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Effects of Combination Between Nitrogen and Potassium Fertilization on Yield and Quality of Valencia Orange Fruits

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Abstract

Nitrogen (N) and potassium (K) are the most important nutrients for fruit yield and quality of citrus. Farmers - growing orange is usually applied high rates of N and K fertilizers. The study was carried out during 2017 and 2018 production year on a 4-year Valencia orange. The objective of the present paper was to evaluate the effect of combination between nitrogen and potassium on fruit yield and quality of Valencia orange. The experiment was used three doses of N (0.5, 1.0, and 1.5 kg/tree) in form of urea and three doses of K (0.6, 0.9, and 1.2 kg/tree) in form of potassium chloride in all combinations. The obtained results showed that N and K concentrations in soil did not increase with increment of N and K fertilization. Increment of N and K fertilization increased N content but did not increase K content in leaves. Fruit weight, fruit diameter and peel thickness increased with increasing of N fertilization. Maximum fruit yield of Valencia orange was attained with rates of 0.5 kg N/tree combined with 0.9 kg K/tree. Juice content increased with increasing amount of N fertilization. Increment of K fertilization tend to increase total acidity in fruit juice. The highest TSS and TSS/TA were attained with rates of 0.5 kg N/tree combined with 0.9 kg K/tree.

Keywords: Valencia orange, fruit yield, fruit quality, plant nutrient

1. Introduction

Orange is the most important fruit crop in Vietnam. During the last few years the area of orange cultivated was increased rapidly reach to 56,738 ha with total production of 768,319 tons in the 2017 season. N and K are the most important nutrients for citrus growth, fruit yield and quality. They are needed in adequate amounts, especially at critical crop growth stages, especially, fruit initiation and development (Obreza & Morgan, 2008; Alva et al., 2005). N is pre-requisite and the most important nutrient for citrus cultivation (Alva & Tucker, 1999; Boman & Obreza, 2002; Alva, Paramasivam, Graham, & Wheaton, 2003). Fruit yield of citrus trees depends largely on N fertilization, because this element plays an important role in vegetative and reproductive growth (Jackson, Alva, Tucker, & Calvert 1995). N is essential to enhance plants biological processes and enables plants to use the energy of sunlight to form sugars from carbon dioxide and water (Abbas & Fares, 2008). K is necessary for several basic physiological functions, such as, sugars and starch metabolism, synthesis of proteins, normal cell division and growth and neutralization of organic acids (Abbas & Fares, 2008). It will increase fruit size, yield, vitamin C content and fruit quality (Ritenour, Wardowski, & Tucker , 2002). Excessive high K levels, however, will result in large and coarse fruit with a rather thick and greenish peel and high juice acidity (Wutscher & Smith, 1993). High N and K levels increase acidity of juice and delayed maturity. High N increases the amount of green color pigment on the peel fruit, increasing N tends to decrease fruit size, while increasing K tends to increase fruit size, indicating that the K effect is greater influence (Herman & Koo, 1959). K deficiency induces the strongest effects, resulting in less starch and more soluble sugar (Ruth et al., 1995). High fruit yield is obtained with N and K at the rates of 192 and 200 kg/ha/year. TSS/TA ratio slightly decreases as N leaf concentration is increased (Hammmami, Rezgui, & Hellali, 2010). In a soil with very low K concentration, maximum lemon yield averages over six harvests, is attained with the rates of 220 kg N/ha, 20 kg P/ha, and more than 225 kg K/ha. Fruit size of lemon increases with increasing rates of K and decreasing rates of N (Quaggio, Mattos, Cantarella, Almeida, & Cardoso, 2002). For Pera and Valencia oranges in Brazil, the maximum fruit yield of Pera is obtained with 242 kg K/ha, while fruit size is maximized with 282 kg K/ha. Similarly, fruit yield of 'Valencia' is obtained with 302 kg K/ha and maximum fruit size with 248 kg K/ha. However, the K rate for maximum profit is obtained with approximately 200 kg/ha for Pêra and 270 kg/ha for Valencia (Quaggio, Junior, & Boaretto, 2011).

