Cultivos Tropicales, 2017, vol. 38, no. 4, pp. 22- 29 October-December

ISSN impreso: 0258-5936
ISSN digital: 1819-4087

Ministerio de Educación Superior. Cuba
Instituto Nacional de Ciencias Agrícolas
http://ediciones.inca.edu.cu

FOLIAR FERTILIZATION WITH POTASSIUM, CALCIUM AND BORON. INCIDENCE ON NUTRITION AND QUALITY OF FRUITS IN 'NOVA' MANDARIN

Fertilización foliar con potasio, calcio y boro. Incidencia sobre la nutrición y calidad de frutos en mandarino 'Nova'

María de las M. Yfran✉, Marco D. Chabbal, Analía B. Píccoli, Laura I. Giménez, Víctor A. Rodríguez and Gloria C. Martínez

ABSTRACT. The splitting or "cracked fruit" is a factor that determines the production of mandarin 'Nova' in the Northeastern Argentina. The objective was to evaluate the incidence of foliar fertilization with potassium, calcium and boron on splitting, nutrition, productivity and fruit quality. Six treatments T1: control, T2: Ca $(NO_3)_2$ at 2 %, T3: 0,2 % Ca-B, T4: Ca-B at 0,4 %, T5: Ca-B at 0,6 %, T6: 4 % KNO_3, applied at three times, except the control, in a randomized complete block design with four replicates and four plants per replicate. Leaf samples were taken in March, September and December for each treatment in three consecutive seasons, with concentrations of nitrogen, phosphorus, boron, potassium, calcium, magnesium, zinc, iron, copper and manganese being determined. Before harvest, 20 fruits were sampled per experimental plot, and the following variables were evaluated: bark thickness (mm), equatorial diameter (mm), fresh mass (g), juice content, juice percentage, total soluble solids (°Brix), total acidity (expressed as % citric acid) and maturity index (MI). The addition of Ca and K was associated with increases of these nutrients in plant shell thickness, size, weight and fruit juice, as well as with the least amount of windfalls by splitting or cracked: the contribution of Ca and B to fruit quality variables related. Provide Ca, K and to a lesser extent, decreases the incidence of splitting or cracking in mandarin 'Nova'.

Key words: fruit quality, Citrus, nutrition, yield

RESUMEN. El splitting o "rajado de la fruta" es un factor que condiciona la producción de mandarina 'Nova' en la región nordeste argentina. El objetivo fue evaluar la incidencia de la fertilización foliar con potasio, calcio y boro sobre el splitting, la nutrición, productividad y calidad de los frutos. Se probaron seis tratamientos T1: testigo, T2: Ca $(NO_3)_2$ al 2 %, T3: Ca-B al 0,2 %, T4: Ca-B al 0,4 %, T5: Ca-B al 0,6 %, T6: KNO_3 al 4 %, aplicados en tres momentos, excepto el testigo, en un diseño de bloques completos al azar con cuatro repeticiones y cuatro plantas por réplica. Se tomaron muestras foliares en marzo, septiembre y diciembre para cada tratamiento en tres campañas consecutivas, determinándose concentraciones de nitrógeno, fósforo, boro, potasio, calcio, magnesio, zinc, hierro, cobre y manganeso. Antes de la cosecha se muestrearon 20 frutos por parcela experimental, evaluándose las variables: espesor de corteza (mm), diámetro ecuatorial (mm), masa fresca (g), contenido de jugo (ml), porcentaje de jugo, sólidos solubles totales (°Brix), acidez total (expresado en % de ácido cítrico) e índice de madurez (IM). El agregado de K y Ca se asoció con incrementos de estos nutrientes en planta. El aporte de Ca y B se relacionó a las variables de calidad de frutos: corteza, diámetro ecuatorial, masa fresca y contenido de jugo de los frutos, como también con la menor cantidad de frutos abscididos por splitting o rajado. Aportar Ca, y en menor medida K, disminuye la incidencia del splitting o rajado en mandarina 'Nova'.

Palabras clave: calidad de frutos, Citrus, nutrición, rendimiento

INTRODUCTION

In the northeast region of Argentina, within the group called hybrid mandarins, Nova has managed to occupy a prominent place.

It presents a medium-sized fruit, which matures at the beginning of May, with good color, firm texture, without seeds and with a balanced and pleasant taste.

The splitting or "cracking of the fruit" is a factor that conditions the production of mandarin Nova. When the fruit comes from plants with low calcium content, it loses its capacity to resist transport, and it ages prematurely in the marketing nacelles (1,2).

Universidad Nacional del Nordeste (UNNE). Sargento Cabral 2131, CP 3400 Corrientes, Argentina
✉ mariyfran077@hotmail.com

This alteration begins in February, extending until after March, reaching its maximum incidence in March, which coincides with the stage of expansion of the pulp and the minimum thickness of the bark (1,3,4).

Some management factors, such as pruning, the time of harvest, the ripeness state of the harvested fruit, the water balance and the nutritional balance, could favor the risk of inducing splitting or cracking (4).

