levels of insoluble calcium such as calcium carbonate, but crops grown in these soils will often show a calcium deficiency **(Boyonton *et al.*, 2006)**. Calcium can only be supplied in the xylem sap (**Banath *et al.*, 1966**). High levels of other cations such as magnesium, ammonium, iron, aluminum and especially potassium, will reduce the calcium uptake in some crops due to their antagonistic effect on their absorption High levels of other cations such as magnesium, ammonium, iron, aluminum and especially potassium (**Kulkani *et al.*, 2010**). Necrosis at the tips and margins of young leaves, anomalies in the bulb and fruit, deformation of damaged leaves, highly branching, short, brown root systems, severe, stunted growth, and chlorosis are the most often recorded signs of calcium deficiency in plants. (**Jones and Lunt, 1967**). Calcium will be toxic if it is supplied in excess quantities (**Kumar *et al.*, 2006**).

Because calcium spraying reduced abscission, mango productivity rose. (**Kumar *et al.*, 2006**). By keeping the center lamella cells intact and making the fruit firmer, it improves the quality of mangos. Calcium nitrate and calcium chloride treatment (0.6–2.0%) decreased weight loss, decreased respiration rates, and postharvest ripening. (**Bender, 1998**). Fruits storability was also improved by CaCl2 under cold storage (**Wahdan *et al.*, 2011**). Fruit quality and shelf life are known to be impacted by the pre- and post-harvest use of chemicals such as calcium chloride and calcium nitrate (**Gill *et al.*, 2005**).

Moreover, some writers have stated that the fruit has access to calcium in the early phases of fruit growth (**Stino *et al.*, 2011)** However, some studies have shown that calcium can still be utilized efficiently after physiological maturity (**Karemera NJU and S Habimana, 2014)**

To study some of the effects of calcium on mango trees, this study aimed to investigate the following objectives:

1- The importance of using different forms of Calcium on vegetative growth and nutritional status.
2- The importance of using different methods of addition on vegetative growth and nutritional status.
3-The importance of using different forms of Calcium and method of addition together on vegetative growth and nutritional status.

Materials and Methods

This study was carried out on eight-year-old Naomi mango trees in a private orchard located in the International Coastal region - Kafr El-Sheikh Governorate-Egypt during the 2023 and 2024 seasons. The trees were planted on sandy soil at two by four meters each, with drip irrigation using water from the Nile.

Table 1. The maximum and minimum temperature and rain data for the whole year as an average taken from the last 12+ years of historical data for Kafr El-Sheikh.

Month	Day	Night	Rain Days
January	19°c	9°c	1
February	21°c	10°c	1
March	25°c	11°c	1
April	29°c	14°c	1
May	33°c	18°c	0
June	36°c	21°c	0
July	37°c	22°c	0
August	37°c	22°c	0
September	35°c	21°c	0
October	31°c	19°c	1
November	26°c	16°c	1
December	21°c	12°c	1

*Average weather in Kafr El-Sheikh during treatment periods (World WeatherOnline.com)

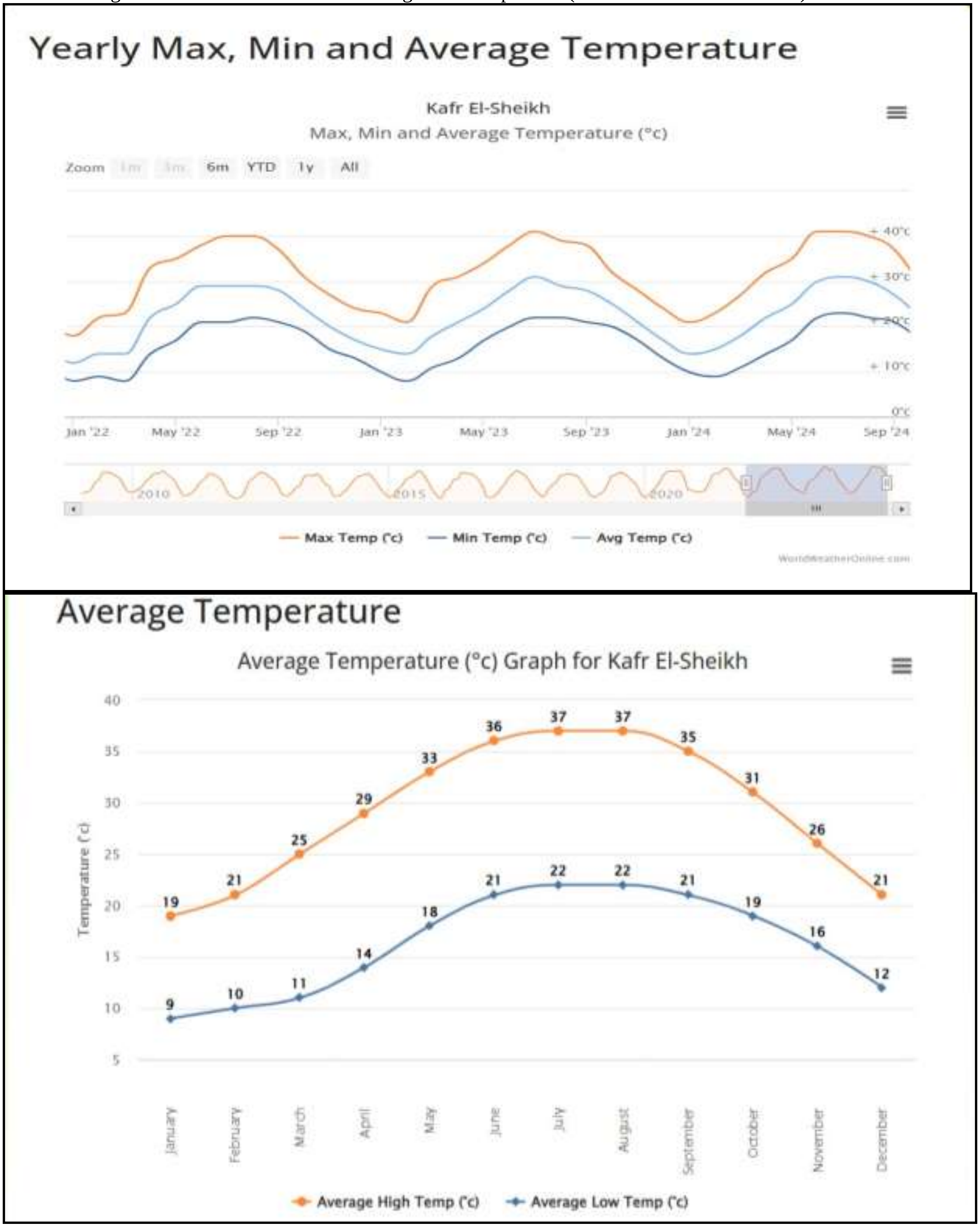

Fig. (1): The maximum and minimum temperature and rain data for the whole year as an average taken from the last 12+ years of historical data for Kafr El-Sheikh.

Two factors were included in the factorial experiment: the first factor Calcium nitrate biofertilizers as soil and the second factor some forms of Calcium were sprayed and combined in the two factors in this study.

Table (2): The following therapies were used in this study:

Zero	Calcium Nitrate (1)	Calcium Nitrate (2)
1- Control (Water spray)	**2- Control (Water spray)**	**3- Control (Water spray)**
4- Calcium Boron Acetate 1 (1 Cm/L.)	**5- Calcium Boron Acetate 1 (1 Cm/L.)**	**6- Calcium Boron Acetate 1 (1 Cm/L.)**
7- Calcium Boron Acetate 2 (2 Cm/L.)	**8- Calcium Boron Acetate 2 (2 Cm/L.)**	**9- Calcium Boron Acetate 2 (2 Cm/L.)**
10- Calcium Boron pectate1 (1 Cm/L.)	**11- Calcium Boron pectate 1 (1 Cm/L.)**	**12- Calcium Boron pectate 1 (1 Cm/L.)**
13- Calcium Boron pectate2 (2 Cm/L.)	**14- Calcium Boron pectate2 (2 Cm/L.)**	**15- Calcium Boron pectate 2 (2 Cm/L.)**

Experimental layout:

The differential treatments (combinations between two parameters included in this study) were arranged using a full randomized block design with three replications. Three trees were used to symbolize each replication. As a result, the projected number of trees needed for each study was as follows: To represent soil addition with Calcium Nitrate and (Calcium Boron Acetate, Calcium Boron Pectate) foliar spray and soil additional under sandy soil conditions, forty-five healthy uniformed and disease/insect-free Naomi mango trees were carefully chosen. In addition, 45 more trees were planted to create a reserve. For this experiment, Within the 15 trees of each category, the examined treatments were grouped.

