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ORIGINAL ARTICLES

A Comparative Study on the Effect of Traditional and Controlled Release N Fertilizers on Fruiting and Fruit Quality of Balady Mandarin Trees

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ABSTRACT

A four year trial was conducted during 2006-2009 seasons in Balady mandarin orchard .Two N fertilizer forms: a. traditional N fertilizers i.e. ammonium sulfate and ammonium nitrate and b. controlled release N fertilizers namely urea formaldehyde and phosphorus coated urea .Two N fertilizer rates 200 & 300g N/tree and 400 & 600g N/tree were tested for conventional N fertilizers in an expected "Off" and "On" years, respectively. Moreover, 100 & 150g N/tree and 200 & 300g N/tree were tested for controlled release N fertilizers in an expected "Off" and "On" years, respectively. Application frequency of traditional N fertilizers was tested under four application systems, whereas, controlled release N fertilizers were applied once a year. Briefly, the two tested controlled release N fertilizers at the two rates reduced N application rate and enhanced the studied tree productivity parameters without adverse effect on fruit quality.

Key word: Balady mandarin, Traditional N fertilizers**,** Controlled release N fertilizers, Fruiting , Fruit quality.

Introduction

Citrus is considered one of the most important fruit crops in the world and ranks the second after grape. In Egypt, citrus ranks the first of the cultivated fruit crop production and most attention is given to enhance its cultivation by many horticulturists.

Thereupon, strenuous efforts have always been extended to enhance citrus production through a better understanding of its nutritional requirements and fertilization programs i.e. source, rate and frequency of fertilizer application. It is well known that more than 40% of production costs is devoted to nutrition practices. Besides, the need for fertilizers particularly nitrogen is in a continuous demand to compensate the reduction of soil fertility that results from intensive cultivation over the years and the depletion of loamy colloids after building the High Dam.

Consequently, it is important to improve the efficiency of nitrogen fertilization by introducing other nitrogen forms, techniques and alternative systems. The utilization of slow release fertilizers with irrigation is another solution to this problem. The efficiency of nitrogen fertilizer can be increased through the use of slow release nitrogen form, which potentially reduce nitrogen leaching and improve the efficiency of plant recovery (Diez *et al.,* 1994). These fertilizers can show clearing advantages as compared to conventional ones in a great varieties of horticultural crops in different soil types, climates and growing techniques (Abbes *et al.,* 1994).

In this concern, Raigon *et al.,* (1999) compared two doses of a standard fertilizer (ammonium nitrate sulphate ANS), applied in the quantities of 11.55kg N/ha (ANS-350) and 49.50kg N/ha (ANS-2x750) and two doses of slow release fertilizer (sulphur-coated urea, SCU), applied in the quantities of 11.55kg N/ha (SCU-350) and 24.25kg N/ha (SCU-750), in nine consecutive years in a Spanish orange orchard. A good crop of fruits were obtained with SCU treatments, which in conjunction with the reduction in dosage and rate justified its application. Also, Tayeh *et al.,* (2003) demonstrated that fertilizing Valencia orange trees with slow release nitrogen fertilizers i.e. sulfur coated urea, urea formaldehyde and phosphorus coated urea enhanced tree fruiting parameters expressed as fruit set and tree yield rather than the use of fast release nitrogen fertilizers i.e. urea, ammonium sulfate, calcium nitrate and ammonium nitrate.

Thereupon, the present study has been initiated to evaluate the response of Balady mandarin trees to nitrogen fertilizer rate, form and application frequency during an expected "Off" and "On" years.

Material and Methods

This study was conducted during four successive seasons 2006-2009 i.e. 2006 & 2008 an expected "Off" years and 2007&2009 an expected "On" years at Citrus Farm of Moshtohor Agricultural Secondary School at

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Kalubia Governorate. The plant material devoted for this study was 11-year-old Balady mandarin trees (*Citrus reticulata*, Blanco) growing on sour orange rootstock (*Citrus aurantium*, L.) planted at 5x5m apart in clay soil. The mechanical and chemical analyses of experimental soil were conducted according to Wilde *et al*., (1979) are illustrated in Table 1.

Table 1: Mechanical and chemical analyses of the experimental soil (0-40cm).

Mechanical analysis		Chemical analysis			
				Available nutrients	
Coarse sand	2.55%	$CaCO_3$	2.28%	N	6.75 %
Fine sand	23.25%	Ph	7.7	P	0.013 %
Silt	25.72%	Ec (ds/m)	2.20	K	0.69 %
Clay	48.48%	Organic matter	1.90%	Ca	2.33 %
Texture class	clay soil			Mg	0.54 %
				Fe	27 ppm
				Zn	23ppm
				Mn	29ppm

Chemical analysis in extraction 1:20 calculated as milliequivalent in 100g soil.

Selected trees devoted for this study were healthy, nearly uniform in growth vigour and received regularly the recommended horticultural practices.

The effects of nitrogen fertilization form, rate and frequency of application on Balady mandarin trees during "Off" and "On" years was studied as follows:-

I. Nitrogen fertilization form (In both an expected "Off" and "On" years):

a- Conventional or fast release nitrogen fertilizers.
1- Ammonium sulfate [$(NH_4)_2 SO_4$ – 20.5% N]
2- Ammonium nitrate [NH_4NO_3 – 33.5% N].
b- Controlled or slow release nitrogen fertilizers.
1- Urea formaldehyde – Urea form (UF-38%N).
2- Phosphorus coated urea (PCU-37% N).

II. Nitrogen fertilization rate.

a- Fast release nitrogen fertilizers i.e. ammonium sulfate and ammonium nitrate were tested at 200 and 300g N/tree/year in 2006 & 2008 an expected "Off" years and 400 and 600g N/tree/year in 2007 & 2009 an expected "On" years.

b- Slow release nitrogen fertilizers i.e. UF and PCU were applied at 100 and 150g N/tree/year in 2006 & 2008 an expected "Off" years and 200 and 300g N/tree/year in 2007 & 2009 an expected "On" years.

III. Frequency of application.:

a- Conventional nitrogen fertilizers i.e. ammonium sulfate and ammonium nitrate at 200 and 300g N/tree/year in an expected "Off" years and 400 and 600g N/tree/year in an expected "On" years were applied according to the following frequencies:-

1- Each tested nitrogen fertilization rate was divided into three equal doses (33.3%) applied at three times a year i.e. mid-February, mid-May and mid-August, respectively.