This alteration has been detected in all citrus areas of the world and on different cultivars, however, Nova is the most sensitive variety ¨Clementines and Satsumas¨ are the least affected (1,3,4).

Calcium is an important part of the constitution of the cell membrane and accumulates between the cell wall and the middle lamina, where it interacts with pectic acid to form calcium pectate which confers stability and maintains the integrity of these; from this point of view, calcium has great importance in the water economy (1,3,5). This nutrient acts as a cementing agent of cells, is closely related to meristematic activity, has an influence on the regulation of enzymatic systems and phytohormone activity and increases tissue resistance to pathogens, increasing post-harvest shelf life and nutritional quality (2,6,7). Deficiency symptomatology occurs in leaves that do not reach their final size (stage 1: 15 according to BBCH scale (3)), plants generally lose vigor and fruits show cracking or splitting (1,3).

Potassium (K) is characterized by the great mobility and solubility inside the tissues, exerts a great influence on the permeability of cell membranes and the hydration of tissues. It intervenes in the water economy of the plant, regulating the absorption and loss by transpiration. The deficiency of K is not very visible in the leaves, it basically produces a reduction in the size of the fruits with thinner and smoother rind, and it is associated with the cracking of the bark (1,4).

Experiments carried out in Israel show that potassium fertilization significantly reduces the cracking in 'Valencia' sweet orange. The use of potassium and calcium has been studied to reduce the cracking of fruits of orange and mandarin cultivars and boron to prevent early abscission of the fruits (4).

Boron (B) is an element whose role in metabolism is not known with certainty, but it is considered that it could function as a coenzyme or intervene in enzymatic processes and in the metabolism and translocation of carbohydrates and, like calcium, it would also play an important role in the structure of the cell and the integrity of the cell wall. The foliar symptoms that indicate its deficiency are observed in leaves without reaching their final size (stage 1:15 according to the BBCH scale (3)), which are somewhat smaller than the normal ones with wavy limbs, some deformed, but with green coloration. The fruits are smaller and somewhat deformed, which, when cut, show an excessively thick crust, with a closed columella, where the seeds are very small and dark in color. The deficiency of this element affects the K/Ca ratio and influences the content of foliar P (1). As a consequence of the effect of calcium, potassium and boron on the stabilization of the membrane, maintaining the selective permeability and its cellular integrity, its foliar application could reduce the cracking of the fruits.

In the northeastern region of Argentina there have been losses of up to 30 % of the fruits in lots of mandarin 'Nova' as a result of cracking. This situation has led to the realization of this work that aims to assess the incidence of foliar fertilization with potassium, calcium and boron on nutrition, yield and splitting or cracking of fruits.

MATERIALS AND METHODS

The work was carried out in San Lorenzo, department of Saladas, Corrientes-Argentina, in commercial lots of mandarin 'Nova' [*Citrus clementina* Host. ex Tanaka x Tangelo Orlando (*Citrus reticulata*, White x *Citrus paradisi*, Macf)] of 12 years, grafted on trifolium (*Poncirus trifoliata* Raf.), Implanted in a loam soil, 1 m deep, and density of 416 plants ha^{-1}. To eliminate the year effect, the experiments were repeated three times in the 2008/2009, 2009/2010 and 2010/2011 campaigns.

The content of the macronutrients and organic matter (OM), as well as the pH of the soil are shown in Table I.

Table I. Chemical characteristics of the experimental plot in San Lorenzo (32 ° 45'S, 60 ° 45'W and 79 ma.s.l.) Corrientes, Argentina

MO (g kg^{-1})	N (g kg^{-1})	P (ppm)	K ($cmol_c$ kg^{-1})	Ca ($cmol_c$ kg^{-1})	Mg ($cmol_c$ kg^{-1})	pH H_2O
17,2	0,8	14,3	0,4	4	0,9	5,35

The quantitative determination of soil OM was made by the Walkey and Black method, the P method by the Bray Kurtz I method, the K by flame photometry, the Ca and the Mg by EDTA complexometry. The pH was measured potentiometrically in a mixture of soil and water in a ratio 1: 2.5

The treatments consisted in the application of nutrients by means of foliar fertilizations. Three applications of all the treatments were carried out except for the control, in pre-flowering, to 90 % of falling petals and 40 days after the latter. For foliar applications, a sprayer was used for two-hose fruit trees, and as a source of calcium and boron CaB (CaO 8 % and B soluble in water in the form of boron ethanolamine 0,5 %); of K, foliar potassium nitrate (N 13 % and K_2O 44 %) and calcium as calcium nitrate (N 16 % and Ca 26 %) with an expense of 6 L plant^{-1}.

A soil-based fertilization of 1,5 kg plant^{-1} from 06-15-15-06 (NPK-Mg) providing 225 g of N, 120 g of P_2O_5, 225 g of K_2O and 120 g of MgO was performed 50 % (750 g plant^{-1}) in the month of December and 50 % (750 g plant^{-1}) remaining, in the month of March.

The treatments are detailed in Table II.