The objective of this study is to evaluate the effects of N and K fertilizer combination on yield and fruit quality of Valencia orange.

2. Materials and Methods

2.1 Experimental Design

This study was conducted during the seasons of 2017 and 2018 on 54 Valencia orange trees of 4-year old budded on sour orange rootstock with a similar canopy volume selected for placing into each treatment. The experimental deign was a randomized complete block with nine fertilizer treatments replicated three times. The trees grown in clay Loam soil at experimental farm of Nghia Dan district, Nghe An province, Vietnam. The orange trees pleated at 4 × 5 m apart with about 500 trees/ha.

Table 1. Fertilizer rates in a year for each treatment

The applied treatments: No	**Treatment (kg/tree)**
T_1	0.5 N + 0.6 K
T_2	1.0 N + 0.6 K
T_3	1.5 N + 0.6 K
T_4	0.5 N + 0.9 K
T_5	1.0 N + 0.9 K
T_6	1.5 N + 0.9 K
T_7	0.5 N + 1.2 K
T_8	1.0 N + 1.2 K
T_9 (Farmer practice)	1.5 N + 1.2 K

Note. Nitrogen fertilization: Three doses of nitrogen were used, *i.e.*, 0.5; 1.0 and 1.5 kg/tree yearly in the form of urea (N = 46%). These does of nitrogen fertilizer were added as soil application. Each dose was divided into 4 equal amounts and added in January, May, August and September.

Potassium fertilization: Three doses of nitrogen were used, *i.e.*, 0.6; 0.9 and 1.2 kg/tree yearly in the form of potassium chloride (K_2O_2 = 60%). These does of potassium fertilizer were added as soil application. Each dose was divided into 4 equal amounts and added in January, May, August and September.

2.2 Soil Sampling and Analysis

Soil samples were taken twice (January, 2017 and November, 2018). The samples were taken by a sampling tube from 4 positions directly beneath the outer canopy of each tree, sampling depths were 0 to 20 cm. The samples were mixed, dried by air, and gravels and debris were removed by a 2 mm sieve from the ground samples. Soil pH was measured using 1:2.5 soil:water ratio. Total nitrogen was analyzed by Kjeldahl method. Exchangeable K, Ca and Mg were extracted with 1 M NH_4OAc at pH 7.0. Concentration of K was analyzed by a flame photometer. Concentrations of Ca and Mg were analyzed by an atomic absorption spectrophotometer (AAS) (Jones, 2001, 2003).

2.3 Leaf Sampling and Analysis

Orange leaves were sampled twice (January, 2017 and November, 2018). The leaves were sampled from the third or fourth position, 3 to 5 months old, newly flush, and non-fruiting twig on the outer canopy. The samples were dried at 65 °C, ground, and passed through a 1 mm sieve. N was analyzed by the Kjeldahl method. The samples were digested with 2:1 HNO_3:$HClO_4$ for K, Ca and Mg analysis. Concentration of K was analyzed by a flame photometer. Concentrations of Ca and Mg were analyzed by an AAS (Soil and Plant Analysis Council, 1998).

2.4 Fruit Sampling and Analysis

Orange fruits were sampled twice, on December 2017 and December 2018. A medium size of fully ripen orange fruits were sampled from each replication (three fruits from each tree). Fruit weight was determined, thickness of flavedo and albedo (peel) was measured at four points equatorially using a ruler. The orange juice was extracted by a blander, and the juice content was calculated from juice volume and fruit weight. The total soluble solid (TSS) was determined using a hand refractometer. The titratable acidity (TA) was determined by titration of 50 ml juice with 0.1 M NaOH and calculated by assuming that all acids in the juice are equivalent to citric acid (Boland, 1995). The test index (TSS/TA) was calculated from the ratio of TSS and TA.

