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The Effect of Controlled Deprivation of Nitrogen, Potassium and Ringing the Bearing Branches on the Incidence of Misshapen Navel Disorder and Fruit Quality in "Washington" Navel Oranges

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Abstract:

There is a lack of information about the causes leading to misshapen navel formation which obviously flourishes in young bearing navel oranges whether under arid or moderate conditions. Thirty "Washington" navel oranges at the age of 4 years old were treated on May 1st with 3 different deprivation regimes of Nitrogen (N), Potassium (K) and 2 ringing positions at the bearing branches to investigate the role of the increase of N and K leaf content, and carbohydrate availability on the incidence of misshapen navel disorder (MND). Either nutrient deprivation treatments or ringing processes remarkably reduced such disorder during two seasons 2013 and 2014. N leaf content increase was found to have a strong positive coefficient correlation with MND. Moreover, N deprivation for one month was the only treatment that didn't cause consistent change in any fruit characteristic. Thus, the present study revealed that N deprivationwas the most effective treatment on mitigating incidence of MND.

Keywords: *Carbohydrate Allocation, Deprivation Regimes, Leaf content, Navel-end opening*

Introduction

Seedless orange fruits as "Washington" navel are highly demanded by consumers all over the world. However, the abnormal appearance of the secondary fruitlet may adversely affect grading and marketability of such fruits (Verreynne, 2008). The secondary fruit (navel) develops within the primary fruit. In addition, the navel may protrude outside the primary fruit causing navel-end opening, also called the stylar-end aperture (Davies, 1986), and misshapen navel disorder, MND, (Kallsen, 2004; Farag *et al.,* 2015). Therefore, fruits that have large navel are only acceptable for the local market with a large loss in yield price. Moreover, there are many problems related with MND in navel oranges production. Physiological disorders like splitting, and fruit drop are associated with the size of the navel-end opening in citrus (Lima and Davies, 1984[a]; Davies, 1986). Furthermore, misshapen navel gets stylar-end decay to be remarkably increased (Lima and Davies, 1984[a]). In addition, large navels create a good shelter place to hide insects making their control more difficult (Soule and Grierson, 1986). The application of 2, 4-D at full bloom was the only observed study that was performed to reduce the navel-end opening, MND, in navel orange fruits. It reduced the average navel-end size and increased the percentage of closed navel-ends, irrespective of 2, 4-D concentration,15-25- 30 ppm, (Verreynne and Mupambi, 2010).

MND incidence is related to low fruit-set and warm temperature (Kallsen, 2004). It can also occur whether the tree grows under arid conditions as well as under moderate environment. Therefore, such disorder has been mostly related to the unbalanced relationship between the source of carbohydrates and the fruit as the strong sink (Soule and Grierson, 1986).

Thus, misshapen navel disorder can be obviously noticed in young-bearing navel oranges due to excessive partition of carbohydrates that might cause undesired pressure on the weak spot of the fruit which is the navel spot. Much more studies are needed for the factors that might be involved in the incidence of navel protrusion in different severities. Research in this area is still very limited, scant and needs further elaboration especially on the applicable field treatments affecting the partitioning of assimilates. Thus, the objectives of this study were;

- To investigate the influence of hindering carbohydrate partitioning into the fruit at certain stage on the ability to form misshapen navel and the effect of N and K on the incidence of Misshapen navel disorder.
- To explore the consequences of deprivation and ringing regimes on fruit quality in "Washington" navel oranges and to establish a well-studied regime that could be adopted by navel oranges producers and growers and feasible on a field scale

Materials and Methods

1. Field work: Field experiment was conducted under drip irrigation system during two successive seasons of 2013 and 2014 on "Washington" navel orange trees (*Citrus sinensis L. Osbeck*) at Elbehera region, North west of Egypt. Trees were 4 years old, budded on sour orange rootstock (*Citrus aurantium L.*), spaced at 4×5 m. Trees have been received standard agricultural practices, free from physiological disorders and visible pathological problems. Soil texture was sandy with electronic conductivity at 2ds/m, and its pH was (6.9) suitable for citrus trees. Treatments were conducted at the onset of cell enlargement stage of citrus fruit growth and arranged in randomized complete block design. Five replications were used for every treatment, and one tree represented one replication. Six treatments were carried out on 30 optimal trees randomly as follow; Control, N deprivation from May 1st to June1st, K deprivation from May 1stto June1st, deprivation of both N, K from May 1st to June1st, as well as ringing at the base of fruiting branches or ringing at the middle of fruiting branches on May1st.

