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Growth and Leaf Mineral Content of Some Fruit Species Seedlings as Affected by a Slow Release Nitrogen Fertilizer

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Abstract: Urea-formaldehyde (UF) (38% N) was used as a slow release nitrogen fertilizer on four fruit seedling species (grape, mango, banana and date palm) comparing with the traditional urea (46% N) to investigate the effect of using UF at the same or half dose of the traditional urea on growth parameters and leaf mineral content, also on the soil chemical properties. Results indicated that UF treatments either as full or half dose had a positive effect on vegetative growth parameters, also enhanced leaf mineral content in the leaves especially grape and date palm seedlings. Moreover, it is noticed that UF treatments increased the available forms of N, P and K in the soil of the four crops seedlings in comparing with the traditional urea.

Key words: Urea-formaldehyde, seedlings, vegetative growth, leaf mineral content, soil chemical properties.

INTRODUCTION

Nitrogen is the main nutrient affecting plant growth. Good nitrogen fertilization resulted in healthy and proper seedlings which are an essential factor to establish an ideal orchard. Consequently, it is important to improve the efficiency of nitrogen fertilizer by introducing other nitrogen forms, techniques and alternative systems. The efficiency of nitrogen fertilizer can be increased through the use of slow release nitrogen forms, which potentially reduce the nitrogen usage and improve the efficiency of plant recovery[1]. These fertilizers can be clearing advantages as compared to conventional ones in a great variety of horticultural crops in different soil types, climates and growing techniques[2]**.** On the other hand, slow-release nitrogen (N) materials are often used to reduce N leaching losses from sandy soils[3] and extend N availability over a growing season[4].

Using slow release nitrogen fertilizers reduce the total amount of nitrogen needed, number of fertilizing applications, the residual of nitrogen fraction through the soil and the plant, cost of producing process and finally improve yield with a good quality[5,6]. Urea-formaldehyde (UF) was the first synthetic organic fertilizer and remains the most common. Reacting urea with formaldehyde yields some un-reacted urea with various urea-polymer chains of varying lengths depending upon the reaction conditions. Abd El-Kader[7] pointed out that urea-formaldehyde (UF) was applied to sandy soils to improve the physical properties and fertility. The application of UF increased the quantity of water holding capacity, porosity and permeability of the soil. However, using urea-formaldehyde (UF) and phosphorus coated urea (PCU) fertilizers enhanced the studied parameters of tree growth, leaf mineral content [8]. Also, Eman *et al.*[9] reported that UF had a positive effect on leaf mineral contents of mango than the traditional urea.

MATERIALS AND METHODS

This study was carried out during two successive seasons (2006 and 2007) and included four individual experiments, the first on Thompson seedless grape seedlings, the second on Alphones mango seedlings, the third on Grand naine banana suckers and the fourth on Zaghloul date palm seedlings.

Seedlings of the previous fruit crops were planted in plastic bags each was filled with 30 kg fertile sandy clay loam soil under conditions of green house belonged to Pomology Department, National Research Centre, Cairo, Egypt.

Urea-formaldehyde (UF) (38% N) was used as a slow release nitrogen fertilizer to investigate its effect on vegetative growth and leaf mineral content of the previous seedlings comparing with the traditional urea (U) (46% N). Urea-formaldehyde (UF) was added at two rates and applied once at the beginning of the growing season (early March) for the four experiments, while traditional urea (U) was divided into three equal doses and added at (early March, mid May and early August) of each season.

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Treatments and determinations of the four experiments were done as follows:

- Treatments of the first experiment on Thompson seedless grape seedlings:

1- 15 gm N/seedling as traditional urea (46% N) (control).
2- 15 gm N/seedling as urea-formaldehyde (38% N).
3- 7.5 gm N/seedling as urea-formaldehyde (38% N).

Determinations: At the end of the growing season (before leaf abscission), the following determinations were recorded:

Shoot length (cm), number of shoots, number of nods/shoot, number of total leaves, leaf area (cm2) and total leaf area (crn2).

