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Effects of nitrogen source, rate and foliar application on some leaf mineral nutrient contents and yield of "Sinnari" sweet oranges (*Citrus sinensis* L.) in the River Nile State, Sudan

Mohammed H. Mekki, Osman M. Elamin and Mohamed E. Elkashif

Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.

ABSTRACT

Sweet orange production in the Sudan is characterized by low yield and poor fruit quality. This research was aimed at determining the effects of nitrogen source, rate and foliar application on some leaf mineral nutrient content and yield of "Sinnari" sweet oranges in the River Nile State during 2010/11 and 2011/12. Nitrogen sources were urea (100%), sheep manure (SM) (100%), or a combination of them (50% each), beside Wuxal foliar fertilizer. Nitrogen rates were 0, 43 and 86 kg N/ha. Treatments were arranged in a randomized complete block design with three replicates and 2 trees/plot. Results showed that nitrogen sources and rates were effective in increasing leaf nitrogen content and the highest values were obtained by the application of 86 kg N/ha using urea (100%) or a combination of urea and sheep manure. Application of Wuxal foliar fertilizer resulted in a significant increase of Zn and Fe leaf contents and total yield. Nitrogen source had significant effects on yield components and total yield. The highest values were obtained by a combination of urea and sheep manure or 100% urea, and the lowest values were recorded for 100% sheep manure. Nitrogen rate of 86 kg N/ha resulted in the highest yield components and total yield. It is recommended to fertilize sweet orange trees in the River Nile State with a combination of urea and sheep manure at the rate of 86 kg N/ha (12.4 kg SM/tree and 0.5 kg urea/tree) in addition to Wuxal foliar fertilizer.

INTRODUCTION

Nitrogen is of primary importance in citrus production. It has more influence on tree growth, healthy appearance, fruit production and fruit quality than any other element (Obreza and Morgan, 2008). Optimizing nitrogen in citrus trees is necessary to regulate vegetative growth, promote flower induction and bud differentiation, as well as increasing fruit set (Menino *et al.,* 2003). Nokrashy *et al.* (1977) reported that the heaviest weight and biggest volume of fruits were produced when Balady orange trees (*Citrus sinensis* Osbeck) were supplied with 500 g N/tree and manure. Davies and Albrigo (1994) suggested that maintaining leaf nitrogen in the optimum range of 2.5-2.7% resulted in a moderate number of flowers and produced the greatest fruit set and yield in citrus. Trials to study response of citrus to nitrogenous fertilizers in Sudan indicated positive response to nitrogen. Nitrogen fertilizers, in the form of urea, ammonium sulphate nitrate, alone or in combination with micronutrients, as foliar fertilizer, gave significant increases in "Shendi" navel orange yield (Sharafeldian *et al.,* 2008). They found that application of urea at 0.6 kg/tree to navel orange trees resulted in the optimum level of leaf nitrogen. Elhassan *et al.* (2005) reported an increased yield of "Foster" grapefruit fertilized with one kg N/tree in the form of urea.

In addition to N, deficiencies of Zn, Mn and Fe are commonly observed in all citrus growing areas in the Sudan and they contribute to reduced yields and poor fruit quality (Babiker *et al.,* 2006). In all citrus growing areas in the Sudan, foliar application of fertilizers to fruit trees is limited. Foliar fertilizer trails in various parts of the Sudan had positive results on citrus yield and fruit quality parameters (Babiker *et al.,* 2006).

Therefore, the objective of this research was to determine the effect of nitrogen source, rate and foliar application on some leaf mineral nutrient contents, yield components and total yield of sweet oranges in the River Nile State (Sudan).

MATERIALS AND METHODS

Field experiments were conducted in a private orchard at Ala'liab Eastern Project, River Nile State, Sudan, during 2010/11 and 2011/12 seasons. The area lies within an arid climate (latitude 17^0N and longitude 33^0E), of relatively very low rainfall (25 mm in July and August), and relatively warm winter.

