New Valley Journal of Agricultural Science
Published by Faculty of Agriculture, New Valley University, Egypt
DOI: 10.21608/NVJAS.2023.204595.1195
Research Article Open Access

Impact of Foliar Application with Zinc Sulfate on Vegetative Growth and Fruit Quality of Two Pomegranate Cultivars

Ahmed Mohamed Mohamed Abd-El- Ghany

Department of Pomology, Faculty of Agriculture, Assiut university, Egypt

*** Corresponding author**
Ahmed Mohamed Mohamed Abd-El- Ghany

Received: 06/04/2023
Revised: 28/05/2023
Accepted: 23/06/2023
Published: 27/06/2023

Abstract

The pomegranate (*Punica granatum* L.), a plant of the Punicaceae family, is one of the first known edible fruits. To determine the impact of four levels of zinc sulphate (500, 1000, 1500, and 2000 ppm) on vegetative growth and fruit quality, this study was conducted during the 2021 and 2022 growing seasons on Manfalouty and Hejazy pomegranate cultivars in the Pomology Orchard at the Faculty of Agriculture, Assiut University. Three replicates of a factorial experiment were done following the (RCBD). The findings showed that the application of Zinc Sulfate at 2000 ppm had led to a significant effect on leaf area (cm2) and almost physical and chemical properties (excluding acidity, TSS/acid that were most affected by 500 ppm). Hence, it could be concluded that application of ZnSo4 (2000 ppm) at full bloom and a month after full bloom was the best treatment to improve vegetative, physical properties and fruit quality of Manfalouty and Hejazy Pomegranate cultivars under Assiut climatic conditions.

Keywords: spraying, micronutrients, *Punica granatum*.

Introduction

An essential fruit crop of the world's tropical and subtropical climates is pomegranate (*Punica granatum L.*). From the lowlands to elevations of up to 2,000 meters, it can be grown. It behaves as a deciduous plant in a temperate environment, but as an evergreen or partially deciduous plant in a subtropical or tropical one. Arils, the fruit's edible component, are consumed raw and can be kept as syrup or used to make jam. Secondary products like tannins, dyes, and alkaloids can be found in abundance in the fruit's rind, stem, root bark, and leaves. Pomegranate arils contain a significant amount of the antioxidant anthocyanin. Fruit's edible components are rich in polysaccharides, polyphenols, minerals, sugars, vitamins, proteins, and carbs. The quality of the fruit juice in pomegranates is mostly determined by the reducing sugars, non-reducing sugars, total sugars, acidity, ascorbic acid, and total soluble solids, among other factors. Pomegranate fruit quality has been reported to be effectively managed by the use of micronutrients (**Malhotra *et al*. 1983; Venkatesan and Mohideen, 1994**). Zinc (Zn) is a crucial trace element for plants since it participates in numerous enzymatic processes and is required for healthy growth and development. The metabolism of carbohydrates and proteins is also controlled by zinc (**Swietlik, 2010**). In this regard, **Kumar *et al*. (2016)** discovered that ZnSo4 treatment at 0.2% improved the ascorbic acid content, TSS/acid ratio, and arils/rind weight ratio, where it decreased acidity. Moreover, 0.4%. Zn impacts were found to be substantial for TSS, TSS/TA ratio, juice content of arils and leaf area by **Hasani *et al*. (2012)**. According to **Balakrishna *et al*. (1996),** foliar applications of 0.25% of zinc sulphate greatly boosted pomegranate fruit output and juice content. Moreover, foliar applications of Zn significantly increased the fruit yield of sweet oranges (**Tariq *et al*., 2007**). According to **Obaid and Al-Hadethi (2013)** findings, in the first and second seasons, respectively, pomegranate trees sprayed by 3% zinc gave the highest leaf area and fruit weight, where the control treatment yielded the lowest values for these metrics.

Hence, the purpose of this study was to evaluate the impact of Zinc Sulphate foliar spray on some characteristics of two pomegranate cultivars.

Materials and Methods

Experiment site

The current study was carried out on Manfalouty and Hejazy pomegranate cultivars grown in the research farm and laboratories of the Pomology Department, Faculty of Agriculture, Assiut, Egypt, throughout two successive seasons in 2021 and 2022.

