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RESPONSE OF WASHINGTON NAVEL ORANGE TREES GROWN ON SLIGHTLY ALKALINE CLAY SOILS TO MAGNESIUM RATES, METHODS AND NUMBER OF APPLICATIONS

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Abstract

the response of mature Washington Navel orange trees to Mg SO_4, soil (0.5, 1.0 and 1.5 Kgs / tree / year) or foliar (1.0, 1.5 and 2.0 % / tree / year) applications, each added at 1, 2 and 3 times of application was investigated in two successive seasons (97/1998 and 98/1999), at Biyala citrus orchard, where the soil is classified as slightly alkaline clay soil, exchangeable Mg 22 mg/100g soil and mean leaves Mg concentration (D.W) was 0.136%.

Yield as Kgs and fruit number was increased by all Mg SO_4 rates, methods and numbers of application, but the highest significant increase was obtained by 1.5% (spray) or 1.0 Kg (soil application) Mg SO_4 / tree / year added 3 times annually for foliar and soil application, respectively. Moreover, the highest average fruit weight, TSS, vitamin C, juice volume and lowest acidity were obtained by Mg SO_4 foliar spray 3 times, while peel thickness was unaffected.

Magnesium treatments markedly increased leaf area, shoot length and numbers, total chlorophyll and Mg %, but slightly increased P, Fe, Mn, and Zn. leaf Ca and K content were decreased, whereas, N was unaffected. Generally, spraying Mg SO_4 gave the highest values for yield, fruit quality vegetative growth, chlorophyll and total carbohydrate percent.

The best treatment is spraying 1.5% or adding 1.0 Kg soil application Mg SO_4/tree/year three times annually, but the superior treatment is spraying trees with 1.5% Mg SO_4.

INTRODUCTION

Magnesium deficiency is well known in some Egyptian soils after building the High Dam (Fathi and Soliman, 1977). Moreover, heavy application of K fertilization reduced the ability of trees to Mg uptake (Embleton and Jones, 1959). Also, the wide spread uses of chemical fertilization free of Mg accentuated the problem (Embleton *et al.*, 1973).

It is well known that, citrus trees are very sensitive to Mg deficiency in soils (Martin and Page, 1969). Magnesium deficiency symptoms appeared on old leaves with Mg concentration > 0.13%, the content of exchangeable Mg in the soil being > 21 mg/100 g, (Shimizu and Morii, 1985). Also, chlorotic trees were deficient in Mn, Mg and Zn; leaf Mg content was (0.193-0.194%) (Xie *et al.*, 1993). And leaf analysis of leaf-yellowing affected trees contained low Mg (0.22-0.31) concentration, (Zhang *et al.*, 1991). While, maximum yield was attained where the exchangeable Mg in the soil and leaf Mg exceeded 0.9 meq/liter and 0.35%respectively (Quaggio et *al.*, 1994).

Moreover, oranges responded positively and pronouncedly to Mg supply (Moss and Higgins, 1974). Mg increased yield, leaf chlorophyll content and improved fruit quality (Haggag *et al.*, 1987; Desai *et al.*, 1991 and Maksoud et *al.*, 1994).

Accordingly, the purpose of this study was to determine the response of Washington Navel orange trees (0.136% leaf Mg) grown on slightly alkaline clay soil with 22 mg/100g exchangeable Mg to magnesium fertilization and its effect on yield, fruit quality, and leaf chlorophyll and leaf mineral content.

MATERIALS AND METHODS

Field trees and soil: The present investigation was carried out during 97/1998 and 98/1999 seasons on 22 years old Washington Navel orange on sour orange rootstock. The orchard is located at Ebshan Village, Biyala City, Kafr El-Seikh Governorate. The trees are planted at 5x5 meters apart. The orchard soil is classified as slightly alkaline clay soil. Some soil properties of this orchard are presented in table (1) using the methods of Chapman and Pratt (1978).

Table 1. Some soil properties of the experimental orchard.

Texture class	Soil pH 1-2.5	EC ds/m	SAR	Exch. Mg (mg/100g)	Organic Matter%	$CaCo_3$ %	Available nutrients (ppm)					
							N	P	K	Fe	Mn	Zn
Clay	8.26	3.92	7.84	22	1.23	2.36	62.8	2.76	274	2.45	1.82	0.32

The experiment comprised 18 treatments (2 methods x 3 Mg-rates x 3 $MgSO_4$ applications), plus the control. Each treatment was replicated by two trees plot three times in a randomized complete block design. For that, 114 trees, as uniform in vigour as possible, were selected. The replicates were surrounded on all sides by guard rows. All trees received the regular fertilization and cultivation practices as recommended by the Ministry of Agricultural.