2- Each tested nitrogen fertilization rate was divided into three fractions namely 60, 20 and 20%, applied three times a year i.e. mid-February, mid-May and mid-August, respectively.

3- Each tested nitrogen fertilization rate was divided into three fractions namely 50, 20 and 30% applied at three dates yearly i.e. mid-February, mid-May and mid-August, respectively.

4- Each tested nitrogen fertilization rate was fractionated into five equal doses (20%) applied five times a year i.e. mid-February, mid-April, mid-May, mid-July and mid-August, respectively.

b- Slow release nitrogen fertilizers i.e. UF and PCU at 100 and 150g N/tree/year in an expected "Off" years and 200 and 300g N/tree/year in an expected "On" years. were applied once a year in mid-February**.**

These treatments were arranged in a completely randomized block design with five replicates for each treatment and each replicate was represented by one tree.

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Data recorded:

1. Tree fruiting.:

1.1. Fruit set and fruit drop percentage:

In each season, nearly 300 leafy inflorescences well distributed around each treated tree were selected and tagged and their flowers were counted at full bloom (April, 21th, 22th, 22th and 24th in 2006, 2007, 2008 and 2009 seasons, respectively). Moreover, number of set fruitlets was also counted at fruit set (May, 7th, 9th, 9th and 10th in 2006, 2007, 2008 and 2009 seasons, respectively). Fruit set percentages were calculated on the basis of the initial number of flowers at full bloom. Furthermore, number of retained and dropped fruits was counted at monthly intervals of each season and fruit drop percentages were calculated on the basis of number of set fruits.

1.2. Tree yield.:

On January, 29th, 30th, 30th and 31th of 2006, 2007, 2008 and 2009 seasons, respectively, fruits of the treated trees were harvested as soon as the fruits attained the maturity indices. Number of fruits of each tree was counted and weighed (in kg). Moreover, biennial bearing index of the different treated trees was calculated according to Wilcox (1944) as follows:-

$$\text{Biennial bearing index} = \frac{\text{Differences in yield between successive years} \times 100}{\text{Sum of yield of successive years}}$$

1.3. Fruit quality:

Fifteen fruits from each treated tree were randomly sampled and tested for the following physical and chemical properties.

1.3.1. Fruit physical properties.:

Fruit weight, length, diameter and fruit shape index were determined and recorded. Moreover, juice weight were determined.

1.3.2. Fruit chemical properties.:

Total soluble solids (TSS) determined using a Carl Zeiss hand refractometer, Percentage of titratable acidity was determined according to Vogel (1968) and Total soluble solids: acid ratio (TSS/acid ratio) was also calculated and recorded. Moreover, Ascorbic acid was determined as mg/100 ml juice according to Horwitz (1972) and recorded.

Statistical analysis.:

The obtained data in 2006 & 2008 an expected "Off" years and 2007 & 2009 an expected "On" years were subjected to analysis of variance according to Clarke and Kempson (1997). The percentages were transsourced to angles. Means of the treatments of the three experiments were differentiated using L.S.D method at 5% level.

Results and Discussion

I: Effect of nitrogen fertilizer form, rate and frequency of application on Balady mandarin trees during an expected "Off" years:
1. Tree fruiting:
1.1. Fruit set percentage:

Statistical analysis demonstrates that slight increases in fruit set percentage of Balady mandarin trees during 2006 & 2008 an expected "Off" years due to urea formaldehyde (UF) and phosphorus coated urea (PCU) at 100 & 150g N/tree were so small to be considered when compared with those produced by ammonium sulfate (AS) and ammonium nitrate (AN) at 200 & 300g N/tree with the four tested application frequencies (AF), Table, 2.

Table 2: Effect of nitrogen fertilizer form, rate and application frequency rate on fruit set and dropping percentage of Balady mandarin trees during "Off" years (2006 & 2008 seasons).

Fertilizer Form & Rate	Application frequency rate (AF)					Fruit set (%)		Fruit dropping (%)							
								Up to May, 31th		June, 1st - July, 1st		July, 2nd - August, 1st		August, 2nd - Sept, 1st	
	February	+	May	+	August	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008
Ammonium sulfate (AS) 200g N/tree	33.3%	+	33.3%	+	33.3%	18.30	18.60	39.83	38.13	18.67	17.30	10.87	11.63	4.37	4.40
	60%	+	20%	+	20%	18.47	18.68	37.50	38.10	18.20	17.30	10.93	11.57	4.33	3.93
	50%	+	20%	+	30%	19.17	18.57	36.90	37.97	17.40	16.67	10.40	11.50	4.33	4.10
	20% (five times a year)					18.47	18.60	37.83	37.80	18.17	17.57	11.13	11.73	4.37	4.37
Ammonium sulfate (AS) 300g N/tree	33.3%	+	33.3%	+	33.3%	19.33	19.53	37.50	37.20	16.97	16.23	10.60	11.47	4.33	4.07
	60%	+	20%	+	20%	19.42	19.53	36.83	37.33	16.97	16.23	10.67	11.40	4.37	4.07
	50%	+	20%	+	30%	19.33	19.37	37.90	37.03	17.37	16.23	10.50	11.53	4.37	4.23
	20% (five times a year)					18.23	18.53	39.87	39.43	18.07	16.27	11.10	11.90	4.50	4.43
Ammonium nitrate (AN) 200g N/tree	33.3%	+	33.3%	+	33.3%	20.83	20.13	37.17	37.13	16.83	16.10	10.00	11.30	4.37	4.40
	60%	+	20%	+	20%	20.00	20.07	37.83	36.63	16.77	16.83	10.10	11.33	4.37	4.20
	50%	+	20%	+	30%	19.20	19.67	37.60	35.90	16.77	16.87	10.47	11.00	4.30	4.17
	20% (five times a year)					19.93	19.73	38.97	37.20	17.13	16.23	10.17	11.60	4.23	4.07
Ammonium nitrate (AN) 300g N/tree	33.3%	+	33.3%	+	33.3%	19.80	19.87	36.33	36.60	16.57	15.67	10.00	11.53	4.27	4.27
	60%	+	20%	+	20%	20.37	19.47	37.07	35.00	16.33	16.47	9.87	11.33	4.37	4.37
	50%	+	20%	+	30%	19.67	20.10	37.27	35.43	16.23	15.70	10.07	11.63	4.37	4.27
	20% (five times a year)					19.30	19.03	38.30	37.13	17.50	16.57	10.43	11.17	4.47	4.30
UF (100g N/tree)						20.60	19.60	33.87	34.13	15.50	14.90	9.17	10.15	4.13	3.87
UF (150g N/tree)						20.13	19.53	33.33	33.43	15.70	15.40	9.20	10.0	4.13	3.90
PCU (100g N/tree)						20.70	19.77	32.00	33.03	15.57	15.13	9.17	10.07	4.07	3.83
PCU (150g N/tree)						20.93	20.00	32.43	32.90	15.40	14.87	9.10	10.17	4.03	3.97
L.S.D at 5% level						N.S	N.S	3.73	3.55	2.28	2.08	1.31	1.37	N.S	N.S