Application time and method:

During the first week of February in the two experimental seasons, the soil was added with Calcium Nitrate at two concentrations (4 Kg & 6 Kg per feddan) five times a year starting in early February at one-month intervals. Additionally, foliar sprays of various solutions (Calcium Boron Acetate and calcium Boron pectate with two concentrations for every form 1 & 2 cm per L.), including tap water spray (control), were applied five times a year starting in early February at the one-month interval, in the first and second experimental seasons. Four liters of spray solution per tree were sufficient in this respect, however, each treatment's spray solution was administered until it ran off. To assess the specific and interaction impacts of two factors under study in either the first or second experimental seasons, the following measurements were examined to see how they changed (reacted):

2.1. Vegetative growth parameters:

In this instance, the two growth indices assessed for the Naomi mango trees were shoot length and average leaf area (cm2). The latter week of September was when these measurements were made.

2.2. Total chlorophyll and the amount of N, P, K, Ca, Mg, Fe, Mn, and Zn in the leaves indicate the nutritional status:

In the first and second seasons, samples of fully grown leaves from the spring-flushed shoots were collected during the last week of September. Using damp cloths, it was coarsely cleaned, then distilled water was added and dried in an electric oven at 80 degrees Celsius until its weight didn't change. Finally, a stainless-steel mill was used to grind it up to avoid any metal contamination. As clarified by (**Chapman and Pratt, 1961**), About 0.5 g of dry matter from leaves was wet digested using a solution of sulphuric and perchloric acids.

Total N was measured using a micro Kjeldahl (**Pregl, 1945**), The Flam photometer was used to calculate K following **(Chapman and Pratt, 1961)**. and phosphorus was measured using a Spekol spectrophotometer set at 882.0 UV under **Murphy and Riely, 1962)** technique according to (**Jackson, 1973) and (Wild *et al*., 1985)**, atomic absorption (3300) was used to identify Ca, Fe, Mg, Mn, and Zn respectively.

Statistical Analysis:

The data gathered from each experiment over both experimental seasons was subjected to analysis of variance, and significant differences between means were found (**Snedecor and Cochran, 1980**). Additionally, Duncan's multiple test range (**Duncan, 1955**) was used to distinguish between noteworthy variations in means. Capital and tiny letters were used to represent the specific and interaction effect values, respectively.

Results and Discussions

To examine how Naomi mango trees responded to foliar application and soil addition and various forms of Ca (Calcium Nitrate, Calcium Boron Acetate and calcium Boron Pectate). were measured Two vegetative growth parameters (shoot length and average leaf area).

3.1. Vegetative growth measured parameters:

A. Specific effect:

Data obtained in **Table (3**) and **Figs. (2 and 3)** showed the effect of the two elements under investigation soil addition (Calcium nitrate1 and Calcium nitrate 2) and foliar spray by forms of Ca (Calcium Boron Acetate1, Calcium Boron Acetate2, calcium Boron Pectate1, and calcium Boron Pectate2) on the two parameters under investigation (shoot length and average leaf area) of Naomi mango plants. According to the data in **Table (3) and Figs. (2 and 3)**, the two factors under examination were moving in tandem and with equal magnitude in their effects on the two parameters under investigation (shoot length and average leaf area) compared with control treatment during the first and second seasons, respectively. Comparing the two metrics under investigation soil addition and foliar spray, the foliar spray for calcium Boron Pectate was linked to the greatest significant values of the two previously mentioned parameters. During both study seasons, T5 with the Calcium Boron Pectate2 achieved the highest results in this regard, indicating that it was the superior level during the first and second seasons.

B. Interaction effect:

With referring to the interaction between the two investigated factors investigation of soil addition (Calcium nitrate1 and Calcium nitrate 2) and foliar spray by forms of Ca (Calcium Boron Acetate1, Calcium Boron Acetate2, calcium Boron Pectate1, and calcium Boron Pectate2) on the two vegetative investigated parameter (shoot length and average leaf area) of Naomi mango trees, data presented in **Table (3)** and **Figs. (2 and 3)** revealed that the maximum values of the two investigated were detected with the combination of Calcium nitrate 2 soil addition and calcium Boron Acetate 2 foliar spray during both the 2023 and 2024 seasons of study.

Table 3. Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on shoot length (cm) and leaf area (cm^2) of Naomi mango trees during 2023 and 2024 seasons.

Soil addition / Foliar spray	Shoot length (cm)							
	First season; 2023				Second season; 2024			
	Zero	Calcium nitrate 1	Calcium nitrate 2	Mean*	Zero	Calcium nitrate 1	Calcium nitrate 2	Mean*
T1- Water spray	11.03n	11.27m	11.51l	**11.27E**	11.11j	11.33ij	11.55ij	**11.33D**
T2- calcium Boron Acetate 1	11.71k	14.17d	14.74c	**13.54B**	11.72hi	14.23c	14.78b	**13.58B**
T3- calcium Boron Acetate 2	12.13j	15.17b	16.09a	**14.46A**	12.15h	15.18b	16.78a	**14.71A**
T4- calcium Boron pectate 1	12.24i	13.07g	13.43f	**12.91D**	12.22h	13.13fg	13.51ef	**12.95C**
T5- calcium Boron pectate 2	12.72h	13.50f	14.07e	**13.43C**	12.87g	13.68de	14.08cd	**13.54B**
Mean**	**11.97C**	**13.43B**	**13.97A**		**12.01C**	**13.51B**	**14.14A**	
	Leaf area (cm2)							
T1- Water spray	57.25n	58.26l	57.92m	**57.81E**	58.87o	60.33m	59.93n	**59.71E**
T2- calcium Boron Acetate 1	58.37l	67.80d	69.39c	**65.18B**	62.67l	77.12c	76.67d	**72.16C**
T3- calcium Boron Acetate 2	59.34k	75.34b	83.32a	**72.67A**	65.47k	80.38b	83.58a	**76.57A**
T4- calcium Boron pectate 1	60.02j	61.73h	62.80g	**61.52D**	67.43j	71.62h	72.73g	**70.48D**
T5- calcium Boron pectate 2	61.16i	63.12f	65.19e	**63.16C**	70.00i	74.14f	75.15e	**73.10B**
Mean**	**59.23C**	**65.25B**	**67.72A**		**64.94C**	**72.65B**	**73.61A**	

- Means within a column or row having the same letters are not significantly different according to Duncan's New Multiple Range t-Test at 5 % level.