Magnesium treatments: Mg as $MgSO_4$ was applied in 2 methods (soil and foliar application) and 3 rates (0.0, 0.5,1.0 and 1.5 Kg / tree / year) were spread and mixed with the soil under each tree canopy or (0.0,1.0,1.5 and 2.0 % / tree / year) were sprayed to full drenching of trees. Each rate was added once at early April, twice at April and mid of May and at three times at April, May and mid of June (Maksoud *et al.*, 1994).

Yield and fruit quality: Fruit yield was recorded at harvest time as Kgs and numbers on the end of December in both seasons on an individual tree basis. Fruit quality was evaluated on 16 fruits of uniform stage of maturity picked at random from all direction just before harvesting time. Analysis was carried out according to A.O.A.C. methods (1975).

Leaf area and analysis: Sixty mature leaves per replicate were taken from non-fruiting terminal shoots of spring and summer growth cycles in the end of August and end of November. (Embleton *et al.*, 1983). (a) Leaf area was measured as cm^2 per leaf according to Singh and Snyder (1984). (b) Leaf chlorophyll was determined using N-N-dimmethl formamide according to Moran and Porath (1980) method. (c) For leaf mineral content, the leaves were cleaned with damp cloth, then washed three times with redistilled water, dried at 60° c till constant weight and ground with porcelain mortar, Nitrogen was determined by micro-Kjeldahl method (Chapman and Pratt, 1978). Analysis of other elements (P, K, Mg, Ca, Fe, Zn and Mn) was conducted according to Carter (1993) after wet-digestion of a sub sample of 0.5g with H_2So_4 and H_2O_2 (Cottenie, 1980) by using atomic absorption. (d) Total carbohydrates were determined as percent on dry weight basis according to Dubios *et al.* (1956). Also, shoot length and numbers were measured on 4 main branches.

Statistical analysis: All the obtained data were subjected to statistical analysis according to Steel and Torrie (1982).

RESULTS AND DISCUSSION

1. Yield and fruit quality:

(a) Yield: concerning the effect of $MgSO_4$ application rates, data of tables (2 and 3) revealed that, the different levels of Mg fertilization had a significant increase in fruit yield (Kgs) and numbers comparing with control trees. It is clear that, the medium level (1.5% foliar spray or 1.0 Kg soil application of $MgSO_4$ / tree / year) induced the highest significant increase in fruit yield (Kgs) and numbers. While Mg level up to 2.0% or 1.5 Kg $MgSO_4$ / tree / year induced slight decrease than the medium treatment.

As for the effect of $MgSO_4$ application numbers, it is clear that, yield (Kgs) and numbers was significantly increased as the application numbers was increased. Thus, the three applications had higher yield increment than the other ones. Consequently, it is evident that, adding $MgSO_4$ at three applications provided suitable conditions for the tree to make complete benefit from the applied Mg.

Regarding the effect of $MgSO_4$ levels with numbers of application, it was clear that, the highest fruit yield (Kgs) increment was obtained by the medium $MgSO_4$ level (1.5% or 1.0 Kg / tree / year) added at three times annually. These results were true in both seasons of study.

The yield (Kgs) and numbers increment by 1.5% or 1.0 Kg $MgSO_4$ / tree / year may be due to the increase of leaf chlorophyll which lead to increasing carbohydrates content (Table 5 and 6), vegetative growth (Table 5 and 6) and better nutritional balance attained by adding $MgSO_4$ level (Zhang *et al.*, 1991 and Maksoud *et al.*, 1994). These results were in accordance with those reported by Jones *et al.* (1971); Haggag *et al.* (1987) Ghosh *et al.* (1989) and Dai *et al.* (1993). Moreover Quaggio *et al.* (1994) indicated that, maximum yield was obtained where the exchangeable Mg in the soil and leaf Mg exceeded 0.9 meq/liter and 0.35%, respectively.