In addition, the ringing process was conducted by removing a complete ring of bark in four branches in different directions per tree, the width of ring was 0.5 cm, and the ringed branches were one year old. The samples of ringed trees (fruits and leaves) were taken from ringed branches. Fertilizers have been added via drip irrigation system. In the first season; the fertilization program for 4 years old navel orange trees was 113 kg N per fedan in many formulations. Also K was fertilized at a K_2O rate equal to the N rate, while P was fertilized at a P_2O_5 rate equal to 50% of the N rate, and Mg was fertilized at a rate equal to 20% of the N rate (Barakat *et al.,* 2013; Obreza and Morgan, 2011). In the second season; N rate increased to 120 kg per fedan. In addition, other nutrients were increased with their same ratio to N according to (Barakat *et al.,* 2013; Obreza and Morgan, 2011). N deprivation rate during deprivation period was 10.7 kg N and 13.4 kg N in first season and second season respectively. Meanwhile, K deprivation rate was 11.5 kg K and 15 kg K in first season and second season respectively.

The differences among treatments in MND were determined according to grading index describing misshapen navel status as shown in (Fig 1). This grading was designed according to the navel end protrusion grade, and divided to six levels reflecting all cases of navel-end as follow;

1: completely smooth
2: just started
3: started to open
4: opened but flat
5: protruded
6: sharply protruded.

Fig 1. Misshapen navel grades index ranging from completely smooth to sharply protruded.

2. Leaf sample analysis: each leaf sample consisted of five fully expanded leaves (first mature leaf on fruiting shoots) that were taken from fruiting shoots around the periphery of tree (CRI, 1995). Samples were taken from all treatments on June[1st] during 2013 and 2014 respectively after deprivation period of the supply of N or K or both of them (depending on the treatment), and then they were taken to the laboratory for analysis. Each sample was washed with tap water, distilled water, then dried in an airy place under air temperature then transferred to a furnace at (65:70 ^{0}C) until reaching a constant weight. The dried samples were stored in paper bags in a cool and dried place protected against direct sun light. Half gram from dried sample was digested using 2.5 ml of concentrated sulphuric acid and hydrogen peroxide according to (Evenhuis and Dewaard, 1980). The clear digest was quantitatively transferred to 100 ml volumetric flask. In this solution, total nitrogen percentage was colorimetrically determined according to (Evenhuis 1976). Then K and Mg were determined by using the flame device and calculating as percentage values.

3. Fruit quality parameters: Fruits were randomly harvested in ripe stage on 17th December and 20th December during 2013 and 2014 respectively. Samples were transported to the laboratory to determine physical and chemical characteristics. Each sample represented one tree as one replication, and consisted of five fruits. The measured physical fruit characteristics were fruit weight, volume, fruit length to diameter ratio, rag weight, and juice volume. The measured chemical fruit characteristics were TSS %, ascorbic acid, Juice acidity, total sugars and Beta-carotene. TSS percentage in juice was measured by using hand refractometer. L-ascorbic acid content was determined as follow: 5 milliliters (ml) of orange juice was diluted with 5 ml of acid solution, and the solution was titrated with 2, 6-dichloroindophenol dye to light pink color end point. L-ascorbic acid concentrations were determined as mg/ 100 ml (A.O.A.C., 1990). The acidity was measured as a citric acid (dominant acid in orange fruits) by taking 5 ml of juice in each sample, and titrated with sodium hydroxide of a known normality using phenolphthalein as an indicator. The results of these titrations were converted to the percentage of titratable acidity considering citric acid as the dominant one (A.O.A.C., 1990). Total sugars were estimated using the phenol sulfuric acid method (Smith, 1956), and the concentration was calculated from a standard curve of glucose (mg. per gram) fresh weight of fruit tissue. Beta-carotene was measured in the peel according to (Mustapha and Babura 2009). Carotene content was measured as follow; 0.5gm of fresh peel was extracted by about 15 ml of 85% acetone and 0.5g calcium carbonate, the mixture was filtered through a glass funnel and the residue was washed with a small volume of acetone and completed to 25 ml. The optical density of a constant volume of filtrate was measured at a wave length of 445 nm using spectrophotometer. Knowing that, samples of each extract were placed in cuvettes and readings were taken when the figure in the display window became steady. The following equations were used;

$$C = A / E*L.$$

C= concentration of carotene

A= absorbance

E=extinction coefficient

E of β-carotene $=1.25\text{x}10^4 \mu g/l$.