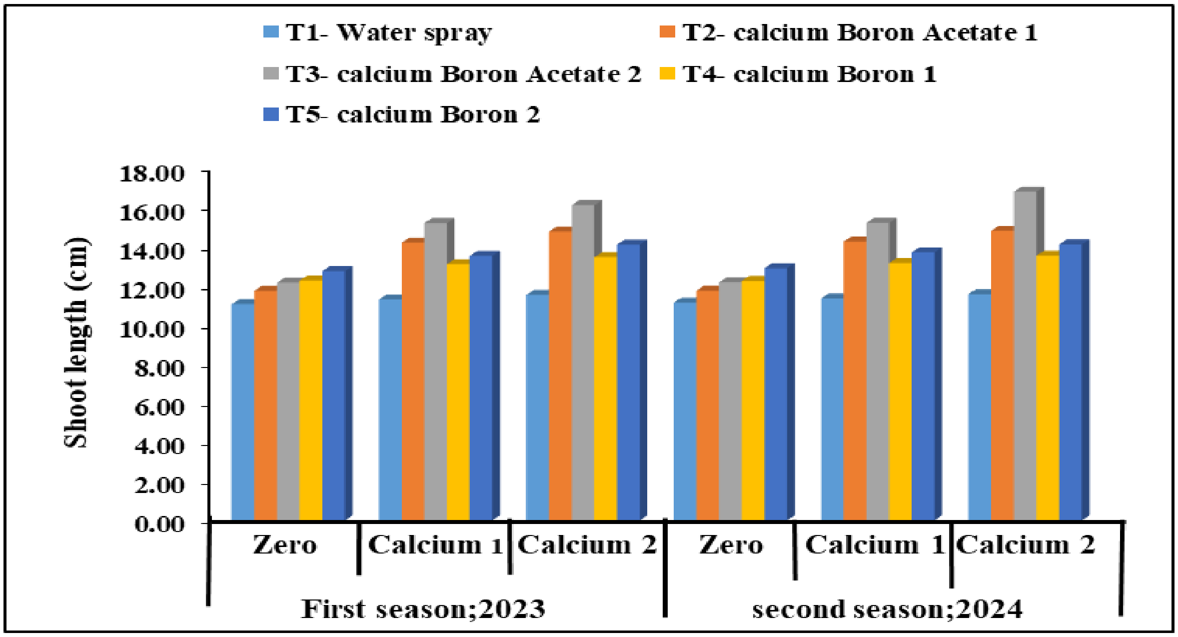

Fig. (2): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on shoot length (cm) of Naomi mango trees during 2023 and 2024 seasons.

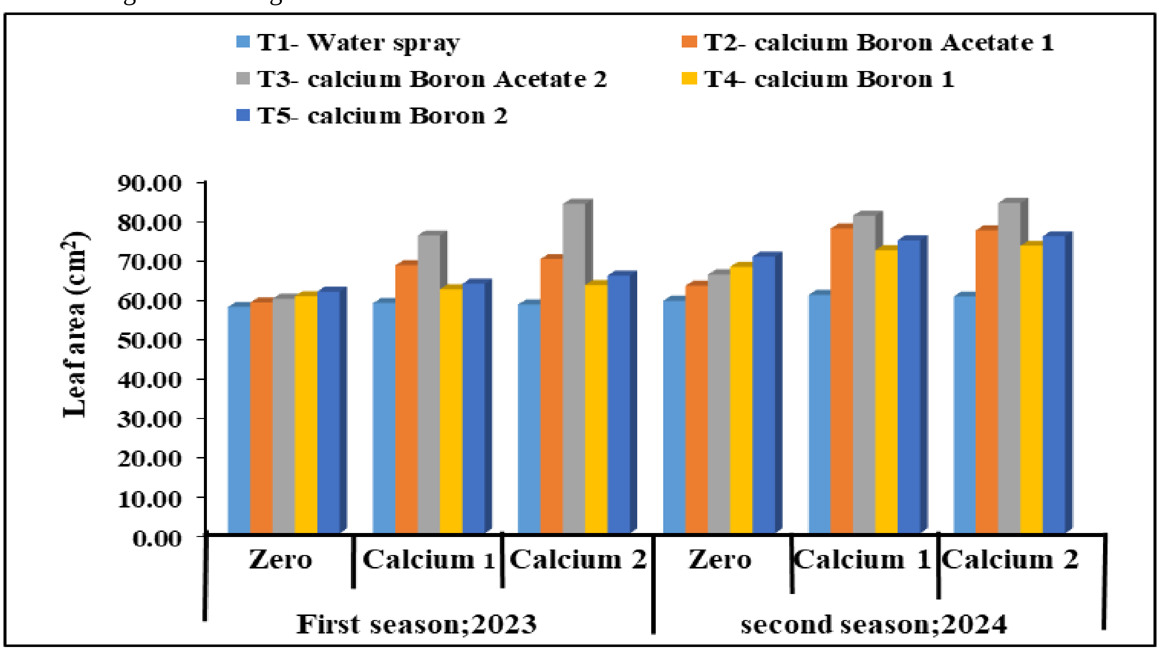

Fig. (3): Effect of different forms of Ca as foliar spray, soil addition and interaction effect on leaf area (cm^2) of Naomi mango trees during 2023 and 2024 seasons.

3.2. Nutritional status:

3.2.1. Total chlorophyll (SPAD):

A. Specific effect:

The results shown in **Table (4)** and **Fig. (4)** regarding the specific effect of the two studied factors soil addition by (Calcium nitrate1 and Calcium nitrate 2) and foliar spray by four forms of calcium; i.e. "calcium Boron Acetate1, calcium Boron Acetate2, calcium Boron Pectate1 and calcium Boron Pectate2" on the total chlorophyll content of Naomi mango trees, show that calcium was used in this study as a soil or foliar supplement. During the two seasons that followed, this treatment increased the leaves' overall chlorophyll content.

B. Interaction effect:

Regarding the effect of the interaction between the two studied factors, Calcium nitrate1 and Calcium nitrate 2 and two different forms of calcium as a foliar spray or soil addition, on the total chlorophyll content in the leaves of Naomi mango trees. The data presented in **Table (4)** and **Fig. (4)** clearly show that the combination of Calcium Boron Acetate2 as a foliar spray and Calcium nitrate2 as soil addition was the best, as it significantly increased the Naomi mango tree total chlorophyll content in the leaves during the two experimental seasons.

3.2.2. Macro-elements (N, P, K, Ca and Mg %) contents: -

A. Specific effect of leaf minerals:

Nitrogen, phosphorus, potassium, calcium, and magnesium elements content of the leaves were the five investigated fruit chemical Macro-nutrients of Naomi mango trees in response to two studied factors Calcium nitrate1 and Calcium nitrate 2as soil addition and foliar spray by two forms of Calcium in different concentration: "calcium Boron Acetate1, calcium Boron Acetate2, calcium Boron Pectate1 and calcium Boron Pectate2". Data obtained during both 2023 and 2024 experimental seasons are presented in **Tables (4) and (5)** and **Figs. (5,6,7,8, and 9)**.

It was so worthy to be noticed that two conflicting trends were detected. Anyhow, N %, P %, Ca and Mg content as shown from tabulated data in **Tables (4) and (5)** displayed clearly that such four chemical constituents followed to a great extent the same trend regarding their response to evaluated spray and soil treatments. Herein, all forms of Ca as spray and Soil addition increased significantly such four chemical properties as each was compared to the corresponding one of water spray (control) during both seasons. On the other hand, T5 spray with calcium Boron2 was statistically the most effective, while spraying calcium Boron1 (T4) descendingly came 2nd from the statistical point of view.

Pertaining the P % fruit of Naomi mango trees, tabulated data in **Table (4)** and **Fig. (6)** declared obviously that this parameter followed similarly a firm trend which completely conflicted with that previously detected with N %, K %, Ca %, and Mg %. Meanwhile, Calcium nitrate1 and Calcium nitrate2 as soil addition and foliar spray by two forms of potassium in different concentrations: "calcium Boron Acetate1, calcium Boron Acetate2, calcium Boron pectate1 and calcium Boron Pectate2" decreased significantly such three chemical measurements with comparison to those of control during two seasons. Hence, (T5) calcium Boron2 and spraying with calcium Boron pectate 2 (T7) resulted significantly in the greatest reduction in this chemical constituent below control. Meanwhile, other spray treatments were in between the abovementioned two extremes.

B. Interaction effect:

Regarding the interaction effect on the nitrogen content in the leaves of Naomi mango trees, soil addition by Calcium Nitrate at different concentrations and foliar spray by different forms of Calcium (calcium Boron Acetate, and calcium Boron Pectate) at different concentrations. The data shown in **Table (4)** and **Figs. (5, and 6)** indicated that the best combination was using Calcium Nitrate2 and Calcium Boron acetate2 during both seasons, respectively. On reverse, it was evident from the results of how the phosphorus element performed, declared obviously that this parameter followed similarly a firm trend which completely conflicted with that previously detected with N % during the research seasons.

The data shown in **Table (5)** and **Figs. (7,8, and 9)** illustrated the effect of the interaction between the two studied factors soil addition by Calcium Nitrate at different concentrations and foliar spray by different forms of Calcium (calcium Boron Acetate, and calcium Boron Pectate) at different concentrations" on the leaf content of potassium, calcium, and magnesium in the leaves of Naomi mango trees. The recorded data indicate that the use of calcium Boron Acetate2 as a foliar or soil addition with Calcium Nitrate2 outperformed all the different treatments during the two study seasons, as this treatment had the highest concentration of potassium, calcium, and magnesium in the leaf content during the two study seasons, respectively.