The mean minimum temperature is 14^0C in January and the mean maximum temperature is 43C^0 in April. Humidity is generally low with a peak of 45% in August and decreases to about 15% in April. Orange trees (*Citrus sinensis* L.) of "Sinnari" cultivar were budded on sour orange (*Citrus aurantium*) rootstock. Trees were planted at a spacing of 7 m x 7 m (196 trees/ha) in 2003. The selected trees were uniform in growth and free from major insects and diseases.

Experimental layout

Treatments consisted of three levels of nitrogen 0, 43 and 86 kg N/ha, three sources of nitrogen (sheep manure, urea and a combination of both) and two treatments of a foliar fertilizer (Wuxal).

Nitrogen was applied either as 100% chemical fertilizer, 100% sheep manure (SM), or a combination of both (50% S.M. and 50% urea). Foliar fertilizer was either applied or not applied. The total treatment combinations were 18 treatments. The experimental design was a randomized complete block design with three replicates and two trees/plot.

Type of fertilizer, nitrogen rate and the corresponding amounts of fertilizer in kg per tree are shown in Table 1.

Table1. Type of fertilizer, nitrogen rate and corresponding amounts of fertilizers per tree in the River Nile State.

Type of fertilizer	Nitrogen rate (kg/ha)	Amount of fertilizer (kg/tree/year)
	Zero	Zero
Urea (100%)	43	0.5
	86	1.0
Sheep manure (SM)	43	12.4
(100%)	86	24.8
Urea (50%) + SM (50%)	43	0.25 Urea+ 6.2 SM
	86	0.5 Urea+ 12.4 SM

SM = sheep manure.

Sheep manure was added before flowering stage in December. Urea was applied in two equal doses/ year, the first dose before flowering stage (in December) and the second dose was added after fruit set (in May).

Sheep manure and urea, each alone, or in combinations, were added in a circle around the tree trunk at a distance of 50 cm from the trunk and a depth of about 10 cm and then covered with soil.

Foliar fertilizer used was "Wuxal" which contained NPK in the percentages of 10: 10: 7.5, respectively and micronutrients were B, Cu, Fe, Mn, Zn, Mo and S in the concentrations of 190, 84, 159, 151, 80, 20 and 164mg/l, respectively. Wuxal was foliar sprayed using a knapsack sprayer covering the whole tree canopy, especially the lower surface of the leaves. Foliar treatment was applied three times/year, before flowering in December, after fruit set (April) and one month after the second spray (May). The added amount of Wuxal was 7.65 litre/ha and 300 ml of Wuxal was used for one sprayer (16 litres). An amount of 18.75ml of Wuxal was used for one litre of water. One sprayer was enough to cover 8 orange trees. Spraying was applied at night, after the trees were irrigated.

Leaf sampling

Leaf samples were collected from non-fruit bearing terminals. Each leaf sample consisted of 100 healthy and fully mature leaves. Samples were transported to the Agricultural Research Corporation laboratory, on the same day and washed by a detergent (Kleen). The leaves were then washed three times with distilled water and oven-dried for 48 hours at 70^0C. The leaves were then ground in a mill and stored in polythene bags pending analysis (Chapman, 1960).

Leaf analysis

Standard analytical procedures were used for leaf samples (Chapman and Pratt, 1961). Leaves were analyzed for N, P, K, Zn, Fe and Mn contents.

Leaf nitrogen content was determined using Kjeldahl method (Okalebo and Gathua, 1993).

The dry ashing method was used for the preparation of the mineral extracts. One gram of the dry ground sample was placed in a porcelain crucible and ashed at 500^0C in a furnace for 24 hours. After cooling, the ash was dissolved in 5 ml of 20% HCl and the solution was filtered through an acid washed filter paper. It was then transferred into a 50 ml volumetric flask and made to volume with distilled water (Okalebo and Gathua, 1993). Leaf contents of Fe, Mn and Zn were determined using an atomic absorption spectrophotometer (Buck scientific, Model 210 VGP). Phosphorus was determined using vanadomolybdate method (Olsen and Sommers, 1982). Potassium was obtained using a flame photometer (Olsen and Sommers, 1982).