Plant Materials

In a complete randomized block design, thirty healthy pomegranate trees of the two examined cultivars (15 trees for each cultivar, 3 trees/treatment) were chosen to carry out the following treatments:

1- Zinc sulfate at 500 ppm
2- Zinc sulfate at 1000 ppm
3- Zinc sulfate at 1500 ppm
4- Zinc sulfate at 2000 ppm
5- Control (water only)

Trees were sprayed using a Knapsack sprayer (20 L). A total volume of 5 lit. was sufficient for each tree at maximum growth. A surfactant "liquid soap" at 0.5 ml/L. was added to the spraying solutions. The spraying compounds were added twice: at full bloom (mid-May) and a month after full bloom. Each treatment consisted of 3 trees (replicates) and horticultural practices such as irrigation, soil management and fertilization have been implemented as proposed.

Vegetative measurement

Leaf area (cm^2): was measured by using the following equation as mentioned by **Ahmed and Morsy (1999)**

Leaf area (cm2) = 0.41 (Length of leaf x Width of leaf) +1.83

Physical characteristics

1- Fruit, arils and rind weight (g): by using sensitivity balance with 0.01g accuracy.

2- Juice volume (ml): by using a measuring cylinder

Chemical characters

1– Total soluble solids (TSS %): By using a hand refractometer (ATAGO N-IE).

2- Total acidity (T.A) (expressed as % Citric acid): according to **Sadler & Murphy (2010).**

The total acidity was expressed as Citric acid according to the following equation:

Acidity (%) = NaOH volume used in titration * NaOH molarity * equivalent weight of Citric acid / (1000 * Sample volume) *100

Where:

Equivalent weight of Citric acid = 64

NaOH molarity = 0.1M

Sample Vol. = 5 ml.

3- TSS / acid ratio was then calculated.

4- Reducing sugars (%): According to **Lane (1923).**

Statistical analysis

The study was designed as a randomized complete block design (RCBD) (5 treatments x 2 cultivars) with three replications for each treatment. The treatments were placed in a subplot, whereas the cultivars were placed in the whole plot. ANOVA was performed using Proc Mixed of the SAS software version 9.2 (**SAS, 2008**), and means were compared using the revised L.S.D. test at the 5% level of probability (**Steel and Torrie, 1980**).

Results

1- Leaf area (cm^2)

According to the results in (Table 1) TSS increased significantly compared to control. 2000 ppm of Zinc Sulphate recorded the highest values of leaf area (cm^2) of Manfalouty Pomegranate cultivar (11.11 and 11.10 cm^2) compared to the check treatment which recorded the lowest values (9.05 and 9.07 cm^2) during both seasons, respectively. Whereas 1500 ppm recorded the highest values for Hejazy Pomegranate cultivar (11.25 and 11.92 cm^2) compared to the check treatment which recorded the lowest values (8.45 and 8.84 cm^2) during both seasons, respectively. This finding was the same trend found by **Obaid and Al-Hadethi (2013).**

- **Fruit, arils and rind weight (g)**

All treatments significantly increased fruit, arils and rind weight compared to the control (Table 2).

2- Fruit weight (g)

The highest Zinc Sulphate concentration (2000 ppm) recorded the highest values of fruit weight of Manfalouty and Hejazy Pomegranate cultivars (434.2, 452.9 and 381.0, 402.8 g) compared to the check treatment which recorded the lowest values (339.5, 337.6 and 360.8, 356.9 g) during both seasons, respectively.

3- Arils weight (g)

Spraying Zinc Sulfate at 1500 ppm recorded the highest values of arils weight for Manfalouty cultivar (277.6 and 307.4 g) compared to the check treatment which gave the lowest values (239.3 and 238.3 g), where at 2000 ppm recorded the highest values for Hejazy cultivar (246.6 and 278.2 g) compared to the check treatment which gave the lowest values (215.5 and 241.8 g) during both seasons, respectively.

Table (1): Effect of foliar application with Zinc Sulfate on leaf area, fruit weight and arils weight of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.