2.5 Analysis of Experimental Data

The data were subjected to an analysis of variance (ANOVA) in a completely randomized design that contained nine treatments and three replicates per treatment. The mean separation was performed by Duncan's multiple range tests at the 5% level of significance.

3. Results and Discussion

3.1 Effects of Fertilzer Application on Soil Chemical Properties

Data from Table 2 indicates that soil pH was significantly higher in T2, T5 and T9 than in the other treatments before application, except for T4. Soil pH tends to decrease with increasing the amount of N and K fertilization. In this respect, when fertilized 1.5 kg N/tree combined with 1.2 kg K/tree (T9) gave significant lower soil pH than the other treatments. In treatment T1 and T4 gave significant higher soil pH than the other treatments after treatment application, except for T7. Optimum soil pH for citrus ranges from 6.0 to 6.5 (Obreza & Morgan, 2008), in this study, however, soil pH, ranging from 4.97 to 5.90, were lower than optimum range in all the treatments after fertilization. Therefore, application of Ca and Mg to increase soil pH should be required every year. Total N in soil was low in all the treatments, ranging from 0.12 to 0.15%, it had no significant differences between treatments in both before and after fertilizer application, indicating that nitrogen fertilization did not affect N concentration in soil. Regarding exchangeable K content, Table 2 reveals that treatment T4, T6 and T7 gave significant higher than the other treatments before fertilizer application, except for T2. The increment of K fertilizer did not increase exchangeable K in soil after fertilizer application. In treatment T3 and T4 gave significant higher exchangeable K than the other treatments after fertilizer application, except for T6. Exchangeable calcium (Ca) varied widely from 656.3 to 1126.5 mg/kg. The highest value of Ca was found in T2, which was significantly higher than the other treatments before fertilizer application. Increment of N and K fertilization tended to decrease exchangeable Ca in all of the treatments. Especially increasing the amount of K fertilizer from 0.6 to 1.2 kg/tree, the concentration of exchangeable Ca significantly decreased. Mobility of Ca ions is affected by high concentrations of K ions, not only in the soil, but also in plants themselves, where they influence Ca distribution and can thus exacerbate Ca deficiencies (Shear, 1975). The exchangeable Ca was significantly higher in treatments T1, T2 T3 and T4 than the other treatments, except for T5 and T6 after fertilizer application.

Table 2. Chemical properties of top-soils (0 to 20 cm) before and after treatment application

Treatments	pH		Total N (%)		Exch. K (mg/kg)		Exch. Ca (mg/kg)		Exch. Mg (mg/kg)	
	Before	After	Before	After	Before	After	Before	After	Before	After
T_1	5.67^b	5.90^a	0.13^a	0.10^a	136.4^b	121.5^{cd}	800.4^c	808.2^a	42.5^c	65.5^a
T_2	6.07^a	5.67^a	0.15^a	0.12^a	153.5^{ab}	116.8^d	1126.5^a	816.8^a	63.9^a	55.6^b
T_3	5.50^b	5.47^b	0.14^a	0.15^a	134.2^b	155.9^a	811.8^c	809.4^a	42.7^c	44.1^c
T_4	5.73^{ab}	5.77^a	0.14^a	0.12^a	157.4^a	152.3^a	791.9^c	768.7^a	42.9^c	53.1^b
T_5	5.80^a	5.10^{cd}	0.13^a	0.12^a	137.9^b	136.2^b	918.7^b	762.0^{ab}	54.7^b	50.9^{bc}
T_6	5.60^b	4.97^{de}	0.15^a	0.11^a	169.3^a	147.4^{ab}	737.6^c	712.6^{abc}	39.4^{cd}	35.9^d
T_7	5.60^b	5.53^{ab}	0.14^a	0.13^a	173.3^a	116.8^d	804.4^c	698.1^{bc}	38.1^d	36.9^d
T_8	5.63^b	5.40^{bc}	0.14^a	0.15^a	146.5^b	134.4^{bc}	732.9^c	676.4^c	36.9^d	36.2^d
T_9 (Farmer practice)	5.83^a	4.57^e	0.15^a	0.13^a	127.6^b	123.8^c	953.6^b	656.3^c	55.0^b	38.0^d
$LSD_{0.05}$	0.39	0.40	0.10	0.10	26.5	14.4	92.3	66.8	4.3	6.2

Note. Different letters within the rows indicate significant differences ($P \leq 0.05$).

