The Response of Nonbearing Navel Orange Trees for Mineral and Organic Nitrogen Fertilization Treatments and K-Humate Addition

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Abstract: T This study was carried out through two successive seasons (2008 and 2009) in a private orange orchard in Qalubia governorate Egypt in a three years old Navel orange trees budded on sour orange rootstock on clay loam soil (Typic Torriorthents). Planting distance was 2.5×5 meters apart and flood irrigation was used by river Nile water. Two nitrogen rates were used 150 and 300 g N/tree/y in three forms 100% mineral nitrogen (M.N.) as ammonium nitrate, 100% organic nitrogen (O.N.) as compost and mixed (50% M.N. + 50% O.N.) each of these treatments with or without K humate addition (6 kg/feddan). All fertilization treatments were divided into equal five doses added every two months from February to October during the two seasons. The obtained results showed that the highest stem thickness increment percentage was recorded by mixed nitrogen form (50% M.N. + 50% O.N.). Mixed nitrogen form with K-humate recorded the highest significant value of plant height increment percentage in the first season, but in the second season, using nitrogen form at 150g N/tree/y without K-humate recorded the highest significant value. Leaf N content had higher significant values with M.N. treatments. Leaf P content showed insignificant differences among treatments. Mixed N source at 300g N/tree/y without K-humate recorded a higher significant value of leaf K content, in the second season compared with other treatments. Leaf Ca content showed a higher significant value by organic and mixed N form treatments in the first season. Leaf Mg, Fe, Mn and Zn contents increased significantly with M.N. treatments in the first season. While in the second season leaf Fe content had a higher significant value with O.N. treatments. Leaf Mn content illustrated the lowest significant mean level by using N form at 150g N/tree/y treatment. While, leaf Zn content recorded a higher significant value with mixed nitrogen source at 150g N/tree/y with K-humate addition compared with all other treatments. From this results we recommended that the mixed sources of N fertilizer (50% M.N. + 50% O.N.) at 150g N/tree/y is the best N fertilizer, and the application of K-humate or humic acid at commercial rate is not recognized for the young Navel orange trees in clay loam (Typic Torriorthents) soil.
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Key words: Ammonium nitrate – Compost – Fertilization – K-humate – Leaf mineral content – Navel orange – Vegetative growth.

1. Introduction:

Thompson *et al*. (2002) used N rates of 0, 0.15, 0.30, and 0.45 lb N/tree/y, and fertigation frequencies of weekly, monthly, and three times per year in five years old 'Newhall' navel oranges on 'Carrizo' rootstock. They found that leaf N in all fertilized plots was above tissue critical levels. There were no significant yield differences among N rates from 0.15 to 0.45 lb N/tree and fertigation frequencies from weekly to three times per year. Menino *et al*. (2003) revealed that in a field experiment conducted in the South of Portugal with young (0-3 years old) non-bearing 'Lane Late' orange trees. The 180g N tree^{-1} over three years led to the greatest canopy width (176 cm). Strong relationships between canopy width and N, which were greater at the larger rates of fertilizer application, and strong and inverse relationships between K and Mg, also with the greatest N rates. Madejon *et al.* (2001) reported that the application of compost significantly increased crop yield.

Fuegoson (1994) found that standard granular fertilizer and processed chicken manure applied at recommended N rates (0.48 lbs N/tree/y) to 1-year old "Hamlin" orange *C. sinensis* (L) Osb. trees on Swingle citruelo rootstock stimulated similar growth increases in stem caliper and plant height. Turan *et al.* (2009) in a comparison of several plant nutrient elements in conventionally (CON) and organically (ORG) grown citrus orchards they recorded that analysis of the samples from 2007 indicated statistically significant differences between the two groups for concentrations of N, K, Mg, B and Mn. Several trace elements (Pb, Cu, Fe, Mn, Ni and Zn) from five randomly chosen soil samples from both CON and ORG growing groups were determined, and the results indicated that the mean concentrations for the two groups were similar for most of the elements (Pb, Cu, Fe and Ni). Their results shed light on the optimization of plant nutrient programs in organic citrus production. Canali *et al.* (2004) found that compost increased soil potentially available nutritive elements to crops.

