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Effect of Some Foliar Applications of Nutrients on Fruit Set and Yield of Valencia Orange Trees in Newly Grown Orchards

R. A. Abdel-Aziz and A. M. El-Azazy
Horticulture Research Institute, Agricultural Research Centre, Cairo, Egypt.

THE RECENT investigation was conducted in two successive seasons 2012 & 2013 in commercial citrus orchard of 5-year-old Valencia orange (Citrus sinensis L. Osbek).Trees grafted on Volkamer lemon (*Citrus Volkameriana)* rootstock planted on 6 x 4m apart and located in Kafr Daoad, Behira gov., Egypt. The objective was to study the effect of spraying trees, three times; during winter time (mid of January) , full bloom and after two weeks with eight treatments of low biuret urea (LBU 1%), amino acids (AA 1%), calcium-boron (Ca-B 1.5%) and their combinations on the formation of inflorescences leaves, tree canopy volume, fruit set%, some fruit physical characteristics and the final yield. The combination of (LBU1%+Ca-B1.5%+AA1%) showed the best results with all the studied parameters in particular leafy inflorescence density and final yield.

Keywords: Valencia Orange, nutrition, low biuret urea, amino acids, foliar spray.

Valencia orange orchards havelargely expanded in newly reclaimed lands in Egypt. Usually, the new plantations start the commercial production around the fifth year. However, using some agricultural techniques such as plantation methods, suitable fertilization and irrigation programs can shorten the period needed for commercially production. Generally, Valencia orange yields is closely related to total flowers in the spring bloom even though most of the flowers do not set fruit that remain until harvest Moss *et al*. (1972). Although it is proved that climatic stress factors such as cold and /or drought (Davis and Albrigo, 1994) are natural inducers of flower buds in citrus, but in Egypt, winter temperature may not be an adequate to induce maximum flowering every year.

Moreover, it is well known that inflorescence leaves have positive effect on improving fruit set and final fruit yield. An explanation for this effect can be the carbon demand by developing fruit versus potential supply from adjacent leaves. Leafy inflorescences had sufficient foliar surface and photosynthetic capacity to support early development of fruits on the same shoot, and to make a substantial contribution towards subsequent growth. The carbon assimilates derived from new leaves were distributed towards adjacent fruit which showed strong competition for labeled substrate (Moss *et al*., 1972).

By contrast, fruit borne on leafless inflorescences have contrary negative effect on fruit production, fruit set and yield since it had to obtain all their assimilates from older leaves whose photosynthetic capacity and individual area were generally insufficient to wholly sustain fruit growth.

In addition, foliar spraying of urea or amino acids as a source of $NH_4$and its timing have been reported to enhance the number of flower buds, flower per inflorescence and yields (Ali and Lovatt, 1994). Whether this is due to short-term ammonium or urea concentration stress due to phytotoxicity in the buds (Krogmeier *et al*., 1989) or leaves or due to nutritional enhancement factors (Lovatt *et al*., 1988). Nutrition such as amino acids, Calcium and Boron could influence the number of flowers and fruit set. Other work has demonstrated a depletion of NPK of old leaves during the flowering and fruit set periods along with a large increase in nutrients in new leaves and setting fruit (Ruíz and Guardiola, 1994)

Concerning boron and on a molar basis plantsrequire more boron than any othermicronutrient. Boron plays a very critical key role in cell-wall synthesis. Boron complexes strongly with cell wall constituents as well as help to maintain structural integrity. It is bound less strongly to the cell wall than calcium. Moreover boron play evident role in pollen tube growth.(Blevins and Lukaszewski, 1998**)**. Generally, boron deficiency affects vegetative and reproductive growth of plants resulting in inhibition of cell expansion, death of meristem and reduced fertility (Marschner, 1995).

Regarding Calcium, it is a divalent cation that is extremely important in maintaining the strength of stems and stalks of plants. This mineral also regulates the absorption of nutrients across plasma cell membranes. Calcium functions in plant cell elongation and division, structure and permeability of cell membranes, nitrogen metabolism, and carbohydrate translocation. So that it is a significant factor in inflorescence and flower formation (White, 2000).