(b) Fruit quality: Data presented in tables (2 and 3) showed the effect of Mg rates, methods and number of applications on fruit quality of Washington Navel orange in both study seasons. With regard to the effect of $MgSO_4$ rates, it was clear that, fruit weight, total soluble solids, vitamin C, and juice volume were significantly increased with increasing $MgSO_4$ rates. However, it were decreased with $MgSO_4$ rate increasing over 1.5%or 1.0 Kg $MgSO_4$ / tree / year annually. Meanwhile, juice acidity was decreased with increasing $MgSO_4$ rates. Also, data indicated that $MgSO_4$ applications frequency gave the same results. According to the interaction between $MgSO_4$ rates and number of applications, it seemed that the medium Mg level (1.5% or 1.0 Kg $MgSO_4$ / tree / year) added at three times annually was the best treatment for enhancing fruit quality. These results came true in both study seasons and confirmed by Jones *et al.* (1971); Haggag *et al.* (1987) and Desai *et al.* (1991) who reported that highest average fruit weight, TSS, Vit.C concentration and lower acidity of sweet orange were obtained with $MgSO_4$ application. Such data might be attributed to the effect of Mg on increasing gross-yield which affected the fruit quality. Oranges responded positively and pronouncedly to Mg supply (Moss and Higgins, 1974).

Table 2. Yield and fruit quality of Washington Navel orange tree as affected by different magnesium ($MgSO_4$) rates, methods and number of applications during 1998 season.

Treatments			Yield / tree		Fruit quality					
M	Rates	No	Kgs	No	Weight (g)	TSS (%)	Acidity (%)	V.C (mg/100 ml)	Juice volume (cm^2)	Peel thickness (mm)
Soil application	Control	0	49.72	262.2	192.6	10.32	1.286	46.22	68.24	0.412
	0.5kg/tree	1	51.91	266.8	196.2	10.84	1.266	47.34	72.34	0.408
		2	54.38	271.3	201.9	10.92	1.256	47.58	73.36	0.402
		3	56.83	277.9	206.1	11.32	1.247	47.92	74.12	0.396
	Mean		54.37	272.0	201.4	11.03	1.256	47.61	73.27	0.402
	1.0 kg/tree	1	53.69	271.6	198.6	11.34	1.234	48.56	74.63	0.401
		2	56.67	279.7	204.3	11.62	1.220	48.66	75.81	0.398
		3	59.64	291.3	205.2	11.92	1.218	48.89	77.35	0.392
	Mean		56.67	280.9	202.7	11.63	1.225	48.70	75.93	0.397
	1.5 kg/tree	1	52.18	268.3	196.3	10.96	1.152	47.35	71.92	0.409
		2	54.43	274.4	199.4	11.08	1.141	47.52	72.66	0.412
		3	55.66	271.8	205.7	11.36	1.136	47.63	74.18	0.416
	Mean		54.09	271.5	200.5	11.13	1.143	47.50	72.92	0.412
Foliar application	1.0%/ tree	1	54.89	271.9	204.9	10.91	1.259	47.56	72.58	0.406
		2	58.73	281.2	210.9	11.01	1.241	47.72	73.81	0.401
		3	60.66	288.3	212.3	11.38	1.231	47.98	74.73	0.395
	Mean		58.09	280.5	209.4	11.10	1.244	47.75	73.71	0.401
	1.5%/ tree	1	57.68	277.7	211.3	11.42	1.234	48.81	74.88	0.398
		2	62.58	295.6	214.5	11.72	1:210	49.18	76.13	0.396
		3	66.59	306.7	219.4	12.11	1.119	49.36	77.92	0.391
	Mean		62.28	293.3	215.1	11.75	1.188	49.12	76.31	0.395
	2.0%/ tree	1	58.16	278.2	212.8	11.06	1.219	47.91	72.39	0.409
		2	61.16	288.9	213.4	11.28	1.119	48.02	73.22	0.413
		3	63.72	296.3	216.5	11.56	1.116	48.11	74.78	0.417
	Mean		61.01	287.8	214.2	11.30	1.156	48.01	73.46	0.413
Treatment L.S.D at 5%			3.22	9.2	6.8	0.43	0.021	0.37	3.14	NS
Mean L.S.D at 5%			2.16	5.1	5.1	0.32	0.016	0.23	2.16	NS
Interaction L.S.D at 5%			5.51	14.2	11.7	0.76	0.036	0.64	5.39	NS

Table 3. Yield and fruit quality of Washington Navel orange tree as affected by different magnesium ($MgSO_4$) rates, methods and number of applications during 1999 season.

