

## **RESPONSE OF WILLIAMS BANANA PLANTS TO UREA FOLIAR SPRAYS**

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### **ABSTRACT**

The present investigation was carried out during 1996/1997 and 1997/1998 growing seasons on Williams banana plants. All combinations of two, four and six foliar sprays of 0, 1, 2, 3 and 4% urea (i.e. 15 treatments) were used in this experiment. The results revealed that, spraying banana plants with different urea concentrations increased the vegetative growth parameters (pseudostem height, girth, height/girth ratio and number of green leaves) as compared with the control plants (0% urea) in both seasons. The concentration of 2% urea gave the highest pseudostem height, girth and number of green leaves. Meanwhile, it gave the lowest pseudostem height/girth ratio. Increasing the number of urea sprays, generally, increased the growth of banana plants. Increasing the concentration of urea progressively delayed fruit maturity. Likewise, increasing the number of urea sprays significantly delayed maturity in the second season, whereas, fruit maturity was not greatly affected in the first season. The urea application showed a positive effect on yield (as bunch weight), stalk length, and number of hands and fingers per bunch. The maximum increase was associated with the 2% urea. Moreover, increasing the number of urea sprays slightly increased bunch weight and markedly increased other bunch parameters. The application of urea, in general, increased fingers length, weight and girth, pulp and peel weights, pulp/peel ratio, fruit TSS and acidity percentages. The effect was more pronounced with urea at 2%. Increasing urea concentration increased leaf N, K, Mg, Ca and Zn contents, Meanwhile, P, Na, Fe, Mn and Cu were not significantly affected. On the other hand, the number of urea sprays did not show a clear effect.

### **INTRODUCTION**

Banana (*Musa spp.*) is one of the most important tropical fruits. The total world production is about 39 million tons of fresh fruit. In the local market of Egypt, banana took a good position between other fruits for its important alimentary and fast profitable economic.

Banana is fast-growing herbaceous plant. Its rapid growth rate makes it heavy feeders and needs fertile conditions and an abundance of soil moisture for best growth and production. In soils of low fertility, banana should be fertilized frequently for maximum growth and production. Due to the high need of bananas to nutrients, the rich soil became depleted and need fertilizers addition (Gowen, 1992). Growth in banana plants is positively correlated with yield. Hence the importance of nitrogen to bananas (Lahav, 1980). Banana plants cannot store nitrogen other than by using it for growth (Martin-preval and Montagut, 1966). Since no nitrogen storage occurs within the banana plants, nitrogen additional promotes growth. Therefore, nitrogen is almost universally in short supply, even on the very fertile soils (Butler, 1960). Beyond its effects on growth and production, nitrogen is reported to affect bunch maturation period. Fox (1989) indicated that as nitrogen levels increase, the length of maturation period also increases. Moreover, nitrogen affects bunch weight through its effect on number of hands and fingers, fruit

circumference and weight (Baghel *et al*, 1987 and Singh and Kashyap, 1992). It also affects fruit quality by reducing total sugars and total soluble solids and increasing acidity (Mustaffa, 1983), but these results are controversial (Hazarika and Mohan, 1990).

Urea has the chemical formula  $\text{CO}(\text{NH}_2)_2$  and called carbamide. It is very concentrated and contains about 46% N, all soluble in water. On the other hand, foliar fertilization has been used extensively for horticultural fruit trees in the last decades. The large oblong or elliptic leaf blades of banana incitement to exploitation this characteristics for foliar fertilizer. Application of urea to banana leaves might save a lot of nitrogen that lost by leaching in case of the soil application.

Thus, the present work was outlined as a trial to clarify the effect of urea concentration and number of sprays as a foliar application on the vegetative growth, fruit maturity, yield, fruit quality and leaf mineral contents of banana plants under the local conditions and on the most widely banana variety cultivated in Egypt "Williams".