1.2. Fruit drop percentage:

1.2.a. Fruit drop percentage (up to May, 31th):

Table, 2 illustrates that UF and PCU slow release N fertilizers at 100 & 150g N/tree scored lower values of fruit drop percentage up to May, 31th of Balady mandarin trees during 2006 & 2008 the expected "Off" years than those recorded by AS at 200 & 300g N/tree at the four tested application frequencies. Such reduction effect was more pronounced and recorded an obvious significant effect when PCU at 100 & 150g N/tree were compared with the previously mentioned AS combinations. On the other side, AN combinations gave an intermediate values in this concern from the statistical stand point.

1.2.b. Fruit drop percentage (June, 1st – July, 1st):

UF and PCU at the two tested rates caused significant reduction effect in drop percentage of Balady mandarin fruitlets during June, 1st up to July, 1st when compared with AS at 200g N/tree with AF (three equal patches, 33.3%), (60 + 20 + 20%) and (five equal patches, 20%) during 2006 & 2008 an expected "Off" years as well as AS at 300g N/tree with AF (five equal patches, 20%) during 2006 season, only, (Table, 2). Other AS and AN combinations gave inbetween values in this respect.

1.2.c. Fruit drop percentage (July, 2nd – August, 1st):

Table, 2 shows that UF and PCU at the two tested rates succeeded in reducing fruit drop percentage of Balady mandarin trees during July as compared with AS and AN at 200 & 300g N/tree with the four tested AF. Such reduction effect was more pronounced and significant when PCU at 100 & 150g N/tree and UF at 100g N/tree were compared with AS at 200 & 300g N/tree with the four tested AF, except for AS at 200g N/tree with AF (50 + 20 + 30%) in 2006 season. On the other hand, in 2008 season, UF at 150g N/tree and PCU at 100g N/tree produced remarkable reductive effect on fruit drop percentage as compared with AS at 200 & 300g N/tree with the four tested AF and AN at 200g N/tree with AF (five equal patches, 20%) and AN at 300g N/tree with the four tested AF (except, five equal patches, 20%).

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1.2.d. Fruit drop percentage (Aug, 2nd up to Sept., 1st):

Statistical analysis emphasizes that AS and AN at 200 & 300g N/tree with the four tested AF and UF and PCU at 100 & 150g N/tree produced similar value of fruit drop percentage of Balady mandarin trees during August, 2nd up to Sept., 1st of the two expected "Off" years, (Table, 2).

1.3. No. of fruits/tree:

Table, 3 illustrates that PCU at 100 & 150g N/tree scored the highest No. of fruits/tree, followed descendingly by UF at the two tested rates in 2006 season. The values in this respect recorded by the previously mentioned two forms of controlled release N fertilizers at the two tested rates were significant when compared with the analogous ones produced by AS and AN at 200 & 300g N/tree with the four tested AF. The differences between or within the combinations of AS and AN in this concern were so small to reach the significant level. On the other hand, in 2008, UF and PCU at the two tested rates induced slight positive effect on number of fruits per tree as compared with AS and AN at the two tested rates and the four tested AF. Such enhancing effect was so small to be considered.

1.4. Yield (kg/tree):

PCU-fertilized trees at the two tested rates produced the highest yield, followed by UF-fertilized trees at the two tested rates. Such values of tree yield produced by the aforementioned two forms of slow release N fertilizer were significant when compared with the combinations of AS and AN in 2006 season. The differences between or within the combinations of AS and AN in this respect were so small to be neglected. On the other side, in 2008 season, PCU and UF at the two tested combinations scored similar and higher values of tree yield (kg) from the statistical standpoint as compared with the combinations of AS and AN. No significant differences were noticed among or within AS and AN combinations in this respect, (Table, 3).

Table 3: Effect of nitrogen fertilizer form, rate and application frequency rate on No. of fruits/tree, yield (Kg/ tree) and biennial bearing index of Balady mandarin trees during "Off" years (2006 & 2008 seasons).

Fertilizer Form & Rate	Application frequency rate (AF)					No. of fruits/tree		Yield (kg/tree)		Biennial bearing index
	February	+	May	+	August	2006	2008	2006	2008	
Ammonium sulfate (AS) 200g N/tree	33.3%	+	33.3%	+	33.3%	110.7	116.0	15.93	16.23	68.88
	60%	+	20%	+	20%	108.7	117.3	15.67	16.53	67.70
	50%	+	20%	+	30%	109.7	122.0	15.83	17.08	65.97
	20% (five times a year)					108.3	117.3	15.58	16.50	64.85
Ammonium sulfate (AS) 300g N/tree	33.3%	+	33.3%	+	33.3%	112.3	119.0	16.03	16.57	65.88
	60%	+	20%	+	20%	112.3	116.3	16.22	16.33	67.99
	50%	+	20%	+	30%	114.0	113.3	16.48	15.90	66.51
	20% (five times a year)					116.7	114.7	16.73	16.12	66.95
Ammonium nitrate (AN) 200g N/tree	33.3%	+	33.3%	+	33.3%	109.0	115.3	15.20	16.20	71.71
	60%	+	20%	+	20%	112.7	114.7	16.08	16.05	68.77
	50%	+	20%	+	30%	111.3	113.7	16.17	15.88	70.82
	20% (five times a year)					112.0	117.3	16.35	16.33	68.88
Ammonium nitrate (AN) 300g N/tree	33.3%	+	33.3%	+	33.3%	111.0	115.7	16.15	16.20	70.60
	60%	+	20%	+	20%	110.0	117.0	16.08	16.43	70.92
	50%	+	20%	+	30%	111.0	119.3	16.13	16.67	70.06
	20% (five times a year)					112.7	115.7	16.45	16.15	68.87
UF (100g N/tree)						121.0	123.7	18.13	18.62	61.79
UF (150g N/tree)						122.0	121.0	18.47	18.87	62.48
PCU (100g N/tree)						133.0	126.7	20.00	18.52	61.19
PCU (150g N/tree)						134.0	125.3	20.40	18.75	61.25
L.S.D at 5% level						4.9	11.9	0.91	1.64	3.15