Treatments			Yield / tree		Fruit quality					
M	Rates	No	Kgs	No	Weight (g)	TSS (%)	Acidity (%)	V.C (mg/100 ml)	Juice volume (cm^3)	Peel thickness (mm)
Soil application	Control	0	51.31	267.8	189.8	10.41	1.316	41.62	66.52	0.422
	0.5kg/tree	1	53.68	271.6	199.4	10.91	1.301	41.86	69.16	0.416
		2	55.48	274.2	203.3	11.16	1.288	41.98	71.42	0.412
		3	56.86	275.4	205.7	11.33	1.263	42.12	72.69	0.408
	Mean		55.34	274.7	202.8	11.13	1.284	41.99	71.09	0.412
	1.0 kg/tree	1	55.36	268.3	206.1	11.34	1.282	41.96	72.85	0.412
		2	57.76	281.5	207.8	11.67	1.269	42.16	74.14	0.406
		3	58.84	287.6	209.9	12.10	1.252	42.29	76.32	0.401
	Mean		57.32	279.1	207.9	11.70	1.268	42.14	74.44	0.406
	1.5 kg/tree	1	54.58	269.0	204.9	11.12	1.256	41.82	70.63	0.415
		2	55.42	266.3	207.1	11.26	1.248	41.91	72.15	0.418
		3	56.63	264.1	208.8	11.38	1.239	42.13	72.87	0.422
	Mean		55.54	266.5	206.9	11.25	1.248	41.95	72.88	0.418
Foliar application	1.0%/ tree	1	56.74	279.5	202.7	11.02	1.284	41.98	69.87	0.414
		2	60.69	290.6	209.3	11.58	1.267	42.18	72.18	0.411
		3	62.59	296.8	212.1	11.82	1.258	42.31	73.52	0.407
	Mean		59.99	289.0	208.0	11.47	1.270	42.16	71.86	0.411
	1.5%/ tree	1	59.81	285.4	208.5	11.68	1.266	42.16	73.22	0.411
		2	64.87	302.6	211.8	11.92	1.256	42.39	75.33	0.403
		3	68.71	316.7	218.3	12.16	1.241	42.48	76.69	0.399
	Mean		64.46	301.6	212.9	11.92	1.254	42.34	75.08	0.404
	2.0%/ tree	1	60.13	283.2	209.4	11.36	1.258	42.08	71.88	0.416
		2	63.11	295.7	212.6	11.43	1.243	42.23	73.12	0.421
		3	65.22	301.6	214.2	11.83	1.232	42.39	73.88	0.426
	Mean		62.82	293.5	212.1	11.54	1.244	42.23	72.96	0.421
Treatment L.S.D at 5%			3.29	8.7	8.4	0.36	0.023	0.39	3.08	NS
Mean L.S.D at 5%			2.36	4.6	6.2	0.22	0.018	0.26	2.26	NS
Interaction L.S.D at 5%			5.63	13.9	14.3	0.51	0.040	0.67	5.28	NS

(2) vegetative growth, leaf chlorophyll and carbohydrates:

(a) Leaf area and shoot: Parameters of leaf area, shoot number and length were greatly increased. Whereas, leaf area and shoot length and numbers were decreased with $MgSO_4$ rates over 1.5 % or 1.0 Kg /tree/year compared to the medium treatment. These results are in agreement with those reported by Haggag *et al.* (1987); Desai *et al.* (1991); Maksoud *et al.* (1994) and Lavon *et al.* (1995).

(b) Leaf chlorophyll: apparently, leaf chlorophyll a, b and their total were markedly increased (Table 4 and 5) as a result of added $MgSO_4$ rates, methods and number of applications. This may be due to that Mg is a constituent of chlorophyll molecule, which holds up to about 10-15 of total leaf-Mg (Maksoud *et al.*, 1994).

(c) Leaf carbohydrates: Carbohydrates were greatly increased (Table 4 and 5) as a result of leaf-Mg increase. This may be due to the close relationship between Mg and chlorophyll increase, which promote photosynthesis (Peaslee and Moss, 1966 and Bottrill *et al.*, 1970).

Table 4. vegetative growth, leaf chlorophyll and carbohydrates of Washington Navel orange tree as affected by different magnesium ($MgSO_4$) rates, methods and number of applications during 1998 season.