## MATERIALS AND METHODS

The present study was carried out during the 1996/1997 and 1997/1998 growing seasons on Williams banana plants (*Musa spp.*) grown in a private orchard at El-Tarh region, Beheira Governorate. The soil of the orchard is clay type with the characteristics shown in Table (1).

**Table (1) : Some physical and chemical properties of the experimental orchard soil**

Parameters	Soil depth (cm)		
	0 – 30	30 – 60	60 – 90
Texture	Clay	Clay	Clay
CaCO <sub>3</sub> (%)	16.56	12.74	14.74
pH	7.80	7.90	7.50
E.C. (ds/m)	0.90	1.00	2.50
S.P. (%)	74.00	75.00	84.00
<b>Macro-elements</b>			
N (%)	0.07	0.10	0.11
P (mg/kg)	55.00	26.00	42.00
K (mg/kg)	0.10	0.60	1.100
Ca <sup>++</sup> (meq/l)	6.00	5.60	12.00
Mg <sup>++</sup> (meq/l)	2.80	2.60	5.80
Na <sup>+</sup> (meq/l)	2.40	2.80	7.20
<b>Micro-elements</b> (mg/kg)			
Fe	20.70	19.70	20.00
Mn	54.00	31.00	47.00
Zn	13.20	7.20	12.60
Cu	13.30	8.40	10.20
<b>Anions</b> (meq/l)			
CO <sub>3</sub> <sup>=</sup>	0.00	0.00	0.00
HCO <sub>3</sub> <sup>-</sup>	5.90	5.10	4.50
Cl <sup>-</sup>	1.80	2.60	10.00
SO <sub>4</sub> <sup>=</sup>	3.60	3.90	11.60

The orchard was fertilized with organic manure at a rate of 30 cubic meters per feddan in November of every season and irrigated with Nile water every 15 days by the flood method. In both seasons, the mother plants were removed and three offshoots were selected in each hole (spacing of 3.5 × 3.5 m) in order to prepare those plants to carry out the present experiment. In mid-May, 45 healthy plants, as uniform as possible, having 120 to 135 cm heights were selected for the present study.

Five urea concentrations; 0, 1, 2, 3 and 4% were used in this study and each concentration was sprayed through 2, 4 and 6 sprays. The interval between the consecutive sprays was 21 days. The dates of application were illustrated in Table (2). Saliant-film (phosphoric acid 3%) was added as a surfactant at the rate of 0.3 % and plants were sprayed on both leaf surfaces in the afternoon.

**Table (2): Urea spraying dates during 96/97 and 97/98 growing seasons.**

<b>Sprays</b>	<b>First</b>	<b>Second</b>	<b>Third</b>	<b>Fourth</b>	<b>Fifth</b>	<b>Sixth</b>
<b>Date</b>	15 May	5 June	20 June	17 July	7 August	28 August

The fifteen treatments (5 urea concentrations × 3 dates) of the present factorial experiment were conducted in a completely randomized design. Each treatment included three replicates with one plant per replicate.

Regarding the effect of treatments on vegetative growth, after flowering, plant height (pseudostem height) in cm was measured from ground level to the top of the curve of the bunch stalk, pseudostem girth in cm was measured 30 cm above ground level and number of green leaves was also counted. Harvest index (maturity) was measured by counting the number of days from the time of inflorescence appearance to harvest. To study bunch characteristics, at harvest, bunch weight (kg), stalk length (cm), number of hands per bunch and number of fingers per bunch were calculated. Finger parameters were determined by taking 10 ripened fruits (fingers) from the middle of the bunch. In each fruit sample, finger weight (g), length and girth (cm) and pulp and peel weights (g) were measured. In addition, pulp/peel ratio was calculated. Twenty five grams of fresh pulp were mixed with 100 ml distilled water by mixer, and the obtained juice was filtered and used to determine the total soluble solids (TSS) and acidity. The percentage of TSS was calculated by the use of hand refractometer. The acidity percent as malic acid was determined according to A.O.A. C. (1980).