Shiralipour *et al.* (1992) recorded that the organic matter content of compost is high and its addition to soil often improves soil physical and chemical properties and enhances biological activities. Most agricultural benefits from compost application to soil are derived from improved physical properties related to increase organic matter content rather than its value as a fertilizer. Compost provide a stabilized form of organic matter that improves the physical properties of soil by increasing nutrient and water holding capacity, total pore space, aggregate stability, erosion resistance, temperature insulation and decreasing apparent soil density. Application of compost improves the chemical properties by increasing cation exchange capacity and soil nutrient content. Alva and Obreza (1997) studied the demonstrated significant improvements in growth and Fe availability to non-bearing trees and Fe availability and fruit yield of bearing trees in high pH soils with application of Fe humate as compared to the amendments treated.

This investigation aimed to study the effect of nitrogen form (mineral and organic and their combination) at two rates (150 and 300g N/tree/y) with or without K-humate (humic acid) addition on growth and leaf mineral content of the three year old Navel orange trees budded on sour orange rootstock grown on clay loam soil (Typic Torriorthents). In order to define the suitable form and rate of nitrogen fertilizer and the important of humic acid addition at the first few years of tree planting in the orchard which induce great tree growth and optimum leaf mineral content.

2. Materials and Methods:

This study was carried out in two successive seasons (2008 and 2009) in a private orange orchard in Qalubia governorate, Egypt. Three year old Navel orange trees budded on sour orange rootstock were used. The soil was characterized by: pH = 7.55, ECe = 1.66 dS/m, organic matter = 2.18%, CaCO3 = 1.7%, Sand = 31%, Silt = 36% and clay = 33%, the soil texture class was clay loam (Typic Torriorthents). Flood irrigation system was used. Planting distance was 2.5×5 meters apart. Nitrogen fertilizer was added at two rates (150 and 300g N/tree/y) as treatment of mineral type (ammonium nitrate, 33.5% N), organic type (compost) and mixed (50% M.N. + 50% O.N.) with or without addition of K-humate (humic acid, Power Humus, Humintech Co., Germany) addition at rate of 6 kg/feddan. Compost was characterized by: humidity = 20%, Salts = 3.0%, pH = 8.7, organic matter = 37.5%, intinisity = 1.2 g/cm^3, N = 1.9%, K = 2.1%, P = 0.52%, Fe = 944 mg/kg, Zn = 58 mg/kg and Mn = 473 mg/kg. K-humate was characterized by: organic matter = 87.5%, N = 0.8%, P = 0.16%, K = 7%, Zn = 20 mg/kg, Fe = 500 mg/kg and Mn = 125 mg/kg.

Treatments were as follow:

1- 100 % M.N at 150g N/tree/y;
2- 100 % M.N at 150g N/tree/y + K-humate;
3- 100 % M.N at 300g N/tree/y;
4- 100 % M.N at 300g N/tree/y + K-humate;
5- 100 % O.N at 150g N/tree/y;
6- 100 % O.N at 150g N/tree/y + K-humate;
7- 100 % O.N at 300g N/tree/y;
8- 100 % O.N at 300g N/tree/y + K-humate;
9- 50 % M.N + 50 % O.N (at 150g N/tree/y);
10- 50 % M.N + 50 % O.N (at 150g N/tree/y) + K-humate;
11- 50 % M.N + 50 % O.N (at 300g N/tree/y);
12- 50 % M.N + 50 % O.N (at 300g N/tree/y) + K-humate.

All fertilization treatments were divided into equal five doses and added every two months from February to October during both seasons. The treatments were arranged in a randomized complete block design in a factorial experiment (three factors the first is the form of nitrogen, the second is application rate and the third is with or without addition of humic acid) with five replicates for each treatment and each replicate was represented by one tree.

The following data were recorded:

1- Stem thickness increment percentage of (10 cm above union zone) was recorded every two month from May to November.
2- Leaf dry matter percentage was calculated at the end of each season in spring flushes leaves.
3- Leaf mineral content was determined as follow:

Twenty leaves 5-7 months old from spring flushes leaves were collected randomly from each replicate. The leaf samples were washed several times with tap water then rinsed with distilled water, dried at 70^{o}C in an electric oven till a constant weight, grounded in electric mill and digested according to Chapman and Prat (1961). Nitrogen was determined by MicroKjeldahl method. While, phosphorus was determined colorimetrically by spectrophotometer (Lambda 1A, Perkin Elmer, Inc., MA, USA), using the ascorbic acid method. Potassium was determined by the method of the flame photometer (JENWAY, PFP-7, ELE Instrument Co. Ltd., UK). Whereas, calcium and magnesium were determined by titration against versenate solution. Also, iron, zinc and manganese were estimated by using Atomic Absorption spectrophotometer (Varian Spetra AA20, Victoria, Australia). All elements were determined according to Page *et al.* (1982).