Yield

Yield components and total yield were determined after harvest from several picks, and included number of fruits/tree, yield of fruits/tree (kg/tree) and total yield (ton/ha).

Statistical analysis

Data were statistically analyzed using MSTAT programme. Means separation was done according to Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

This experiment was conducted during two consecutive seasons of 2011 and 2012. Since the results of both seasons were similar, only the results of the second season were reported and discussed.

Leaf analysis of the experimental orchard

Data in Table 2 showed the main effects of nitrogen source, rate and foliar fertilizer on orange leaf mineral contents. Nitrogen source had significant effects on leaf N and Zn but had no significant effects on leaf P, K, Fe and Mn. Application of urea (100%) or a combination of urea and SM resulted in the highest leaf N content. Application of sheep manure (SM) (100%) or a combination of SM and urea recorded the highest Zn content whereas the lowest leaf Zn content was recorded by urea (100%). The results indicated that application of a combination of urea (50%) and SM (50%) is as effective as application of 100% urea in increasing leaf nitrogen.

The effect of nitrogen rate on orange leaf mineral contents was highly significant on leaf composition of nitrogen and phosphorus. Nitrogen rate of 86 kg N/ha recorded the highest levels of leaf N and P.

Table 2. Effects of nitrogen source, rate and foliar fertilizer on
some leaf mineral contents of sweet oranges in the River Nile State.

Treatments	N	P	K	Zn	Fe	Mn
		(%)			(mg/kg)	
N source						
Urea (100%)	2.08 a	0.55	1.60	22.27 b	42.81	16.79
SM (100%)	1.95 b	0.57	1.60	30.63 a	43.28	17.27
Urea (50%)+ SM (50%)	2.04 a	0.57	1.61	30.21 a	44.20	17.66
Sig. level	*	NS	NS	**	NS	NS
SE±	0.03	0.01	0.01	0.33	0.41	0.26
CV%	7.13	5.17	5.29	5.09	3.98	6.34
N rate (kg N/ha)						
0	1.57 c	0.51 b	1.59	21.64	43.7	17.40
43	2.13 b	0.60 a	1.63	22.22	42.7	17.04
86	2.38 a	0.56 a	1.62	22.25	40.7	17.28
Sig. level	**	**	NS	NS	NS	NS
SE±	0.03	0.01	0.01	0.33	0.41	0.26
CV%	7.13	5.17	5.29	5.09	3.98	6.34
Foliar						
With	2.04	0.56	1.61	34.5	46.3	17.8
Without	2.01	0.57	1.60	20.9	42.5	17.7
Sig. level	NS	NS	NS	**	**	NS
SE±	0.03	0.01	0.01	0.27	0.33	0.21
CV%	7.13	5.17	5.29	5.09	3.98	6.34

*,** and NS Significant at the $P \leq 0.05$ and 0.01 levels and not significant, respectively.
Means followed by different letters within the same column are significantly different according to Duncan's Multiple Range Test.

The effects of foliar fertilizer was highly significant on Zn and Fe leaf contents. Addition of foliar fertilizer recorded the highest leaf content of Zn and Fe. The response of citrus trees to foliar application of zinc fertilizer under Sudan conditions was well documented in the literature (Dawoud *et al.*, 2004; Babiker *et al.*, 2006) and in Navel sweet oranges (Sharafeldian *et al.*, 2008). The present results indicated that although foliar fertilizer increased Fe leaf content, it did not bring leaf Fe to the optimum level. This result is in agreement with that of Sharafeldian *et al.* (2008) who reported that content of Fe in navel orange leaf, remained on the low range when "Bashaer" foliar fertilizer was applied. However, Zekri *et al.* (2003) reported little response of Fe to foliar application due to the formation of insoluble Fe compounds.