- Treatments of the second experiment on one year seeded Alphones mango seedlings:

1- 25 gm N/seedling as traditional urea (46% N) (control).
2- 25 gm N/seedling as urea-formaldehyde (38% N).
3- 12.5 gm N/seedling as urea-formaldehyde (38% N).

Determinations: - At the end of the growing season (November of each season) the following determinations were recorded:

Stem length (cm), stem girth (cm), number of total leaves, leaf area (cm^2) and total leaf area (cm^2).

-*Treatments of the* third experiment on *in vitro* propagated suckers of Grand naine banana suckers:

1- 25 gm N/sucker as traditional urea (46% N) (control).
2- 25 gm N/sucker as urea-formaldehyde (38% N).
3- 12.5 gm N/sucker as urea- formaldehyde (38% N).

Determinations: At the end of the growing season (November of each season) the following determinations were recorded:

Length and girth of pseudostem, number of leaves, length, width and area of the third leaf.

- Treatments of the fourth experiment on Zaghloul date palm offshoots:

1- 25 gm N/seedling as traditional urea (46% N) (control).
2- 25 gm N/seedling as urea-formaldehyde (38% N).
3- 12.5 gm N/seedling as urea-formaldehyde (38% N).

Determinations: At the end of the growing season, stem length, stem girth, leaf length, leaf width and leaf area were determined.

Among all experiments, samples of leaves were collected, washed, dried and finally grind to determine nitrogen, phosphorus and potassium content in the leaves. The N rates added as a control treatments for grape, mango, banana and date palm experiments were used according to the bulletins issued by Ministry of Agriculture and Land Reclamation (2000) for grape (1989) for mango, (1999) for banana and (1989) for date palm. Treatments of all the previous experiments were replicated five times in a completely randomized design. Some physical and chemical properties of the studied media before planting are presented in Table (1).

Available N, P and K in soil samples and nutrients content in plant samples were determined according to Page *et al*.[10] and Cottenie *et al*.[11].

The data were subjected to analysis of variance and Duncan's multiple range test was used to differentiate means[12].

RESULTS AND DISCUSSION

First Experiment of Thompson Seedless Grape Seedlings:

Leaf Mineral Content: Table (2) showed that fertilizing Thompson seedless grape seedlings with urea-formaldehyde (UF) was significantly affected on leaf nitrogen content in both studied seasons since using UF at full dose (30 gm N) or at half dose (15 gm N) were greatly enhanced N% in the leaf comparing with the traditional urea (30 gm N). The half dose of UF recorded the highest N value in both studied seasons.

Regarding phosphorus content in the leaf, no significant effect was detected in the first season while in the second one UF at any concentration significantly increased it than the traditional urea. The same results were observed for potassium percentage in the leaf, since both UF concentrations increased potassium value specially the half dose which recorded the highest value. On the other hand, no significant differences were detected between the two concentrations of UF on N, P and K content in the leaf of Thompson seedless grape seedlings.

Vegetative Growth: Table (3) showed the effect of UF as slow release N fertilizer on vegetative growth. As for shoot length, it is clear that UF at half dose (15 gm N) lengthened the shoots and gave the tallest shoot in both seasons compared with the other treatments but this increment was significant in the first season only. Number of shoots per seedling was significantly affected in the second season only. However, the full dose of UF followed by the half dose gave the higher values. This was true in both two seasons.

Table 1: some physical and chemical properties of the growing media.

1- Mechanical analysis											
Sand				Silt 20-2 μ %		Clay <2 μ %		Soil texture			
Course 2000-200 μ %			Fine 200-20 μ %								
13.4			41.2	16.6		28.2		Sandy clay loam			
2- Chemical analysis											
pH 1:2.5	EC dSm^1	$CaCO_3$	OM %	CEC Cmole Kg^{-1}	Soluble cations meq/100g				Soluble anions meq/100g			
					Na^+	K^+	Ca^{+2}	Mg^{+2}	Co_2^{-3}	HCO^{-3}	Cl^-	So_2^{-4}
7.9	1.5	0.5	0.76	8.8	0.12	0.21	1.0	2.5	--	0.75	6.25	6.25
Available macronutrients and micronutrients (ppm)												
N		P		K	Fe			Zn			Mn	
130		12		150	9.2			4.3			6.9	

Table 2: Effect of urea-formaldehyde fertilization on leaf mineral content of Thompson seedless grape seedling in 2004 and 2005 seasons.

