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Diagnosis and Remedy of Boron deficiency in Valencia Orange trees under Two Different Sites conditions

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Abstract

This study was carried out during three consecutive (2016/019) experimental seasons on 15- year-old fruitful Valencia orange trees (*Citrus sinensis L. Osbeck*) Olinda cv., budded on Volkamer lemon rootstock, grown in reclaimed soil at two sites (**South of El Tahreer& West of Al Nubaria** regions) under drip irrigation system (Nile water) and subjected to the same cultural practices. This work aim to study the role of Boron in fruitful Valencia orange trees during the 1st season through an exploratory study at the 1st season (phase "I"), then using foliar application of different Boron sources (Boric acid at 1% ; Boron / Molybdenum compound at 1% ; Mulase "CM" at 3ml / L., and Boric acid at 1% + Mulase " CM" at 3ml / L. and control treatment, at the suitable stage to compensate Boron deficiency during the other two seasons (phase "II"). Results indicated that, there is a fluctuation in Leaf Boron content (ppm) from one site to another during the phase "I" of the study for both sites, whereas, at the 1st site seemed to be constant during the most samples (from 10 to 20 ppm) and slightly reduction (<10 ppm) in March and May samples then have sharply increased (> 50 ppm) for October sample. On the other hand, leaf Boron content under "Site II" conditions was higher (from 30 to 40 ppm) than the site"I" (from 10 to 20 ppm).Moreover, it has increased during February (up 30 ppm), then sharply reduced at the March sample (<5 ppm), then increased from October to December samples (from 30-40 ppm). Regarding phase "II" experiment: Both Boric acid or CMs or Boric acid plus CMs applications significantly increased leaf B contents, improved root Mycorrhiza fungi Colonization at root area horizontal, increased tree yield productivity, fruit juice total soluble solids and reduced total Acidity. Moreover, Boron/Molybdenum compound was the most treatment for increasing juice Vitamin C contents, while the control treatment has a lower rank if compared to other treatments under study.

Keywords: Valencia orange; Mycorrhiza; Boron; Boric acid; Mulase.

1. Introduction

Boron (B) is one of the essential micronutrients for various physiological metabolisms in plant. Borontoxicities appear under arid and semiarid regions conditions, particularly when irrigated with water that has high Boron content [1]. Under Boron deficiency conditions, soil application of boric acid provides Boron requirements for various metabolism processing, absorbed Boron by hairy roots translocated directly to other parts of the tree [2]. Understanding the responses of citrus trees to the low availability of Boron may help the development of tolerant cultivars and proper management for citrus orchards. Due to the alkalinity of Egyptian soil particularly under new reclaimed land conditions, there is a high percentage of calcium carbonate, in addition to using well water for citrus irrigation, the Boron deficiency commonly in citrus leaves during fruiting, which causes economic loss and affects the fruit quality.

The deficiency symptoms are deformation in young leaves and corky split veins in mature leaves, as well as early leaf senescence. Also, the tree vigor declines speedily after the fruit set, which negatively affects fruit yield and quality in the coming years [3].Previous studies showed that soil or foliar

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application of boron increases fruit yield and improves fruit quality [4]. While, Boron application could cause Boron toxicity, due to the requirement of citrus trees is a very slight of Boron[5]. Till now, there is no sufficient information on the effect of Boron deficiency on photosynthetic enzymes, carbohydrates, as well as the antioxidant system of citrus leaves.

The objectives of this study were to determinethe suitable time for Boron applications under the two sites conditionsto overcome the Boron problem in the largest area cultivated by Valencia orange cultivar in Egypt and applier that recommendation to the same conditions.