This might partially explain why the leaf Fe content in this experiment still remained in the low range. The decreased efficiency of foliar fertilizers in the arid tropics has also been attributed to environmental conditions such as high temperature and low relative humidity which might cause loss of the spray solution off the leaves by the presumable fast evaporation (Babiker *et al.,* 2006).

Data in Table 3 showed significant interaction between nitrogen source and rate on orange leaf N, P, Zn and Fe. Generally, application of N at both rates and from all sources increased leaf N and P contents. However, the interaction between N source and rate on Zn and Fe were not consistent.

The level of potassium was in the optimum range in all treatments and the effect of fertilizers on potassium leaf contents were not significant. Babiker *et al.* (2006) found that the level of K in grapefruit leaves was 1.4% which was lower than what was reported in this study (Table 3).

Sharafeldian *et al.* (2008) reported that application of urea at 0.6 kg/tree to navel orange trees resulted in the optimum level of leaf nitrogen. Babiker *et al.* (2006) found similar results and stated that when adequate amounts of nitrogen were added to grapefruit trees, they led to optimum leaf nitrogen. Results obtained by Nokrashy *et al.* (1977) showed an increase in yield when nitrogen fertilizer rate was increased. They also reported that the heaviest weight and the biggest volume of fruits were produced when Balady orange trees (*Citrus sinensis* Osbeck) were supplied with 500 g N/tree and manure. In general, all treatments recorded leaf P contents (0.51-0.64%) above deficiency levels according to Embelton *et al.* (1975). On the other hand, Elhassan *et al.* (2005) reported that P content in grapefruit leaves was in the range of 0.51% to 0.67%. Although, the effects of nitrogen source and rate on Fe levels were highly significant, but the levels of Fe were still below the optimum (60 mg/kg). Generally, addition of nitrogen fertilizer increased leaf Zn content.

Table 3. Interaction between of nitrogen source and rate on some leaf mineral contents of sweet oranges.

Nitrogen source	Nitrogen rate (kg N/ha)	N	P	K	Zn	Fe	Mn
		(%)			(mg/kg)		
Urea (100%)	0	1.57 d	0.51b	1.56	16.20 f	46.7 a	17.40
	43	2.12bc	0.61ab	1.63	17.28 f	44.6 b	16.33
	86	2.56a	0.53ab	1.62	20.33 e	37.2 e	16.63
SM (100%)	0	1.57d	0.51b	1.56	16.87 f	46.7 a	17.40
	43	1.98c	0.59ab	1.62	41.33a	42.4 c	16.95
	86	2.30ab	0.61ab	1.62	33.7 d	40.7 d	17.46
Urea (50%)+	0	1.57d	0.51b	1.56	16.37 f	46.7 a	17.40
SM (50%)	43	2.30ab	0.64a	1.64	38.05 b	41.8 c	17.84
	86	2.27ab	0.55ab	1.64	35.72 c	44.1 b	17.75
Sig. level		**	**	NS	**	**	NS
SE±		0.06	0.01	0.01	0.58	0.70	0.45
CV%		7.13	5.17	5.29	5.09	3.98	6.34

** Significant at the P≤0.01.
NS = Not significant.
Means followed by different letters within the same column are significantly different
according to Duncan's Multiple Range Test.

Information in Table 4 showed significant interaction between nitrogen source and foliar fertilizer on orange leaf P and Zn. The effect of nitrogen source and foliar fertilizer on leaf N, K, Fe and Mn were not significant. Although, urea (100%) with or without foliar recorded the highest leaf N content, followed by SM (100%), but they were below the optimum level of leaf N. This result was in agreement with that of Elhassan *et al.* (2005). Generally, leaf K level was above the deficiency level, but Fe and Mn were below the optimum level.

Table 4. Interaction between nitrogen source and foliar fertilizer on some leaf mineral contents of sweet oranges.