Treatments / cultivars	leaf area (cm2) *				Fruit weight (g)**				Arils weight (g)**			
	Manfalouty		Hejazy		Manfalouty		Hejazy		Manfalouty		Hejazy	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Zinc Sulfate 500 ppm	9.99	9.48	10.21	10.88	410.6	424.4	344.3	375.1	264.0	293.8	225.3	249.7
Zinc Sulfate 1000 ppm	10.07	10.05	9.63	10.76	410.4	386.6	363.9	389.2	258.2	270.9	233.0	264.6
Zinc Sulfate 1500 ppm	11.04	10.52	11.25	11.92	433.3	448.7	367.3	396.8	277.6	307.4	238.9	263.3
Zinc Sulfate 2000 ppm	11.11	11.10	10.68	11.80	434.2	452.9	381.0	402.8	271.8	284.5	246.6	278.2
Control (water only)	9.05	9.07	8.45	8.84	339.5	337.6	360.8	356.9	239.3	238.3	215.5	241.8
L.S.D 0.05	0.20	0.16	1.06	1.12	66.3	42.3	13.0	16.2	24.1	27.7	16.5	6.2

- The values shown are means of Three replicates (trees) (30 samples/ each replicate)

** The values shown are means of Three replicates (trees) (3 samples/ each replicate).

Table (2): Effect of foliar application with Zinc Sulfate on rind weight, juice volume and TSS of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.

Treatments / cultivars	Rind weight (g)				Juice volume (ml)				TSS (%)			
	Manfalouty		Hejazy		Manfalouty		Hejazy		Manfalouty		Hejazy	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Zinc Sulfate 500 ppm	146.6	130.6	119.0	125.4	219.4	230.2	160.1	191.8	17.06	17.04	17.09	17.17
Zinc Sulfate 1000 ppm	152.2	115.7	130.9	124.6	204.6	200.8	183.1	202.8	17.04	17.16	17.11	17.16
Zinc Sulfate 1500 ppm	155.7	128.4	128.4	133.5	233.0	243.8	173.7	205.4	17.16	17.19	17.13	17.11
Zinc Sulfate 2000 ppm	162.4	141.3	134.4	134.0	218.2	214.4	196.7	216.4	17.09	17.07	17.16	17.20
Control (water only)	100.2	99.3	105.3	105.1	178.1	181.9	149.1	131.2	16.77	16.75	16.77	17.04
L.S.D 0.05	36.6	10.6	11.9	15.1	15.2	14.4	9.7	6.8	0.11	0.16	0.20	0.03

The values shown are means of Three replicates (3 samples/ each replicate).

4- Rind weight (g)

Rind weight takes the same path as fruit weight where the highest Zinc Sulfate concentration (2000 ppm) recorded the highest values of both cultivars (162.4, 141.3 and 134.4, 134.0 g) compared to the check treatment, which gave the lowest values (100.2, 99.3 and 105.3, 105.1g) during both seasons, respectively.

The findings of fruit weight are similar to those reported by **Babu and Singh (2001)** in litchi, and **Davarpanah *et al.*, (2017)** in pomegranate where the findings of arils and rind are consistent with the findings of **Yadav *et al*., (2018), Kumar et al., (2016), Singh *et al*. (1990), Zhang and Whiting (2011), and Khalil & Aly (2013).**

In terms of juice volume, spraying Zinc Sulphate 1500 ppm recorded the highest values for Manfalouty cultivar (233.0 and 243.8 ml) compared to the check treatment which gave the lowest values (178.1 and 181.9 ml), while treatment 2000 ppm recorded the highest values for Hejazy cultivar (196.7 and 216.4 ml) compared to the check treatment which gave the lowest values (149.1 and 131.2 ml) during both seasons, respectively.

The findings of juice volume did not match those reported by **Yadav *et al*., (2018).**

5- TSS (%)

All treatments significantly increased TSS increased significantly compared to the control (Table 3). 1500 ppm of Zinc Sulphate recorded the highest values of TSS of Manfalouty Pomegranate cultivar (17.16 and 17.19 %) compared to the check treatment which recorded the lowest values (16.77 and 16.75 %) during both seasons, respectively.

On the other hand, 2000 ppm recorded the highest TSS values for Hejazy cultivar (17.16 and 17.20 %) compared to the check treatment which gave the lowest values (16.77 and 17.04 %) during both seasons, respectively.

6- Acidity (%)

In terms of acidity, there was no significant variation between all treatments and control. Results showed that 500 ppm recorded the lowest acidity values for Manfalouty and Hejazy cultivars (0.78, 0.88 and 0.88, 0.91 %) compared to the check treatment which gave the highest values (1.11, 1.17 and 1.17, 1.22 %) during both seasons, respectively.