2. Material and methods

This investigation was carried out over three consecutive years (2016/2017, 2017/2018 & 2018/2019) experimental seasons on15 years old fruitful trees of Valencia orange (*Citrus sinensis L. Osbeck*) Olinda cultivar budded on Volkamerlemon stock planted at 4×5 M and grown in reclaimed soil **Table (1a&b)** under drip irrigation system with Nile water, (subjected to the same cultural practices such as: irrigation, weeding, insect pest, and disease control in the two separate sites. The 1st site located at Badr-District-Al Buhira Governorate "Site I "the other orchard located atAl Nubaria region (west of Cairo/Alex. desert Road), Egypt "Site II". During the 1st season ten homogenous Valencia orange trees for the two sites (five trees/site) were selected at the fruit mature stage (Nov. 2016 season). Leaf samples monthly were gathered for 12 months from "January to December 2017" without any treatment applications, **(this experiment named as exploratory studies to estimate leaf Boron content during full season "phase I")**. Leaves samples were carefully taken out from the plants, washed several times with tap water followed by distilled water and wipe it with Blotting paper, then quitted it to dry in the air for some minutes. Samples were dried in an oven at 70° C for constant weight. Then samples were ground to a fine powder and ached at 500 °C for 5 h, followed by dissolving the ashes in 0.1M HCl. Boron contents in leaveswas measured at 540 nm Spectro-photo-metrically (**Model- Beckman Du 7400**), according to the Azomethine-H colorimetric method [6, 7, 8].

Table (1a): Physical characteristics of the tested soil.

Sample No.	The size distribution of soil particles (%)			Textures
	sand	silt	clay	
Site I	85.5	13	1.5	Sandy
Site II	83.5	15	1.5	Sandy loam

Table (1b): Chemical characteristics of the tested soil.

Sample No.	pH 1:2.5	EC (dS/m)	SP	Anions (meq/ liter)				Cations (meq./ liter)				Boron (mg/kg)
				CO_3^-	HCO_3^-	Cl	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+	
Site I	8.31	0.94	23.0	--	0.5	6.5	2.38	2.5	1.5	5.2	0.18	0.02
Site II	8.33	0.96	25.0	--	0.5	6.5	2.57	2.5	1.5	5.30	0.22	0.02
Opt.	7.0±0.5	1-2		--	--	- 6	--	0.3	0.3	0.3	--	--

As for the exploratory studies results, it can be determining the suitable time and the best Boronrateand sourceto investigate the influence of foliar spray with three Boron sources i.e., Boric acid (H_3BO_3), Boron / Molybdenum compound and Mulase (Sugar cane bye-product "CM") either each was applied solely or in combination, beside Nile water spray (control). So, the investigated spray treatments were as follows**"phase II":**

1- Nile water sprays (the control).
2- Boric acid at 1% conc.
3- Boron / Molybdenum compound at 1% concentration.
4- Mulase "CMs" at 3ml / L.
5- Boric acid at 1% conc. + Mulase "CM" at 3ml / L.

As a result of Exploratory studies in two experimental sites, spraying process was carried out in Aprilfor **site "I"** and mid of February at **site "II"**. The suitable dose and the number of applications of Boroncomponents recourses that during the second and third seasons **phase "II"**.

- **Experimental analysis:**

After conducting different treatments at each site, leaf samples were taken in mid-September from the leaves of the mature spring cycle as is common in citrus trees, processing and digesting them for the estimation of Boron in them as previously mentioned according to [6, 7, 8]. Soil samples were taken from both sites containing rootsfibrous for evaluation the microbial load of Mycorrhiza fungus because of this fungus on the soil with the state of Boron in citrus

trees, this is consistent with [9] suggested that foliar application of Boron stimulated the efficacy of citrus Mycorrhiza symbiosis, keeping in mind that no treatment with this fungus has been done before in both sites according to [10].At ripening stage "March- April", tree yield was estimated, and sample of fruits were collected to determine some fruit properties as: juice Vitamin C. content**,** total soluble solids (TSS%) and total acidity according to [11].

- **Statistical analysis:**

The investigation was planned out as a factorial experiment in a complete randomized block design. Each treatment was represented by3 replicates with 2 trees per a replicate. The statistical analysis of the present data was carried out as indicated by [12]. Significant differences among the means of various treatments were compared by LSD at 5% level of probability. Data were analysed by MSTAT-C.