Table II. Foliar dose per plant corresponding to each treatment

Tratamientos	Dosis
1: Testigo	Sin aplicación
2: Ca-B al 0,2 %	7,6 ml planta^{-1}
3: Ca-B al 0,4 %	15 ml planta^{-1}
4: Ca-B al 0,6 %	20 ml planta^{-1}
5: KNO_3 al 4 %	0,24 g planta^{-1}
6: $Ca(NO_3)_2$ al 2 %.	0,12 g planta-^{1}

To evaluate the nutritional status of the plants, fruiting branch foliar samples were taken in March, September and December in each of the plants evaluated for each treatment in three consecutive seasons. They were dried in an oven at 60 - 65 °C until constant weight, ground in a 20 mesh Willey type mill. The nitrogen (N) concentrations were determined by the Kjeldhal method; phosphorus (P), by the Murphy-Riley method; boron (B) by molecular absorption spectrometry; potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) by atomic absorption spectrometry (8).

At the time of harvest in each experimental plot, the total production (kg plant^{-1}) was determined. To determine the quality characteristics of the fruits, random samples of 20 fruits were taken per plot, in which the following variables were determined: bark thickness (mm), equatorial diameter (mm), fresh mass (g), content of juice (ml), percentage of juice = fresh mass of the juice / mass of 10 fruits x 100, content of soluble solids (SST) expressed in ºBrix, total acidity by volume of neutralization (expressed in % of citric acid) and maturity index (IM) (ratio = SST / acidity) that indicates the degree of ripeness of the fruit (1).

We worked with an experimental design of complete blocks at random with four repetitions, using an experimental plot of four plants, evaluating the two plants. The data obtained were subjected to normality tests by means of a goodness-of-fit test with the modified Shapiro-Wilks (9) statistic ($p \leq 0,05$) and analyzed statistically by means of ANOVA and Duncan's test (10) ($p \leq 0,05$) using the Infostat software (11).

Through the Analysis of Principal Components (PCA), the behavior of the treatments was analyzed with respect to the variables studied, considering the treatments as classificatory variables. Artificial axes were constructed that allowed obtaining Biplot graphs with optimal properties to interpret and identify associations between observations (treatments) and variables in the same space (12).

RESULTS AND DISCUSSION

Figure 1 shows the graphic representation of Principal Component Analysis (PCA) of foliar concentrations of macro and micronutrients. The treatment with the contribution of potassium nitrate, presented a greater association with the contents of N, Ca and K, the treatment with calcium nitrate was associated with the Cu, while the control was associated more with the B. The treatments with contribution of Ca and B at 0,2 % were associated with the foliar content of Fe, Ca-B at 0,4 % with P and Ca-B at 0,6 % with Mg.

In general, foliar N levels were found between low to normal values (2 to 2,4 %), P between normal (0,13 %) and high (0,18 %) levels, and Ca and K were found in normal ranges (0,71 -1,00 % and 3–5 % respectively) (Table III).

The association of the treatment with potassium nitrate intake and the K content in the plant was confirmed by corroborating that in this treatment a significant increase of this nutrient was observed in 70 % of the samplings evaluated. It should be noted that the treatments that did not present an association with the K content presented the minimum values.

The remobilization of P reserves in citrus fruits would be more important to satisfy the demands of a new vegetative and reproductive growth than the absorption of P (13). Therefore, the supply of P should allow the plants to accumulate adequate quantities of P in order to provide growth demands for the next season. In this sense, at times of greater demand for P by the plant, the content of foliar P as well as that available in soil increase at the expense of the more stable P edaphic pool (14).

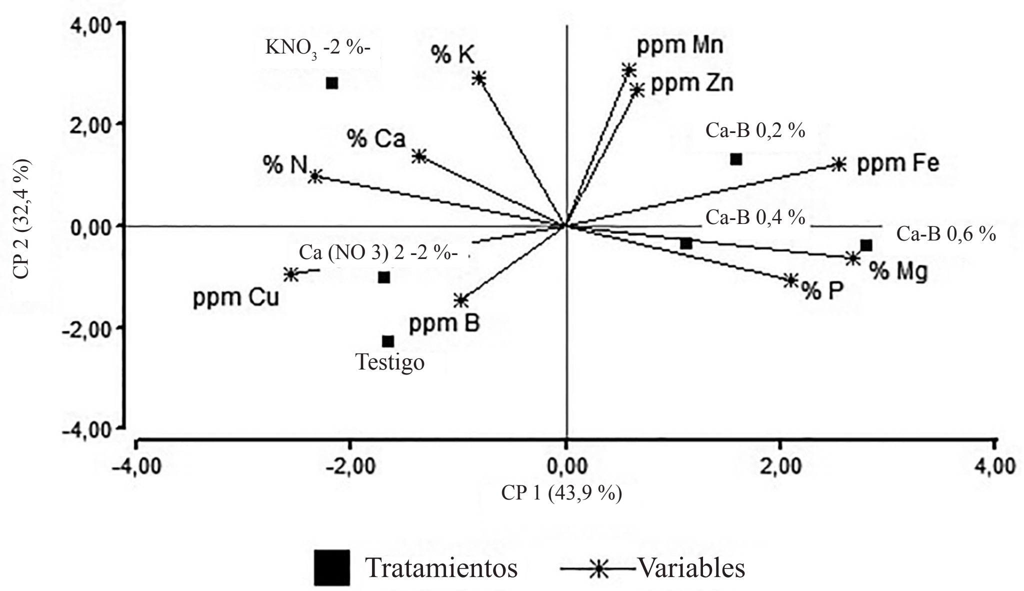


Figure 1. Biplot resulting from the Principal Components Analysis (ACP) of the foliar concentrations of nutrients in the six treatments tested