Treatments			vegetative growth			Leaf chlorophyll µg/cm² F.W			Total Carbohydrates (%)
M	Rates	No	Leaf area (cm²)	Shoot length (cm)	No	(a)	(b)	Total	
Soil application	Control	0	21.32	8.21	16.12	38.6	13.3	51.9	7.38
	0.5kg/tree	1	22.39	10.03	18.26	41.7	14.4	56.1	7.86
		2	23.16	10.92	18.83	42.4	14.6	57.0	7.98
		3	25.11	11.42	19.21	45.1	15.6	60.7	8.12
	Mean		23.55	10.79	18.77	43.1	14.9	57.9	7.99
	1.0 kg/tree	1	23.97	11.52	19.56	46.5	16.1	62.6	8.39
		2	25.38	12.85	19.78	49.3	16.8	66.1	8.63
		3	26.22	14.36	21.16	52.7	18.0	70.7	8.92
	Mean		25.19	12.91	20.17	49.5	17.0	66.5	8.65
	1.5 kg/tree	1	23.81	12.18	19.92	48.6	16.7	65.3	8.42
		2	24.96	12.67	20.01	51.2	17.6	68.5	8.66
		3	26.21	13.92	20.51	53.6	18.4	72.0	8.94
	Mean		25.00	12.92	20.15	51.1	17.6	68.7	8.67
Foliar application	1.0%/ tree	1	22.58	10.68	19.21	42.6	15.1	57.7	7.92
		2	23.32	11.12	19.63	43.9	15.6	59.5	8.01
		3	25.63	11.69	19.93	46.2	15.9	62.1	8.14
	Mean		23.84	11.16	19.59	44.2	15.5	59.8	8.02
	1.5%/ tree	1	24.18	11.92	20.67	47.2	16.9	64.1	8.31
		2	25.96	13.47	20.96	50.2	18.2	68.4	8.69
		3	26.81	14.82	21.82	53.3	19.6	72.9	8.98
	Mean		25.65	13.40	21.15	50.2	18.2	68.5	8.66
	2.0%/ tree	1	24.36	12.36	20.18	49.1	17.3	66.4	8.46
		2	25.81	12.85	21.12	52.8	18.9	71.7	8.74
		3	26.48	13.81	21.11	54.7	19.9	74.6	9.13
	Mean		25.55	13.01	20.80	52.2	18.7	71.0	8.78
Treatment L.S.D at 5%			1.18	1.26	1.12	3.3	1.6	5.2	0.31
Mean L.S.D at 5%			0.82	0.68	0.73	1.8	1.1	2.6	0.18
Interaction L.S.D at 5%			2.02	2.17	1.98	5.7	2.8	8.9	0.54

Table 5. vegetative growth, leaf chlorophyll and carbohydrates of Washington Navel orange tree as affected by different magnesium ($MgSO_4$) rates, methods and number of applications during 1999 season.

Treatments			vegetative growth			Leaf chlorophyll µg/cm² F.W			Total Carbohyd-rates
M	Rates	No	Leaf area (cm²)	Shoot length (cm)	No.	(a)	(b)	Total	(%)
Soil application	Control	0	21.48	7.83	15.63	40.8	13.9	54.7	7.63
	0.5kg/tree	1	23.11	10.12	19.56	42.4	14.6	57.0	7.96
		2	23.98	11.81	20.29	44.5	15.4	59.9	8.13
		3	24.15	12.14	21.19	46.5	16.0	62.5	8.29
	Mean		23.75	11.36	20.35	44.5	15.3	59.8	8.13
	1.0 kg/tree	1	24.38	11.68	23.22	46.8	16.1	62.9	8.43
		2	25.31	12.48	23.78	48.3	16.7	65.0	8.66
		3	26.92	13.86	24.36	51.2	18.1	69.3	8.99
	Mean		25.54	12.67	23.79	48.7	17.0	65.7	8.69
	1.5 kg/tree	1	24.23	11.52	22.86	49.3	16.9	66.2	8.49
		2	25.56	11.98	23.18	51.2	17.6	68.8	8.57
		3	26.18	13.26	23.56	54.3	18.6	72.9	8.98
	Mean		25.32	12.25	23.20	51.6	17.7	69.3	8.68
Foliar application	1.0%/ tree	1	23.86	10.43	19.86	43.6	15.2	58.8	8.02
		2	24.42	11.86	20.83	45.3	16.1	61.4	8.18
		3	24.56	12.08	21.59	47.4	16.8	64.2	8.31
	Mean		24.28	11.46	20.76	45.4	16.0	61.5	8.17
	1.5%/ tree	1	24.62	12.05	23.62	48.5	17.2	65.7	8.48
		2	25.47	12.39	24.12	49.7	17.9	67.6	8.69
		3	26.98	14.13	24.91	52.6	19.2	71.8	8.96
	Mean		25.69	12.86	24.22	50.3	18.1	68.4	8.71
	2.0%/ tree	1	24.73	11.54	23.10	49.7	17.8	67.5	8.59
		2	25.83	11.92	23.71	52.3	18.3	70.6	8.94
		3	26.39	13.96	23.70	55.1	19.8	74.9	9.08
	Mean		25.65	12.47	23.50	52.4	18.6	71.0	8.87
Treatment L.S.D at 5%			1.28	1.32	1.19	3.6	1.8	5.7	0.32
Mean L.S.D at 5%			0.83	0.81	0.76	1.9	1.1	3.2	0.19
Interaction L.S.D at 5%			2.19	2.61	2.05	6.2	3.1	9.8	0.55