3. Results and Discussion

A) Exploratory studies "phase I":

Valencia orange leaf content of Boron was estimated monthly during the exploratory season in both experimental sites. Data in Fig. (1) revealed that, there was variability in leaf Boron (ppm) content from site to another. Whereas, at "Site I", there was slightly reduced (<10 ppm) at March and May samples, on the contrary there was excessive increasing (> 50 ppm) in October sample, while, there was a stability in leaves Boron content in other samples(from 10 to 20 ppm),On the other hand, leaf Boron content under "Site II" conditions was higher (from 30 to 40 ppm) than the site" I" (from 10 to 20 ppm), furthermore, the fluctuation is clear in leaf Boron content from February whereas it has increase (> 30 ppm), then sharply reduced at March sample (<5 ppm), while leaf Boron content is stable till September samples and increases again from October to December samples (from 30-40 ppm).

Soil type could play important role in plant nutrition, soil analysis for both experimental sites (Tables 1a & b) indicated that there was a difference in soil physical texture, for instance site "I" has sandy soil, and Site "II" Sandy loam. While chemical analysis of soil was nearly similar for both sites. This mean that soil characters play a significant role in nutrient availability and elements uptake.

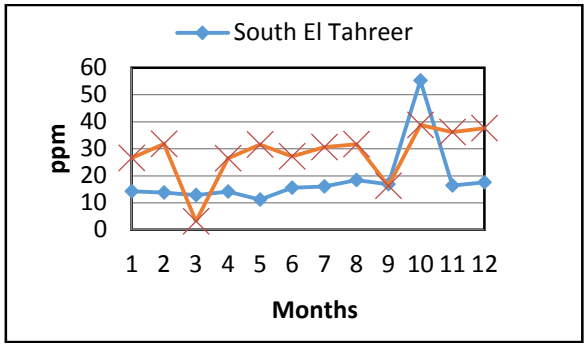

Figure (1): Valencia orange Leaves B (ppm) monthly content during the primer season under South El Tahreer"site I"and Al Nuparia "site II"conditions.

B) The main experiment "phase II":

a. Leaf B content and Root Mycorrhiza fungi Colonization activity:

Regarding leaves B content, data in Fig. (2) indicated that foliar application of boric acid at 1% gave the highest effect with significant value of B content (20.30 & 17.50) ppm at the 1st site. While, in the 2nd site, CMs treatment has the highest values (39.27 &47.05) ppm respectively when compared with the control treatment which has the lowest for both seasons.

Previous results were in agreement with [13] who found a significant increase in the value of Boron in the leaves of 'Kinnow' mandarin trees, budded on Rough Lemon (*Citrus jambiri L.*) after the foliar application by different sources of Boron to treated deficiency, he showed that boric acid was the best treatment, in addition, he indicated that foliar application of Boron could compensated the deficiency in leaves contents.

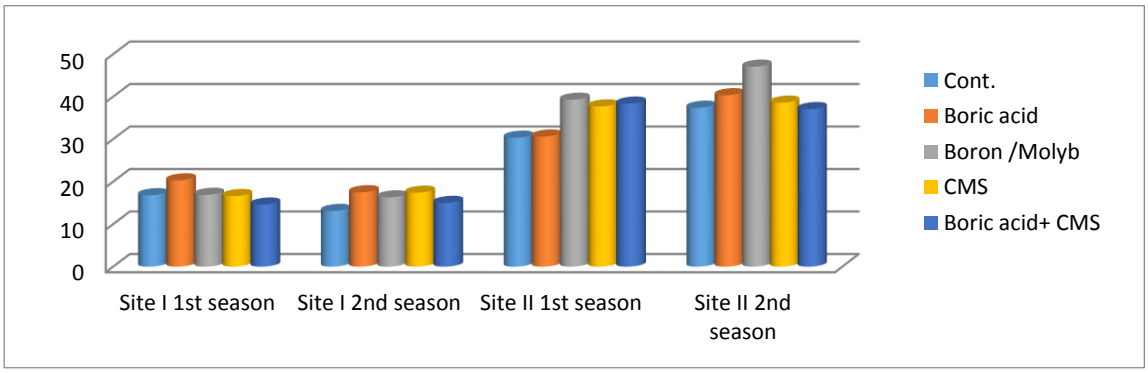

Figure (2): Effect of some Boron sources on leaf Boron content of Valencia orange trees for the two sites during (2017/018 and 2018/019) seasons.