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1.5. Biennial bearing index:

It is important to remember that biennial bearing index was calculated upon tree yield of 2006,2007 and 2008 seasons. Table, 3 illustrates that UF and PCU at 100 & 150g N/tree reduced the tendency of Balady mandarin trees to produce their yield in an alternative pattern as compared with AS and AN at 200 & 300g N/tree with the four tested AF. Such enhancing effect was pronounced from the statistical standpoint. Furthermore, AS at 200g N/tree with AF (five equal patches, 20%) treatment showed statistically similar values in this respect to that of the previously two mentioned categories. Besides, differences between and/or within UF and PCU combinations on one hand and AS & AN combinations on the other one were neglectful.

Briefly, UF and PCU at the two tested rates induced slight positive effect on fruit set percentage and reductive effect on fruit dropping percentages during August, 2nd up to Sept., 1st period of Balady mandarin trees as compared with AS and AN at the two tested rates with the four tested AF during the expected "Off" years. Moreover, UF and PCU at the two tested rates produced significant reductive effect on fruit dropping percentage during May (in 2008 season, only as compared with most AS & AN combinations), June, 1st up to July, 1st (as compared with few combinations of AS and AN) and July, 2nd up to August, 1st (as compared with most AS and AN combinations). Furthermore, UF and PCU at the two tested rates exerted a pronounced and significant positive effect on number of harvested fruits per tree and tree yield (kg/tree) of Balady mandarin trees as compared with all tested combinations of AS and AN (rates and AF) during the expected "Off" years. Finally, UF and PCU combinations succeeded in reducing alternative bearing habit of Balady mandarin trees as compared with AS and AN combinations (rate and AF).

The effect of slow release N fertilizers in improving some fruiting parameters of Balady mandarin trees may be attributed to their effect on regulating the release of their own nitrogen at the proper time as the plant need. Also, they gave the highest values of residual N due to their low acidity index, while soluble ones gave the lowest values of available N left in the soil. In addition, the role of N as a constituent of amino acids and protein as well as its importance in cell division and development of meristematic tissues (Mengel and Kirby, 1987).

The positive results of slow release N fertilizers on fruiting parameters of Balady mandarin trees are in harmony with the findings of Scuderi *et al.,* (1983) on Valencia late orange trees, Sharashenidze *et al.,* (1986) on mandarins, Obreza and Rouse (1992) on Hamlin orange trees, Alva and Tucker (1993) on citrus trees, Boman (1993) on Marsh grapefruit, Raigon *et al.,* (1999) on citrus trees and Tayeh *et al.,* (2003) on Valencia orange trees. They mentioned that controlled release N fertilizers enhanced tree fruiting parameters expressed as fruit set and tree yield rather than the use of fast release nitrogen fertilizers i.e. urea, ammonium sulfate, calcium nitrate and ammonium nitrate.

1.6. Fruit quality:

1.6.1. Fruit physical properties:

1.6.1.a Fruit weight (g.):

Table, 4 illustrates that Balady mandarin trees fertilized with UF and PCU at 100 & 150g N/tree produced statistically similar and heavier fruits than those produced by fast release N fertilized trees at the two tested rates with the four tested AF during the two expected "Off" years. Moreover, the differences between and/or within AS and AN combinations in this respect were so small to reach the significant level.

1.6.1.b. Fruit shape index (L/D):

Table, 4 demonstrates that slow release N fertilized trees at the two tested rates produced less flatten fruits than those produced by fast release N fertilized- ones at the two tested rates with the four tested AF during the two expected "Off" years with a few exceptions. In this respect, AN at 300g N/tree with AF (50 + 20 + 30%) and (five equal patches) in 2006 season as well as AS at 300g N/tree with AF (60 + 20 + 20%) in 2008 season exit from this comparison.

1.6.1.c. Juice weight (g.):

UF and PCU at the two tested rates of produced fruits richer in their juice content than the analogous ones produced by fast release N fertilized trees during the two expected Off years, (Table, 4). Such positive effect was significant from the statistical standpoint. Furthermore, the differences within and between UF and PCU combinations on one hand, and AS & AN on the other one were neglectful.

Abstractly, UF and PCU at 100 & 150g N/tree succeeded in producing heavier and less flatten fruits richer in their juice content than the analogous ones produced by AS and AN at 200 & 300g N/tree with the four tested

AF during the two expected "Off" years. Moreover, UF and PCU combinations produced statistically similar effect on fruit shape index and juice content of Balady mandarin trees to that produced by AS and AN combinations (rate and AF) during the expected "Off" years.

The obtained positive results of fruit physical properties due to slow release N fertilizers are in agreement with the findings of Tavdgiridze and Putkaradze (1976) on Satsuma mandarin, Sharashenidze *et al.,* (1988) on mandarin trees and Alva and Tucker (1993) on citrus trees. They mentioned that controlled release N fertilizers induced an enhancing effect on some fruit physical traits, particularly fruit weight. Moreover, Obreza and Rouse (1992) on Hamlin orange trees, Zekri and Koo (1992) on Valencia orange trees Boman (1993) on Marsh grapefruit and Raigon *et al.,* (1999) on citrus trees. They found that there were no significant differences in fruit quality between slow and fast release N fertilizer treatments.

Table 4: Effect of nitrogen fertilizer form, rate and application frequency rate on fruit physical and chemical properties of Balady mandarin trees during "Off" years (2006 & 2008 seasons).