L= thickness of cuvettes (path length) =1cm

Statistical analysis: Data were analyzed as a factorial arrangement in a randomized complete block design. Comparisons among means were made via the Least Significant Differences (LSD) multiple ranges at the 5% of the probability according to (Snedecor and Cochran, 1980). The data were analyzed using SAS software (2000) program.

Results and Discussion

1. Leaf content of N, K, and Mg in response to treatments:

The leaf content of N, K, and Mg of "Washington" navel orange trees as influenced by various levels of deprivation and ringing was illustrated in Table (1). The data revealed that the control trees had significantly the highest N content in the first mature leaves in both seasons among all other treatments. Nitrogen-deprived leaves for one month had a significant reduction in N concentration in both seasons as compared with the control. Moreover, such content was still similar to that in the leaves that were deprived of both N and K in both seasons. Furthermore, K limited deprivation also led to a significant reduction in N content in the leaves in a constant manner and these results agreed with the findings of Marschner (1995) who illustrated that K plays an important role as counter ion for nitrate transport in the xylem, consequently K deprivation reduced leaf nitrogen content. However, N content in the leaves was similar whether due to K deprivation, ringing at the branch base or at the middle.

On the other hand, potassium content in the leaves was similar whether in the control and N-deprived trees. K deprivation resulted in a significant reduction in potassium content as compared to the control. However, such content was similar whether with both ringing positions or with K-deprived trees. With regard to Mg content in the first mature leaves as influenced by various deprivation treatments or by ringing positions, the results indicated that all treatments including the two ringing positions had no significant difference in their Mg content of the first mature leaves in a consistent manner in both seasons.

The reduction in nitrogen and potassium content in the leaves could be a direct reflection of depriving the tree from such mobile nutrients since the plant cannot synthesize nutrients and must be supplied from external source. Such reduction, however, was not reflected on Mg content that is usually affected by N mobility in the tree. Moreover, the reduction in nitrogen or potassium was not too severe to adversely affect the leaf health or vigor as indicated by their magnesium content. In terms, Mg is a structural component of chlorophyll (Chl) and needed for its biosynthesis (Hermans *et al.*, 2004).

Table 1. The percentage of N, K, and Mg in the first mature leaves of "Washington" navel orange trees as influenced by different applied treatments in two consecutive seasons

Treatments	N %		K %		Mg %	
	2013	2014	2013	2014	2013	2014
Control	2.46 a*	2.44 a	0.75 a	0.760 a	0.348 a	0.300 a
N deprivation	2.104 c	2.09 c	0.708 ab	0.723 ab	0.352 a	0.370 a
K deprivation	2.32 b	2.35 b	0.696 b	0.696 b	0.354 a	0.330 a
N+K deprivation	2.054 c	2.04 c	0.688 b	0.693 b	0.368 a	0.350 a
Ringing in branch basic	2.388 b	2.38 ab	0.662 b	0.679 b	0.342 a	0.350 a
Ringing in middle of branch	2.366 b	2.37 b	0.67 b	0.713 ab	0.344 a	0.264 a

*Values within a column of similar letters are not significantly different according to the least significant difference (LSD) at 0.05 levels.