Data obtained throughout this study were statistically analyzed using the analysis of variance method as reported by Snedecor and Cochran (1980) and the differences between means were differentiated by using Tukey's multiple range test.

3. Results and Discussion

Data presented in Table (1) showed that the stem thickness increment percentage of young Navel orange trees as affected by different forms and rates of N and K-humate addition in both seasons. Only second interaction between N form X rate always had a significant effect by analysis of variance for all 8 measurements, whereas, the K-humate application had no constant effect. The highest significant stem thickness increment percentage by Tukey's multiple range test for first season in May and July were obtained with mixed N form X 150g N/tree/y treatments (Table, 1). These increment percentages were 13.1% and 18.1%, respectively. For the second season the highest significant increment percentage in May, July and September were obtained with mixed N form X 300g N/tree/y treatments (Table, 1).

Data shown in Table (2) indicated that the leaf dry matter percentage of young Navel orange trees in the first season, without K-humate treatments gave a higher significant value than with K-humate treatments, but in the second season all data lake significance among them.

Plant height increment percentage of young Navel orange trees was significantly affected by the different forms and rates of N and K-humate addition as shown in Table (2). In the first season both the second interaction between N forms X rates and N forms X K-humate had significant effects. The highest mean of plant height increment percentage were obtained with mixed N form X 150 and 300g N/tree/y treatments. This increase was 72.0 and 69.5%, respectively. For the interaction between N form X K-humate, the highest mean increase percent was 75.5% for the treatments with mixed N form with K-humate. While in the second season all treatment factors and its interactions were recorded significant effects. For the third interaction the highest mean of plant height increment percentage were 87 and 78% for mixed N X 150g N/tree/y with K-humate and organic N X 150g N/tree/y with K-humate, respectively, (Table, 2). On the other hand, the treatment with mineral N at 150 or 300g N/tree/y with or without K-humate recorded little significant effect on plant height increment percentage. These results are in contrary with those found by Menino *et al*. (2003) concluded that using 180g N $tree^{-1}$ over three years led to the greatest canopy width and volume. In the same regards, Fuegoson (1994) had the same trend of these results and found that granular fertilizer and processed chicken manure nitrogen form stimulated similar growth increases in stem caliper and plant height of Hamlin" orange trees.

Data in Tables (3 and 4) generally showed that N, Ca, Mg, Fe, Mn and Zn contents in young Navel orange trees in the first and second seasons were significantly affected by N forms while N rates and K-humate application and its interactions were recorded no significant affects.

Nitrogen content of young Navel orange trees significantly increased with mineral N form application in the first and second seasons.

Navel orange trees P and K contents were not affected with N form, rates and K-humate application and its interactions in both seasons. Only the third interaction between N form X rates X K-humate for the second season had a significant effect on the K content. The treatment of mixed N form X 300g N/tree/y X without K-humate application had the highest K content (Table, 4). In spite of K-humate contain 7% K, plant K content was not affected may be due to the inadequate K-humate rate (commercial recommended amount). These results are in harmony with those found by Turan *et al.* (2009) in a comparison of several plant nutrient elements in conventionally (CON) and organically (ORG) grown citrus orchards. They recorded significant differences between the two groups for concentrations of N, K, Mg, B and Mn.

Calcium content of young Navel orange tree increased significantly for organic and mixed N treatments in the first season (Table, 3). This increment of Ca content may be due to the Ca content of compost.