Fertilizer Form & Rate	Application frequency rate (AF)					Fruit physical properties						Fruit chemical properties			
						Fruit weight (g)		Fruit shape index (L/D)		Juice weight (g)		T.S.S/acid ratio		Ascorbic acid mg/100 ml juice	
	February	+	May	+	August	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008
Ammonium sulfate (AS) 200g N/tree	33.3%	+	33.3 %	+	33.3%	144.0	140.3	0.90	0.89	58.7	59.3	11.86	12.08	51.7	52.7
	60%	+	20%	+	20%	144.0	141.7	0.89	0.89	59.0	59.3	11.98	12.08	51.3	52.0
	50%	+	20%	+	30%	144.3	140.0	0.90	0.89	58.7	59.3	11.91	12.02	50.7	53.0
	20% (five times a year)					144.0	141.0	0.90	0.89	59.3	58.7	11.95	11.94	51.0	52.0
Ammonium sulfate (AS) 300g N/tree	33.3%	+	33.3 %	+	33.3%	145.0	139.3	0.90	0.89	59.0	59.3	11.85	11.94	51.7	52.7
	60%	+	20%	+	20%	144.7	141.7	0.89	0.92	58.7	58.7	11.87	12.02	51.7	52.3
	50%	+	20%	+	30%	145.0	141.0	0.89	0.90	59.0	59.0	12.07	12.01	51.0	52.7
	20% (five times a year)					145.0	140.7	0.89	0.88	58.7	58.7	11.83	12.01	52.0	52.0
Ammonium nitrate (AN) 200g N/tree	33.3%	+	33.3 %	+	33.3%	145.7	140.7	0.90	0.90	58.7	59.3	11.89	11.99	52.0	52.3
	60%	+	20%	+	20%	145.3	140.0	0.90	0.90	59.0	58.7	12.13	12.09	51.0	51.7
	50%	+	20%	+	30%	145.3	140.0	0.89	0.90	58.3	58.7	11.95	12.01	51.3	52.0
	20% (five times a year)					145.7	139.3	0.89	0.89	58.7	59.0	11.86	12.08	51.0	52.0
Ammonium nitrate (AN) 300g N/tree	33.3%	+	33.3 %	+	33.3%	145.3	141.0	0.90	0.90	59.7	59.0	11.87	12.01	51.7	52.3
	60%	+	20%	+	20%	145.7	141.0	0.90	0.90	59.3	58.7	12.05	12.20	52.7	51.3
	50%	+	20%	+	30%	145.7	139.7	0.91	0.90	59.3	59.3	12.01	12.12	52.7	51.3
	20% (five times a year)					145.0	140.7	0.91	0.89	59.3	58.7	12.09	12.12	52.0	52.0
UF (100g N/tree)						150.0	150.0	0.92	0.92	61.3	61.7	11.97	12.17	52.0	51.3
UF (150g N/tree)						150.7	150.0	0.92	0.91	61.7	61.3	12.16	12.16	52.0	51.0
PCU (100g N/tree)						150.3	149.3	0.92	0.92	61.3	61.7	11.88	12.12	52.7	51.3
PCU (150g N/tree)						152.0	149.7	0.92	0.92	61.3	62.0	12.02	12.20	52.3	51.7
L.S.D at 5% level						2.1	2.4	0.02	0.02	0.52	0.72	N.S	N.S	N.S	N.S

1.6.2. Fruit chemical properties:

Table, 4 illustrates that UF and PCU at 100 & 150g N/tree and AS and AN at 200 & 300g N/tree with the four tested AF induced statistically similar effect on fruit chemical traits i.e. T.S.S/acid ratio and ascorbic acid content (mg/100 ml juice) of Balady mandarin fruits during the two expected "Off" years (2006 & 2008).

The obtained results of fruit chemical properties of Balady mandarin trees are in harmony with the findings of Obreza and Rouse (1992) on Hamlin orange trees, Zekri and Koo (1992) on Valencia orange trees, Boman (1993) on Marsh grapefruit and Raigon *et al.,* (1999) on citrus trees. They found that controlled release N fertilizers had a slightly positive effect on fruit quality parameters as compared with the conventional soluble ones. Furthermore, Tavdgiridze (1979) on Satsuma mandarin and Sharashenidze *et al.,* (1986) on mandarin trees found that controlled release N fertilizers enhanced fruit chemical properties than did traditional soluble ones.

Consequently, under similar conditions to that of the present study, it is preferable to fertilize Balady mandarin trees with UF and PCU controlled release N fertilizer at 150g N/tree once a year during an expected

"Off" years to enhance tree productivity and reduce N losses that have important repercussions on the economy of crop production apart from harming the environment, since residues of the non- absorbed nitrogen may cause nitrate pollution.

II. Effect of nitrogen fertilizer form, rate and frequency of application on Balady mandarin trees during an expected "On" years.:

1. Tree fruiting:

1.1. Fruit set (%):

Table, 5 illustrates that UF and PCU- fertilized Balady mandarin trees at 200 or 300g N/tree had similar and higher capacity to set fruits than the analogous ones fertilized with AS and AN the conventional soluble N fertilizers at 400 & 600g N/tree with the four tested AF during the two expected "On" years. The differences in this respect between and/or within the combinations of AS and AN (rate & AF) were lacking from the statistical standpoint.

Table 5: Effect of nitrogen fertilizer form, rate and application frequency rate on fruit set and dropping percentage of Balady mandarin trees during "On" years (2007 & 2009 seasons).