Treatments	N %		P %		K %	
	2004	2005	2004	2005	2004	2005
Urea	0.06b	0.06b	0.012	0.021b	0.67	0.57b
UF half dose	0.11a	0.15a	0.013	0.043a	0.71	1.19ab
UF full dose	0.12a	0.19a	0.016	0.035a	0.72	1.31a
Significance at 5 % level	S	S	NS	S	NS	S

S: Significant; NS: Not significant

Table 3: Effect of urea-formaldehyde fertilization on vegetative growth of Thompson seedless grape seedling in 2004 and 2005 seasons.

Treatments	Shoot length (cm)		No. of shoots		No. of nods/shoot		No. of total leaves		Leaf area (cm^2)		Total leaf area (cm^2)	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Urea	18.9b	15.1	3.0	2.6b	7.4	7.9	23.0	18.3b	65.0	51.3	1407b	814b
UF half dose	18.1b	14.8	4.0	5.6a	8.5	6.9	33.0	31.0a	54.1	44.4	1473a	1430a
UF full dose	31.6a	18.7	3.3	4.3a	11.2	7.1	30.6	33.3a	83.8	52.5	2608a	1783a
Significance at 5 % level	S	NS	NS	S	NS	NS	NS	S	NS	NS	S	S

S: Significant; NS: Not significant

Number of nods per shoot was not affected by treatments in both studied seasons. Number of total leaves per seedling was significantly affected in the second season only, since UF at both concentrations increased it and the maximum number was obtained by the half dose of UF. Regarding leaf area, no significant differences were observed between treatments although UF at half dose enhanced it than the other treatments. Total leaf area was significantly affected in the two seasons. However, it is clear that UF at half dose (15 gm N) recorded the highest value and no differences were detected between UF doses in the second season. This was true in both studied seasons.

Second Experiment of Seeded Mango Seedlings:

Leaf Mineral Content: Table (4) showed the effect of UF treatments on leaf mineral contents of mango seedlings. In general, no significant differences for treatments were detected on N, P and K percentages in the leaf although the half dose of UF (25 gm N) tented to increase N, P and K values in the leaves compared with the other treatments.

Vegetative Growth: Results in Table (5) indicated the effect of UF fertilizer on vegetative growth of mango seedlings. As for stem length, no differences were observed in the first season, while in the second one UF at half dose significantly increased this parameter than the traditional urea and gave the tallest stem. Stem girth was significantly increased in the second season only and the half dose of UF recorded the highest value compared with the other treatments.

Regarding number of leaves, there was a significant increase in the second season only, since the half dose of UF gave the maximum number of leaves.

As for means of leaf area, there was a significant increase in the second season only and the full dose of UF (50 gm N) recorded the largest leaf area. In respect of total leaf, UF treatments increased it compared with the traditional urea, but the increment was significant in the second season only, since the half dose of UF gave the highest value followed by the full dose treatment.

Table 4: Effect of urea-formaldehyde fertilization on leaf mineral content of Mango seedling in 2004 and 2005 seasons.

Treatments	N %		P %		K %	
	2004	2005	2004	2005	2004	2005
Urea	0.15	0.13	0.02	0.01	0.75	0.70
UF half dose	0.14	0.14	0.01	0.01	0.99	0.91
UF full dose	0.19	0.14	0.02	0.01	0.98	0.98
Significance at 5 % level	NS	NS	NS	NS	NS	NS

S: Significant; NS: Not significant

Table 5: Effect of urea-formaldehyde fertilization on vegetative growth of Mango seedling in 2004 and 2005 seasons.