Exchangeable of magnesium (Mg) was very low in soil, it ranged from 36.2 to 65.5 mg/kg. The highest exchangeable Mg was found in T4 before fertilizer application, the exchangeable Mg tended to decrease after N and K fertilization, except for in T1, T3 and T4. Exchangeable Mg was significantly higher in T1 than the other treatments. Optimum ranges of N, K, Ca and Mg in soil for "Khasi" mandarin were 220.8 to 240.6, 252.2 to 300.8, 278.1 to 318.6, and 67.2 to 92.5 mg/kg, respectively (Srivastava & Singh, 2006).

3.2 Effects of Fertlizer Application on Nutrient Uptake

Table 3 shows that N content of T5 leaves was significantly lower than that of the other treatments before fertilization, excepted for T1. The other treatments were not significantly diffrent. N content in the leaves increased with increasing the amount of N after fertilization. However, additional N fertilizer from 0.5 to 1.0 kg/tree did not increase N content in the leaves, N content in the leaves of T1, T2, T4, T5, T7 and T8 had not significant diffrent after fertilization. When fertilized with 1.5 kg N/tree combined with 1.2 kg K/tree (T9) gave significant higher N content in the leaves of Valencia orange (29.20 g/kg), except for T7 and T8. Increasing N ferlitizers tended ton increase N content in leaves of orange. The results are in agreement with those obtained by Nguyen, Maneepong, and Suranilpong (2016), El-Khawaga and Maklad (2013). The optimum range N content in orange leaves recommended was 23 to 27 g/kg (Quaggio, Mattos, & Bosrtto, 2010). In this study, the N content in leaves was higher than optimum range in treatment T3, T6 and T9 (nitrogen fertilizer was applied 1.5 kg/tree), the other treatments were in optimum range. However, Abdelkade, Salah, and Rachid (2010) suggested optimum of leaf N for mandarin 27 to 29 g/kg.

Table 3. Effects of nitrogen and potassium fertilization rates of some leaf chemical constituents of Valencia orange

Treatments	N (g/kg)		K (g/kg)		Ca (g/kg)		Mg (g/kg)	
	Before	After	Before	After	Before	After	Before	After
T_1	26.33^{ab}	26.60^{b}	17.36^{ab}	15.08^{c}	27.45^{b}	29.31^{ab}	2.67^{b}	2.72^{c}
T_2	27.23^{a}	27.21^{b}	18.21^{a}	15.87^{c}	28.61^{ab}	31.30^{a}	2.94^{a}	2.80^{bc}
T_3	26.69^{a}	28.97^{a}	17.25^{ab}	15.10^{c}	28.93^{a}	28.85^{b}	2.59^{b}	2.97^{ab}
T_4	26.97^{a}	27.17^{b}	17.99^{a}	19.03^{a}	26.89^{c}	29.36^{a}	2.69^{b}	3.10^{a}
T_5	25.40^{b}	27.23^{b}	16.55^{bc}	17.83^{b}	28.74^{a}	28.52^{b}	2.64^{b}	2.70^{c}
T_6	26.77^{a}	28.90^{a}	16.97^{a}	17.62^{b}	26.66^{c}	27.12^{b}	2.60^{b}	2.75^{bc}
T_7	26.53^{a}	27.15^{b}	16.34^{bc}	17.65^{b}	27.26^{bc}	28.35^{ab}	2.57^{b}	2.75^{bc}
T_8	27.13^{a}	27.20^{b}	16.12^{bc}	17.72^{b}	26.66^{c}	27.52^{b}	2.54^{b}	2.71^{c}
T_9 (Farmer practice)	27.27^{a}	29.20^{a}	15.51^{c}	17.81^{b}	29.52^{a}	30.32^{a}	2.74^{ab}	2.84^{bc}
$LSD_{0.05}$	1.52	1.66	1.25	1.08	1.61	2.41	0.21	0.22

Note. Different letters within the rows indicate significant differences ($P \leq 0.05$).