Table (4): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on total chlorophyll (SPAD); N and P (%) concentrations of Naomi mango trees during 2023 and 2024 seasons.

treatments Soil addition / Foliar spray	2023 Season Zero	Calcium nitrate 1	Calcium nitrate 2	Mean*	2024 Season Zero	Calcium nitrate 1	Calcium nitrate 2	Mean*
				Total Chlorophyll (SPAD)				
T1- Water spray	40.28n	41.04m	41.69l	**41.00A**	39.79n	40.35m	41.07l	**40.41E**
T2- calcium Boron Acetate 1	42.17k	47.36d	47.84c	**45.79B**	41.67k	47.33d	47.66c	**45.55B**
T3- calcium Boron Acetate 2	42.51j	48.74b	49.44a	**46.89A**	42.02j	48.05b	49.29a	**46.46A**
T4- calcium Boron pectate 1	42.88i	43.59h	44.03g	**43.50D**	42.81i	43.57h	43.98g	**43.45D**
T5- calcium Boron pectate 2	43.17i	45.09f	45.63e	**44.63C**	42.94i	44.36f	45.78e	**44.36C**
Mean**	**42.20C**	**45.16B**	**45.73A**		**41.85C**	**44.73B**	**45.56A**	
				N %				
T1- Water spray	1.99o	2.02n	2.09m	**2.03D**	2.03n	2.11m	2.16l	**2.10E**
T2- calcium Boron Acetate 1	2.23l	2.69d	2.73c	**2.55B**	2.26k	2.73d	2.78c	**2.60C**
T3- calcium Boron Acetate 2	2.31k	2.78b	2.85a	**2.64A**	2.32j	2.83b	2.86a	**2.67A**
T4- calcium Boron pectate 1	2.37j	2.50h	2.54g	**2.47C**	2.39i	2.56g	2.60f	**2.52D**
T5- calcium Boron pectate 2	2.45i	2.58f	2.63e	**2.55B**	2.49h	2.64e	2.72d	**2.62B**
Mean**	**2.27C**	**2.52B**	**2.57A**		**2.30C**	**2.57B**	**2.62A**	
				P %				
T1- Water spray	0.263a	0.259ab	0.256abc	**0.259A**	0.259a	0.253ab	0.251ab	**0.254A**
T2- calcium Boron Acetate 1	0.251abcd	0.227fg	0.222g	**0.233B**	0.247ab	0.228cdef	0.222def	**0.232BC**
T3- calcium Boron Acetate 2	0.246abcde	0.222g	0.223fg	**0.230B**	0.244abc	0.219ef	0.214f	**0.226C**
T4- calcium Boron pectate 1	0.241bcdef	0.236defg	0.232efg	**0.236B**	0.239bcd	0.234bcde	0.236bcde	**0.236B**
T5- calcium Boron pectate 2	0.239cdefg	0.230efg	0.228efg	**0.232B**	0.238bcde	0.227cdef	0.224def	**0.231BC**
Mean**	**0.248A**	**0.235B**	**0.232B**		**0.245A**	**0.232B**	**0.231B**	

- Means within a column or row having the same letters are not significantly different according to Duncan's New Multiple Range t-Test at 5 % level.

Table (5): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on K, Ca and mg (%) concentrations of Naomi mango trees during 2023 and 2024 seasons.

treatments Soil addition / Foliar spray	2023 Season Zero	2023 Season Calcium nitrate 1	2023 Season Calcium nitrate 2	Mean*	2024 Season Zero	2024 Season Calcium nitrate 1	2024 Season Calcium nitrate 2	Mean*
				K %				
T1- Water spray	2.21o	2.33n	2.27m	**2.24E**	2.24n	2.26m	2.30l	**2.27E**
T2- calcium Boron Acetate 1	2.32l	2.63d	2.67c	**2.54B**	2.34k	2.66d	2.71c	**2.57B**
T3- calcium Boron Acetate 2	2.35k	2.72b	2.75a	**2.61A**	2.37j	2.74b	2.79a	**2.63A**
T4- calcium Boron pectate 1	2.38j	2.46h	2.49g	**2.44D**	2.42i	2.47h	2.53g	**2.48D**
T5- calcium Boron pectate 2	2.43i	2.55f	2.58e	**2.52C**	2.46h	2.59f	2.62e	**2.56C**
Mean**	**2.34C**	**2.52B**	**2.55A**		**2.37C**	**2.55B**	**2.59A**	
				Ca %				
T1- Water spray	1.23o	1.28n	1.31m	**1.27E**	1.21n	1.29m	1.31l	**1.27E**
T2- calcium Boron Acetate 1	1.34l	1.73d	1.80c	**1.63B**	1.37k	1.75d	1.81c	**1.64B**
T3- calcium Boron Acetate 2	1.41k	1.84b	1.94a	**1.73A**	1.41j	1.89b	1.99a	**1.76A**
T4- calcium Boron pectate 1	1.45j	1.51h	1.54g	**1.50D**	1.46i	1.53h	1.58g	**1.52D**
T5- calcium Boron pectate 2	1.47i	1.57f	1.62e	**1.55C**	1.52h	1.61f	1.69e	**1.61C**
Mean**	**1.38C**	**1.59B**	**1.64A**		**1.40C**	**1.61B**	**1.68A**	
				Mg (%)				
T1- Water spray	0.441k	0.449k	0.451jk	**0.447D**	0.444i	0.451hi	0.458hi	**0.451D**
T2- calcium Boron Acetate 1	0.456jk	0.541cd	0.551c	**0.516B**	0.462h	0.545cd	0.558c	**0.522B**
T3- calcium Boron Acetate 2	0.467ij	0.603b	0.654a	**0.575A**	0.469h	0.612b	0.652a	**0.578A**
T4- calcium Boron pectate 1	0.481hi	0.505fg	0.516ef	**0.501C**	0.491g	0.510f	0.527e	**0.509C**
T5- calcium Boron pectate 2	0.496gh	0.522ef	0.532de	**0.517B**	0.503fg	0.531de	0.531de	**0.522B**
Mean**	**0.468C**	**0.524B**	**0.541A**		**0.474C**	**0.530B**	**0.545A**	

- Means within a column or row having the same letters are not significantly different according to Duncan's New Multiple Range t-Test at 5 % level.

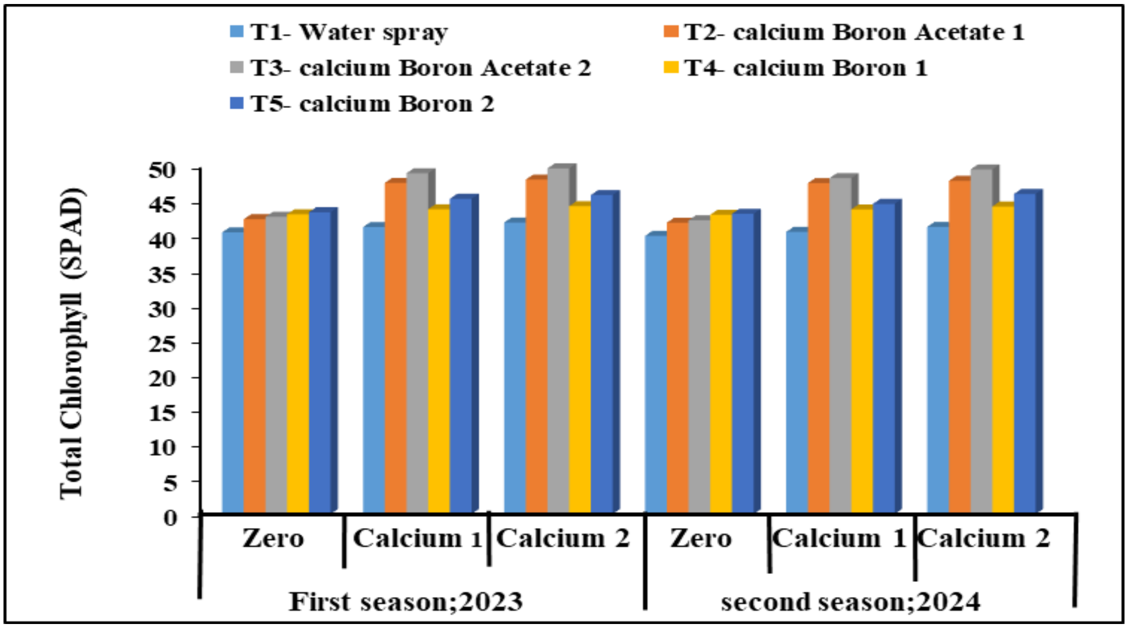

Fig. (4): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on total chlorophyll (SPAD) of Naomi mango trees during the 2023 and 2024 seasons.