(3) Leaf mineral content:

Data concerning the effect of $MgSO_4$ levels, methods and numbers of applications on leaf minerals content of Washington Navel orange trees in both study seasons are presented in (Table 6 and 7).

(a) Macronutrients: The obtained data revealed that, $MgSO_4$ application induced non-significant increase in leaf-N content. This may be due to better growth and yield attained by $MgSO_4$ rates and number of applications (Tables 4 and 5). As for leaf-p it was clear that, $MgSO_4$ levels and number of applications significantly increased leaf-P content. This increment may be attributed to that Mg application enhances the absorption and translocation of P by plants (Girdhar and Yadav, 1982). On the other hand, K and Ca were significantly decreased with $MgSO_4$ levels and number of applications. This may be related to the antagonistic effect of K-Mg and Ca-Mg (Rassmussen and Smith, 1960 and Fageria, 1974). Also, Schwartz and Kafkakfi (1978) reported that Mg suppressed the uptake of K and Ca. On the other hand a pronounced increase in leaf-Mg was observed when $MgSO_4$ was added at any rate, method and number of application.

Table 6. Leaf mineral content of Washington Navel orange tree as affected by different magnesium ($MgSO_4$) rates, methods and number of applications during 1998 season.

Treatments			Macronutrients (%)					Micronutrients (ppm)		
M	Rates	No	N	P	K	Ca	Mg	Fe	Zn	Mn
	Control	0	2.53	0.126	0.92	3.82	0.136	104.3	16.8	22.6
Soil application	0.5kg/tree	1	2.56	0.132	0.88	3.74	0.148	109.5	18.2	26.8
		2	2.67	0.136	0.86	3.63	0.172	111.6	19.1	28.1
		3	2.69	0.144	0.82	3.51	0.196	112.5	21.5	33.8
	Mean		2.64	0.137	0.85	3.63	0.172	111.2	19.6	29.6
	1.0 kg/tree	1	2.58	0.143	0.83	3.60	0.256	111.6	22.3	32.7
		2	2.68	0.148	0.81	3.52	0.293	114.2	26.4	36.2
		3	2.72	0.152	0.76	3.46	0.321	118.6	29.7	42.4
	Mean		2.66	0.148	0.80	3.44	0.290	114.8	26.1	37.1
	1.5 kg/tree	1	2.55	0.148	0.81	3.48	0.262	113.2	23.6	31.5
		2	2.66	0.151	0.78	3.36	0.312	115.4	24.7	35.3
		3	2.68	0.153	0.74	3.22	0.332	117.2	28.3	41.6
	Mean		2.63	0.151	0.78	3.35	0.302	115.3	25.5	36.1
Foliar application	1.0%/ tree	1	2.57	0.133	0.90	3.62	0.830	112.3	19.8	28.2
		2	2.69	0.141	0.88	3.46	0.218	115.3	21.6	30.6
		3	2.72	0.148	0.86	3.36	0.243	116.4	22.9	33.9
	Mean		2.66	0.141	0.88	3.48	0.215	114.7	21.4	30.9
	1.5%/ tree	1	2.61	0.145	0.87	3.41	0.266	116.4	23.1	33.5
		2	2.70	0.151	0.85	3.33	0.316	119.2	26.8	37.8
		3	2.74	0.154	0.84	3.28	0.384	122.5	30.8	42.5
	Mean		2.68	0.150	0.85	3.34	0.322	119.4	26.9	37.9
	2.0%/ tree	1	2.59	0.150	0.84	3.32	0.271	118.6	24.6	32.6
		2	2.67	0.153	0.81	3.18	0.324	122.3	25.6	36.6
		3	2.71	0.156	0.79	3.01	0.396	126.9	28.7	42.1
	Mean		2.66	0.153	0.81	3.17	0.330	122.6	26.3	37.1
Treatment L.S.D at 5%			NS	0.003	0.04	0.06	0.011	6.3	2.6	3.4
Mean L.S.D at 5%			NS	0.002	0.02	0.04	0.008	2.1	1.2	1.5
Interaction L.S.D at 5%			NS	0.005	0.07	0.10	0.019	10.2	4.5	5.9