Table III. Nutrient foliar concentrations and standard error according to the fertilization treatments in mandarin trees'Nova', in San Lorenzo, Corrientes, Argentina, in the 2008/2009, 2009/2010 and 2010/2011 campaigns

Tratamientos	Muestreos	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Testigo	1	1,7 bc ±0,21	0,1 a ±0,02	0,84 a ±0,01	3,08 a ±0,19	0,25 a ±0,03
$Ca(NO_3)_2$ -2 %-	1	1,8 bc ±0,17	0,09 a ±0,01	0,87 a ±0,07	4,33 b ±0,2	0,25 a ±0,03
Ca-B 0,2 %	1	1,65 ab ±0,08	0,11 a ±0,01	0,85 a ±0,08	4,73 d ±0,12	0,29 a ±0,03
Ca-B 0,4 %	1	1,66 ab ±0,06	0,1 a ±0,02	0,83 a ±0,11	4,54 c ±0,15	0,29 a ±0,03
Ca-B 0,6 %	1	1,54 a ±0,06	0,11 a ±0,01	0,78 a ±0,06	4,54 c ±0,12	0,29 a ±0,03
KNO_3-2 %-	1	1,82 c ±0,18	0,09 a ±0,01	0,95 b ±0,11	4,45 ab ±0,15	0,23 a ±0,03
Testigo	2	2,04 ab ±0,19	0,15 a ±0,01	0,71 a ±0,08	2,94 a ±0,16	0,13 ab ±0,01
$Ca(NO_3)_2$ -2 %-	2	2 ab ±0,22	0,14 a ±0,01	0,76 a ±0,10	3,01 a ±0,16	0,11 a ±0,01
Ca-B 0,2 %	2	2,08 b ±0,10	0,14 a ±0,01	0,87 b ±0,02	3,31 a b ±0,17	0,14 ab ±0,01
Ca-B 0,4 %	2	1,9 a ±0,14	0,16 a ±0,01	0,90 b ±0,04	3,33 b ±0,21	0,13 ab ±0,01
Ca-B 0,6 %	2	1,91 a ±0,14	0,15 a ±0,01	0,78 a ±0,06	3,87 b ±0,17	0,15 b ±0,01
KNO_3-2 %-	2	2 ab ±0,22	0,15 a ±0,01	0,92 b ±0,01	3,36 b ±0,14	0,11 a ±0,01
Testigo	3	2,05 a ±0,10	0,16 a ±0,01	0,71 a ±0,04	3,29 a ±0,2	0,18 a ±0,01
$Ca(NO_3)_2$ -2 %-	3	2,2 a ±0,18	0,17 a ±0,04	0,79 a ±0,03	3,40 a ±0,14	0,17 a ±0,08
Ca-B 0,2 %	3	2,15 a ±0,19	0,18 a ±0,01	0,83 a ±0,05	3,60 ab ±0,13	0,18 a ±0,09
Ca-B 0,4 %	3	2,0 a ±0,21	0,17 a ±0,04	0,85 a ±0,08	3,59 ab ±0,12	0,19 ab ±0,08
Ca-B 0,6 %	3	2,13 a ±0,18	0,17 a ±0,04	0,83 a ±0,10	3,42 a ±0,15	0,16 a ±0,1
KNO_3-2 %-	3	2,09 a ±0,15	0,16 a ±0,01	0,95 b ±0,02	3,44 a ±0,11	0,18 a ±0,1

* Different letters indicate significant differences ($p \leq 0.05$). (Mean ± standard error)

Figure 2 shows the graphic representation of the Principal Components Analysis (PCA) of the fruit quality variables. The treatments with calcium contribution, in the form of nitrate and with boron in concentration 0,4 and 0,6 % respectively and the control had greater association with all the fruit quality variables while the contribution of potassium nitrate and Ca-B 0,2 % were not associated with any variable.

Treatments with 0,4 % Ca-B and 2 % calcium nitrate were associated with fresh fruit mass (g) and juice content (ml) respectively. Ca-B 0,6 % with bark thickness, equatorial diameter, percentage of juice; and the control with ºBrix, acidity and maturity index (IM).