The K content was significantly higher in T2 (18.21 g/kg) than T5, T7, T8 and T9; it had no significant differnces between T2 and the other treatments before fertilization (Table 3). K content in the leaves of orange tended to decrease in T1, T2 and T3 when fertilized 0.6 kg K/tree, these amounts of K fertilizers may not enough for oranges. K content in the leaves increased with increasing amount of K from 0.9 to 1.2 kg K/tree and gave significant higher than fertilzed 0.6 K/tree. In this respect, when fertilized 0.9 kg K/tree with 0.5 kg N/tree gave significant higher K content in the leaves of Valenica orange. Increased K fertilizer to 1.2 kg/tree did not increase K content in the leaves. The optimum range recommended was 10 to 15 g/kg (Quaggio et al., 2010), 10 to 12 g/kg (Hammmam et al., 2010). The results in Table 3 shows that K content in the leaves were higher than optimum range. However, the TSS/TA of Valencia orange gave the highest value when K content in leaves was 1.82% (El-Khawaga & Maklad, 2013). Regarding Ca content Table 3 reveals that the Ca content in the leaves of Valencia orange ranged from 26.66 to 29.52 g/kg; it was significantly higher in treatment T3, T5 and T6 than the other treatments, except for T2 before fertilization. The Ca content tended to increase after fertilization, although Ca fertilizer was not applied by authors but by farmer. The high content of Ca was found in treatment T2, T4 and T9, these treatments were significantly higher Ca content than the other treatments, except for T1 and T7. The optimum range of Ca content in the leaves of orange was 35 to 40 g/kg (Quaggio et al., 2010); the Ca content in the leaves of this study was lower than optimum range. Data from Table 3 shows that Mg content in the leaves was significantly higher in treatment T2 than other treatmets, except for T9 before fertilzation. The Mg content sighly increased after fertilzation, it was significantly higher in treatment T4 than the other treatments, except for T3. The Mg content in the leaves was lower than optimum range for orange (3.0 to 4.0 g/kg; Quaggio et al., 2010) and it was only in optimum range in T4 after fertilization.

3.3. Effects of Fertilizer Application on Fruit Yield and Quality of Valencia Orange

Data from Table 4 shows that using 1.5 kg N combined with 1.2 kg K/tree (T9) gave higher average fruit weight than the other treatments which gave 221.23 and 264.17 g/fruit during the first and second seasons, respectively. Fruit weight tended to increase with increasing N fertilizer from 0.5 to 1.5 kg N/tree. This result partially agrees with the finding of Zaied, Khafagy, and Shale (2006) on Washinton Navel orange mentioning that fruit weight increased with increasing N application. However, the fruit weights had no significant differences between treatments in both studied seasons. Fruit diameter was significantly higher in T8 than in T5 of the first season, but no significant diifferences among the other treatements. The fruit diameter inceased with increasing N application, but it had no significant differences among treaments in the second season. The peel thickness ranged from 0.35 to 0.44 cm, it tended to increase with increasing N application in the second season. Nath and Mohan (1995) reported that higher level of N application caused thicker fruit peel of lemon. However, the peel thickness had no significant differences in treatments of both studied season. Also, Table 4 clearly indicates that fruit yield of Valencia orange trees were significantly affected by using N and K fertilizers, tended to increase in the second season, except for T1 and T2. The best treatmet was found in T4 when trees recieved 0.5 N and 0.9 kg K/tree (55.7 and 58.37 kg/tree) in both seasons, increasing by 17.32 kg/tree and 12.46 kg/tree in the first and second season, respectively, than using the farmer practice treament (T9). Potassium plays important role in in many biochemical and physiological reaction such as enzyme activation, photosynthesis, stomata activity and osmoregulation, carbohydrate and sugar transport, nutrient transport, protein and starch synthesis (Havlin, Beaton, Tisdale, & Nelson, 1999) resulting in increased yield, weight and size. The K requirement for lemon trees was higher than for N, the maximum fruit yield was obtained when applied 220 kg N/ha, and more than 225 kg K/ha (Quaggio et al., 2002). Table 4 shows that fruit yield of Valencia orange did not increase with increasing N and K fertilizers, treatment T9 (farmer practice) was applied 1.5 kg N/tree and 1.2 kg K/tree, but the fruit yield was significantly lower than T4. Fruit yield of Valencia orange increased with increasing N fertilizer from 30 to 170 kg/ha/year, but it tended to decrease when N fertilizer increased to 240 kg/ha/year, it slightly decreased with increasing K fertilizer (Quaggio et al., 2006).