Fertilizer Form & Rate	Application frequency rate (AF)					Fruit set (%)		Fruit dropping (%)							
								Up to May, 31th		June, 1st - July, 1st		July, 2nd - August, 1st		August, 2nd - Sept, 1st	
	February	+	May	+	August	2007	2009	2007	2009	2007	2009	2007	2009	2007	2009
Ammonium sulfate (AS) 400g N/tree	33.3%	+	33.3%	+	33.3%	20.89	21.60	35.68	36.63	18.63	18.34	12.15	11.96	4.46	4.20
	60%	+	20%	+	20%	21.05	20.23	35.56	37.32	18.62	18.40	12.32	12.20	4.50	4.36
	50%	+	20%	+	30%	20.79	21.48	35.67	37.02	19.21	18.91	12.41	11.87	4.34	4.31
	20% (five times a year)					21.18	21.80	35.50	37.33	1852	18.60	12.55	11.77	4.22	4.40
Ammonium sulfate (AS) 600g N/tree	33.3%	+	33.3%	+	33.3%	21.86	21.57	35.37	37.02	18.80	18.45	12.09	11.88	4.36	4.24
	60%	+	20%	+	20%	21.07	21.44	35.50	37.29	18.52	18.94	12.15	11.97	4.44	4.32
	50%	+	20%	+	30%	21.48	21.37	34.76	36.54	18.72	18.41	11.95	11.86	4.52	4.08
	20% (five times a year)					21.82	21.43	35.77	36.69	18.65	18.56	11.89	12.88	4.45	4.30
Ammonium nitrate (AN) 400g N/tree	33.3%	+	33.3%	+	33.3%	21.10	21.44	35.40	36.33	17.56	18.19	12.71	11.96	4.45	4.02
	60%	+	20%	+	20%	20.84	21.35	36.69	36.41	17.62	18.92	12.00	11.77	4.35	4.33
	50%	+	20%	+	30%	20.91	21.70	36.85	36.03	17.91	15.45	11.89	11.99	4.52	4.19
	20% (five times a year)					20.17	21.12	36.87	36.42	18.26	18.69	11.85	11.89	4.42	4.36
Ammonium nitrate (AN) 600g N/tree	33.3%	+	33.3%	+	33.3%	21.10	21.83	36.06	36.90	17.75	18.54	12.12	11.91	4.21	4.20
	60%	+	20%	+	20%	20.62	21.66	36.47	36.63	17.57	18.37	11.88	11.93	4.38	4.18
	50%	+	20%	+	30%	21.43	21.05	36.87	36.84	18.01	18.64	11.93	11.71	4.36	4.28
	20% (five times a year)					20.93	22.70	36.63	36.83	17.97	18.74	11.97	12.26	4.02	3.88
UF (200g N/tree)						25.66	26.45	31.13	31.63	15.57	16.24	9.58	9.73	3.66	3.97
UF (300g N/tree)						25.63	26.35	31.12	31.35	15.65	16.56	9.49	9.43	3.66	3.97
PCU (200g N/tree)						25.76	26.23	30.15	31.58	15.46	16.70	9.75	9.56	3.71	3.64
PCU (300g N/tree)						25.63	26.32	30.27	31.29	15.55	16.64	9.82	9.76	3.68	3.65
L.S.D at 5% level						3.64	3.20	4.76	4.46	2.69	1.81	2.05	1.92	N.S	N.S

1.2. Fruit dropping (%):

As for fruit dropping (%) during the May period tabulated data demonstrate that in 2007 season, UF and PCU- fertilized Balady mandarin trees at 200 & 300g N/tree retained similar and higher number of fruits during the aforementioned period as compared with AN-fertilized trees at 400 and 600g N/tree with the four tested AF, except for AN-fertilized trees at 400g N/tree with AF (three equal patches, 33.3%) which exhibited similar number of retained fruits to those of UF and PCU combinations, (Table, 5). The differences in this concern within and/or between AN combinations were statistically so small to be considered. Furthermore, AS combinations (rate & AF) occupied an intermediate positions from the statistical standpoint between the two aforementioned categories i.e. UF & PCU combinations and AN combinations. On the other hand, in 2009, UF

and PCU controlled release N fertilizer at the two tested rates succeeded in retaining similar and higher percentage of fruits during May than AS and AN fast release N fertilizers at the two tested rates with the four tested AF. The differences in this respect between and/or within AS and AN combinations were so small to reach the significant level.

Regarding fruit dropping percentages during June month, Table, 5 shows that UF and PCU-fertilized Balady mandarin trees at the two tested rates dropped statistically similar and lower number of fruits during June as compared with AS combinations (rate & AF) in 2007 season and most AS and AN combinations in 2009 season. However, AN combinations produced an intermediate values in this respect in 2007 season. Furthermore, the differences between and/or within AS and AN combinations (rate & AF) were so small to be considered in 2007 and 2009 seasons. Concerning fruit dropping percentage during July Table, 5 illustrates that fertilizing Balady mandarin trees with UF and PCU at 200 or 300g N/tree succeeded in producing similar reductive effect on fruit dropping percentage during the two studied "On" years as compared with those fertilized with AS and AN at 400 or 600g N/tree with the four tested AF. The differences between and/or within AS and AN fast release N fertilizers at the two tested rates and the four tested AF were lacking from statistical standpoint.

As for fruit dropping percentage of Balady mandarin trees during August, statistical analysis emphasizes that UF and PCU controlled release N fertilizers at the two tested rates exerted similar effect on fruit dropping percentage during the aforementioned period as compared with AS and AN combinations (rate & AF) during the two studied "On" years, (Table, 5).

2.3. No. of fruits/tree:

Table, 6 demonstrates that UF and PCU-fertilized Balady mandarin trees at 200 or 300g N/tree proved to be superior in their cropping capacity, since they produced similar and higher number of harvested fruits (327-346 fruits/tree) as compared with AS and AN-fertilized trees at the two tested rates with the four tested AF (282-302 fruit/tree) during the two studied "On" years. Furthermore, the differences between and/or within UF and PCU combinations in this concern on one hand and AS & AN combinations on the other one were so small to be neglected from the statistical standpoint.

Table 6: Effect of nitrogen fertilizer form, rate and application frequency rate on No. of fruits/tree, yield (Kg/ tree) and biennial bearing index of Balady mandarin trees during "On" years (2007 & 2009 seasons).