Data in Fig. (3) showed that Boric acid treatment stimulates Mycorrhiza fungi colonization roots of Valencia orange trees for both studied sites and there is a significant increment (63.03, 64.17 in site I and 65.93, 67.27 % in site II) in comparison to the control (25.25, 24.13 in site I and treatment with B/Mo combined 24.68, 25.2 % in site II) during the two seasons, while the other treatments provide moderate increasing.

It can be concluded that boric acid treatments increase Boron absorption due to the acidity of Boric acid which stimulates Boron uptake by leaves, furthermore, there was a positive correlation between leaf Boron content and Mycorrhiza fungi Colonization activity in the root area of citrus trees.

Our results in the same line with [14] who found that inoculation of *Acaulospora Morrowae, G. clarum,* and *G. etunicatum* enhancing the growth of Cleopatra mandarin cv. and increased shoots Boron contents. In addition, mannitol–B complex mobility has been observed in mycorrhiza mycelium, which allows the continuous uptake and translocate of B in plants.

b- Tree yield productivity and fruit juice Vit. C contents:

Date in Fig. (4) explaining the significant differences between the various treatments under the two sites for this study. Whereas Boric acid applications produce the highest tree yield (kg) in the 1st site (118.5&117.6 kg) during the two seasons. While Boric acid+ CMS treatment in the 1st season (79.4 kg) and the control (78.43 kg) in the 2ndseason were the lowest, respectively.

Regarding the 2nd site, data presented in Fig. (4) revealed that (B /Mo) treatment was the best for tree yield production (131.0 kg) in the 1st season and CMs (130.0 kg) in the 2nd season. While the control treatment was the lowest (95.27 &94.30 kg) for both seasons.

Moreover, data in Fig. (5) illustrated that, B/Mo combined increased significantly juice Vit. C (58.20 &60.37 and74.37 & 75.03 mg/100g) values respectively for both experimentally sites and during the two seasons. Whereas Boric acid treatment was the lowest (52.93 & 49.21 mg/100g) in the 1st site and the Boric acid plus CMs treatment (65.43 &66.51 mg/100g) in the 2nd site during both experimental seasons.

Generally, Valencia orange trees were more productivity and higher in Vit.C contents under site "II" conditions than the site "I", this may be due to orchard management efficiency. these foundations are agreement to [15]who found Boric acid at 0.2 % was more effective in increasing TSS %, and vitamin C content than all other treatments in Washington navel orange (*Citrus sinensis* L. Osbeck) trees in response to spraying boric acid (H_3BO_3) under El-Qalyubeia Governorate Egypt conditions.

Boron may cause an increase in the Valencia orange yield, due to the ease of movement of the sugar molecule through the cell membranes, after combining with Boron, which then allows the transport of carbohydrates from the leaves the places where they are produced to the places where they are stored in the roots and then to the fruits that return on the yield in the end, and that agrees with [16] who agreed that Boron foliar applications positively improved tree yield and fruit quality and increased producers return.

b- Some fruit juice chemical characters:

Regarding influence of applications of various Boron sources on Valencia orange juice TSS, acidity at both experimental sites, data tabulated in figures (6, 7, 8) confirmed the following results:

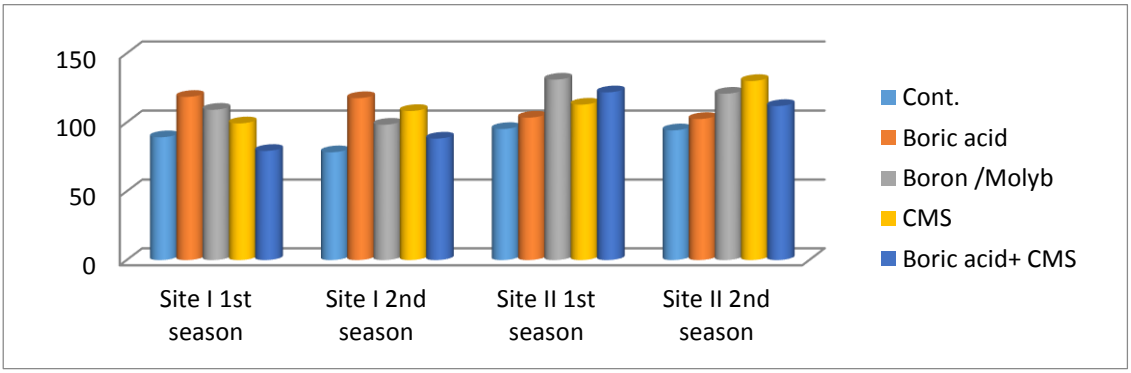

Figure (3): Effect of some Boron sources on root Mycorrhiza fungi Colonization (%) of Valencia orange trees for the two sites during (2017/018 and 2018/019) seasons.

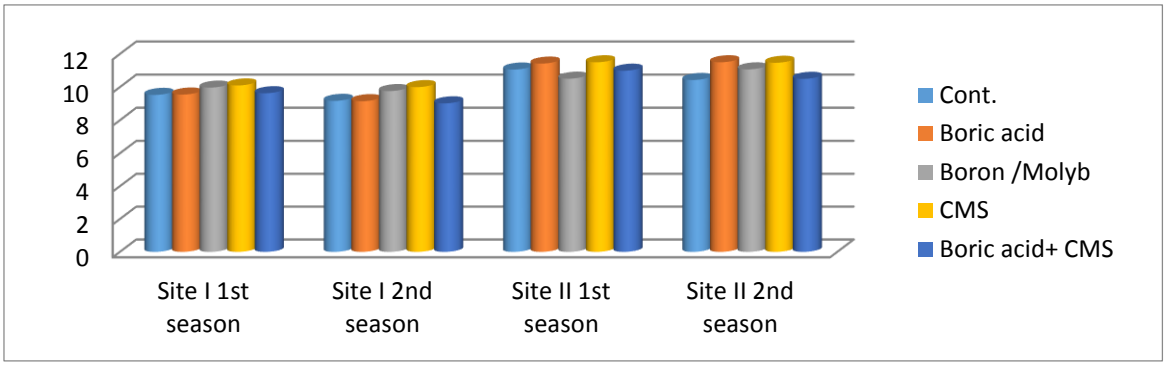

Figure (4): Effect of some Boron sources on yield (kg/tree) of Valencia orange trees for the two sites during (2017/018& 2018/019) seasons

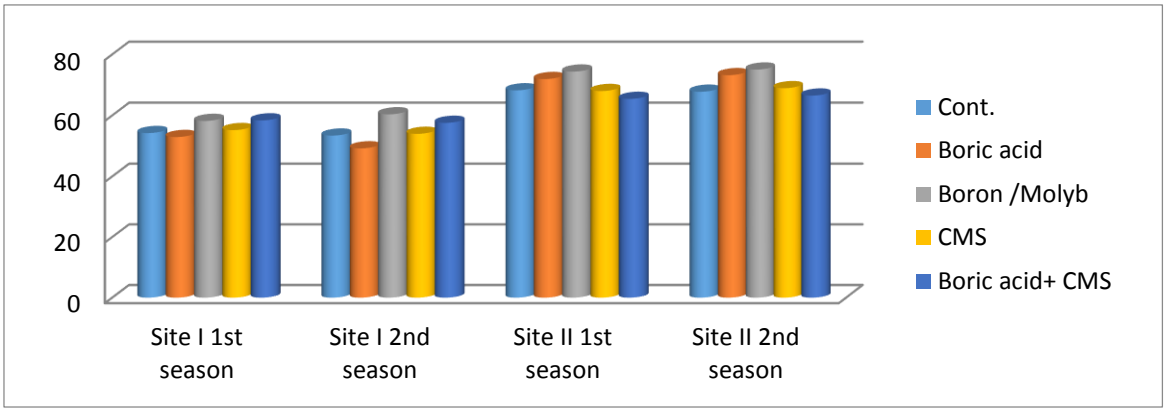

Figure (5): Effect of some Boron sources on Vit.C (mg/100g) of Valencia orange trees for the two sites during (2017/018& 2018/019) seasons