There is also a symbiotic relationship between boron and calcium. Each benefit from the other and without the other, the success of both is extremely limited. In order for plants to effectively utilize calcium, boron must also bepresent. Essentially, this means that if the nutritional situation in which the crop does not have sufficient levels of boron in the tissue; calcium applications will notbe nearly as effective as they could be if there was sufficient boron present (Jeremy O' Brien 2007).

The purpose of our study is to clarify the effect of spraying Valencia orange trees with low biuret urea, amino acids, calcium-boron and their combinations on the formation of inflorescences leaves and the final yield.

Materials and Methods

The experiment location

A field study was conducted in two consecutive seasons 2012 & 2013 in commercial citrus orchard Kafr Daoad, Behira governorate, Egypt.

Seventy two 5-year-old Valencia orange (Citrus sinensis L. Osbek) trees grafted on Volkamer lemon(*CitrusVolkameriana)* rootstock planted on terraces at 6 x 4m apart were selected for this investigation. The trees are of almost uniformity and received the recommended fertilization program and the yearly horticultural practices according to the recommendation of Ministry of Agriculture, Egypt (1994).

Experimental design and statistical analysis

Eight treatments with three replicates of foliar application were applied three times in mid of Jan., full bloom *i.e.* 10^{th} of April and after two weeks of full bloom *i.e.* 25^{th} April in a complete randomize design(CRD). Each replicate was represented by three trees. The treatments were:

- Foliar spray with low biuret urea (LBU 1%)
- Foliar spray with amino acids (AA 1%)
- Foliar spray with Calcium-Boron (Ca-B 1.5%)
- Foliar spray with low biuret urea + amino acids (LBU 1%+AA 1%)
- Foliar spray with low biuret urea + Calcium-Boron (LBU 1%+Ca-B 1.5%)
- Foliar spray with amino acids + Calcium-Boron (AA 1%+ Ca-B 1.5%)
- Foliar spray with low biuret urea + Calcium-Boron + amino acids (LBU 1%+ Ca-B 1.5% + AA 1%)
- Foliar spray with tap water (Control)

The data obtained were statistically analyzed using the Statistical Analysis System (SASM-Agri). The effects were tested using the general Linear Model. Multiple comparisons of means were performed according to Duncan test (Duncan, 1955) & (Snedecor & Cochran, 1980).

Measurements

Leafy inflorescences: During the spring flush, a square frame (0.5 m^2) was used in each season to count leafy inflorescences in the four crown tree directions. Counts were made within the frame at two thirds of tree height. The leafy inflorescence density (no./m^2) was calculated. This position approximately represents the average fruit distribution in the tree **(**Albrigo, *et al*., 1975) and the average was calculated.

Fruit set (%): twenty new spring shoots were labeled around each experimental tree; the number of flowers on each labeled shoot was counted inthe bloom reached open flower stage. Later on, the numbers of set fruitlets were counted on the same tagged shoots. Fruit set percentage was calculated [(number of set fruitlets) /number of flowers x 100].

Tree canopy volume increments (m^3): The tree canopy volume (m^3) was calculated at the beginning and at the end of each experimental growing season according to the equation: Canopy volume (m^3) =0.5236 x height x diameter square as stated by (Turell, 1965). Then, the yearly increments were calculated.

Nitrogen, Calcium and Boron: By the end of each growing season (Sept.) samples of mature leaves were taken from the middle locations of non fruiting shoots of the previous autumn flush around the four tree's directions (north, south, east, and west). The leaf samples were dried at 70 ^{o}C and finely ground and digested in a mixture of perchloric: sulphoric acid (1:3 v/v). The following determinations were carried out: total nitrogen (%) using Kjeldahl method (Naguib, 1969), calcium (%) and Boron (ppm) was determined by the Atomic Absorption apparatus (Jackson, 1967).

Yield parameters

Fruit weight (g) and juice volume (cm^3): Ten fruits were randomly collected at time of harvest from each tree; the fruit weight (g) and the fruit volume (cm^3) were measured.

Fruit TSS: At time of harvesting, the extracted juice was used to determine total soluble solids percent (TSS) using hand refractometer.

Yield(ton/fed.)