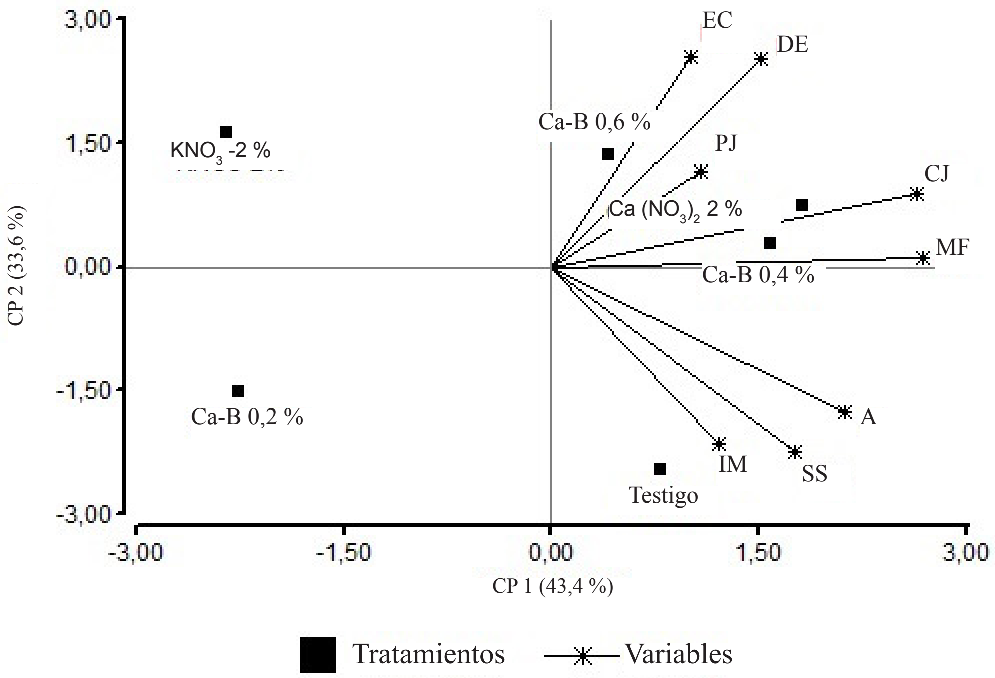


Figure 2. Biplot resulting from the Principal Component Analysis (ACP) of the variables:bark thickness (EC), equatorial diameter (DE), juice percentage (PJ), juice content (CJ), fresh mass (MF), content of soluble solids (SS), acidity (A) and maturity index (IM) in mandarin fruits'Nova' for the six treatments tested in the 2008/2009, 2009/2010 and 2010/2011 campaigns

The contribution of calcium favors the increase in the size of fruits (1,3,15), since it has the advantage of slowing cellular respiration and favoring the maintenance of firmness for a longer time (16). However, the evaluated variables fresh mass, equatorial diameter, juice content, °Brix, acidity and IM did not show significant differences between treatments. However, the thickness of the bark increased significantly in the treatments with contribution of Ca and K with respect to the control. These results could indicate that the contribution of these nutrients promotes greater thickness of the bark, which could affect the susceptibility to splitting or cracking of the fruits.

In addition, the contribution of calcium in pre-harvest significantly improves the firmness of the fruit (16,17), one of the most important attributes when it comes to post-harvest handling and product commercialization (2), which highlights the role of Ca that maintains the stability and integrity of the cell wall (1,3,5). In the same way, the Ca diminishes the maturation of the fruits and the speed of deterioration of the same ones in postharvest, since it retards the breaking of the soluble pectins of the cellular wall because these strengthen the ionic bonds between the molecules of the wall cellular (1,3,16). If Ca is available in the initial stages, more tissue in the cell walls will be formed, which implies that the contribution of Ca decreases the amount of small fruits. It also has the advantage of slowing cellular respiration and favoring the maintenance of firmness for a longer time (16).

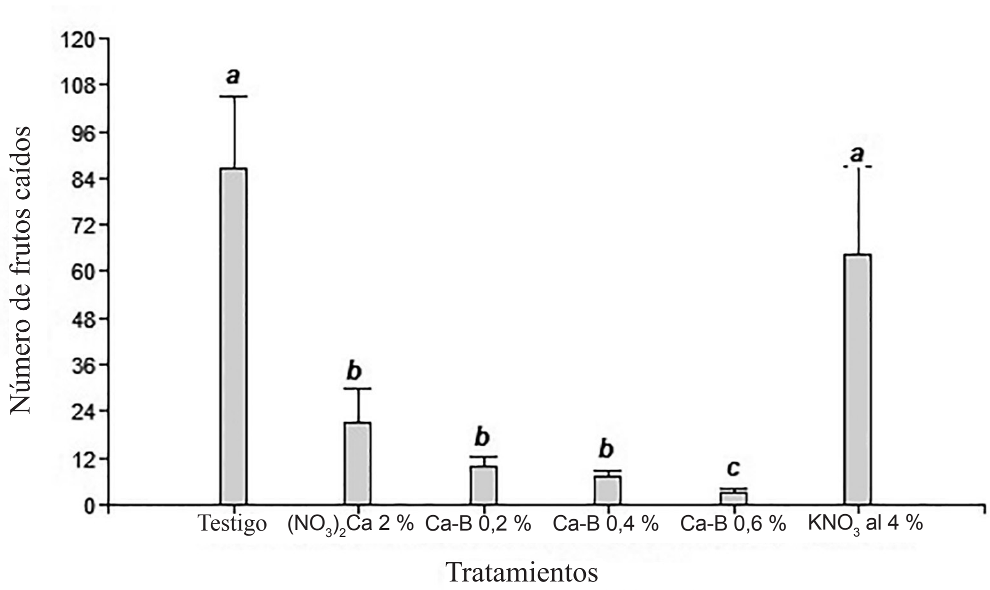
Evaluation of fallen fruits by splitting