7- TSS/ acid

TSS/ acid behaves the same path of acidity (with significant differences between treatments and control), where 500 ppm recorded the highest values for Manfalouty and Hejazy cultivars (21.86, 19.36 and 19.42, 18.87) compared to the check treatment which gave the lowest values (15.11, 14.32 and 14.33, 13.97) during both seasons, respectively.

8- Reducing sugars (%)

Finally, reducing sugars followed the same way as TSS, where spray at 1500 ppm recorded the highest reducing sugars values for Manfalouty cultivar (10.13 and 10.16 %) compared to the check treatment which gave the lowest values (9.61 and 9.60 %), where at 2000 ppm recorded the highest values for Hejazy cultivar (10.13 and 10.15 %) compared to the check treatment which gave the lowest values (9.61 and 9.76 %) during both seasons, respectively.

The findings of (TSS and sugars contents) are conflict with those found by **Kumar *et al*., (2016)**, while the findings of (acidity and TSS/acid) are in agreement with the same researcher. Where they were concomitant with the findings of **Yadav *et al*., (2018)** in terms of TSS, where they were in conflict with the same researcher in terms of acidity, TSS/acid and sugars content.

Table (3): Effect of foliar application with Zinc Sulfate on acidity, TSS/ acid and reducing sugars of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.

Treatments / cultivars	Acidity (%)				TSS/ acid				Reducing sugars (%)			
	Manfalouty		Hejazy		Manfalouty		Hejazy		Manfalouty		Hejazy	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Zinc Sulfate 500 ppm	0.78	0.88	0.88	0.91	21.86	19.36	19.42	18.87	10.10	10.07	10.09	10.02
Zinc Sulfate 1000 ppm	0.78	0.89	0.89	0.92	21.85	19.28	19.22	18.65	10.07	10.13	10.10	10.13
Zinc Sulfate 1500 ppm	0.84	0.93	0.92	0.93	20.43	18.48	18.62	18.40	10.13	10.16	10.12	10.03
Zinc Sulfate 2000 ppm	0.83	0.90	0.93	0.97	20.59	18.97	18.45	17.73	10.11	10.10	10.13	10.15
Control (water only)	1.11	1.17	1.17	1.22	15.11	14.32	14.33	13.97	9.61	9.60	9.61	9.76
L.S.D 0.05	0.04	0.05	0.05	0.04	0.54	0.43	0.47	0.63	0.22	0.24	0.26	0.30

The values shown are means of Three replicates (3 samples/ each replicate).

Discussion

Zinc influences fruit output and quality through enzyme activation, cell wall strengthening, and cell division.

The increase in fruit weight could be attributed to a faster rate of cell division and cell enlargement, resulting in higher metabolite accumulation in the fruit (**Babu and Singh, 2001**).

According to the results of **Hasani *et al*., (2012),** the difference in the number of arils per fruit owing to the administration of different micronutrients could be attributable to an increase in fruit weight.

The variation in the number of arils per fruit due to application of different micronutrients might be due to an increase in fruit weight and fruit diameter as shown by the result of **Hasani *et al*., (2012)**.

The improvement in fruit quality could be attributed to the fact that micronutrients have a direct role in plant metabolism, as zinc is required in enzymatic reactions such as hexokinase, carbohydrate production, and protein synthesis (**Pamila et al., 1992**).

The decrease in acidity could be attributed to the accumulation of reducing and non-reducing carbohydrates (**Davarpanah *et al*., 2017**). Consequently, zinc, boron, and iron increased fruit quality in terms of TSS, total sugar, and reducing sugar.

Conclusions

Application of $ZnSo_4$ at 2000 ppm full bloom and a month after full bloom was the best to improve almost vegetative, physical properties and fruit quality of Manfalouty and Hejazy Pomegranate cultivars under Assiut climatic conditions.

Conflicts of Interest/ Competing interest

All authors declare that they have no conflicts of interest.

Data availability statement:

All data sets collected and analyzed during the current study are available from the corresponding author on reasonable request.

List of Abbreviations

RCBD Randomized complete block design.
T. A Total acidity
TSS Total soluble solids

Fig. (1): Effect of foliar application with Zinc Sulfate on leaf area, fruit weight and arils weight of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.