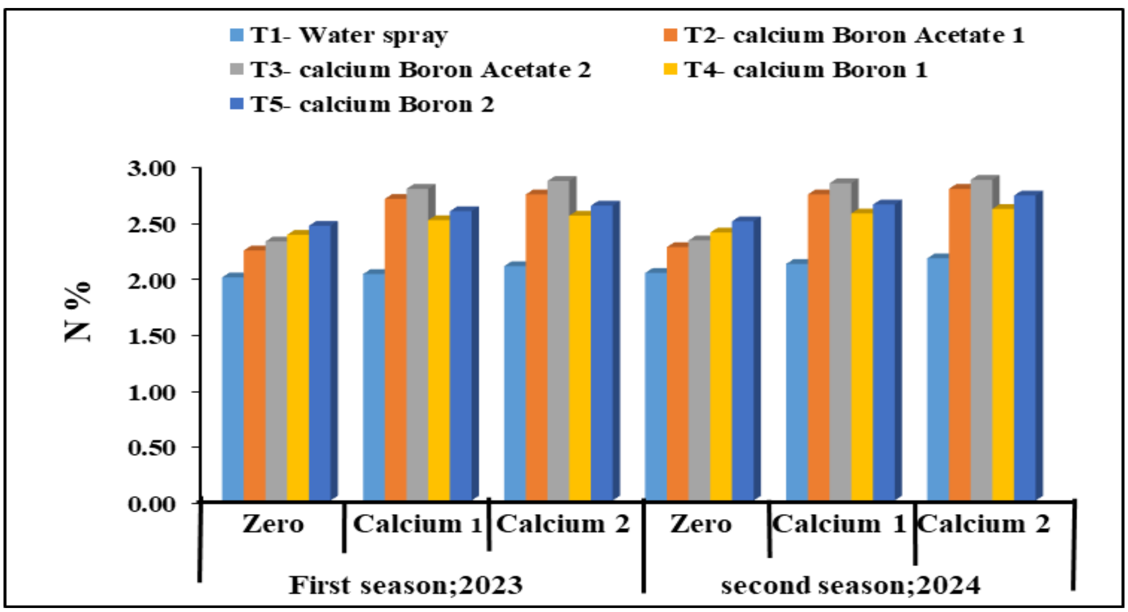

Fig. (5): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on N % of Naomi mango trees during 2023 and 2024 seasons.

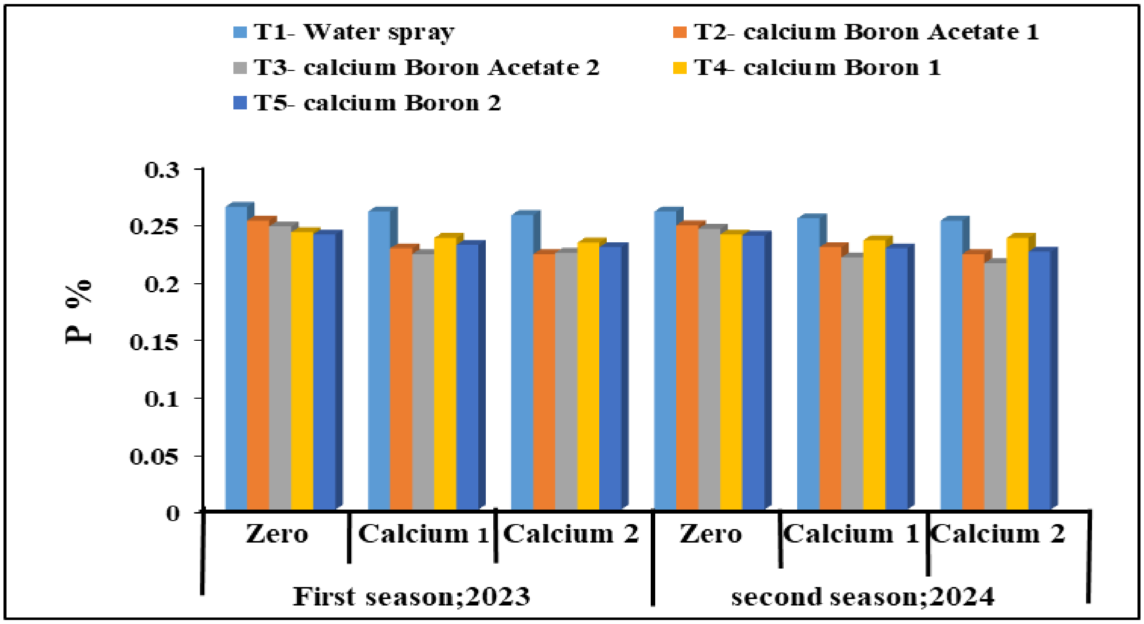

Fig. (6): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on P % of Naomi mango trees during the 2023 and 2024 seasons.

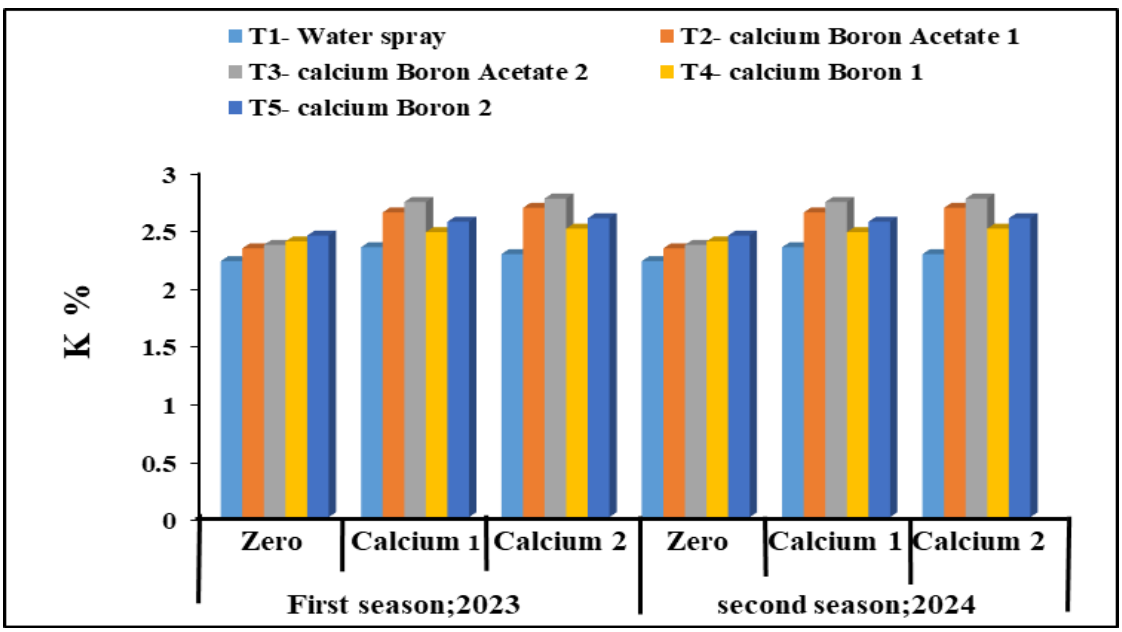

Fig. (7): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on K % of Naomi mango trees during the 2023 and 2024 seasons.