Nitrogen source	Foliar	N	P	K	Zn	Fe	Mn
		(%)			(mg/kg)		
Urea (100%)	With	2.08	0.49b	1.61	27.4d	41.72	17.44
	Without	2.08	0.61a	1.63	17.2e	43.89	17.13
SM (100%)	With	2.06	0.58ab	1.66	43.9a	44.02	18.26
	Without	2.03	0.55ab	1.64	16.5e	44.39	18.06
Urea (50%)+ SM (50%)	With	1.98	0.57ab	1.63	32.3b	41.88	17.60
	Without	1.92	0.56ab	1.62	29.0c	44.68	17.94
Sig. level		NS	**	NS	**	NS	NS
SE±		0.05	0.01	0.01	0.47	0.58	0.36
CV%		7.13	5.17	5.29	5.09	3.98	6.34

** Significant at the P≤0.01.
NS = Not significant.
Means followed by different letters within the same column are significantly different according to Duncan’s Multiple Range Test.

Results in Table 5 showed significant interaction between nitrogen rate and foliar fertilizer on sweet orange leaf N, P, Zn and Fe content. Nitrogen rate of 86 kg N/ha with or without foliar fertilizer raised leaf N content close to the optimum level. The foliar fertilizer had no effects on leaf N content. Generally, leaf K level was above the deficiency level (0.4%) but Mn was below the optimum level. The effects of nitrogen rate and foliar fertilizer on P and Zn were highly significant. Leaf P level was not affected by foliar fertilization, but it was above the deficiency level (0.09%). Application of foliar fertilizer with different nitrogen rates increased leaf Zn level compared to nitrogen rates without foliar application. Leaf Mn level was below the optimum level (25 mg/kg) (Embelton *et al.*, 1975).

Table 5. Interaction between nitrogen rate and foliar fertilizer on some leaf mineral contents of sweet oranges.

Nitrogen rate (kg N/ha)	Foliar	N	P	K	Zn	Fe	Mn
			(%)			(mg/kg)	
0	With	1.60 c	0.46 c	1.56	20.5 d	47.9 a	18.67
	Without	1.53c	0.55 b	1.56	20.8 d	45.5 b	18.13
43	With	2.13b	0.63 a	1.64	30.8a	44.5 c	17.0
	Without	2.13b	0.60 a	1.62	28.2 c	41.4 d	17.09
86	With	2.38 a	0.55 b	1.62	29.0 b	40.7 d	17.65
	Without	2.37a	0.57 b	1.63	27.7 c	40.6 d	17.91
Sig. level		*	**	NS	**	*	NS
SE±		0.05	0.01	0.01	0.47	0.58	0.36
CV%		7.13	5.17	5.09	5.09	3.98	6.34

*, ** Significant at the P≤0.05 and 0.01 levels, respectively.
NS = Not significant.
Means followed by different letters within the same column are significantly different according to Duncan’s Multiple Range Test.

Effect of fertilizers on yield components and total yield of sweet oranges

Data in Table 6 showed the influence of N source, rate and foliar fertilizer on yield components and total yield of sweet oranges. Nitrogen source had highly significant increase in number of fruits/tree and total yield. Urea (100%) recorded the highest number of fruits per tree and total yield. The combination of urea and sheep manure gave the highest yield per tree and total yield and the lowest values were recorded by SM (100%). These results were in conformity with those reported by Embelton *et al.* (1975) who found that an increase in nitrogen fertilizer increased number of fruits and total yield of Valencia oranges. Sharafeldian *et al.* (2008) reported that addition of nitrogen fertilizers, in the form of urea alone or in combination with micronuteients as foliar fertilizer resulted in significant increases in “Shendi” navel orange yield. Also, Elhassan *et al.* (2005) reported increased yield of Foster grapefruit fertilized with nitrogen in the form of urea.

Table 6. Effect of nitrogen source, rate and foliar fertilizer on yield components and total yield of sweet oranges.