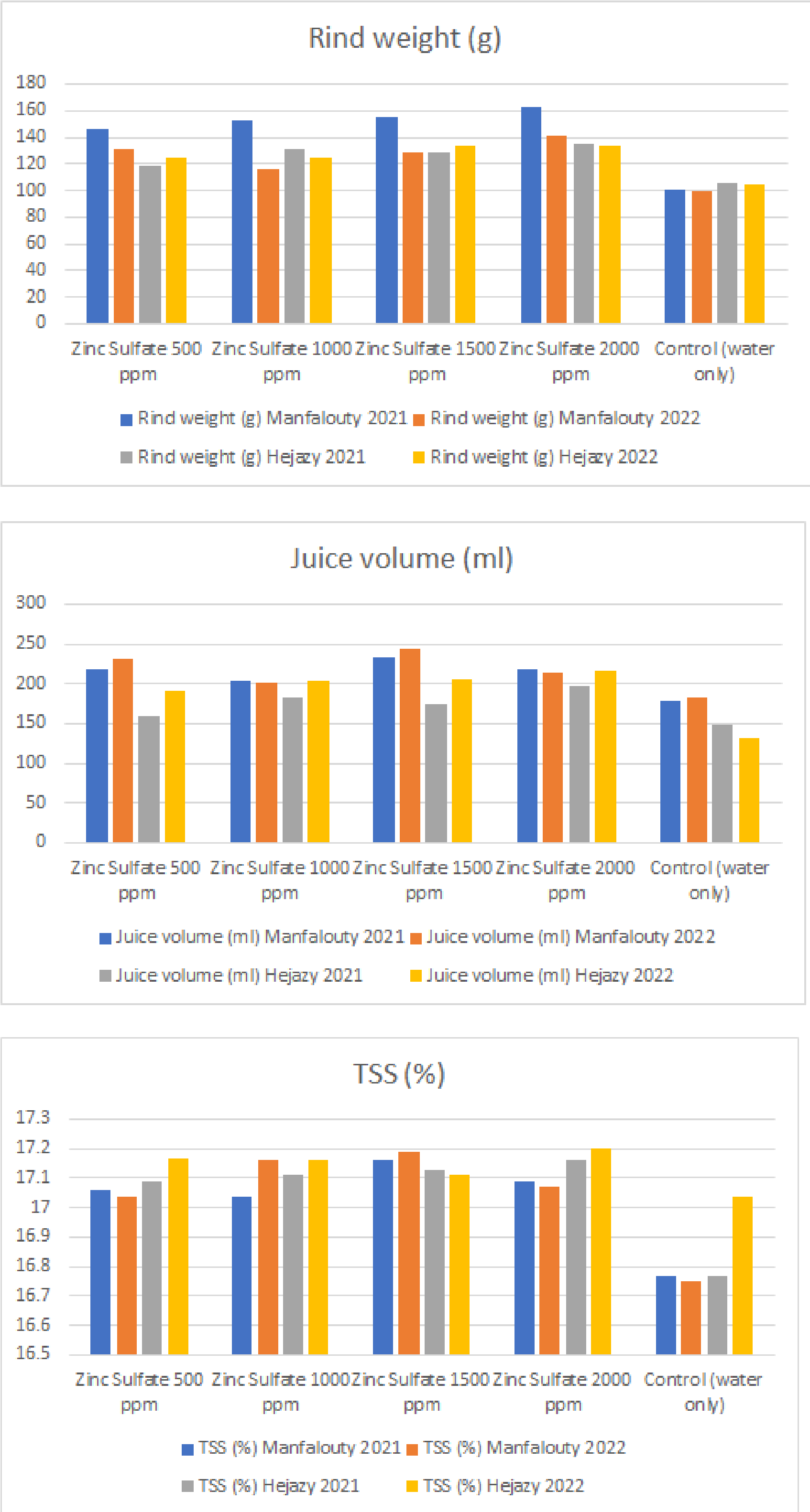
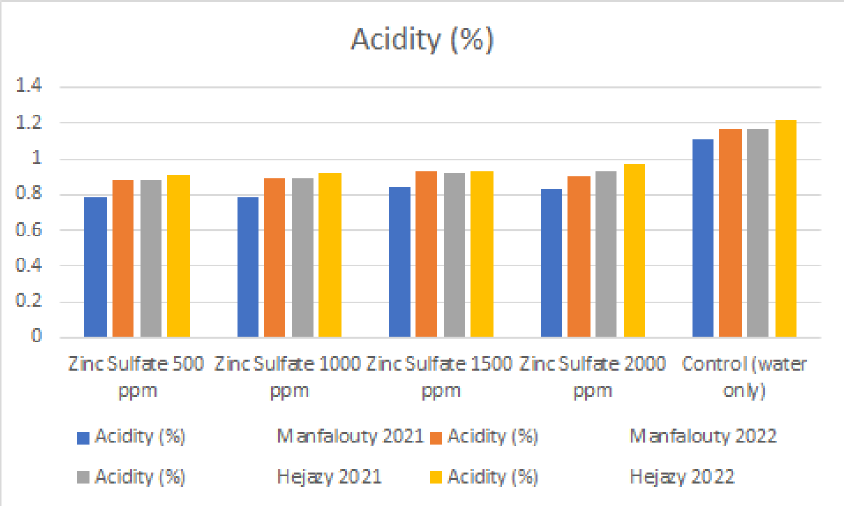
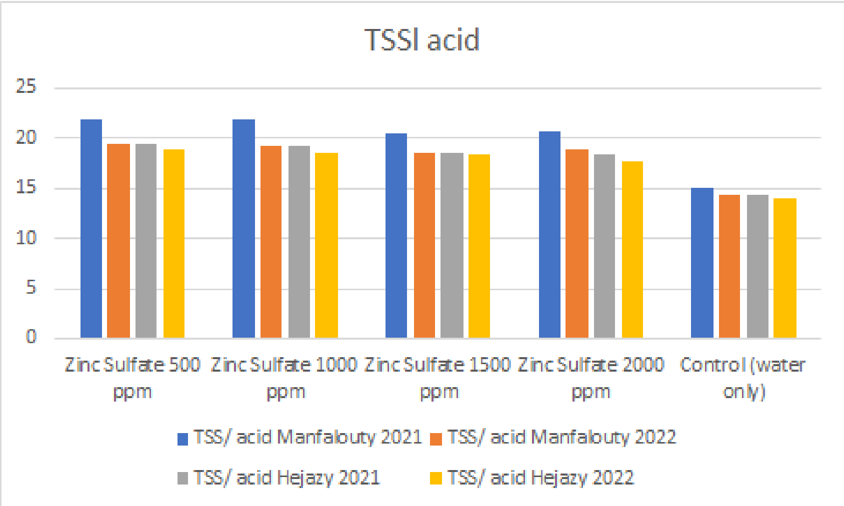