2. The effect of treatments on misshapen navel grade;

There were considerable variations in the incidence of MND in response to various mentioned treatments as shown in Fig (2). It was obvious that N or K limited deprivation led to a significant reduction in the incidence and grade of misshapen navel of "Washington" navel orange. Similarly, the two used ringing positions resulted in a significant reduction of such disorder as compared with the control. However, there was no significant difference between N or K limited deprivation treatments in both seasons. That was also the trend when both positions of ringing were compared in terms of their influence on the misshapen navel formation in both seasons. Moreover, depriving the tree from both N and K together resulted in further reduction of the incidence of misshapen navel only during the second season when compared with just depriving the tree from either N or K alone. Furthermore, limited deprivation of either N or both N and K together was more effective in reducing the grade of misshapen navel than that obtained in response to the ringing treatment at the base of the fruiting branches of "Washington" navel orange trees. The reduction in the incidence and degree of misshapen navel of "Washington" navel orange in response to whether nutrients deprivation treatments or ringing position might be occurred due to reducing carbohydrate allocation to secondary fruit. As, with the low fruit load and the imbalance between vegetative stage and reproductive stage in first bearing years of "Washington" navel oranges, the rapid flux of assimilates resulting photosynthesis excesses primary fruit requirements. This cause inundation of assimilates on the navel leading to increase in navel size, then it might be distorted and giving MND.

Kallsen (2004) was in line with these findings, he demonstrated that with low fruit set, the secondary fruit enlarges and causes stylar-end aperture. So, the factors which cause reducing photosynthetic rate or decreasing the rate of assimilates translocation to fruits at the beginning of cell enlargement stage achieve significant results in reducing misshapen navel grade like (N or K limited deprivation and two ringing positions). Lakso *et al*. (2009) were in line with N limited deprivation results. They reported that the trees grown under low N supply are more source-limited than those at higher N supplies. In addition, the photosynthetic capacity of leaves is related to N content primarily. Moreover, N involves in biosynthesis of chloroplast either enzymes of the Calvin cycle or protein in the thylakoid membranes (Evans, 1989). The rate of CO_2 assimilation is relative with the maximum RuBP carboxylase activity per unit leaf area, and both the rate of CO_2 assimilation and RuBP carboxylase correlate with soluble protein per unit area (Ferrar and Osmond, 1986). Thereby, the deprivation of N at the beginning of cell enlargement stage (fruit growth stage) reduced the photosynthetic capacity and CO_2 assimilation leading to a decrease in pressure of assimilates on the navel in this stage causing deceleration in navel growth.

Furthermore, as supporter findings to K limited deprivation results, Marschner (1995) revealed that in plants well supplied with K, the osmotic potential of the phloem sap and the volume flow rate, are all higher than in plants supplied with a lower K level. Also, he showed that K plays as counter ion for nitrate transport in the xylem and increase efficiencies of the enzymes involved in photosynthesis like (RuBP carboxylase) and CO_2 uptake through opening stomata. Moreover, Herilihy (1989) found that K promotes phloem transport of photosynthates - mainly sucrose. Therefore, the limited deprivation of K at the beginning of cell enlargement stage was able to reduce the photosynthetic capacity and assimilates translocation ratio leading to minimize pressure of assimilates on the navel in this stage and slowing down the navel growth.

The ringing is a common practice in citriculture using to interrupt photosynthates flow to the roots to increase flower induction and fruit filling, apparently through increased assimilates availability in the aerial parts of the tree (Iglesias *et al*., 2007), but the ringing practice in the present study was performed at fruiting branches were 1 year ago to reduce carbohydrates availability to fruits by deterring assimilates supply from other tree parts to ringed branch, and let fruits at ringed branches depend mainly on assimilates resulting from these branches only. As a result, assimilates pressure on fruits at ringed branches became less strengthen than assimilates pressure on fruits at other branches. So, the navel became less in assimilates pressure, growth, and misshapen grade.

3. The correlation between leaf content of nitrogen and potassium, and the incidence of misshapen navel disorder in "Washington" navel oranges;

The correlation coefficients were determined to document if there was any positive correlation between average leaf content of N and K, and the incidence of MND in both seasons as shown in Fig (3). The data illustrated that there was a high positive correlation between leaf N content in fruiting branches and the incidence of misshapen navel in both seasons (0.74 and 0.79) in 2013 and 2014 respectively. In addition, the leaf K content in fruiting branches was positively correlated with the incidence of misshapen navel in both seasons (0.58 and 0.65) in 2013 and 2014 respectively. The correlation coefficient between the incidence of MND and leaf N content was found to be stronger than the correlation coefficient between such physiological disorder and leaf K content on June[1st]. Thus, the increase in leaf N content during cell enlargement stage of fruit growth was more effective in enhancing the incidence of MND in “Washington” navel oranges.