Plant contents of Mg, Fe, Mn, and Zn in the first season were significantly affected by the main effect of N form (Table, 3). These elements increased significantly with mineral N treatments compared with organic or mixed N treatments may be due to decrease the soil availability of these elements by the chelation effect of compost organic matter. Manganese and zinc in the plant increased significantly with the main effect of K-humate application. In the second season (Table, 4), iron content of Navel orange trees was significantly affected with the main effect of N form and the interaction between N form X K-humate treatments. The level of mean Fe content of Navel orange ranged from 82 to 161 mg/kg for the interaction between N forms X K-humate treatments. The highest significant content was organic N with K-humate and organic N without K-humate treatment. Alva and

Obreza (1997) studied the demonstrated significant improvements in growth and Fe availability to non-bearing trees and Fe availability and fruit yield of bearing trees in high pH soils with application of Fe-humate as compared to the amendments treated. Manganese content of trees affected significantly with the N form and rates of N and the interaction between them. The level of mean Mn content of plant ranged from 17 to 26 mg/kg for the interaction between N forms X rates treatments. The lowest significant mean level was mixed N form X 150g N/tree/y treatments. Zinc content in plant was affected significantly with the interaction of N form X rates X K-humate. The highest mean level of Zn content was mixed N form X 150g N/tree/y X with K-humate treatment as shown in Table (4).

Finally it could be concluded that the highest stem thickness increment percentage was recorded by mixed nitrogen form (50% M.N. + 50% O.N.). Leaf dry matter percentage gave a higher significant value without K-humate addition than that of with K-humate, but in the second season all data recorded lake significance among them. Concerning plant height increment percentage, mixed nitrogen form with K-humate recorded the highest significant value. While, in the second season mixed nitrogen form at 150g N/tree/y without K-humate recorded the highest significant value. Leaf nitrogen content had higher significant values with mineral nitrogen form treatments. Leaf phosphorus content showed insignificant differences among treatments. Leaf potassium content, in the second season mixed nitrogen source at 300g N/tree/y without K-humate recorded a higher significant value compared with other treatments. Leaf calcium content showed a higher significant value by organic and mixed N form treatments in the first season. Leaf Mg, Fe, Mn and Zn contents increased significantly with mineral N treatments compared with the organic or mixed N treatments in the first season. While in the second season leaf Fe content had a higher significant value with organic nitrogen form treatments. Leaf manganese content illustrated the lowest significant mean level by mixed N form X 150g N/tree/y treatments compared with the other N form X rates interaction treatments. Leaf zinc content recorded a higher significant value with mixed nitrogen source at 150g N/tree/y with K-humate addition compared with all other treatments.

From these results we recommended that the mixed source of N fertilizer (50% M.N. + 50% O.N.) at 150g N/tree/y is the best N fertilizer, and the application of commercial K-humate or humic acid is not recognized for the young Navel orange trees in clay loam (Typic Torriorthents) soil.

Table 1. Stem thickness increment percentage of young Navel orange trees as affected by different forms and rates of N and K-humate addition in seasons of 2008 and 2009.

Analysis of variance		Stem thickness increment percentage							
		First Season				Second Season			
		May	Jul.	Sep.	Nov,	May	Jul.	Sep.	Nov,
Analysis of variance									
N forms		***	**	***	**	NS	***	*	**
Rates		**	NS	NS	NS	NS	***	NS	NS
K-humate		**	NS	***	***	NS	NS	*	NS
N forms X Rates		***	***	***	***	*	***	***	***
N forms X K-humate		NS	*	***	*	NS	***	***	NS
Rates X K-humate		*	NS	***	**	NS	**	***	***
N forms X Rates X K-humate		**	NS	***	NS	NS	NS	NS	NS
Tukey's Multiple range test									
Main effect									
N Forms	Mineral	9.1B	14.3B	8.3B	10.5A	8.5A	11.1B	6.0B	9.75A
	Organic	7.3C	15.1B	11.7A	7.9B	87.8A	9.2C	7.3AB	8.00B
	Mixed	12.4A	16.5A	6.2C	7.7B	9.1A	15.1A	7.7A	8.00B
Rates	150g N/tree/y	10.2A	15.2A	8.4A	9.2A	8.7A	10.7B	6.9A	8.94B
	300g N/tree/y	9.1B	15.4A	9.1A	8.1A	8.9A	13.0A	7.1A	8.22B