In the studied campaigns, the treatment with the best statistical behavior was the treatment with contribution of Ca-B at 0,6 % with the least amount of fruits dropped due to cracking; Ca-B treatments at 0,2 and 0,4 % and calcium nitrate presented intermediate values, results that coincide with what was found by the authors (4,18). The control and potassium nitrate treatments showed the significantly higher values of fruits fallen by splitting, (Figure 3).

Evaluation of production

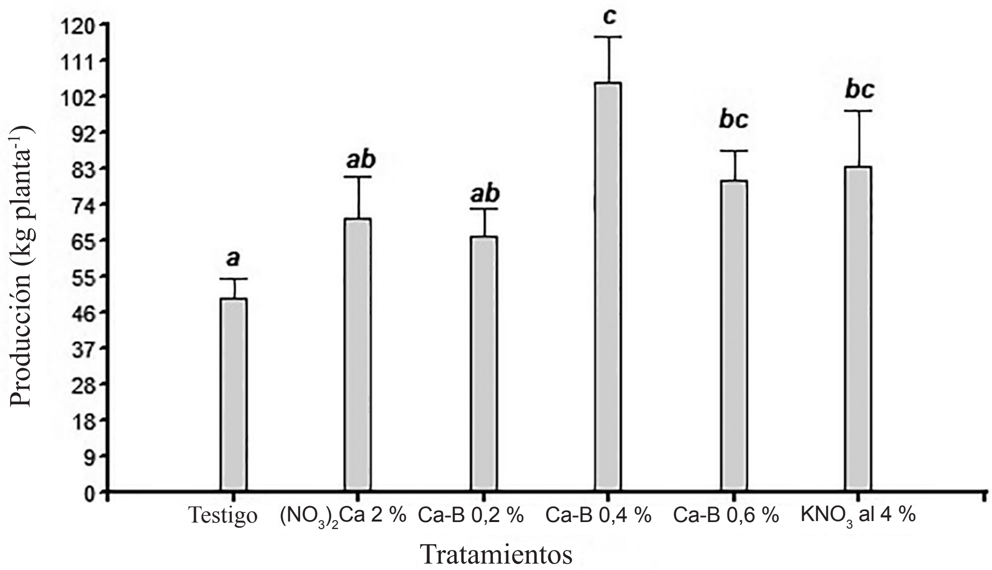
The mandarin fruits from plants that received Ca and K input had higher production (kg plant^{-1}) than the control treatment (Figure 4).

The increase in productivity by the addition of K in orange 'Valencia Late' and tangor 'Murcott' cited by another author coincides in part with our results (19). The highest production was registered in the plants that received contribution of Ca-B 0,4 %; the treatments with Ca-B 0,6 % and potassium nitrate the intermediate values, while the control, Ca-B at 0,2 and calcium nitrate presented the statistically lower values (Figure 4).



T1: control, T2: Ca(NO3)2 to 2 %, T3: Ca-B al 0,2 %, T4: Ca-B to 0,4 %, T5: Ca-B to 0,6 %, T6: KNO3 to 4 %. The values represent the mean of three years ± standard error. Different letters indicate significant differences between treatments (Duncan's test, $p \leq 0.05$, a>b>c, n = 4)

Figure 3. Total fruit fallen by splitting or cracking of the bark



T1: control, T2: Ca(NO3)2 to 2 %, T3: Ca-B to 0,2 %, T4: Ca-B to 0,4 %, T5: Ca-B to 0,6 %, T6: KNO3 to 4 %. The values represent the mean of three years ± standard error. Different letters indicate significant differences between treatments (Duncan's test, $p \leq 0.05$, a<b<c, n = 4)

Figure 4: Fruit production (kg plant^{-1}) average of the three evaluated campaigns

This highlights that sprays with Ca-B at 0,4 and 0,6 % showed a significant reduction in fruit abscission and at the same time higher production. It is worth mentioning that the plants that received K's contribution despite having numerous abscissions of fruits were not detrimental to their production. These results would be indicating that the contribution of Ca and B, and to a lesser extent of K, decreases the incidence of splitting in mandarin 'Nova'.