Treatments	Number of fruits/tree	Yield (kg/tree)	Total yield (ton/ha)
N source			
Urea (100%)	557.2 a	70.1 b	14.3 a
SM (100%)	480.3 c	63.4 c	12.9 b
Urea (50%) + SM (50%)	549.8 b	71.6 a	14.6 a
Sig. level	***	***	***
SE±	0.6939	0.2642	0.1193
CV%	6.95	7.80	7.80
N rate (kg N/ha)			
0	425.2 c	55.2 c	11.3 c
43	545.7 b	71.5 b	14.6 b
86	616.4 a	78.6 a	16.0 a
Sig. level	***	***	***
SE±	0.6939	0.2642	0.1193
CV%	6.95	7.80	7.80
Foliar			
With	548.1	71.3	14.6
Without	510.1	65.4	13.4
Sig. level	***	***	***
SE±	7.076	1.026	0.2093
CV%	6.95	7.80	7.80

*** Significant at the $P \leq 0.001$ level.
Means followed by different letters within the same column are significantly different according to Duncan's Multiple Range Test.

The effect of nitrogen rate on number of fruits/tree, yield per tree and total yield were highly significant. Nitrogen rate of 86 kg N/ha recorded the highest values for number of fruits/tree and total yield, followed by 43 kg N/ha and the lowest values were obtained by unfertilized control. These results were in agreement with those reported by Embelton *et al.* (1975).

Application of foliar fertilizer had significant effects on yield components and total yield. Hamid (1995) reported that foliar spraying with micronutrients (Wuxal) at Sennar increased yield in grapefruit and Valencia oranges by 52% and 48%, respectively, and improved fruit physiochemical characteristics. Dawoud *et al.* (2004) also reported that spraying grapefruit and orange trees with a foliar fertilizer known as "Kassab" at Elgaili, Khartoum State, increased yield by 55% and 66%, respectively, and improved fruit quality. Elhassan *et al.* (2005) reported an increase in Foster grapefruit yield due to application of "Terra-sorb", a foliar fertilizer containing N, Mn, Zn and B.

Data in Table 7 showed significant interaction between nitrogen source and rate on yield components and total yield. Application of urea (100%) at 86 kg N/ha, recorded the highest number of fruits/tree and total yield, followed by that of the combination of urea and SM, whereas the control had the lowest values. These results were in agreement with those of Embelton *et al.* (1975) who reported that number of fruits/tree and total yield of sweet oranges increased when leaf nitrogen reached the optimum range of 2.4-2.6%. Application of adequate amounts of soil applied N as urea, increased number of fruits in grapefruit (Babiker *et al.,* 2006; Dawoud *et al.,* 2004; Elhassan *et al.,* 2005). Addition of urea (100%) at the rate of 86 kg N/ha led to the optimum leaf N (2.56%).

Sheep manure (100%) or urea (50%) + SM (50%) at both rates, increased number of fruits/tree and total yield over that of the control. Elhassan *et al.* (2005) reported that manure increased the yields of grapefruit over the control. However, the effect of manure on yield was not largely due to its nutrient contents. In this regard, most research workers related this to cumulative addition of one dressing after another on the structural improvement of the soil and consequently the nitrogen supplying power of the soil was improved. Elhassan *et al.* (2005) indicated that one of the major limiting factors of fruit yield is water infiltration. It is clear that trees responded to improvement of soil structure and soil- plant–water relationships which resulted from manure application.

Table 7. Interaction between nitrogen source and rate on yield components and total yield of sweet oranges.

Nitrogen source	Nitrogen rate (kg N/ha)	Number of fruits/tree	Yield (kg/tree)	Total yield (ton/ha)
Urea (100%)	0	425.2 g	55.2 f	11.3 e
	43	571.3 d	71.2 d	14.5 c
	86	675.2 a	84.1 a	17.1 a
SM(100%)	0	425.2 g	55.2 f	11.3 e
	43	466.7 f	64.4 e	13.1 d
	86	549.2 e	70.8 d	14.4 c
Urea (50%) + SM (50%)	0	425.2 g	55.2 f	11.3 e
	43	599.2 c	78.8 c	16.1 b
	86	625.0 b	80.8 b	16.5 ab
Sig. level		*	**	**
SE±		1.582	0.6023	0.2720
CV%		6.95	7.80	7.80

*,** Significant at the P≤0.05 and 0.01 levels, respectively.