Fig. (2): Effect of foliar application with Zinc Sulfate on rind weight, juice volume and TSS of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.





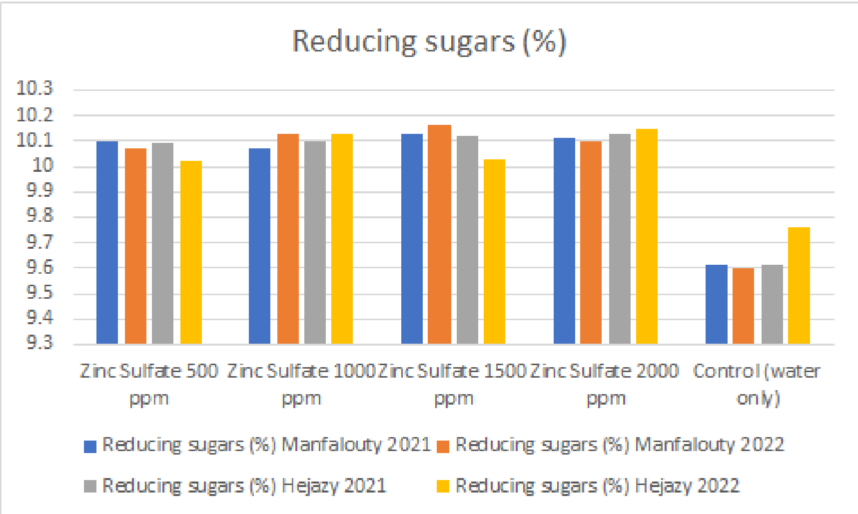


Fig. (3): Effect of foliar application with Zinc Sulfate on acidity, TSS/ acid and reducing sugars of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.