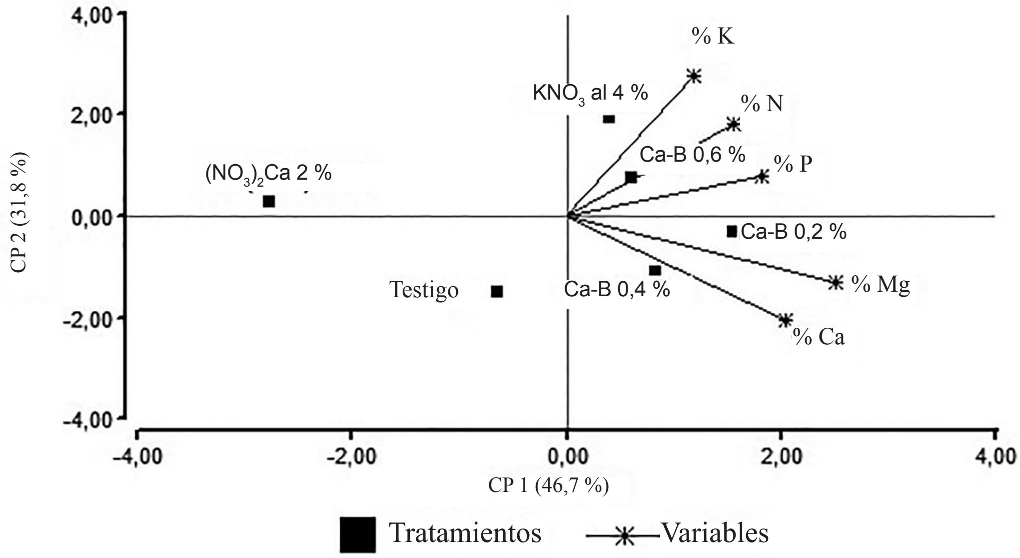
Figure 5 shows the graphical representation of the analysis of the main components of the macro nutrients concentrations in the bark of the mandarin 'Nova' fruits. The treatments with contribution of Ca-B 0,2 % were associated with the content of Mg, Ca-B 0,4 % with the content of Ca and Ca-B 0,6 % with the content of N and P, while the treatment with potassium nitrate was positively associated with the K content in the cortex. The control treatment and calcium nitrate were not associated to any variable.

It was found that the application of calcium-boron and potassium increased the K levels in the fruit's bark; likewise, greater production is found in these treatments. With higher calcium contents in the leaves and fruits, greater fruit firmness is achieved (16). However, our results show that all the treatments tested had higher K contents in the bark compared to the control, while the Ca content in the fruit bark did not present a significant difference between treatments (Table IV).

The treatment Ca-B 0,6 % presented the best results, with greater thickness of bark and equatorial diameter of fruits, lower abscission of fruits by splitting, and higher production.

CONCLUSIONS

- Foliar fertilization with K, Ca and B evidences a positive effect on nutrition, with significant increases of these nutrients in mandarin 'Nova' plant.
- Fertilization with Ca and B is associated with the variables of fruit quality, thickness of the bark, equatorial diameter, fresh mass and juice content of the fruits and with the lowest amount of fruits abscissed by splitting.
- The contribution of Ca, and to a lesser extent the K, decreases the incidence of fruit splitting in mandarin 'Nova'.



T1: control, T2: Ca(NO3)2 to 2 %, T3: Ca-B to 0,2 %, T4: Ca-B to 0,4 %, T5: Ca-B to 0,6 %, T6: KNO3 to 4 %

Figure 5. Biplot resulting from the Analysis of Principal Components (PCA) of the macro-nutrient concentrations in the bark of the fruits by treatment, for the 2008/2009, 2009/2010 and 2010/2011 campaigns

Table IV. Averages of the three evaluated campaigns of nutrient concentrations and standard error in the fruit bark according to the fertilization treatments in mandarin 'Nova', in San Lorenzo, Corrientes, Argentina

Tratamientos	% N	% P	% K	% Ca	% Mg
Testigo	0,68 ab ±0,05	0,08 a ± 0,01	0,74 a ±0,10	0,72 a ± 0,23	0,06 a ± 0,02
$Ca(NO_3)_2$ -2 %-	0,61 a ±0,06	0,09 ab ± 0,02	0,81 ab ±0,08	0,65 a ± 0,15	0,05 a ± 0,01
Ca-B 0,2 %	0,68 ab ±0,08	0,11 b ± 0,03	0,84 bc ±0,06	0,72 a ± 0,27	0,06 a ± 0,02
Ca-B 0,4 %	0,66 a ±0,09	0,09 ab ± 0,02	0,85 bc ±0,09	0,75 a ± 0,27	0,06 a ± 0,02
Ca-B 0,6 %	0,70 ab±0,10	0,10 ab ± 0,06	0,88 bc ±0,08	0,70 a ± 0,15	0,06 a ± 0,01
KNO_3-2 %-	0,76 b ±0,07	0,09 ab ± 0,02	0,93 c ±0,12	0,69 a ± 0,17	0,05 a ± 0,01

* Different letters indicate significant differences (p <= 0.05). (Mean ± standard error)