(b) Micronutrients: Regarding the effect of $MgSO_4$ application on leaf micronutrients, it was clear that, Fe, Zn and Mn were significantly increased with adding $MgSO_4$ rates and number of applications. This increase may be attributed to that Mg fertilizers enhances the accumulation of micronutrients in citrus leaves (Smith and Reuther, 1954), due to the role of Mg in promoting Mg involving ATPase reaction responsible for providing energy to roots, resulting in an improvement of root ability to absorb nutrients (Clarkson and Hanson, 1980). While, Zn and Mn were decreased with increasing $MgSO_4$ over 1.0% or 1.5 Kg $MgSO_4$ / tree / year compared to the medium treatment. The obtained results concerning the effect of $MgSO_4$ rates, methods and number of applications on leaf mineral content were true in both study seasons.

Conclusively, foliar or soil application of $MgSO_4$ to Washington Navel orange trees grown on slightly alkaline clay soil at Kafr El-Sheikh Governorate induced markedly leaf-Mg increases and significantly increasesd leaf P, Fe, Zn and Mn. But leaf-N was not affected. Meanwhile, K and Ca were significantly decreased, causing a better nutritional balance for growth and yielding (Maksoud *et al.*, 1994). These results are supported by the findings of Erner *et al.*, (1984); Haggag *et al.* (1987); Ghosh *et al.* (1989); Zhang (1991); Xie *et al.* (1993); Maksoud *et al.* (1994) Sale (1994) and Quaggio *et al.* (1994).

The following conclusion could be drown:

It could be concluded that, $MgSO_4$ application may be necessary and should be included in the fertilizer program of slightly alkaline clay soil at Kafr El-Sheikh. Moreover, application of 1.0% (spray) or 1.5 Kg (soil application) $MgSO_4$ annually at three times could overcome Mg deficiency of Washington Navel orange trees and produce the highest yield with better fruit quality. Spraying 1.0 % $MgSO_4$ added three times annually was the superior treatment.

Table 7. Leaf mineral content of Washington Navel orange tree as affected by different magnesium ($MgSO_4$) rates, methods and number of applications during 1999 season.

Treatments			Macronutrients (%)					Micronutrients (ppm)		
M	Rates	No	N	P	K	Ca	Mg	Fe	Zn	Mn
Soil application	Control	0	2.61	0.131	1.01	3.96	0.134	108.6	15.7	23.8
	0.5kg/tree	1	2.67	0.138	0.98	3.81	0.146	113.2	18.8	25.2
		2	2.71	0.143	0.95	3.70	0.181	113.6	20.6	26.9
		3	2.76	0.148	0.92	3.52	0.216	114.5	22.8	30.7
	Mean		2.71	0.143	0.95	3.68	0.181	113.8	20.7	27.6
	1.0 kg/tree	1	2.74	0.146	0.95	3.63	0.261	114.8	23.1	32.1
		2	2.79	0.149	0.93	3.49	0.287	115.8	26.2	36.5
		3	2.81	0.154	0.88	3.35	0.336	119.8	30.1	41.6
	Mean		2.78	0.150	0.92	3.49	0.295	116.8	26.5	36.7
	1.5 kg/tree	1	2.69	0.149	0.90	3.46	0.273	115.6	25.3	31.7
		2	2.73	0.152	0.89	3.32	0.293	116.5	26.9	35.6
		3	2.78	0.153	0.86	3.18	0.338	117.9	29.2	40.8
	Mean		2.73	0.151	0.88	3.32	0.301	116.7	27.1	36.0
Foliar application	1.0%/ tree	1	2.67	0.142	0.99	3.66	0.179	116.8	19.7	26.4
		2	2.73	0.153	0.97	3.54	0.223	118.4	21.2	29.2
		3	2.77	0.156	0.96	3.39	0.256	121.7	23.4	31.4
	Mean		2.72	0.150	0.97	3.53	0.219	119.0	21.4	29.0
	1.5%/ tree	1	2.75	0.148	0.96	3.42	0.273	119.7	24.6	33.2
		2	2.81	0.157	0.93	3.31	0.328	123.1	27.3	37.8
		3	2.83	0.159	0.91	3.22	0.396	126.3	31.2	42.3
	Mean		2.80	0.155	0.93	3.32	0.332	123.0	27.7	37.8
	2.0%/ tree	1	2.74	0.152	0.93	3.34	0.288	121.5	25.2	31.9
		2	2.76	0.158	0.91	3.23	0.331	126.3	26.9	33.6
		3	2.78	0.161	0.89	3.11	0.405	131.1	29.8	41.2
	Mean		2.76	0.157	0.91	3.23	0.341	126.3	27.3	36.6
Treatment L.S.D at 5%			NS	0.004	0.05	0.09	0.012	5.6	2.9	3.1
Mean L.S.D at 5%			NS	0.003	0.02	0.05	0.007	2.2	1.3	1.1
Interaction L.S.D at 5%			NS	0.006	0.09	0.16	0.021	9.7	5.0	5.3