At the end of each experimental season, the number of fruit per tree was counted then a sample of 10 fruits was weighted and the average fruit weight was used to calculate the yield per ton/fed., theoretically, as follows = [average fruit weight (g) x number of fruit/tree x number of trees/fed.]/1000

Results and Discussions

Leafy inflorescence density (no./m^2)

Figure 1 shows a significant relationship and positive correlation between the foliar applications and density of leafy inflorescences.It is clear from the obtained results that application of the combination treatment LBU 1%+ Ca-B 1.5% + AA 1% show the highest leafy inflorescences density followed by the application of LBU 1% and AA 1%for both seasons. While lowest leafy inflorescences density was recorded for control treatment. In fact, the effect of LBU and AA applications may be related to that they are a source for nitrogenous compounds and according to the suggestion of Sagee and Lovatt (1991) that NH_3ammonia and NH_4^+ammonium ion accumulated during stress- as winter low temperature (that induced flowering in citrus)resulted in stimulation of new arginine biosynthesis and the accumulation of putrescine at an early stage of floral organogenesis, followed by rapid metabolism of these compounds during flower development.

Moreover, Legas *et al.* (1982)noticed an increase in nitrogen content in whole ovaries and young fruits, throughout the period from flowering initiation until 90 days after petal fall indicating a continuous transfer of nitrogen to reproductive organs and this nitrogen demand may be substituted partially bythe application of LBU and AA.

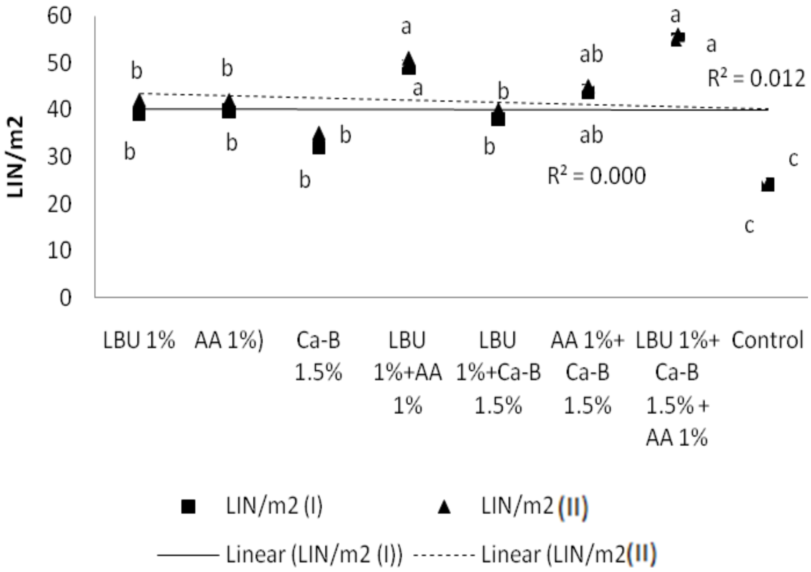

Fig. 1. The effect of some foliar applications on Valencia orange leafy inflorescences (LIN) density (no./m^2 of tree crown) in first (I) and second (II) experimental seasons.

Moreover, the effect of amino acids might be explained as Xing-Quan and Kyu-Seung (2012) where the application of high mixed amino acid rates could be the direct cause of increasing activities of the three enzymes (Nitrate reductase, Nitrite reductase and glutamine synthetase of the NO_3 assimilatory pathway).

Concerning the effect of the combination treatment of both urea and boron, Lovatt (1999) mentioned that the combined foliar application of boron plus urea, despite having positive effects on the number of pollen tubes that successfully reached the ovule and on ovule viability significantly increased the number of flowers with double pistils.

Fruit set (%)

Concerning the effect of treatments on fruit set, it is obvious from obtained data in Fig. 2 that the percentages of fruit setwere increased for all treatments combination. This result is more confirmed in the second season where those treatments show highly significant values as compared with the other treatments and the control.