Table 4. Effects of nitrogen and potassium fertilization on fruit weight, fruit diameter, peel thickness and yield of Valencia orange

Treatments	Fruit weight (g/fruit)		Fruit diameter (cm)		Peel thickness (cm)		Yield (kg/tree)	
	2017	2018	2017	2018	2017	2018	2017	2018
T_1	248.17^a	245.72^a	7.90^{ab}	7.70^a	0.39^a	0.40^a	46.59^a	46.32^b
T_2	268.87^a	250.68^a	7.83^{ab}	7.73^a	0.35^a	0.39^a	50.16^a	46.80^b
T_3	239.17^a	258.37^a	7.63^{ab}	8.12^a	0.38^a	0.46^a	46.81^a	50.72^{ab}
T_4	245.77^a	257.32^a	7.66^{ab}	7.93^a	0.44^a	0.37^a	55.72^a	58.37^a
T_5	244.67^a	258.48^a	7.30^b	7.82^a	0.40^a	0.41^a	39.97^b	42.26^b
T_6	221.67^a	260.82^a	7.60^{ab}	7.90^a	0.36^a	0.43^a	31.83^c	45.56^b
T_7	240.43^a	242.36^a	7.70^{ab}	7.62^a	0.42^a	0.38^a	44.75^{ab}	45.15^b
T_8	264.47^a	258.76^a	8.07^a	7.85^a	0.41^a	0.40^a	42.90^b	44.25^b
T_9 (Farmer practice)	221.23^a	264.17^a	7.53^{ab}	7.88^a	0.38^a	0.44^a	38.40^{bc}	45.91^b
$LSD_{0.05}$	57.38	33.14	0.67	0.58	0.38	0.32	11.05	10.62

Note. Different letters within the rows indicate significant differences ($P \leq 0.05$).

Data represented in Table 5 show the average Juice content (%) of Valencia fruit under different level of N and K. In this respect, using 1.5 kg N/tree and 0.9 kg K/tree gave a significant higher values of juice in Valencia orange fruits than using the others of N and K fertilizers, except for T3 (1.5 kg N/tree and 0.6 kg K_2O/tree) in the first season. The juice content tended to increase in the second season, except for T1 and T6, it increased with increasing amount of N fertilzation. Applied 1.5 kg N/tree (T3, T6 and T9) combination with deffrent levels of K fertilizer gave higher juice content than the others amount of N fertilizers, except for T8.