K-humate	Without	10.3A	15.6A	9.9A	10.0A	8.7A	12.1A	7.7A	9.0A
	With	9.0B	15.0A	7.6B	7.4B	8.8A	11.6A	6.3B	8.16A
N forms X Rates									
Mineral X 150		8.3D	11.8D	6.7C	8.6BC	8.6B	11BC	8.5AB	9.5AB
Mineral X 300		10.1C	17AB	10.0B	12.4A	8.3B	11BC	3.5D	10.0A
Organic X 150		9.4CD	16BC	12.6A	9.4B	9.2AB	8.8D	6.8BC	10.3A
Organic X 300		5.4E	14.4C	10.8B	6.5CD	8.3B	9.7CD	7.8ABC	5.6C
Mixed X 150		13.1A	18.1A	6.0C	9.9B	8.2B	12.3B	5.3CD	7.0BC
Mixed X 300		11.8B	14.9C	6.4C	5.5D	10.0A	18.0A	10.0A	9.0AB
N forms X K-humate									
Mineral X Without		9.5A	15BC	9.9BC	10.5A	8.3A	11.5C	5.5BC	11.0A
Mineral X With		8.9A	13.5C	6.7D	10.5A	8.6A	10.7C	6.5BC	8.5A
Organic X Without		8.1A	16AB	10.6B	9.6A	8.8A	11.2C	10.0A	8.0A
Organic X With		6.6A	14BC	12.7A	6.2B	8.7A	7.3D	4.6C	8.0A
Mixed X Without		13.4A	16AB	9.0C	10.0A	9.1A	13.7B	7.5AB	8.0A
Mixed X With		11.5A	17.1A	3.3E	5.4B	9.0A	16.7A	7.8AB	8.0A
Rates X K-humate									
150 X without		10.6A	15.5A	10.5A	11.7A	8.9A	10.2C	6.0BC	8.3AB
150 X with		9.9A	14.9A	6.3C	6.8B	8.4A	11BC	7.8AB	9.5A
300 X Without		10.1A	15.8A	9.2B	8.3B	8.6A	14.0A	9.3A	9.6A
300 X With		8.1B	15.0A	8.9B	7.9B	9.1A	12.0B	4.8C	6.7B
N forms X Rates X K-humate									
Mineral X 150 X without		8.5BC	12.5A	9.2DE	9.2A	8.7A	10.3A	7.0A	9.0A
Mineral X 150 X with		8.0C	11.0A	4.2F	8.0A	8.5A	11.3A	10.0A	10.0A
Mineral X 300 X Without		10.5B	17.7A	10CD	11.7A	7.9A	12.6A	4.0A	13.0A
Mineral X 300 X With		9.8BC	16.0A	9.4DE	13.0A	8.7A	10.0A	3.0A	7.0A
Organic X 150 X without		10.5B	17.2A	13AB	13.0A	10.0A	10.0A	8.0A	10.0A
Organic X 150 X with		8.3C	14.2A	12BC	5.7A	8.3A	7.7A	5.7A	10.7A
Organic X 300 X Without		5.7D	14.5A	7.9E	6.3A	7.6A	12.3A	12.0A	6.0A
Organic X 300 X With		5.0D	14.2A	13.8A	6.7A	9.1A	7.0A	3.7A	5.3A
Mixed X 150 X without		12.8A	16.7A	8.8DE	13.A	8.0A	10.3A	3.0A	6.0A
Mixed X 150 X with		13.5A	19.5A	3.1F	6.7A	8.4A	14.3A	7.7A	8.0A
Mixed X 300 X Without		14.0A	15.0A	9.3DF	7.0A	10.2A	17.0A	12.0A	10.0A
Mixed X 300 X With		9.5BC	14.7A	3.5F	4.0A	9.6A	19.0A	8.0A	8.0A

*, ** and *** significant effect at $P < 0.05$, 0.01 and 0.001, respectively, NS = not significant.
The same streaks within factors are not different but a value A > B > C …etc at 5% level.

Table 2. Dry matter and plant height increment percentages of young Navel orange trees as affected by different forms and rates of N and K-humate addition in seasons of 2008 and 2009.