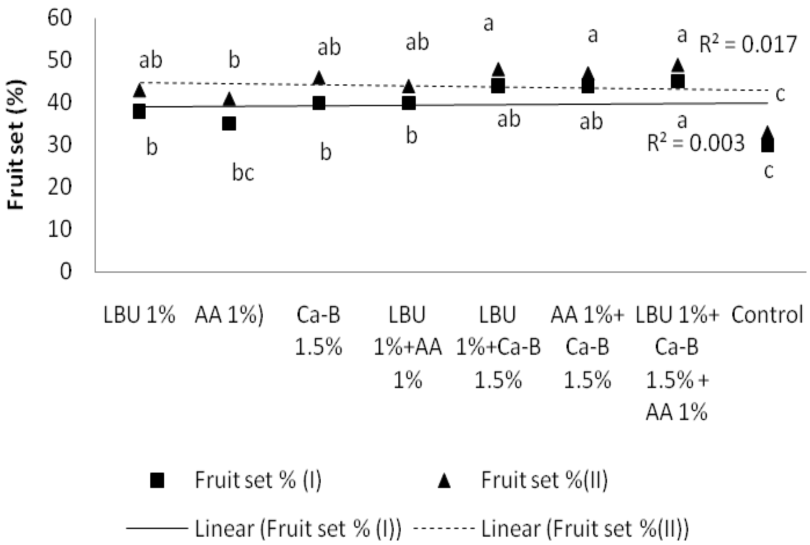

Fig. 2. The effect of some foliar applications on Valencia orange fruit set (%) in first (I) and second (II) experimental seasons.

The obtained results are in agreement with the finding of Lovatt (1999) who declared that winter or spring foliar nutrient applications increase fruit set since the essential nutrients for flowering and set are limited due to the reduction in transpiration rate and consequently reduction in nutrient gained by roots when air and soil temperatures are low. Also, the same author Lovatt *et al*. (1992) mentioned that foliar urea applied during or after a low temperature period increased citrus flowering by elevating the ammonia status of the tree and increased the polyamine content, growth rate, and size of developing citrus fruit, as well as their potential to set. Concerning the effect of boron in the combination treatments López-Lefebre *et al.* (2002) mentioned that addition of boron stimulates ammonium assimilation in leaves of tobacco plants, they, also, reported that the increase in the amino-acid and protein concentration with greater boron dosages, supports assumption of a direct positive effect of boron on ammonium ion assimilation ,also boron had a positive effect on thefoliar activities of the enzymes involved in assimilating the NH_4+ as glutamine synthetase, glutamate synthase, glutamate dehydrogenase, and phosphoenolpyruvate carboxylase enzymes. Boron could acts in the reaction medium by altering the conformation of the enzyme or by augmenting the affinity of some substrate or cofactor for the enzyme.

In the same concern Bariya *et al.* (2014) stated that that reproductive growth, mainly flowering, fruit and seed set and seed yield, is particularly sensitive to boron deficiency.

Tree volume increments (m^3)

As regard to tree volume increments, obtained data demonstrated that all applications show an increment in the tree canopy volume for both seasons over the control. The highest increase in canopy volume recorded for the combination treatment LBU 1%+ Ca-B 1.5%+ AA 1% followed by the combination treatment (LBU 1%+ AA 1%) in both seasons. The reason of that increase in canopy volume with those applications may be due to that the amino acids may help in supplying the leaves with nitrogen needed for spring flush growth which contributes positively to the final tree volume Menino *et al.* (2007).

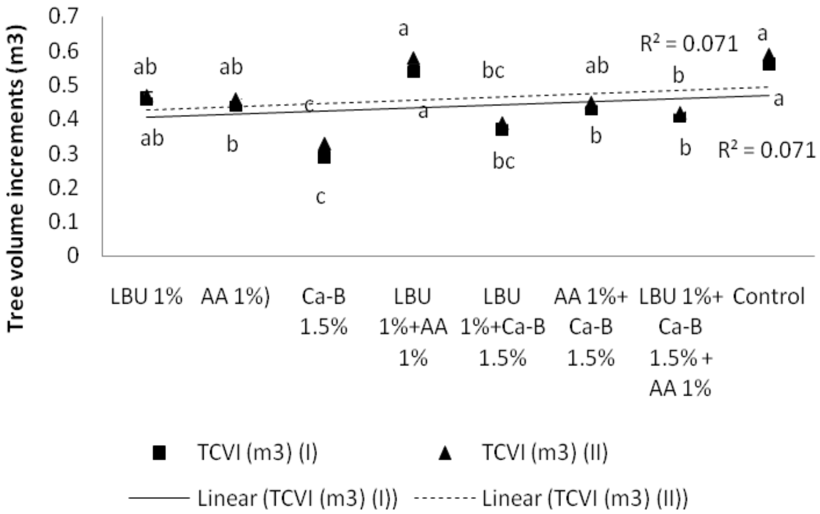

Fig. 3. The effect of some foliar applications on Valencia orange tree volume increments (m3) in first (I) and second (II) experimental seasons.