Treatments	Stem length (cm)		Stem girth (cm)		No. of leaves		Leaf area (cm^2)		Total leaf area (cm^2)	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Urea	46.6	36.3b	1.03	0.80c	4.3	8.6ab	94	109ab	376	667c
UF half dose	48.0	40.6ab	1.16	1.23a	4.3	5.6b	99	146a	420	788b
UF full dose	42.0	48.3a	1.16	1.00b	5.0	12.6a	113	87b	514	1106a
Significance at 5 % level	NS	S	NS	S	NS	S	NS	S	NS	S

S: Significant; NS: Not significant

Third Experiment of Grand naine Banana Suckers:
Leaf Mineral Content: Results in Table (6) indicated the effect of UF treatments on leaf mineral content of Grand naine banana suckers. Nitrogen and phosphorus percentages in the leaf were not significantly affected by treatments in both studied seasons although, UF treatments tended to increase N and P content in the leaves than the traditional urea. As for potassium content in the leaf, UF treatments caused an increase in potassium value in the two seasons, but this increment lacked significance in the second season. However, UF at half dose (25gm N) recorded the highest potassium value in both seasons.

Vegetative Growth: Results in Table (7) showed the effect of UF fertilization on vegetative growth of Grand naine banana suckers. As for length and girth of pseudostem, no significant differences were detected between treatments in the first season, while in the second season; UF treatments increased this parameter specially the low dose (25 gm N) which gave the tallest pseudostem. Similar results were obtained among number of leaves, since the half dose of UF significantly increased the girth in the second season only compared with the traditional urea.

Regarding third leaf length no significant differences were detected in both studied seasons and no constant trend was observed. Results of third leaf width and third leaf area followed the same line since; they were reduced by UF treatments in the first season than the traditional urea, while no effect for treatments was observed in the second season.

Fourth Experiment of Seeded Date Palm Suckers:
Leaf Mineral Content: Table (8) showed the effect of UF treatments on leaf mineral content of date palm suckers. In this respect, it is clear that UF treatments increased N, P and K percentages than the traditional urea and the half dose of UF fertilizer gave the higher values of these parameters among the two studied seasons.

Vegetative Growth: Table (9) showed the effect of UF on vegetative growth of date palm suckers. Results of both length and girth of the stem followed the same trend, since UF at full dose (50 gm N) significantly increased these parameters and recorded the highest values. The same trend was obtained on leaf width in the second season only. Regarding leaf length and leaf area, it is noticed that both UF concentrations increased these parameters and the half dose of UF recorded the higher values. This was true in both studied seasons.

From the abovementioned results in the four experiments, it is observed that there was a positive effect for UF treatments on vegetative growth of grape, Mango, banana and date palm seedlings (suckers). However, the half dose of UF gave the promising results compared the full dose of this fertilizer.

Effects on Some Soil Properties: The effect of urea-formaldehyde, its application rate on some chemical properties and some soil characteristics related to plant nutrition. The obtained results from soil analysis as shown in Table (10) indicated a slightly decrease in soil pH due to the acidic effect of urea-formaldehyde; it is well known that lowing soil pH improves the availability of many nutrients needed for growing plants. Abd El-Kader[7] and Christianson *et al.*[13] found that values of electrical conductivity had been lowered due to the acidic effect of urea-formaldehyde hydrolysis. Also it was noticed that the effect on pH and EC differed with different plant kind, this may be due to the root exudates[7].

Table 6: Effect of urea-formaldehyde fertilization on Grand naine banana suckers in 2004 and 2005 seasons.

Treatments	N %		P %		K %	
	2004	2005	2004	2005	2004	2005
Urea	1.21	1.20	0.030	0.034	2.27b	2.26
UF half dose	1.29	1.30	0.046	0.050	2.31ab	2.32
UF full dose	1.32	1.32	0.076	0.073	2.40a	2.33
Significance at 5 % level	NS	NS	NS	NS	S	NS

S: Significant; NS: Not significant

Table 7: Effect of urea-formaldehyde fertilization on vegetative growth of Grand naine banana suckers in 2004 and 2005 seasons

Treatments	Pseudostem length(cm)		Pseudostem girth (cm)		No. of leaves		Third leaf length (cm)		Third Leaf Width (cm)		Third leaf Area (cm^2)	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Urea	36.0	35.7b	14.4	12.3b	6.8	9.7b	41.8	35.1	19.5a	17.3	819a	610b
UF half dose	37.4	40.7ab	13.0	14.4ab	7.6	11.4a	37.0	40.9	16.7b	18.7	622b	767a
UF full dose	39.4	47.4a	14.1	15.8a	6.8	11.2a	39.0	42.4	17.4ab	16.4	681ab	783a
Significance at 5 % level	NS	S	NS	S	NS	S	NS	NS	S	NS	S	S

S: Significant; NS: Not significant

Table 8: Effect of urea-formaldehyde fertilization on leaf mineral content of date palm suckers in 2004 and 2005 seasons.