Source of variance		Dry matter%		Plant height increment%	
		First season	Second season	First season	Second season
Analysis of variance					
N forms		*	NS	***	***
Rates		NS	NS	***	***
K-humate		*	NS	**	***
N forms X Rates		NS	NS	***	***
N forms X K-humate		NS	NS	**	***
Rates X K-humate		NS	NS	NS	**
N forms X Rates X K-humate		NS	NS	NS	**
Tukey's multiple range test					
Main effect					
N Forms	Mineral	46.9A	44.6A	36.0B	29.6C
	Organic	47.9A	45.0A	39.0B	50.6B
	Mixed	44.5B	44.3A	70.7A	67.5A
Rates	150g N/tree/y	46.6A	44.5A	53.3A	58.0A
	300g N/tree/y	46.2A	44.8A	43.8B	40.5B
K-humate	Without	47.6A	44.2A	46.0B	46.8B
	With	45.2B	45.1A	51.2A	51.6A
N forms X Rates					
Mineral X 150		46.6A	43.8A	47.8B	24.6E
Mineral X 300		47.1A	45.5A	24.1D	34.6D
Organic X 150		48.1A	45.6A	40.1C	70.3B
Organic X 300		47.6A	44.5A	37.8C	30.8DE
Mixed X 150		45.0A	44.1A	72.0A	79.0A
Mixed X 300		44.0A	44.5A	69.5A	56.0C
N forms X K-humate					
Mineral X Without		48.0A	44.1A	31.5D	22.8D
Mineral X With		45.8A	45.1A	40.5C	36.5C
Organic X Without		49.0A	44.8A	40.5C	41.5C
Organic X With		46.8A	45.3A	37.5C	59.6B
Mixed X Without		46.0A	43.8A	66.0B	76.2A
Mixed X With		43.0A	44.8A	75.5A	58.8B

Rates X K-humate				
150 X without	47.8A	44.3A	53.0A	57.4A
150 X with	45.3A	44.7A	53.6A	58.5A
300 X Without	47.4A	44.2A	390A	36.2C
300 X With	45.1A	45.4A	48.6A	44.7B
N forms X Rates X K-humate				
Mineral X 150 X without	49.0A	43.0A	44.6A	22.6E
Mineral X 150 X with	44.3A	44.6A	51.0A	26.6E
Mineral X 300 X Without	47.0A	45.3A	18.3A	23.0E
Mineral X 300 X With	47.3A	45.6A	30.0A	46.3D
Organic X 150 X without	49.0A	45.6A	42.3A	62.6C
Organic X 150 X with	47.3A	45.6A	38.0A	78.0AB
Organic X 300 X Without	49.0A	44.0A	38.6A	20.3E
Organic X 300 X With	46.3A	45.0A	37.0A	41.3D
Mixed X 150 X without	45.6A	44.3A	72.0A	87.0A
Mixed X 150 X with	44.3A	44.0A	72.0A	71.0BC
Mixed X 300 X Without	46.3A	43.3A	60.0A	65.3C
Mixed X 300 X With	41.6A	45.6A	79.0A	46.6D

*, ** and *** significant effect at $P < 0.05$, 0.01 and 0.001, respectively, NS = not significant.
The same streaks within factors are not different but a value A > B > C …etc at 5% level.

Table 3. Leaf macro and micronutrient contents of young Navel orange trees as affected by different forms and rates of N and K-humate addition during the first season of 2008.

Analysis of variance		Macronutrients (%)					Micronutrients (mg/kg)		
		N	P	K	Ca	Mg	Fe	Mn	Zn
Analysis of variance									
N forms		**	NS	NS	*	*	**	*	***
Rates		NS	NS	NS	*	NS	NS	NS	NS
K-humate		NS	NS	NS	NS	NS	NS	*	*
N forms X Rates		NS	NS	NS	NS	NS	NS	NS	NS
N forms X K-humate		NS	NS	NS	NS	NS	NS	NS	NS
Rates X K-humate		NS	NS	NS	NS	NS	NS	NS	NS
N forms X Rates X K-humate		NS	NS	NS	NS	NS	NS	NS	NS
TukeyNS's Multiple range test									
Main effect									
N Forms	Mineral	2.75A	0.30A	0.83A	2.8B	0.40A	197A	35A	93A
	Organic	2.76A	0.31A	0.85A	3.5A	0.41A	120B	31AB	49B
	Mixed	2.29B	0.28A	0.80A	3.4A	0.23B	74B	26B	27B
Rates	150g N/tree/y	2.64A	0.30A	0.83A	3.1B	0.30A	123A	30A	49A
	300g N/tree/y	2.55A	0.29A	0.82A	3.5A	0.39A	138A	32A	64A
K-humate	Without	2.60A	0.30A	0.82A	3.3A	0.39A	140A	34A	72A
	With	2.59A	0.29A	0.83A	3.2A	0.30A	121A	29B	41B
N forms X Rates									