Leaf Nitrogen, Calcium and Boron contents

Data in Table 1 revealed obviously that there is no significant difference between treatments except for trees receiving Ca-B 1.5% and control treatments which they both showed significantly low leaf nitrogen contents, as compared with other treatments in both seasons.

This result is due to the absence of source of nitrogen as in all other treatments in the present study. As regard to calcium percentage in leaves, it is apparent that spraying Ca-B 1.5% alone or in combination with LBU 1%or AA 1% both resulted in a significant increase of leaf calcium content compared with other treatments and control for both seasons. As regard to boron concentration, data show that all trees sprayed with Ca-B 1.5% alone or in combination with other treatments show high significant leaf boron concentration for both seasons. Moreover, it could be noticed that the highest significant value recorded for AA 1%+ Ca-B 1.5% and LBU 1%+ Ca-B 1.5% + AA 1% treatments in the second season.

TABLE 1. The effect of some foliar applications on Valencia orange leaf mineral contents in both experimental seasons.

Treatments	Nitrogen (%)		Calcium (%)		Boron(ppm)	
	First season	Secon d season	First season	Second season	First season	Second season
LBU 1%	1.98ab	1.98ab	0.13c	0.14c	33.8b	40.2bc
AA 1%)	2.00ab	2.10a	0.20bc	0.21bc	38.7b	40.0bc
Ca-B 1.5%	1.50bc	1.51b	0.47a	0.56a	61.0ab	65.0b
LBU 1%+AA 1%	2.47a	2.50a	0.18	0.18c	14.0c	15.0c
LBU 1%+Ca-B 1.5%	1.87b	1.90b	0.49a	0.55a	63.8ab	65.0b
AA 1%+ Ca-B 1.5%	1.97ab	2.00ab	0.35b	0.38b	72.2a	75.0a
LBU 1%+ Ca-B 1.5% + AA 1%	2.08a	2.10a	0.35b	0.40b	85.3a	88.2a
Control	1.23c	1.20c	0.13c	0.12c	13.0c	14.0c

Fruit weight, fruit juice volume, fruit juice TSS(%) andfruit yield (ton/fed)

As for fruit physical properties, results in table 3 showed that all foliar applications significantly increased fruit weight and fruit juice volume over the control treatment which recorded the lowest fruit weight for both seasons. Moreover, spraying of LBU 1%+ Ca-B 1.5% + AA 1% shows the highest fruit weight and fruit juice volume for both seasons. In the same concern, Wright & Pena (2002)reported an improvement in fruit size with the application of low-biuret urea on 'Washington Navel' sweet oranges.

Concerning total soluble solids, the data in table 2revealed that, LBU 1%+ Ca-B 1.5% + AA 1% treatment, recorded the highest significant values of TSS % in the fruit juice of Valencia orange for both seasons. Also, the lowest significant TSS% value was recorded for control treatment.

TABLE 2. The effect of some foliar application on Valencia orange fruit and yield properties in both experimental seasons.

Treatments	Fruit weight (g)		Juice volume (cm^3)		Fruit TSS (%)		Yield(ton/fed)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
LBU 1%	165.2b	168.0b	115.6b	117.6b	11.0bc	11.0bc	4.1b	4.5b
AA 1%)	165.3b	168.0b	115.7b	117.6b	11.0bc	11.0bc	4.1b	4.5b
Ca-B 1.5%	170.5b	175.0b	119.4b	122.5b	12.0b	12.0b	4.5b	4.9b
LBU 1%+AA 1%	185.0ab	189.0ab	129.5ab	132.3ab	12.3ab	12.5ab	4.8b	5.0a
LBU 1%+Ca-B 1.5%	186.3ab	190.0ab	130.4a	133.0ab	12.0b	12.0b	5.0a	5.3a
AA 1%+ Ca-B 1.5%	185.8ab	190.0ab	130.1a	133.0ab	12.0b	12.1ab	5.0a	5.3a
LBU 1%+Ca-B 1.5%+AA 1%	191.8a	195.0a	134.3a	136.5a	13.0a	13.0a	6.0a	6.2a
Control	140.0c	141.0c	98.0c	98.7c	10.2c	10.5c	3.7c	3.8c