BIBLIOGRAPHY

1. Palacios J. Citricultura. Buenos Aires, Argentina: Hemisferio Sur; 2005. 518 p.
2. Paniagua AC, East AR, Hindmarsh JP, Heyes JA. Moisture loss is the major cause of firmness change during postharvest storage of blueberry. Postharvest Biology and Technology. 2013;79:13–9. doi:10.1016/j.postharvbio.2012.12.016
3. Agusti M. Fruticultura. 2nd ed. Madrid, España: Ediciones Mundi-Prensa; 2010. 507 p.
4. Barry GH, Bower JP. Manipulation of fruit set and stylar-end fruit split in 'Nova' mandarin hybrid. Scientia Horticulturae. 1997;70(2–3):243–50. doi:10.1016/S0304-4238(97)00025-3
5. Rincón-Pérez A, Martínez-Quintero E. Funciones del calcio en la calidad poscosecha de frutas y hortalizas: una revisión. Alimentos Hoy. 2015;23(34):13–25.
6. Aghdam MS, Hassanpouraghdam MB, Paliyath G, Farmani B. The language of calcium in postharvest life of fruits, vegetables and flowers. Scientia Horticulturae. 2012;144(Supplement C):102–15. doi:10.1016/j.scienta.2012.07.007
7. Ciccarese A, Stellacci AM, Gentilesco G, Rubino P. Effectiveness of pre- and post-veraison calcium applications to control decay and maintain table grape fruit quality during storage. Postharvest Biology and Technology. 2013;75(Supplement C):135–41. doi:10.1016/j.postharvbio.2012.08.010
8. Kalra YP. Handbook of reference methods for plant analysis. Boca Raton, USA: CRC Press; 1998. 300 p.
9. Shapiro SS, Wilk MB. An Analysis of Variance Test for Normality (Complete Samples). Biometrika. 1965;52(3–4):591. doi:10.2307/2333709
10. Duncan DB. Multiple Range and Multiple F Tests. Biometrics. 1955;11(1):1–42. doi:10.2307/3001478
11. Di Rienzo JA, Casanoves F, Balzarini MG, González L, Tablada M, Robledo CW. InfoStat [Internet]. Version 2015. Córdoba, Argentina: Grupo InfoStat; 2015. Available from: http://www.infostat.com.ar/
12. Steel R, Torrie J. Bioestadística: Principios y Procedimientos [Internet]. 2nd ed. México: McGraw Hill; 1992 [cited 2016 Aug 18]. 132 p. Available from: https://clea.edu.mx/biblioteca/Steel%20Robert%20G%20-%20Bioestadistica%20Principios%20Y%20Procedimientos%202ed.pdf
13. Zambrosi FCB-, Mattos D, Boaretto RM, Quaggio JA, Muraoka T, Syvertsen JP. Contribution of phosphorus (32P) absorption and remobilization for citrus growth. Plant and Soil. 2012;355(1–2):353–62. doi:10.1007/s11104-011-1107-1
14. Yfran E, Fernández LC, Martínez GC, Collavino MM. Análisis del efecto de bacterias solubilizadoras nativas sobre la movilización de fósforo en suelos rojos argentinos y su absorción en naranjo. Ciencia del Suelo. 2015;33(1):45–53.
15. Figueroa CR, Opazo MC, Vera P, Arriagada O, Díaz M, Moya-León MA. Effect of postharvest treatment of calcium and auxin on cell wall composition and expression of cell wall-modifying genes in the Chilean strawberry (*Fragaria chiloensis*) fruit. Food Chemistry. 2012;132(4):2014–22. doi:10.1016/j foodchem.2011.12.041
16. Hussain PR, Meena RS, Dar MA, Wani AM. Effect of post-harvest calcium chloride dip treatment and gamma irradiation on storage quality and shelf-life extension of Red delicious apple. Journal of Food Science and Technology. 2012;49(4):415–26. doi:10.1007/s13197-011-0289-0
17. Lobos-Manríquez T, Pinilla-Quezada H, Lobos-Alvarez W. Efecto de aplicaciones de calcio en la calidad de la fruta de arándano alto (*Vaccinium corymbosum* L.) cv. Elliot. Idesia (Arica). 2011;29(3):59–64. doi:10.4067/S0718-34292011000300009
18. Alvarez-Herrera J, Balaguera-López H, Fischer G. Effect of irrigation and nutrition with calcium on fruit cracking of the cape gooseberry (*Physalis peruviana* L.) in the three strata of the plant. Acta Horticulturae. 2012;(928):163–70. doi:10.17660/ActaHortic.2012.928.19
19. Alayón-Luaces P, Rodríguez VA, Píccoli AB, Chabbal MD, Giménez LI, Cristina-Martínez G. Fertilización foliar con macronutrientes a plantas de naranja Valencia late (*Citrus sinensis* (L.) Osbeck) y tangor Murcott (*Citrus reticulata* Blanco x *Citrus sinensis* (L.) Osbeck). Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. 2014;46(1):87–96.

Received: December 2nd, 2016
Accepted: July 4th, 2017