Mineral X 150	2.72A	0.29A	0.81A	2.6A	0.33A	167A	33A	71A
Mineral X 300	2.78A	0.30A	0.85A	3.1A	0.47A	228A	37A	116A
Organic X 150	2.89A	0.35A	0.89A	3.2A	0.37A	122A	30A	50A
Organic X 300	2.63A	0.27A	0.82A	3.7A	0.45A	118A	33A	47A
Mixed X 150	2.32A	0.27A	0.80A	3.3A	0.21A	81A	26A	25A
Mixed X 300	2.25A	0.29A	0.80A	3.5A	0.24A	68A	25A	29A
N forms X K-humate								
Mineral X Without	2.78A	0.30A	0.79A	2.9A	0.48A	221A	39A	127A
Mineral X With	2.72A	0.29A	0.87A	2.8A	0.31A	174A	31A	60A
Organic X Without	2.83A	0.32A	0.88A	3.5A	0.48A	121A	32A	54A
Organic X With	2.69A	0.30A	0.83A	3.5A	0.33A	120A	31A	44A
Mixed X Without	2.19A	0.27A	0.80A	3.5A	0.19A	78A	29A	34A
Mixed X With	2.38A	0.29A	0.79A	3.3A	0.26A	70A	22A	20A
Rates X K-humate								
150 X without	2.68A	0.29A	0.83A	3.1A	0.33A	154A	34A	58A
150 X with	2.61A	0.31A	0.83A	3.0A	0.27A	93A	26A	40A
300 X Without	2.53A	0.30A	0.82A	3.5A	0.44A	126A	32A	86A
300 X With	2.58A	0.27A	0.83A	3.4A	0.33A	150A	30A	43A
N forms X Rates X K-humate								
Mineral X 150 X without	2.86A	0.28A	0.81A	2.7A	0.35A	217A	38A	80A
Mineral X 150 X with	2.58A	0.31A	0.81A	2.5A	0.32A	117A	29A	61A
Mineral X 300 X Without	2.70A	0.32A	0.77A	3.1A	0.62A	224A	40A	174A
Mineral X 300 X With	2.86A	0.28A	0.94A	3.1A	0.31A	232A	33A	59A
Organic X 150 X without	2.91A	0.36A	0.88A	3.2A	0.52A	146A	35A	67A
Organic X 150 X with	2.87A	0.35A	0.89A	3.3A	0.22A	98A	25A	34A
Organic X 300 X Without	2.76A	0.29A	0.88A	3.8A	0.45A	96A	29A	41A
Organic X 300 X With	2.50A	0.24A	0.77A	3.7A	0.45A	141A	36A	54A
Mixed X 150 X without	2.25A	0.25A	0.79A	3.5A	0.14A	98A	30A	27A
Mixed X 150 X with	2.39A	0.28A	0.80A	3.2A	0.28A	94A	23A	24A
Mixed X 300 X Without	2.13A	0.29A	0.81A	3.5A	0.25A	58A	29A	42A
Mixed X 300 X With	2.37A	0.30A	0.78A	3.5A	0.24A	77A	22A	16A

*, ** and *** significant effect at $P < 0.05$, 0.01 and 0.001, respectively, NS = not significant.*
The same streaks within factors are not different but a value A > B > C …etc at 5% level.

Table 4. Leaf macro and micronutrient contents of young Navel orange trees as affected by different forms and rates of N and K-humate addition during the second season of 2009.