Table 5. Effects of nitrogen and potassium fertilization on juice ratio, TSS, TA and TSS/TA of Valencia orange

Treatments	Juice content (%)		TSS		TA (% w/v)		TSS/TA	
	2017	2018	2017	2018	2017	2018	2017	2018
T_1	55.5^b	54.3^b	9.03^c	10.32^{bc}	0.67^a	0.58^a	13.49^c	17.79^b
T_2	53.8^b	57.4^{ab}	9.23^b	10.23^{bc}	0.58^a	0.59^a	15.90^b	17.34^{bc}
T_3	59.8^{ab}	61.8^a	9.90^{ab}	10.15^c	0.55^a	0.58^a	18.00^a	17.50^{bc}
T_4	55.5^b	58.6^{ab}	10.57^a	11.52^a	0.54^a	0.58^a	18.54^a	19.86^a
T_5	55.9^b	59.4^{ab}	9.17^{bc}	10.34^b	0.56^a	0.63^a	16.37^b	15.41^d
T_6	66.2^a	62.5^a	9.77^b	10.18^c	0.64^a	0.65^a	15.27^b	15.66^{cd}
T_7	55.7^b	56.2^b	9.73^b	10.81^b	0.61^a	0.70^a	15.95^b	15.44^d
T_8	54.5^b	61.8^a	8.77^c	10.27^{bc}	0.54^a	0.68^a	16.24^b	15.10^d
T_9 (Farmer practice)	54.7^b	62.7^a	8.90^c	10.14^c	0.74^a	0.72^a	12.03^c	14.21^d
$LSD_{0.05}$	7.4	5.5	0.74	0.60	0.21	0.25	1.59	1.74

Note. Different letters within the rows indicate significant differences ($P \leq 0.05$).

Regarding the effect on total soluble solids (TSS) in the juice of Valencia orange fruits, data in Table 5 indicates that using 0.5 kg N/tree combinned with 0.9 kg K/tree (T4) gave signicantly higher values of TSS in orange juice than the other treatments, except for T3 in the first season. The low TSS was found in T1, T8 and T9 in the first season. The TSS in orange juice tended to increase in the second season. The highest value of TSS was obtained in the treatment which was applied 0.5 kg N/tree combined with 0.9 kg K/tree (T4), it had a significant defference between T4 and the other treatments. TSS tended to decrease with increasing amount of N application, especially in the treatments which were applied 1.5 kg N/tree (T3, T6 and T9). The increment of N fertilization decreased TSS of Pera sweet orange (Quaggio et al., 2006). As for total acidity percentage (TA), Table 5 shows that low value in TA was noticed with T4 was (0.54 and 0.58), this treatment was applied 0.5 kg N/tree combined with 0.9 kg K/tree. The TA increased with increasing the N and K levels, thus T9 gave high value (0.74 and 0.72). Increasing N and K levels inceased TA in the juice of Valencia orange was also reported by Quaggio et al. (2006). However, the TA had no significant difference between different levels of N combined with K. TSS/TA is generally used as a test index for indicating balance of sweet and sour. High TSS/TA indicates better taste of fruit juice. The importance of TSS/TA ratio due to determinate the suitable harvesting date. It could be noted in Table 5 that the lowest value of TSS/TA was observed in T1 and T9 in the first season. The TSS/TA was significantly higher in T4 than the other treatments, exccept for T3 in the first season. The lower rate of N (0.5 kg N/tree) promoted the possitive effect on TSS/TA than using 1.5 kg N/tree in the second season. This result is in agreement with those obtained by El-Khawaga and Maklad (2013). The lower TSS/TA was observed in the treatments applied high level of K (T5, T6, T7, T8 and T9), because of increasing total acidity in orange juice. TA in fruit juice of Valencia orange slighly increased with increasing K fertilizer (Quaggio et al., 2011). The highest value of TSS/TA was observed in T4 (19.86), it had a significant difference with the other treatments in the second season. This treatment was also found high content of N, K, Ca and Mg in the leaves of Valencia orange after fertilization (27.17, 19.03, 29.36 and 3.10 g/kg; respectively).

4. Conclussion

The fruit weight, fruit diameter, peel thickness and TA did not have any significant differences between different levels of N combined with K. Juice content increased with increasing amount of N fertilzation. Higher fruit yield, TSS and TSS/TA were observed in the treatment which was applied 0.5 kg N/tree combined with 0.9 kg K/tree.

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