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إستجابه أشجار البرتقال أبو سره النامية فى الأراضى الطينية الخفيفة القلوية لمستويات و طرق و عدد مرات أضافه المغنيسيوم

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أجرى هذا البحث بحديقه موالح بقريه إبشان مركز بيلا – محافظه كفر الشيخ خلال موسمى ١٩٩٨-١٩٩٩ حيث التربة الطينيه خفيفه القلويه ٢٢٪ مغنسيوم متبادل لدراسه مدى أستجابه أشجار البرتقال أبو سره الناضجه ذات تركيز ١٣٦,٠٪ مغنسيوم بأوراقها الجافه لأضافه ٣ مستويات من التسميد المغنسيومى أضيفت أرضا بمعدلات (٠,٥ ، ١,٠ ، ١,٥ كجم كبريتات مغنسيوم) أورشا بمعدلات (١,٠ ، ١,٥ ، ٢,٠ ٪ كبريتات مغنسيوم). و أضيف كل مستوى دفعه واحده أو دفعتين أو ثلاث دفعات سنويا.

وقد أوضحت النتائج أن معاملات التسميد بالمغنسيوم سواء المستويات أوطرق أوعدد مرات الأضافه أدت إلى :

١- **المحصول** : زياده محصول الثمار عددا و وزنا وكانت أكبر زياده معنويه بأستخدم كبريتات مغنسيوم بمعدل ١,٠٪ (رشا) أو١,٥كجم (أضافه أرضيه) تضاف على ثلاث دفعات سنويا.

٢- **جوده الثمار** : زياده وزن الثمره والمواد الصلبه الذائبه الكليه وفيتامين ج وحجم العصير و قلت الحموضه بينما سمك القشره لم يتأثر وكانت أحسن النتائج بأستخدام الرش بمعدل ١,٥٪ أو الأضافه الأرضيه بمعدل ١,٠ كجم كبريتات مغنسيوم تضاف على ثلاث دفعات سنويا.

٣- **النمو الخضرى والكلوروفيل والكربوهيدرات** : زياده واضحه فى مساحه الورقه وعدد و طول الأغصان والنسبه المئويه للكربوهيدرات الكليه بإضافه ١,٥٪ كبريتات المغنسيوم رشا أو ١,٠ كجم كبريتات المغنسيوم أضافه أرضيه تضاف على ثلاث دفعات سنويا.

٤- **وعموما قد أظهرت معاملات الرش بكبريتات المغنسيوم أعلى القيم.**

٥- **المحتوى المعدنى للأوراق**: زياده واضحه فى المغنسيوم بالأوراق وزياده بسيطه فى الفوسفور والزنك والحديد والمنجنيز وتناقص الكالسيوم والبوتاسيوم بينما لم يتأثر النتروجين معنويا.

٦- **أفضل معامله** : أفضل المعاملات هى الرش بمعدل ١,٥٪ أوأضافه أرضيه بمعدل ١,٠ كجم كبريتات المغنسيوم تضاف على ثلاث دفعات سنويا ولكن معامله الرش بمعدل ١,٥٪ كبريتات المغنسيوم تضاف على ثلاث دف[illegible] التى أظهرت لها الأشجار أعلى استجابة