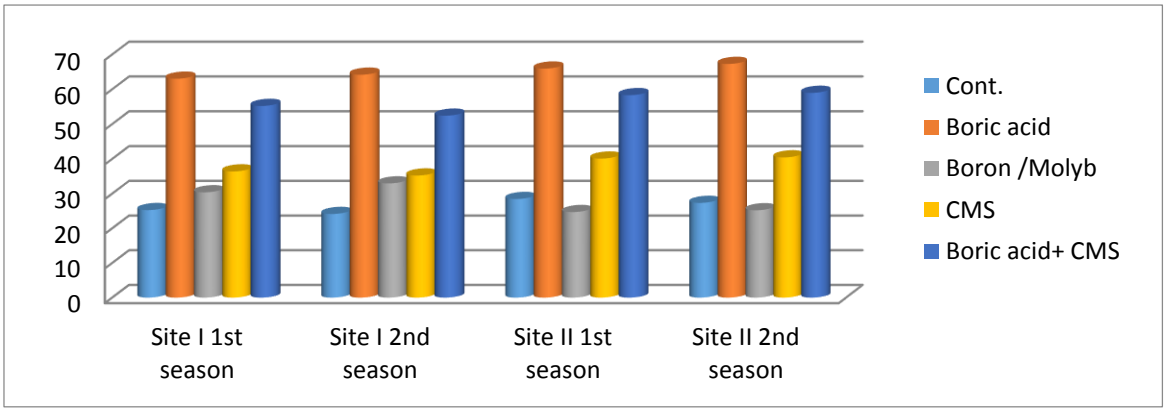

Figure (6): Effect of some Boron sources on total soluble solids in fruit juice during (2017/018 & 2018/019) seasons.

- **Site "I":**

CMs treatment significantly increased fruit juice TSS % (10.10&10.00) in compared to the control treatment which was the lowest for both seasons. Despite all treatments under study had insignificant effect on fruit juice acidity in the 1st season, while Boric acid treatment significantly reduced total acidity (0.84 %) and CMs treatment was the highest (1.15 %) in the 2nd season, in addition CMs treatment increased significantly juice TSS/Acid ratio (12.17) in the 1st season.

Data in Fig. (6) showed that there is a variation of the total soluble solid caused by the different applications, furthermore, Boron plus molybdenum and CM treatments gives the highest significant value in the 1st and 2nd seasons (9.97, 10.1, 9.76, and 10.0) respectively, while the other treatments have no significant effect in both season and B/Mo treatment

(10.97) in the 2ndseason. Except that, Boric acid plus CMs treatment significantly reduced TSS/Acid ratio (9.44) in the 1st season and CMs treatment only (8.70) in the 2nd season.

- **Site "II":**

Data in Figures (6,7& 8) clearly gave the same trend for the effect of treatments on Valencia orange juice TSS, acidity and TSS/Acid ratio at Site "I".
Whereas, either Boric or CMs treatments increased TSS%, reduced Acidity % and increased TSS/ Acid ratio, while the control treatment gave the lowest values of TSS/Acid ratio and highest acidity values during the two seasons.

Practically, it is well known that TSS/acid ratio consider the main aspect for citrus fruit harvesting for the most orange producers. so, as previous results showed, it was noticed that Valencia orange under the Site "II" conditions gave TSS/acid ratio values lower than that at Site "I", consequently, harvesting stage in the Site "II" will be later than whom in the Site "I". These results are harmony with [17, 18]who obtained that all different B sources applications significantly improved fruit quality and the most of juice characters as TSS, acidity, Vit.C content, and total sugars.