Fertilizer Form & Rate	Application frequency rate (AF)					No. of fruits/tree		Yield (kg/tree)		Biennial bearing index
	February	+	May	+	August	2007	2009	2007	2009	
Ammonium sulfate (AS) 400g N/tree	33.3%	+	33.3%	+	33.3%	295.3	289.3	41.4	40.9	64.92
	60%	+	20%	+	20%	288.0	295.3	40.8	41.6	64.98
	50%	+	20%	+	30%	288.3	301.0	40.8	41.7	63.52
	20% (five times a year)					282.0	298.0	39.1	41.8	64.03
Ammonium sulfate (AS) 600g N/tree	33.3%	+	33.3%	+	33.3%	283.7	299.0	40.3	42.2	63.97
	60%	+	20%	+	20%	292.3	297.3	41.4	42.0	65.48
	50%	+	20%	+	30%	282.3	293.7	40.4	41.5	64.77
	20% (five times a year)					287.3	297.3	41.2	42.1	65.03
Ammonium nitrate (AN) 400g N/tree	33.3%	+	33.3%	+	33.3%	294.7	298.0	42.0	42.3	68.02
	60%	+	20%	+	20%	289.0	293.3	41.3	41.5	66.06
	50%	+	20%	+	30%	296.0	292.3	42.4	41.6	67.62
	20% (five times a year)					296.0	286.3	42.0	40.7	65.60
Ammonium nitrate (AN) 600g N/tree	33.3%	+	33.3%	+	33.3%	300.0	296.3	42.7	41.9	67.34
	60%	+	20%	+	20%	299.3	298.5	42.5	42.3	66.80
	50%	+	20%	+	30%	300.1	297.8	42.7	42.2	66.61
	20% (five times a year)					295.1	295.8	41.9	41.8	66.60
UF (200g N/tree)						324.5	321.3	46.5	45.4	65.55
UF (300g N/tree)						323.6	330.3	46.5	46.8	63.98
PCU (200g N/tree)						325.0	327.3	46.9	46.9	63.01
PCU (300g N/tree)						331.5	340.1	47.5	48.3	63.28
L.S.D at 5% level						26.1	25.0	3.60	2.90	2.12

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2.4. Yield (kg/tree):

Statistical analysis emphasizes that UF and PCU controlled release N fertilizer forms at 200 or 300g N/tree showed to be the superior treatments in enhancing tree yield, hence they induced similar and higher yield (45.4-48.3kg/tree) as compared with the yield produced by AS and AN-fertilized trees at the two tested rates with the four tested AF (39.1-42.7kg/tree) during the two expected "On" years, (Table, 6). Furthermore, the differences between and/or within AS and AN combinations in this respect were so small to reach the significant level.

2.5. Biennial bearing index:

It is important to mention that biennial bearing index parameter was calculated throughout 2006-2009 seasons i.e. 2006 & 2008 an expected "Off" years and 2007 & 2009 an expected "On" years. Tabulated data illustrate that UF and PCU-fertilized Balady mandarin trees at 200 or 300g N/tree showed statistically similar and less tendency to bear their crop in an alternative pattern as compared with those fertilized with AN at 400 or 600g N/tree with the four tested AF. The differences between and/or within AN combinations (rate & AF) were lacking. Furthermore, AS combinations (rate & AF) occupied an intermediate positions in this respect between the aforementioned two categories, (Table, 6).

In summary, UF and PCU controlled release N fertilizer at 200 & 300g N/tree succeeded in enhancing fruit set percentage, reducing fruit dropping percentage during May, June and July and improving tree productivity expressed as No. of fruits/tree or yield (kg/tree) as compared with AS and AN the conventional soluble N fertilizer forms at 400 & 600g N/tree with the four tested AF during the two studied "On" years. Furthermore, UF at 300g N/tree and PCU at 200 & 300g N/tree succeeded in reducing the alternative bearing habit of Balady mandarin trees as compared with AN at 600g N/tree with the four tested AF. Finally, the tested N fertilizer form, rate and application frequency induced slight reductive effect on fruit shedding percentage during August month during the two expected "On" years.

The obtained prospective results of slow release N fertilizers on tree fruiting are in harmony with the finding of Scuderi *et al.,* (1983) on Valencia orange trees, Sharashenidze *et al.,* (1986) on mandarin trees, Raigon *et al.,* (1999) on citrus trees and Tayeh *et al.,* (2003) on Valencia orange trees. They found that fertilizing citrus trees with controlled release N fertilizers enhanced tree fruiting parameters expressed as fruit set and tree yield rather than the use of fast release N fertilizers.

2.6. Fruit quality:

2.6.1. Fruit physical properties:

Statistical analysis emphasizes that AS and AN the conventional N fertilizer forms at 400 and 600g N/tree with the four tested AF and UF & PCU controlled release N fertilizers at 200 & 300g N/tree induced slight reductive effect on fruit physical properties of Balady mandarin trees expressed as fruit weight, shape index and juice weight during the two expected "On" years, Table, 7.

2.6.2. Fruit chemical properties:

Table, 7 illustrates that during the two expected "On" years (2007 & 2009), AS and AN conventional N fertilizers at the two tested rates with the four tested AF and the two tested forms of controlled release N fertilizers (UF & PCU) at the two tested rates induced slight enhancing effect on the studied fruit chemical properties of Balady mandarin trees i.e. T.S.S/acid ratio and ascorbic acid (mg/100ml juice).

Conclusively, the tested N fertilizer form, rate and application frequency produced slight enhancing effect on fruit physical properties (fruit weight, shape index and juice weight) and some fruit chemical traits (T.S.S/acid ratio and ascorbic acid content) of Balady mandarin trees during the two expected "On" years.

The obtained results regarding the effect of slow release N fertilizers on fruit quality are in agreement with earlier reports of Tavgiridze and Putkaradze (1976) on Satsuma mandarin trees, Obreza and Rouse (1992) on Hamlin orange trees, Zekri and Koo (1992) on Valencia orange trees, Alva and Tucker (1993) on citrus trees and Boman (1993) on Marsh grapefruit trees. They mentioned that there were no significant differences in fruit quality between slow and fast release N fertilizers. They added that heavier fruits were produced by slow release N fertilized trees.

Thereupon, it is preferable to fertilize Balady mandarin trees grown under similar conditions to that of the present study with PCU or UF at 300g N/tree once a year during an expected "On" years to enhance tree productivity, reduce environmental pollution and produce more healthy fruits.

Table 7: Effect of nitrogen fertilizer form, rate and application frequency rate on fruit physical and chemical properties of Balady mandarin trees during "On" years (2007 & 2009 seasons).