As a result, depriving trees from N for one month at the beginning of cell enlargement stage of fruit growth was more effective in descending the incidence of MND in “Washington” navel oranges relative to k deprivation for one month at the same period.

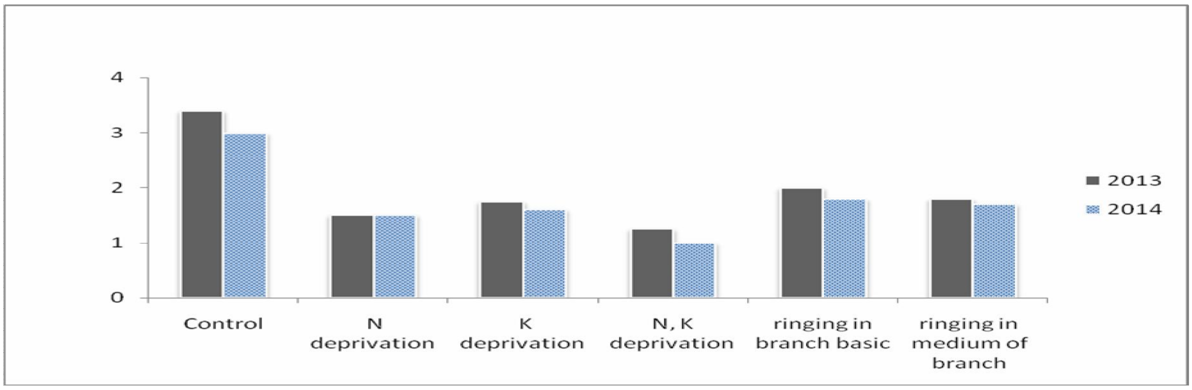

Fig 2. Misshapen navel grade at harvest in “Washington” navel orange fruits as influenced by applying treatments in two successive seasons (2013 – 2014).

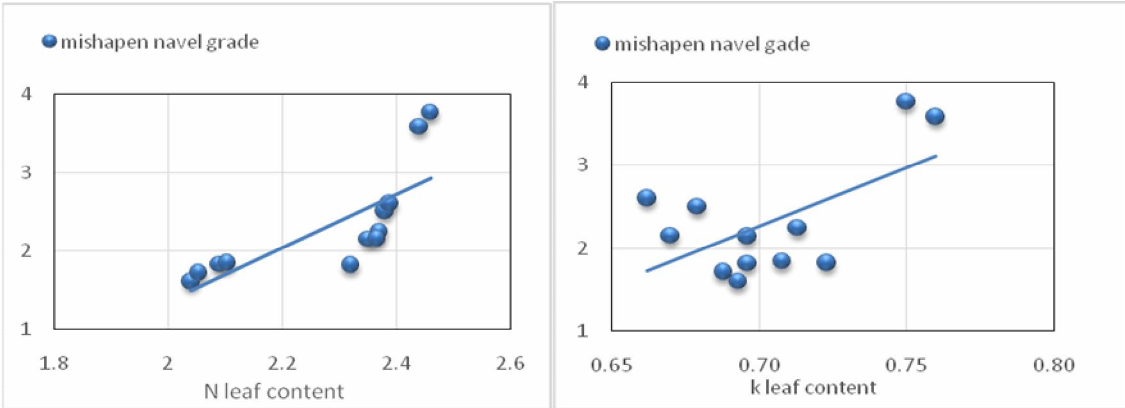

Fig 3. Correlation between the fruiting branch content of N, and K on June 1st and the incidence of misshapen navel in "Washington" navel orange.

4. Fruit characteristics as influenced by various treatments:

Studying the impact of applied treatments on some physical and chemical characteristics of "Washington" navel oranges during the two consecutive seasons (Table 2), the data revealed that length to diameter ratio, as an indicator for a change of fruit shape, was found to be not remarkably changed with whether deprivation treatments or ringing positions as compared with control in both seasons. With regard to fruit weight as influenced by various applied treatments at harvest of "Washington" navel oranges, the data indicated to a similar fruit weight when comparing the control with the used deprivation regimes in a consistent manner in both seasons, even when the trees were deprived of both N and K simultaneously. In addition, ringing at the fruiting branch base didn't significantly affect the fruit weight in a consistent manner similar to what obtained with control but ringing at the middle of branch significantly reduced the fruit weight in both seasons.