This result is in agreement with Wojcik *et al.* (2008) who declared that boron fertilization increase soluble solids concentration, and titratable acidity for apple fruit which can be attributed to transportation of higher amount of assimilates into fruit tissues, also due to the treatments of urea, the leaf age was increased that helped provide better and balanced quantity of metabolites, resulting in better fruit growth and development and improvement in fruit quality.

Table 2 showed that estimated yield (ton/fed) significantly increased by all treatments than the control, and that the highest significant values for both seasons was recorded for the combination treatment of both boron and LBU and amino acids. That increase in yield/tree may be due to the positive effect of sprayed compound on density of leafy inflorescences; fruit set and consequently on number of fruits per tree and in addition the effect of treatment on improving of fruit weight.

The obtained results are in accordance with Wright & Pena (2002) who reported that fruit size was improved by application of low-biuret urea on ‘Washington Navel’ sweet oranges. In addition, Lovatt *et al.* (1992) reported that winter foliar applications of low-biuret urea to commercially-producing, nitrogen-sufficient `Washington' navel orange trees just prior to or during flower initiation increased yield by approximately (17 kg) per tree in three successive years without a reduction in fruit size. Winter and spring foliar fertilizer applications likely increase yield because nutrients essential for flowering and fruit set are limiting due to reduced transpiration and/or nutrient acquisition by roots when air and/or soil temperatures are low (Lovatt, 1999).

Boron fertilization regardless of application mode increases pollination, fruit set, fruit yield and quality of temperate fruits (Ganie *et al*., 2013).

The results are consistent with and strongly support the interpretation that application of urea to the foliage of the 'Washington' navel orange provides sufficient ammonia to accelerate de novo arginine biosynthesis and lead to an increase in one or more species of polyamine that promotes flower initiation and ovary growth by cell division resulting in increased fruit set and yield (Lovatt *et al*., 1992).

Recommendations

According to the obtained results, it can be recommended to spray Valencia orange trees with a mixer of low biuret urea (1%), amino acids (1%) and Calcium-Boron solution (1.5%) three times; starting on mid of Jan., then at full bloom and the third after two weeks. Such treatments generate high density of leafy inflorescences, improve fruit set percentage and consequently increase the final yield.

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تاثير الرش الورقى ببعض المغذيات على عقد الثمار و المحصول لاشجار البرتقال الفالنشيا فى المزارع الحديثة

رضا عبد الله عبد العزيز و امجد محمد العزازى
معهد بحوث البساتين - مركز البحوث الزراعية - القاهرة - مصر.

اجريت هذه الدراسة خلال موسمى ٢٠١٢-٢٠١٣ على اشجار برتقال فالنشيا عمر خمس سنوات مطعومة على اصل فولكا مريانا و على مسافات ٤×٦ فى مزرعة خاصة بكفر داود فى محافظة البحيرة . يهدف هذا بحث الى دراسة تاثيرالرش ببعض المغذيات على العقد والمحصول لاشجار البرتقال الفالنشيا حديثة النمو واشتملت الدراسة على ثمانية معاملات هى الرش باليوريا منخفضة البيوريت و الاحماض الامينية و مركب يحتوى على عنصرى الكالسيوم والبورون والتوافقات المشتركة بينهم.تم الرش فى ثلاث مواعيد فى منتصف يناير وعند التزهير الكامل وبعد اكتمال التزهير باسبوعين وقد تم دراسة تاثير المعاملات على تكوين النورات الورقية وحجم الاشجار ونسبة العقد والصفات الطبيعية للثمار والمحصول وقد اظهرت المعاملة التى تشمل الرش باليوريا منخفضة البيوريت والاحماض الامينية ومركب الكالسيوم والبورون افضل النتائج من حيث نسبة النورات الورقية والمحصول النهائى.