Fertilizer Form & Rate	Application frequency rate (AF)					Fruit physical properties						Fruit chemical properties			
						Fruit weight (g)		Fruit shape index (L/D)		Juice weight (g)		T.S.S/acid ratio		Ascorbic acid mg/100 ml juice	
	February	+	May	+	August	2007	2009	2007	2009	2007	2009	2007	2009	2007	2009
Ammonium sulfate (AS) 400g N/tree	033.3%	+	33.3%	+	33.3%	140.0	141.3	0.92	0.90	63.7	63.0	12.11	12.31	49.0	50.0
	60%	+	20%	+	20%	141.7	141.0	0.92	0.90	64.0	63.3	12.16	12.23	49.3	50.3
	50%	+	20%	+	30%	141.3	140.3	0.94	0.90	63.0	63.0	12.34	12.30	50.0	50.0
	20% (five times a year)					142.0	140.3	0.90	0.90	62.7	63.3	12.34	12.32	49.3	50.7
Ammonium sulfate (AS) 600g N/tree	33.3%	+	33.3%	+	33.3%	142.0	141.0	0.92	0.90	64.0	64.0	12.34	12.43	50.7	50.0
	60%	+	20%	+	20%	141.7	141.0	0.90	0.90	63.7	63.3	12.26	12.42	50.0	51.0
	50%	+	20%	+	30%	143.3	141.3	0.94	0.92	64.0	64.0	12.25	12.29	50.0	49.3
	20% (five times a year)					143.3	141.7	0.90	0.90	64.3	63.7	12.14	12.28	49.0	50.0
Ammonium nitrate (AN) 400g N/tree	33.3%	+	33.3%	+	33.3%	142.7	142.0	0.92	0.92	64.0	63.7	12.38	12.31	50.0	50.7
	60%	+	20%	+	20%	143.0	141.7	0.90	0.90	63.7	63.7	12.13	12.37	50.7	50.0
	50%	+	20%	+	30%	143.0	141.3	0.90	0.90	63.7	63.0	12.24	12.24	50.0	50.3
	20% (five times a year)					142.0	142.0	0.90	0.90	63.3	62.7	12.20	12.30	50.0	50.7
Ammonium nitrate (AN) 600g N/tree	33.3%	+	33.3%	+	33.3%	142.0	141.3	0.90	0.90	63.3	63.7	12.36	12.28	50.0	50.0
	60%	+	20%	+	20%	142.0	141.7	0.92	0.92	63.3	63.3	12.21	12.24	49.7	50.7
	50%	+	20%	+	30%	142.3	141.7	0.90	0.92	63.3	63.3	12.43	12.29	50.0	50.0
	20% (five times a year)					142.0	141.3	0.92	0.90	62.7	63.0	12.39	12.31	50.0	50.7
UF (200g N/tree)						143.3	141.3	0.92	0.92	63.7	63.3	12.23	12.23	50.7	50.0
UF (300g N/tree)						143.7	141.7	0.90	0.92	64.7	64.0	12.45	12.22	51.0	50.3
PCU (200g N/tree)						144.3	143.3	0.90	0.92	64.7	63.7	12.15	12.26	50.0	50.0
PCU (300g N/tree)						143.3	142.0	0.92	0.90	64.7	63.3	12.21	12.20	50.0	50.7
L.S.D at 5% level						N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

References

Abbes, C., L.E. Parent and A. Karam, 1994. Nitrification of ammoniated peat and ammonium sulfate in mineral soils. Soil Biology and Biochemistry, 26: 1041-51.

Alva, A.K. and D.P.H. Tucker, l993. Evaluation of a resin coated nitrogen fertilizer for young citrus trees on a deep sand. Proc of The Florida-State, Hort. Soc., 106: 4-8.

Boman, B.J., 1993. A comparison of controlled release to conventional fertilizer on mature "Marsh" grapefruit. Proc. of The Florida-State Hort. Soc., 106: 1-4.

Clarke, G.M. and R.E. Kempson, 1997. Introduction to the design and analysis of experiments. Arnold, a Member of the Holder Headline Group, 1st Edt., London, UK.

Diez, J.A., R. Roman, M.C. Cartagena, A. Vallejo, A. Bustos and R. Caballero, 1994. Controlling nitrate pollution of aquifers by using different nitrogenous controlled release fertilizers in maize crop. Agriculture Ecosystems and Environment, 48: 49-56.

Horwitz, W., 1972. Official Methods of Analysis. Association of Official Analytical Chemists. 11th ed. Washington, D.C.

Mengel, K. and E.A. Kirby, 1987. Principles of Plant Nutrition. Warblaufen-Bern Swizer land. International Potash Institute.

Obreza, T.A. and R.E. Rouse, 1992. Controlled release fertilizers use on young "Hamlin" orange trees. Proceedings Soil and Crop Science Society of Florida, 51: 64-68.

Raigon, M.D., E. Primo-Yufera, A. Maquierira and R. Puchades, 1999. Available N in the root area for citrus orchards fertilized with sulphur-coated and ammonium nitro-sulphate. Nutrient cycling in Agroecosystems., 55(3): 187-196.

Scuderi, A., G. Raciti and A. Barbagallo, 1983. Manuring of citrus:nutritional and yield effects of using a slow release nitrogen formutation. Informatore-Agrario-39(40): 27731-27735.

Sharashenidze, M.G., R.N. Chanukvadze and R.P. Komakhidze, 1986. Effect of a urea-formaldehyde fertilizer (MFU) on the productivity and fruit quality of mandarins. Subtropicheskie-kul-tury, (5): 90-93.

Tavdgiridze, G.N. and A. Sh. Putkaradze, 1976. The effect of different forms of nitrogen fertilizers on the mechanical composition of Satsumas. Suptropiskie-Kul'tury, 5-6: 140-142.

Tayeh, E.A.H., M.A. Elfangry and M.Y. Hegab, 2003. Effect of some sources of nitrogen fertilizers on pre-bearing and bearing Valencia orange trees. Annals of Agric. Sci., Moshtohor, 41(4): 1655-1680.
Vogel, A., 1968. A test Book of Quantative Inorganic Analysis, Longmans, New York, pp: 1216.
Wilcox, J.C., 1944. Some factors affecting apple yield in the Okanagan Valley. Sci., Agric., Q5: 189-213.
Wilde, S.A., R.B. Corey, J.G. Layer and G.K. Voigt, 1979. Soil and Plant Analysis for Tree Culture. Published by Oxford and IBH Publishing Co., New Delhi India.
Zekri, M. and R.C.J. Koo, 1992. Use of controlled release fertilizers for young citrus trees. Scientia. Horticulture. 49: 3-4, 233-241.