Furthermore, the sole deprivation of N or K had no effect on fruit size as compared with control in both seasons, while depriving trees from both N and K caused a considerable reduction in fruit size in a constant way. Meanwhile, ringing at the branch base significantly decreased the fruit size only in the second season as compared with control. Morover, ringing the bearing branches at the middle caused a significant reduction in fruit size when compared with the control or even with the deprivation of both N and K together in both seasons.

The data of juice volume at harvest as influenced by various used treatments was documented in Table (2). It was obvious again that juice volume was not significantly influenced by either N or K deprivation in both seasons. In addition, when deprivation was implemented for both nutrients at the same time, there was insignificant difference in juice volume as compared with control in both seasons. Meanwhile, juice volume with base ringing of bearing branches was similar to that obtained with simultaneous deprivation of both N and K. the significant reduction was found in a consistent manner with branch ringing at the middle when compared with the control.

In terms of rag weight of "Washington" navel oranges, the results in Table (2) showed that N deprivation for one month was the only treatment that didn't result in a significant change in rag weight in both seasons relative to the control. Moreover, K limited deprivation led to a significant reduction in such rag weight especially in the second season. Meanwhile, when the tree was deprived of both N and K simultaneously, there was a significant reduction in rag weight when compared with the control in both seasons. There was also a significant reduction in rag weight by ringing the branch whether at the base or at the middle when compared with the control or sole N deprivation in a consistent manner.

The response of TSS percentage in the juice of "Washington" navel oranges at harvest as influenced by various treatments was reported in Table (2). The data revealed that neither all deprivation regimes nor base ringing of bearing branches caused a remarkable change in TSS percentage relative to control in both seasons. On the other hand, middle ringing position of bearing branches considerably descended the TSS percentage relative to control in both seasons.

Data of acidity percentage in navel orange juice as affected by applied treatments demonstrated that depriving trees form N or K wasn't able to obviously change acidity percentage in both seasons, while depriving trees from both N and K together led to an apparent increase in acidity only in the second season. In addition, there was no evident addition in acidity percentage with ringing process whether at branch base or at the middle as compared with control in both seasons.

Studying the effect of applied treatments on juice content of ascorbic acid at harvest, the data revealed that either sole deprivation or dual deprivation of N and K didn't add obvious alteration in ascorbic while comparing with control in both seasons. Meanwhile, both base ringing and middle ringing at the bearing branches achieved a significant rise in ascorbic acid only in the first season as compared with control.

With regard to total sugars percentage of "Washington" navel orange fruits at harvest, the data in Table (2) showed that N deprivation regime for one month significantly altered total sugars percentage only in the second season as compared with control. Furthermore, deprivation regime of both N and K together reduced such percentage solely in the first season relative to control. Meanwhile, there was no added advantage from depriving trees of K on total sugars percentage in a consistent manner. Moreover, both ringing positions were not able to significantly change total sugars percentage in both seasons.

The effect of applied treatments on beta-carotene in rind of "Washington" navel orange fruits at harvest, in detail, the data in Table (2) illustrated that the sole deprivation of N regime or deprivation of both N, K were not able to significantly change beta-carotene content in the rind as compared with control in both seasons. Meanwhile, the sole deprivation of K led to significant increase in beta-carotene content of rind only in the first season. On the other hand, the ringing positions, whether at the base of bearing branches or at the middle of bearing branches, significantly increased beta-carotene content as compared with control in a consistent manner.

In conclusion, this study provided evidences for the significant correlation between increasing leaf content of N and K, and the incidence of MND. The reduction in the superfluous growth of navel of "Washington" navel orange in response to whether nutrients deprivation treatments or ringing position might be occurred due to reducing carbohydrate allocation to secondary fruit. In addition, the middle ringing of branches was the most treatment influencing fruit characteristics like fruit weight, size, juice volume, and rag weight. On the other hand, N deprivation only affected the total sugars content, as a fruit characteristic, in the second season and was the sole treatment that didn't influence rag weight in permanent manner.

This study recommends that depriving trees of N for one month at the beginning of cell enlargement stage of fruit growth was the most proper solution alleviating the incidence of misshapen navel without constant change in fruit characteristics, followed by K deprivation regime.