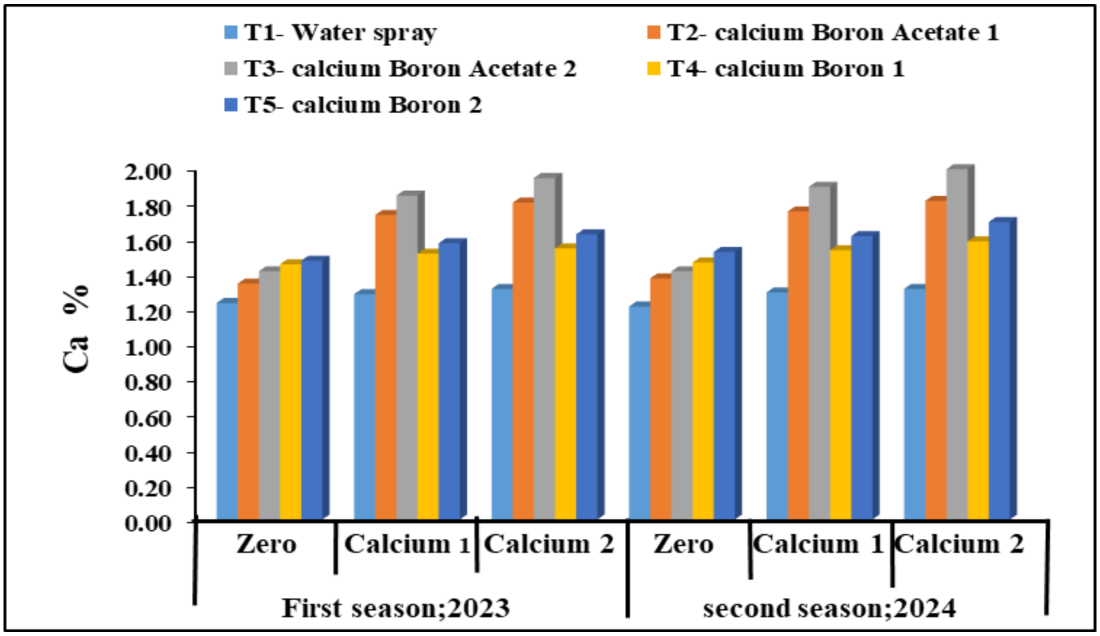

Fig. (8): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on Ca % of Naomi mango trees during the 2023 and 2024 seasons.

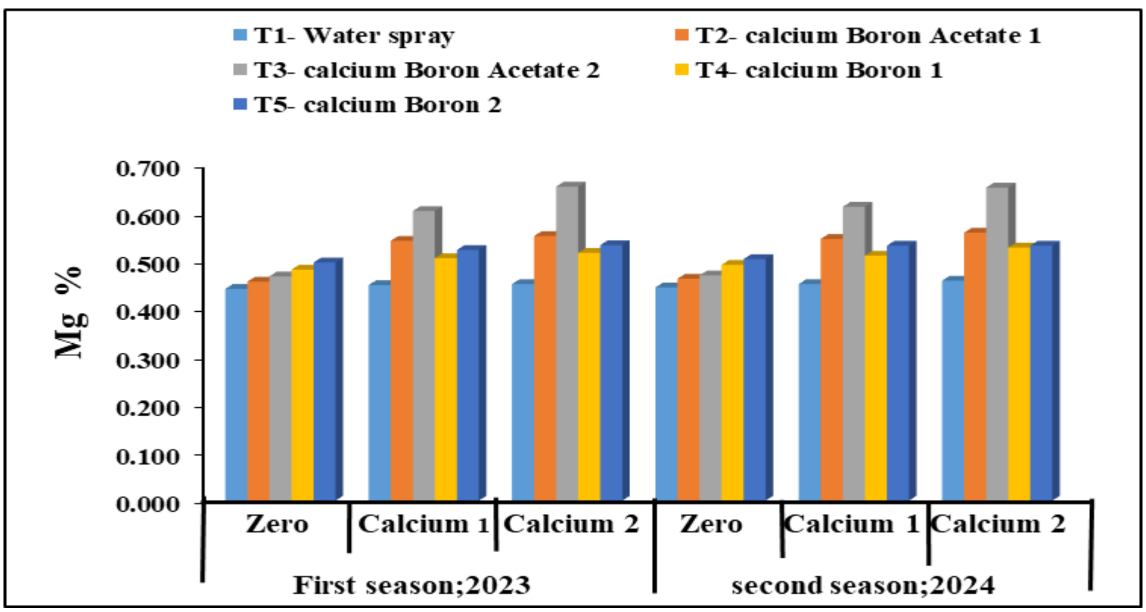

Fig. (9): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on Mg % of Naomi mango trees during 2023 and 2024 seasons.

3.2.3. Micro-nutrients (Fe, Mn, and Zn ppm) contents: -

A. Specific effect:

Data in **Table (6) and Figs. (10, 11 and 12)** cleared that the specific effect of the two studied factors Soil addition by different concentrations of calcium nitrate and two forms of calcium in different concentrations: "calcium Boron Acetate1, calcium Boron Acetate2, calcium Boron Pectate1 and calcium BoronPectate2" on the iron, manganese and zinc content of the leaves of Naomi mango trees showed that the recorded data the using of calcium Boron2 as a foliar and calcium Boron pectate2, as this treatment led to an increase in the three elements (Fe, Mn and Zn) content of the leaves during both seasons. On the contrary, the results recorded in **Table (6)** and **Figs. (10, 11 and 12)** control (Water spray) had the lowest values during both seasons in this study, respectively.

So, concerning the specific effect of the studied factors for two forms of calcium in different concentrations; "calcium Boron Acetate1, calcium Boron Acetate2, calcium Boron Pectate1 and calcium Boron Pectate2" and Soil addition by different concentrations of calcium nitrate "calcium nitrate1, and calcium nitrate2" on the leaf content of potassium, calcium, and magnesium elements in **Table (6)** and **Figs. (10, 11 and 12)**, the using of calcium is better than the control during both seasons of the study.

B. Interaction effect:

Iron, Manganese, and Zinc elements content of the leaves were the five investigated fruit chemical Micro-nutrients of Naomi mango trees in response to two studied factors Calcium nitrate1 and Calcium nitrate 2 as soil addition and foliar spray by two forms of potassium in different concentrations: "calcium Boron Acetate1, calcium Boron Acetate2, calcium Boron Pectate1 and calcium Boron Pectate2". Data obtained during both the 2023 and 2024 experimental seasons are presented in **Tables (6)** and **Figs. (10,11, and 12)**

Data presented in **Table (6)** and **Figs. (10, 11, and 12),** declared that the effect of the interaction between the two studied factors on the leaf content of Fe, Mn, and Zn in the leaves of Naomi mango trees. The values recorded data indicated that the using of combing calcium Boron Acetate2 as a foliar and soil addition with Calcium nitrate2 surpassed all the different treatments during the first and second seasons in this study, as this treatment had the highest concentration of Fe, Mn and Zn in the leaf content during both study seasons, respectively.

Table 6. Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on Fe, Mn and Zn (ppm) concentrations of Naomi mango trees during 2023 and 2024 seasons