Effects of N. source on sweet oranges

Means followed by different letters within the same column are significantly different according to Duncan's Multiple Range Test.

Results in Table 8 showed significant interaction between nitrogen source and foliar fertilizer on yield components and total yield. Application of foliar with soil-applied nitrogen recorded the highest number of fruits/tree and total yield compared to unsprayed trees. These results might be related to effect of nitrogen source and foliar on leaf Zn content as mentioned in Table 4.

Table 8. Interaction between nitrogen source and foliar fertilizer on yield components and total yield of sweet oranges.

Nitrogen source	Foliar	Number of fruits/tree	Yield (kg/tree)	Total yield (ton/ha)
Urea (100%)	With	579.8 a	72.4 b	14.8 b
	Without	534.7 c	67.8 c	13.8 c
SM (100%)	With	492.2 e	66.0 d	13.5 c
	Without	468.4 f	60.9 e	12.4 d
Urea (50%) + SM (50%)	With	572.2 b	75.5 a	15.4 a
	Without	527.3 d	67.6 c	13.8 c
Sig. level		*	*	*
SE±		1.167	0.4443	0.2007
CV%		6.95	7.80	7.80

* Significant at P≤0.05 level.

Means followed by different letters within the same column are significantly different according to Duncan's Multiple Range Test.

In conclusion, it is recommended to fertilize sweet orange orchards in the River Nile State with a combination of urea and SM at the rate of 86 kg N/ha (0.5 kg urea/tree and 12.4 kg SM /tree) in addition to Wuxal foliar fertilizer.

REFERENCES

Babiker, S.I., O.M. Elamin and M.E. Elkashif. 2006. Response of " Miami" grapefruit (*Citrus paradisi* Macf.) to nitrogen and micronutrients as foliar fertilizers. Gezira Journal of Agricultural Science 4(1): 26-37.

Chapman, H.D. 1960. Leaf and soil analysis of citrus orchards. California Agricultural Experiment Station Manual 25: 35-53.

Chapman, H.D. and P.F. Pratt. 1961. Methods of Analysis for Soils, Plants and Waters. Publication of California University.

Davies, F.S. and Albrigo, L.G. 1994. Citrus. Great Britain Redbooks. Trowbridge Wiltshire. 254pp.

Dawoud, H.D., A.A. Salih and F.A. Ahmed. 2004. Recommended husbandry practices for citrus in Sudan. A paper presented in Arabic for Citrus Workshop in Khartoum, April, 2004, Sudan.

Elhassan, A.A.M., A.M.A. Eltilib, H.S. Ibrahim and A.A. Hashim. 2005. Effects of different fertilizers on yield and quality of "Foster" grapefruit (*Citrus paradisi* Macf.) in Sudan central clay plain. A paper submitted to the crop Husbandry committee, ARC Wad Medani, Sudan.

Embelton, T.W., W.W. Jones, C. Coggins and R.C. Platt. 1975. Plant nutrition and citrus fruit quality and yield. Proceedings of the American Society for Horticultural Sciences 10(1): 48-50.

Hamid, G.A. 1995. Nutritional status of fruit crops in the central state of the Sudan and its improvement with special reference to micro-nutrients, pp. 171-181. In : Second Proceedings of Sudanese-Egyptian Workshop on Micro-nutrients and Plant Nutrition Dec. 1992, Wad Medani, Sudan.

Menino, M.R., C. Carranca, A. Varennes, V.V. Almeida and J. Baeta. 2003. Tree size and flowering intensity as affected by nitrogen fertilization in non-bearing orange trees grown under Mediterranean conditions. Journal of Plant Physiology 160: 1435-1440.