Table 2. Physical and chemical characteristics of "Washington" navel orange fruits as influenced by different deprivation nutrients and ringing positions in two consecutive years (2013 – 2014):

treatments	L/D (Ratio)		Fruit weight (gm)		Fruit volume (ml)		Juice volume (ml)		Rag weight (gm)		TSS %		Acidity %		L-ascorbic acid (mg/100 ml)		Total sugars %		Beta-carotene (mg/100 ml)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	1.08 a	1.08 a	331.21 a	345.74 a	347 a	340 a	120 ab	118 ab	129.29 ab	125.95 a	9.2 a	9.2 a	0.94 a	0.95 b	24 b	29.76 a	11.22 ab	11.41 ab	1.72 b	1.73 b
N deprivation	1.07 a	1.09 a	330.69 a	327.55 a	322 ab	328 ab	118 ab	118 ab	136.02 a	116.67 ab	9.5 a	9.4 a	0.91 a	0.86 b	25.88 b	30.26 a	11.14 ab	11.25 c	2.29 ab	2.11 ab
K deprivation	1.08 a	1.07 a	329.69 a	339.45 a	326 ab	347 a	124 a	123 a	115.88 bc	110.27 bc	9.3 a	9.2 a	0.94 a	0.91 b	26.02 b	30.26 a	11.1 b	11.43 ab	2.61 a	2.23 ab
N+K deprivation	1.05 a	1.06 a	322.26 a	317.61 a	303 b	304 b	117 ab	114 ab	104.07 cd	104.87 bcd	9.0 a	9.0 a	0.94 a	1.11 a	24.7 b	28.92 a	10.5 c	11.46 a	2.25 ab	2.27 ab
Ringing in branch basic	1.11 a	1.10 a	305.67 a	310.6 a	320 ab	303 b	111 b	111 bc	92.77 d	95.61 d	9.0 a	9.1 a	0.87 a	0.83 b	30.92 a	30.92 a	11.34 a	11.31 bc	2.67 a	2.51 a
Ringing in middle of branch	1.09 a	1.09 a	262.96 b	264.06 b	267 c	270 c	97 c	100 c	74.1 e	98.13 cd	8.5 b	8.3 b	0.83 a	0.87 b	29.4 a	29.40 a	11.34 a	11.33 bc	2.43 a	2.43 a

*Values within a column of similar letters are not significantly different according to the least significant difference (LSD) at 0.05 levels.

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تأثير منع النيتروجين والبوتاسيوم المتحكم فيه و تحليق الأفرع المثمره على حدوث إختلال تشوه السرَه وصفات الجوده فى ثمار البرتقال أبو سرَه صنف "واشنطن"

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الملخص

لا زال هناك حاجه لمعرفة العوامل المسببه لظهور إختلال تشوه السرَه وزيادتـه بـشكل واضح فى أشجار البرتقال أبو سرَه حديثة الحمل سواء كان تحت ظروف الزراعة الـصحراويه أو الظروف البيئيه المعتدله. تم إجراء التجربه على ٣٠ شجره من أشجار البرتقـال أبـو سـره صنف "واشنطن" عمر ٤ سنوات بحيث تم تعريضهم بداية من أول مـايو الـى ٣ أنـواع مـن معاملات منع تسميد النيتروجين أو البوتاسيوم أو كلاهما لمدة شهر وأيضا معاملتين تحليق فـى الأفرع الحامله للثمار بغرض معرفة دور زيادة محتوى الأوراق من النيتـروجين والبوتاسـيوم وكذلك مدى توفر الكربوهيدرات على حدوث إختلال تشوه السرَه. تـسبب كـلا النـوعين مـن المعاملات (منع التسميد أو التحليق) فى تقليل حدوث إختلال تشوه السرَه. كـان هنـاك معامـل إرتباط قوى بين زيادة محتوى الأوراق من النيتروجين وإختلال تشوه السرَه. وجد أيضا أن منع تسميد النيتروجين المعامله الوحيده التى لم تسبب اختلاف دائم معنوى فى صفات جـودة الثمـره ولذلك كان منع تسميد النيتروجين لمدة شهر أفضل معامله لتقليل حدوث هذا الإختلال.