Analysis of variance	**Macronutrients (%)**					**Micronutrients (mg/kg)**		
	N	**P**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**
Analysis of variance								
N forms	**	NS	NS	NS	NS	***	*	NS
Rates	NS	NS	NS	NS	NS	NS	**	NS
K-humate	NS	NS	NS	NS	NS	NS	NS	*
N forms X Rates	NS	NS	NS	NS	NS	NS	*	NS

N forms X K-humate		NS	NS	NS	NS	NS	*	NS	NS
Rates X K-humate		NS	NS	NS	NS	NS	NS	NS	NS
N forms X Rates X K-humate		NS	NS	*	NS	NS	NS	NS	*
Tukey's Multiple range test									
Main effect									
N Forms	Mineral	2.47A	0.21A	0.92A	4.1A	0.56A	96B	24AB	17A
	Organic	2.27B	0.21A	0.91A	4.2A	0.62A	141A	26A	16A
	Mixed	2.36AB	0.19A	0.95A	4.2A	0.70A	90B	22B	17A
Rates	150g N/tree/y	2.39A	0.21A	0.93A	4.3A	0.62A	111A	22B	17A
	300g N/tree/y	2.34A	0.19A	0.92A	4.1A	0.63A	106A	26A	16A
K-humate	Without	2.41A	0.21A	0.92A	4.3A	0.59A	110A	25A	15B
	With	2.33A	0.19A	0.93A	4.1A	0.66A	109A	23A	18A
N forms X Rates									
Mineral X 150		2.50A	0.23A	0.95A	4.2A	0.58A	112A	24AB	17A
Mineral X 300		2.44A	0.19A	0.89A	4.1A	0.53A	81A	25A	18A
Organic X 150		2.36A	0.21A	0.91A	4.1A	0.62A	139A	26A	17A
Organic X 300		2.19A	0.20A	0.92A	4.4A	0.62A	143A	27A	14A
Mixed X 150		2.32A	0.19A	0.93A	4.6A	0.66A	84A	17B	18A
Mixed X 300		2.40A	0.20A	0.96A	3.9A	0.73A	95A	26A	15A
N forms X K-humate									
Mineral X Without		2.45A	0.23A	0.87A	4.2A	0.58A	111AB	26A	16A
Mineral X With		2.48A	0.19A	0.97A	4.0A	0.54A	82B	23A	19A
Organic X Without		2.31A	0.20A	0.89A	4.4A	0.55A	121AB	27A	15A
Organic X With		2.24A	0.20A	0.92A	4.1A	0.70A	161A	25A	16A
Mixed X Without		2.46A	0.19A	1.01A	4.2A	0.65A	96B	23A	15A
Mixed X With		2.26A	0.19A	0.88A	4.2A	0.74A	83B	22A	19A
Rates X K-humate									
150 X without		2.40A	0.21A	0.90A	4.4A	0.60A	126A	24A	15A
150 X with		2.38A	0.20A	0.96A	4.1A	0.65A	97A	21A	19A
300 X Without		2.41A	0.20A	0.95A	4.2A	0.58A	92A	26A	15A
300 X With		2.27A	0.19A	0.89A	4.1A	0.67A	121A	25A	16A
N forms X Rates X K-humate									
Mineral X 150 X without		2.39A	0.26A	0.9AB	4.3A	0.60A	127A	24A	16AB
Mineral X 150 X with		2.60A	0.20A	1.0AB	4.1A	0.57A	96A	23A	19AB
Mineral X 300 X Without		2.51A	0.20A	0.8B	4.1A	0.55A	94A	26A	16AB
Mineral X 300 X With		2.36A	0.18A	0.9AB	4.0A	0.51A	68A	22A	19AB
Organic X 150 X without		2.44A	0.20A	0.9AB	4.1A	0.56A	137A	26A	14AB
Organic X 150 X with		2.29A	0.22A	0.9AB	4.1A	0.69A	141A	25A	20AB

Organic X 300 X Without	2.19A	0.19A	0.9AB	4.7A	0.54A	105A	29A	17AB
Organic X 300 X With	2.19A	0.20A	0.9B	4.1A	0.71A	182A	26A	12B
Mixed X 150 X without	2.38A	0.18A	0.9AB	4.9A	0.64A	115A	20A	16AB
Mixed X 150 X with	2.26A	0.20A	0.9AB	4.3A	0.68A	53A	15A	20A
Mixed X 300 X Without	2.53A	0.21A	1.1A	3.6A	0.67A	78A	24A	14AB
Mixed X 300 X With	2.26A	0.19A	0.8B	4.2A	0.80A	113A	28A	17AB

*, ** and *** significant effect at $P < 0.05$, 0.01 and 0.001, respectively, NS = not significant.*
The same streaks within factors are not different but a value A > B > C …etc at 5% level.

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