Nokrashy, M.A., S. El-Zorkani, M.A. El-Shorbagey, T.A. El-Baki and L.F. Guindy. 1977. Effect of different rates of nitrogen fertilization on the growth and yield of Baladi orange trees. Agricultural Research Review, Cairo 55(3): 39-45.

Obreza, T.A. and K.T. Morgan. 2008. Nutrition of Florida Citrus Trees. 2nd Edition. University of Florida, IFAS Extension.

Okalebo, J.R. and K.W. Gathua. 1993. Laboratory Methods of Soil and Plant Analysis : A working Manual. ISMB 9966-9892-1-8. Printed by Marvel EPZ (Kenya) LTD, Nairobi, Kenya.

Olsen, S.R. and L.E. Sommers. 1982. Phosphorus. P. 403-430. In A.L. Page (ed.) Methods of Soil Analysis. Part 2. Madison, WI, USA.

Sharafeldian, Y.A., O.M. Elamin and M.E. Elkashif. 2008. Effects of source and rate of N and foliar micronutrients on yield and fruit quality of "Shendi" navel orange in Jebel Marra. Gezira Journal of Agricultural Science 6(1): 57-69.

Zekri, M.; A.T. Obreza and R. Koo. 2003. Irrigation, Nutrition and Citrus Fruit Quality. Cooperative Extension Service. Institute of Food and Agricultural Sciences. University of Florida, USA.

تأثير مصدر ومعدل النتروجين والسماد الورقي على محتوى بعض العناصر الغذائية في الأوراق والإنتاجية لصنف البرتقال "سناري" في ولاية نهر النيل، السودان

محمد حامد مكي و عثمان محمد الأمين و محمد الحاج الكاشف

كلية العلوم الزراعية ، جامعة الجزيرة ، واد مدني، السودان

الخلاصة

يتصف البرتقال في السودان بالإنتاجية المتدنية والنوعية الفقيرة. يهدف هذا البحث إلى تحديد أثر مصادر وجرعات النيتروجين والأسمدة الورقية على محتوى بعض العناصر المغذية في الأوراق وإنتاجية البرتقال "سناري" بولاية نهر النيل. تم إجراء تجارب تسميدية في حديقة برتقال خاصة في العالياب بولاية نهر النيل في الفترة ما بين 11/2010 و12/2011. كانت مصادر النتروجين سماد اليوريا (100%) وروث الضأن (100%) وخليط بينهما بنسبة 50% لكل. بالإضافة إلى السماد الورقي وكسال وكانت معدلات النتروجين هي 0 و 43 و86 كجم نتروجين للهكتار. تم تصميم المعاملات بطريقة القطاعات العشوائية الكاملة بثلاث مكررات وشجرتين في الوحدة. أظهرت النتائج أنّ مصادر ومعدلات النتروجين لها تأثير معنوي في زيادة محتوى النتروجين في الأوراق وأعلى محتوى تم الحصول عليه عند إضافة اليوريا 100% أو خليط اليوريا وروث الضأن. إضافة السماد الورقي وكسال له تأثير معنوي في زيادة محتوى الزنك والحديد في الأوراق وكذلك زيادة الإنتاجية. أوضحت النتائج أنّ لمصدر النيتروجين تأثير معنوي على عناصر الإنتاجية والإنتاجية الكلية. تم تحقيق أعلى إنتاجية وعناصر الإنتاج لأشجار البرتقال عند إضافة خليط من اليوريا وروث الضأن أو سماد اليوريا بنسبة 100%، وأقل إنتاجية وعناصر إنتاجية تم الحصول عليها عند إضافة روث الضأن فقط بنسبة 100%. أدى معدل النتروجين 86 كجم نتروجين/هكتار إلى أعلى إنتاجية وعناصر إنتاجية. يوصى بتسميد أشجار البرتقال في ولاية نهر النيل بإضافة خليط من اليوريا وروث الضأن بمعدل 86 كجم للهكتار (12.4 كجم/شجرة من روث الضأن) و (0.5 كجم يوريا/شجرة) بالإضافة إلى السماد الورقي وكسال.