Treatments	N %		P %		K %	
	2004	2005	2004	2005	2004	2005
Urea	1.82b	2.00b	0.106b	0.030b	1.48c	2.23
UF half dose	2.25a	1.90b	0.116b	0.080a	1.85b	2.30
UF full dose	2.48a	2.20a	0.170a	0.060a	2.37a	2.56
Significance at 5 % level	S	S	S	S	S	NS

S: Significant; NS: Not significant

Table 9: Effect of urea-formaldehyde fertilization on vegetative growth of date palm suckers in 2004 and 2005 seasons.

Treatments	Stem length (cm)		Stem girth (cm)		No. of leaves		Leaf area (cm^2)		Total leaf area (cm^2)	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Urea	37.4c	38.6c	6.6c	9.0c	28.2c	30.8c	1.65	3.08b	46b	95b
UF half dose	44.2a	50.1a	8.6a	12.4a	32.9b	40.9b	1.52	3.68a	50ab	152a
UF full dose	41.4b	44.4b	7.5b	9.6b	37.9a	44.8a	1.54	3.51a	57a	159a
Significance at 5 % level	S	S	S	S	S	S	NS	S	S	S

S: Significant; NS: Not significant

Table 10: Effect of urea-formaldehyde fertilization on some chemical and nutritional status to soil media as an average at the end of studied two seasons.

Seeding	Treatments	pH 1: 2.5	EC dSm^{-1}	Available macronutrients (ppm)		
				N	P	K
Grape	Urea	7.8	0.80	180	29	250
	UF half dose	7.6	0.50	180	32	280
	UF full dose	7.5	0.50	210	35	310
Mango	Urea	5.8	0.28	180	34	220
	UF half dose	5.6	0.25	190	38	240
	UF full dose	4.9	0.20	220	50	300

Table 10: Continue

Banana	Urea	7.7	0.40	200	19	160
	UF half dose	7.6	0.25	220	19	176
	UF full dose	6.7	0.23	270	36	200
Palm	Urea	7.9	1.50	150	15	282
	UF half dose	7.8	0.40	160	15	300
	UF full dose	7.6	0.23	190	19	500

Concerning the extractable nutrients, it was found that increasing availability of macronutrients in soil treated with urea-formaldehyde compared with the traditional urea could be due to the UF effect on soil pH. The availability of macronutrients to plants depends on dissolution process of urea-formaldehyde and its application rate. The dissolved nutrients then diffuse back out through the coating to the environment[14]. Slow-release nitrogen (N) materials are often used to reduce N leaching losses from sandy soils[3] and extend N availability over a growing season[4]. This may explain the enhancement of the mineral content in the leaves especially grape and date palm that resulted from UF treatments among the four experiments, which consequently affected positively in vegetative growth determinations. These results are agree with those obtained by Saleh *et al.*[15] who found that fertilizing pear trees with bentonite coated urea as slow release nitrogen fertilizer enhanced N and K content in the leaves. Also Eman *et al.*[9] who reported that UF had a positive effect on leaf mineral contents of mango than the traditional urea. On the other hand, Saleh *et al.*[15] found no effect for UF treatments on leaf mineral content of Washington navel orange trees. Osman and Abd El-Rahman[8] reported that using urea-formaldehyde (UF) and phosphorus coated urea (PCU) fertilizers enhanced the studied parameters of tree growth, leaf mineral content.

From the abovementioned results, it could be concluded that UF treatments either as full or half dose had a positive effect on vegetative growth parameters, also enhanced N, P and K content in the leaves, especially grape and date palm seedlings. Moreover, it is noticed that UF treatments increased the available forms of N, P and K in the used soil as a media for the four crops seedlings in comparing with the traditional urea.

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