treatments Soil addition / Foliar spray	2023 Season Zero	2023 Season Calcium nitrate 1	2023 Season Calcium nitrate 2	Mean*	2024 Season Zero	2024 Season Calcium nitrate 1	2024 Season Calcium nitrate 2	Mean*
				Fe (ppm)				
T1- Water spray	98.17n	99.44m	101.40l	**99.68E**	97.42cd	98.68cd	100.20bcd	**98.76B**
T2- calcium Boron Acetate 1	103.60k	127.10c	130.20b	**120.30B**	101.20bcd	123.30abc	128.30ab	**117.60A**
T3- calcium Boron Acetate 2	105.40j	130.60b	133.40a	**123.10A**	104.00abcd	130.10a	131.11a	**121.70A**
T4- calcium Boron pectate 1	107.20i	114.70g	117.60f	**113.20D**	105.50abcd	79.61d	117.50abc	**100.90B**
T5- calcium Boron pectate 2	110.90h	122.4e	124.00d	**119.10C**	110.50abc	121.00abc	123.00abc	**118.20A**
Mean**	**105.00C**	**118.90B**	**121.30A**		**103.70B**	**110.60AB**	**120.00A**	
				Mn (ppm)				
T1- Water spray	38.31m	39.62l	41.41k	**39.78E**	38.01m	39.57l	41.05k	**39.54D**
T2- calcium Boron Acetate 1	43.91j	52.32c	52.98b	**49.74B**	43.81j	50.92c	51.89b	**48.87B**
T3- calcium Boron Acetate 2	46.02i	53.46b	54.44a	**51.31A**	45.43i	53.29a	53.84a	**50.85A**
T4- calcium Boron pectate 1	46.89h	47.74g	48.83f	**47.82D**	46.46h	47.29g	48.05f	**47.27C**
T5- calcium Boron pectate 2	47.69g	49.43e	50.84d	**49.23C**	47.14g	48.82e	50.13d	**48.70B**
Mean**	**44.57C**	**48.51B**	**49.70A**		**44.17C**	**47.98B**	**48.99A**	
				Zn (ppm)				
T1- Water spray	36.14L	36.61K	38.20J	**36.98E**	35.92o	36.20n	37.98m	**36.70E**
T2- calcium Boron Acetate 1	40.04I	43.48D	44.62C	**42.71B**	39.25l	43.63d	44.30c	**42.39C**
T3- calcium Boron Acetate 2	40.47H	46.09B	47.00A	**44.52A**	40.29k	45.93b	47.09a	**44.44A**
T4- calcium Boron pectate 1	41.05G	42.24F	42.63E	**41.97D**	40.97j	41.90h	42.75g	**41.87D**
T5- calcium Boron pectate 2	41.38G	42.78E	43.24D	**42.47C**	41.40i	42.95f	43.34e	**42.57B**
Mean**	**39.82C**	**42.24B**	**43.14A**		**39.57C**	**42.12B**	**43.09A**	

- Means within a column or row having the same letters are not significantly different according to Duncan's New Multiple Range t-Test at 5 % level.

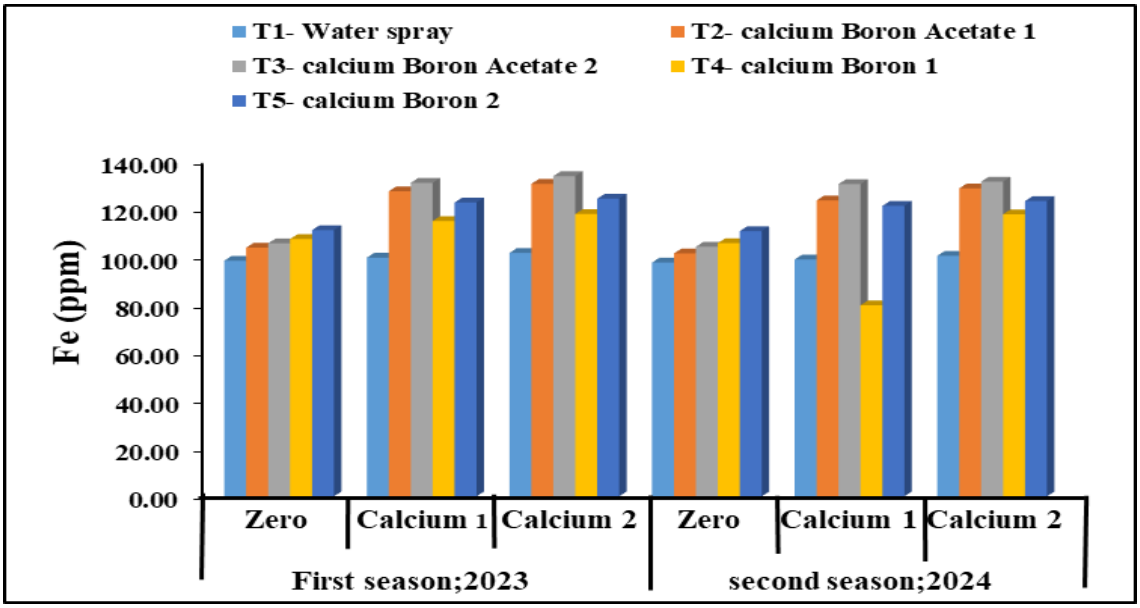

Fig. (10): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on Fe (ppm) of Naomi mango trees during 2023 and 2024 seasons.

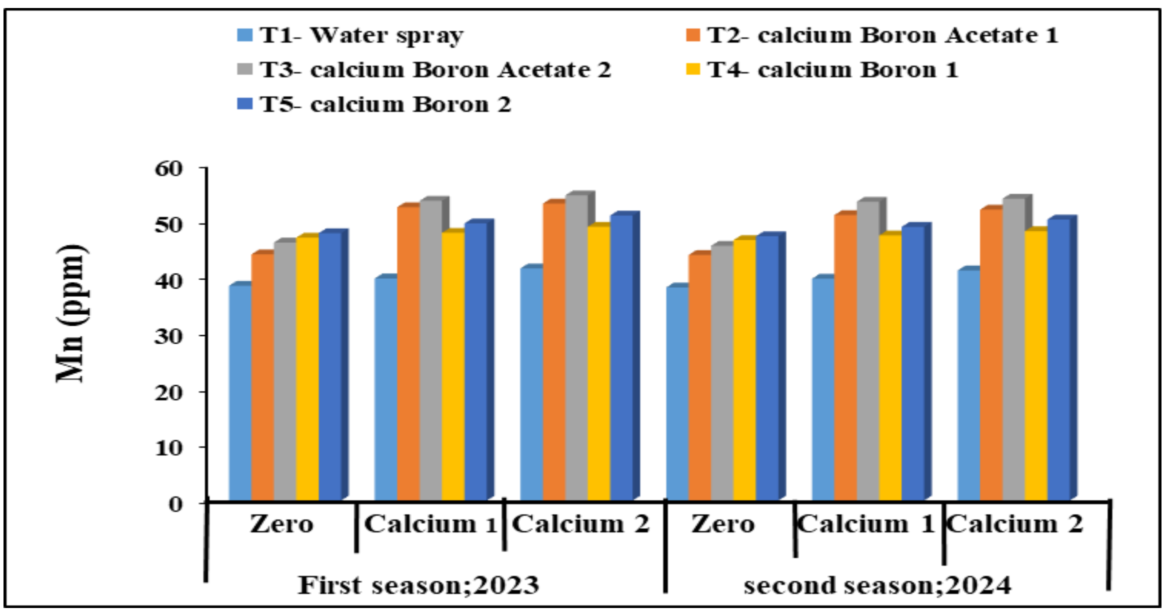

Fig. (11): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on Mn (ppm) of Naomi mango trees during 2023 and 2024 seasons.

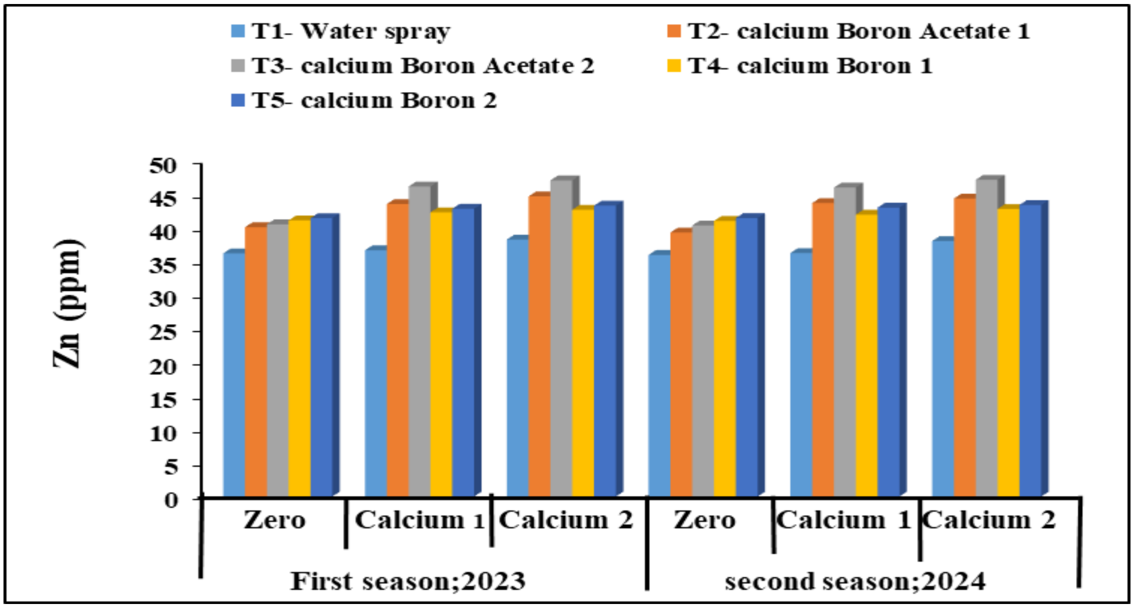

Fig. (12): Effect of different forms of Ca as a foliar spray, soil addition and interaction effect on Zn (ppm) of Naomi mango trees during 2023 and 2024 seasons.