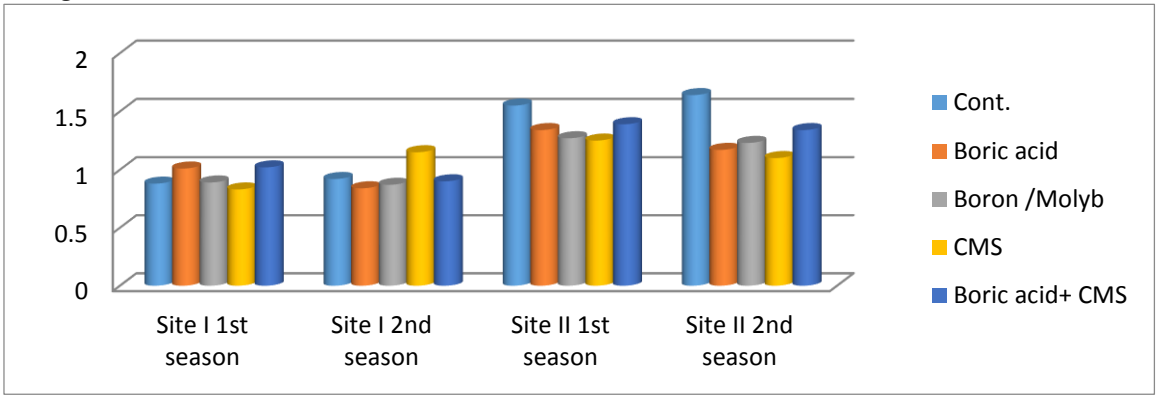

Figure (7): Effect of some Boron sources on acidity of fruit juice during (2017/018 & 2018/019) seasons.

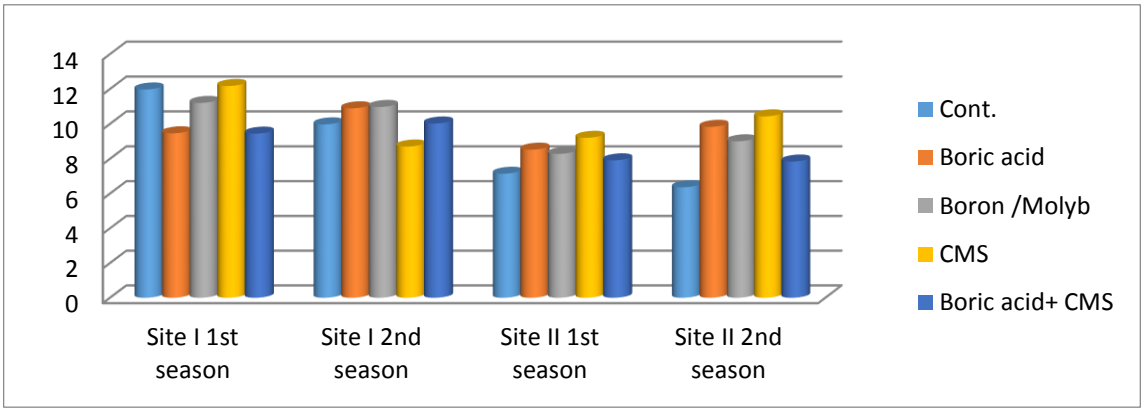

Figure (8): Effect of some Boron sources on TSS/ Acid ratio in fruit juice during (2017/018 & 2018/019) seasons.

4. Conclusions

Through the study, it becomes clear to us that each geographical area must have its own independent studies to find out the appropriate time to conduct the correct fertilization process at the right time. The study revealed that Boron and its available forms in the soil are among the main elements that determine the activity of some microorganisms growing on citrus roots. Boron is one of the basic and crucial elements to produce orange trees in Valencia. Determining the optimal time and appropriate dose for fertilizing with boron is one of the determining factors for the success of compensating for the deficiency of this element without reaching the toxicity of this element.

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