References

Ahmed, F. F., & Morsy, M. H. (1999). A new method for measuring leaf area in different fruit species. *Minia Journal of Agricultural Research and Development (Egypt)*.

Babu, N., & Singh, A. R. (2001). Effect of foliar application of boron, zinc and copper on chemical characteristics of litchi fruits. *Bioved*, *12*(1/2), 45-48.

Balakrishna, K., Vekatesan, K., & Sambandamurthi, S. (1996). Effect of foliar application of Zn, Fe, Mn and B on yield quantity of pomegranate, cv. *Ganesh. Orissa. J. Hor*, *24*, 33-35.

Davarpanah, S., Aakari, M., Babalar, M., Zarei, M., & Aghayeh, R. (2017). Effect of foliar application of phosphorus, potassium and iron on physical and chemical properties of pomegranate fruit. *Jordan Journal of Agricultural Sciences*, *13*(3).

Hasani, M., Zamani, Z., Savaghebi, G., & Fatahi, R. (2012). Effects of zinc and manganese as foliar spray on pomegranate yield, fruit quality and leaf minerals. *Journal of soil science and plant nutrition*, *12*(3), 471-480.

Khalil, H. A., & Aly, H. S. (2013). Cracking and fruit quality of pomegranate (Punica granatum L.) as affected by pre-harvest sprays of some growth regulators and mineral nutrients. *Journal of Horticultural Science & Ornamental Plants*, *5*(2), 71-76.

Kumar, K., Joon, M. S., Yadav, R., & Daulta, B. S. (2016). Effect of growth regulators and micronutrients on fruit quality in pomegranate. *International Journal of Environment, Agriculture and Biotechnology*, *1*(4), 238578.

LANE, J. H. (1923). Determination of reducing sugar by means of Fehling's solution with methylene blue as internal indicator. J. Soc. Chem. Ind., 17, 32-37.

Malhotra, V. K., Khajuria, H. N., & Jawanda, J. S. (1983). Studies on physico-chemical characteristics of pomegranate cultivars. I: Physical characteristics. *Punjab Hort. J*, *23*, 153-157.

Obaid, E. A., & Al-Hadethi, M. E. A. (2013). Effect of foliar application with manganese and zinc on pomegranate growth, yield and fruit quality. *J. Hortic. Sci. Ornam. Plants*, *5*(1), 41-45.

Pamila, S., Chatterjee, S. R., & Deb, D. L. (1992). Seed yield, harvest index, protein content and amino acid composition of chickpea as affected by Sulphur and micronutrients. *Annals of Agriculture Research*, *3*(1), 7-11.

Sadler, G. D., & Murphy, P. A. (2010). pH and titratable acidity. Food analysis, 4, 219-238.

SAS Institute, I. (1999). The SAS system for Windows. *Release 8.0 SAS Institute*.

Singh, R. P., Sharma, Y. P., & Awasthi, R. P. (1990). Influence of different cultural practices on pre-mature fruit cracking of pomegranate. *Progressive Horticulture*, *22*(1-4), 92-96.

Steel, R. G. D., & Torrie, J. H. (1980). *Principles and procedures of statistics, a biometrical approach* (No. Ed. 2). McGraw-Hill Kogakusha, Ltd..

Steel, R. G. D., & Torrie, J. H. Principles and procedures of statistics, a biological approach, 1980.

Tariq, M., Sharif, M., Shah, Z., & Khan, R. (2007). Effect of foliar application of micronutrients on the yield and quality of sweet orange (Citrus sinensis L.). *Pak. J. Biol. Sci*, *10*(11), 1823-1828.

Venkatesan, K., & Koder Mohideen, M. (1994). Effect of growth regulators on fruit characters and yield of pomegranate (Punica granatum L) cv. Ganesh. *South Indian Horticulture*, *42*, 239-244.

Yadav, V. K., Jain, M. C., Sharma, M. K., & Suman, M. (2018). Effect of micronutrients spray on physical and chemical characteristics of pomegranate (Punica granatum L.) cv. Sindhuri. *International Journal of Current Microbiology and Applied Science*, *7*, 998-1005.

Zhang, C., & Whiting, M. D. (2011). Improving 'Bing'sweet cherry fruit quality with plant growth regulators. Scientia Horticulturae, 127(3), 341-346.