Discussion

Applying nutrients to mango trees' leaves and soil is thought to have a significant impact on their development, productivity, fruit quality, and even the management of some illnesses. Mango yield shortage can be resolved by applying certain nutrients topically, which has been shown to improve fruit quality, yield, and setting. Several researchers have tried to improve mango fruit quality and productivity using foliar treatments of macro and micronutrients **(Khattab *et al.*, 2016)**. Particularly needed for energy transfer processes in plants, micronutrients are typically found in combination with bigger molecules including proteins (enzymes), cytochromes, and chlorophyll. Mango trees are among the fruit trees that are most vulnerable to nutritional deficiencies. Therefore, foliar spraying of microelements, particularly boron and zinc, has proven to be a useful method for fruit production (**Patil *et al.*, 2018**).

Calcium is essential for mango development, influencing cell wall structure and stability, which promotes shoot growth and fruit quality **(Tenreiro *et al.*, 2023)**. Calcium plays a crucial role in enhancing the yield and quality of mango trees, as evidenced by various studies. It is an essential nutrient that influences several physiological processes in mango plants, including fruit development, quality, and yield. Different calcium sources and application methods have been explored to optimize these benefits. The following sections detail the effects of calcium on mango trees. Calcium is a crucial and important nutrient element for protecting the plant against stresses and playing a vital role in several physiological functions **(Bhatt *et al.*, 2012)**. Applying calcium topically improved the quality of mango fruits by preserving the central lamella cells and boosting hardness, while also enhancing yield by decreasing fruit abscission. **(Karemera *et al.*, 2013)**. Calcium treatments also led to improved fruit weight and reduced physiological disorders, enhancing overall production **(Tenreiro *et al.*, 2023)**.

Higher plants need boron for several metabolic processes, including vegetative growth and reproductive processes that are necessary for pollen germination, pollen viability, pollen tube growth, blooming, fruit set, cell elongation, and cell division in olive trees **(Stellacci *et al.*, 2010)**. The way that boron increases fruit production may be because it has a role in the metabolism of sugar and nucleic acids, the translocation of carbohydrates, the structure and function of cell walls, and the creation of flowering hormones, which promote growth, blooming, fruit set, and yield **(Ibrahim, 2017)**. Mango tree quality and productivity are enhanced by balanced nutritional treatment of calcium, zinc, and boron, which guarantees optimal concentrations in leaves. In this regard, **(Bhatt *et al.*, 2012)** used calcium as a macronutrient and zinc and boron as micronutrients, either separately or in combination, topically to maintain the quality of mango fruit and rectify mineral nutrient shortages quickly. The mixture of calcium, boron, and zinc applied topically has been shown to improve fruit quality, blooming, fruiting, and growth character development. Moreover, **(Merwad *et al.*,**

2016) Combinations of Zn, Ca, and B spraying on mango trees improved fruit set and retention while lowering the percentage of deformed panicles and fruit drop. They demonstrated that the Alphonso mango plants' output was enhanced by the earlier ingredients. High levels of antioxidant enzymes (superoxide dismutase, catalase, and peroxidase) as well as high levels of free auxin and reducing sugars were associated with foliar boron application. However, fruit petioles had low levels of free phenolic and free amino acids. Additionally, fruit treated with boron showed reductions in fruit firmness and increases in chlorophyll content, pulp (%), TSS (%), and TSS/TA ratio **(Ali *et al.*, 2017)**. The development of flowers and fruits depends on boron, and research indicates that adding it can greatly enhance fruit quality indicators like sugar content and total soluble solids **(Sharma *et al.*, 2020 and Vijayvargiya & Singh, 2024)**.

Mango fruit set and pollen germination have been reported to be improved by calcium and boron together. Increased fruit production resulted from better inflorescence length and the quantity of hermaphrodite inflorescences caused by a particular concentration of calcium-boron solution **(Muengkaew *et al.*, 2017)** When calcium chloride was applied topically along with boron, a study found that the combined effects improved fruit yield (45.93 q/ha) and shoot extension growth (37.20 cm) (**Sharma *et al.*, 2020).**

Conclusion

In conclusion, all successful treatment for most of the parameters studied in this study was the combination of foliar spraying by calcium boron acetate at the rate of 2 cm per liter and soil added with calcium nitrate at the rate of 6 kg per feddan. Therefore, under the same conditions, this treatment is a prospective agent to enhance the vegetative growth and nutritional status of Naomi mango trees under the same conditions.

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تأثير صور الكالسيوم المختلفة وطرق الاضافة علي النمو الخضري والحاله الغذائية لأشجار المانجو الناعومي المثمرة

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أجريت هذه الدراسة خلال موسمين متتاليين 2023 و 2024 على أشجار المانجو المثمره عمر 8 سنوات صنف الناعومي المنزرعة في منطقة الدولي الساحلي محافظة كفر الشيخ، مصر تحت ظروف الري بالتنقيط على مسافات زراعة 2 × 4 متر، بهدف دراسة تأثير استخدام طرق إضافة ومصادر مختلفة من الكالسيوم حيث (أسيتات كالسيوم بورون – كالسيوم بورون – نترات كالسيوم) بالإضافة إلى معاملة الكنترول (المقارنة) وكانت المعاملات كالتالي:

صفر	نترات الكالسيوم (1) 4 كجم للفدان	نترات الكالسيوم (2) 6 كجم للفدان
1- معاملة الكنترول (المقارنه)	2- معاملة الكنترول (المقارنه)	3- معاملة الكنترول (المقارنه)
4- أسيتات كالسيوم بورون 1سم للتر	5- أسيتات كالسيوم بورون 1سم للتر	6- أسيتات كالسيوم بورون 1سم للتر
7- أسيتات كالسيوم بورون 2سم للتر	8- أسيتات كالسيوم بورون 2سم للتر	9- أسيتات كالسيوم بورون 2سم للتر
10- كالسيوم بورون بكتات 1سم للتر	11- كالسيوم بورون بكتات 1سم للتر	12- كالسيوم بورون بكتات 1سم للتر
13- كالسيوم بورون بكتات 2سم للتر	14- كالسيوم بورون بكتات 2سم للتر	15- كالسيوم بورون بكتات 2سم للتر

وتم تقييم استجابة النبات من خلال دراسة بعض القياسات الخضرية وهي (طول الساق ومساحة الورقة) ودراسة بعض قياسات الحالة الغذائية وهي (الكلوروفيل الكلي) والنيتروجين، الفوسفور، البوتاسيوم، الكالسيوم، الماغنسيوم، والحديد، المنجنيز والزنك، وتم إجراء المعاملات بالرش خمس مرات شهرياً بداية من شهر مارس إلى شهر يوليو والمعاملات الأرضية إضيفت اربع مرات بداية من نهاية شهر فبراير إلى نهاية شهر مايو.

استجابت جميع المعاملات (القراءات المدروسة) سابقة الذكر وكانت أفضل المعاملات هي المعاملة الثالثة (اسيتات كالسيوم بورون 2 سم للتر) في وجود نترات الكالسيوم 6 كجم للفدان يليه أسيتات بورون كالسيوم1سم للتر في وجود نترات الكالسيوم 6 كجم للفدان. وعلى العكس من ذلك كانت أقل المعاملات هي معاملة المقارنة (الكنترول).

لذا من خلال النتائج السابقة توصي الدراسة برش بأسيتات كالسيوم بورون سم للتر 2 بالإضافة الي نترات الكالسيوم6 كجم للفدان للحصول على أفضل نمو خضري وحالة غذائية لأشجار المانجو صنف الناعومي تحت نفس ظروف التجربة.