For leaf mineral content determination, a sample of 10 × 10 cm from the middle part of the blade of the third leaf from the top of each plant was taken as recommended by Hewitt (1955) for mineral analysis. Leaf samples were taken 21 days after the 6<sup>th</sup> spray was conducted (18 September) for all treatments in both seasons. Each leaf sample was washed several times with tap water, rinsed with distilled water and then oven dried at 70-80<sup>o</sup> C to a constant weight. The dried leaf materials were ground by stainless steel rotary knife and then analyzed for total nitrogen content by the Micro-Kjeldahl method as described by Jackson (1973). For the determination of the other elements, 0.3 gm of the ground material of each sample was digested with sulphuric acid and hydrogen peroxide according to Evenhuis and dewaard

(1980). Phosphorous was determined with Spectrophotometer according to Murphy and Riley (1962). Potassium and sodium were determined by flame photometer (Chapman and Pratt, 1961). Iron, manganese zinc and copper were determined by Atomic Absorption Spectrophotometer.

The data obtained throughout the course of this study were statistically analyzed according to Steel and Torrie (1980).

## **RESULTS AND DISCUSSION**

### **1- Vegetative growth**

Data presented in Tables (3&4) showed the effect of urea foliar supplements on vegetative growth, maturity, yield and bunch characteristics of Williams banana plants during the two experimental seasons.

#### **1-1- Pseudostem height:**

The data indicated that, in both seasons, the application of urea significantly increased the pseudostem height as compared with the non-treated plants (control). The higher pseudostem height was attained with urea at 2%. Meanwhile, at higher concentrations (3&4%) the pseudostem height started to decrease as compared with urea at 2%. The increment percentages of pseudostem height over the control (0% urea) were 20.50, 44.88, 33.60 and 13.70% for urea at 1, 2, 3 and 4% respectively in the first season. The corresponding values for the second season were 31.09, 59.02, 44.39 and 40.61%, respectively. The data also revealed that increasing the number of urea sprays up to 6 sprays caused an increase for the pseudostem height. No significant difference, however, was found between applying 2 and 4 sprays in the first season. Meanwhile, in the second one, no significant difference was found between the four and six sprays, but the treatment of 2 sprays was significantly less.

#### **1-2- Pseudostem girth**

With respect to pseudostem girth, the data indicated that, in both seasons, spraying with urea at 2% gave the highest girth of pseudostem as compared with the control and other urea concentrations. The one and three 3% of urea also showed a significant increase over the control. No significant difference was found between the girth of non-treated plants and those received 4% urea in the first season only. According to the data of both seasons, the pseudostem girth did not differ significantly by the number of urea sprays.

The increase in pseudostem growth because of urea application may be due to the fact that nitrogen is considered an important element for growth.

Generally, it was clear that the height and girth of the pseudostem responded the same manner to the applied urea concentrations, while the pseudostem height only was affected with the number of urea sprays. These findings are in agreement with those obtained by Oubahou and Dafiri (1987) who found that treating banana plants with N increased the growth in height and pseudostem circumference. Moreover, Hossain and Haque (1988) and Singh and Kashyap (1992) treated banana plants with different N levels and

they reported that the doses in the middle range were found to be more effective in producing better growth. On the other hand, Corrales *et al* (1989) and Hedge and srinivas (1991) reported that increasing the level of nitrogen fertilization had no significant effect on pseudostem height or girth of banana plants

### **1-3- Pseudostem height/girth ratio:**

The averages of pseudostem height/girth ratio are shown in Tables (3&4). The data revealed that, in both seasons, such ratio was increased with increasing urea concentrations. All urea levels markedly increased the height/girth ratio over the control except urea at 2% in the first season. The reduction in the height/girth ratio at 2% urea as compared with the other concentrations (1,3 and 4%) was due to the higher rate of girth increasing than that of height increment.

Regarding the number of urea sprays, the application of 6 sprays significantly increased the height/girth ratio as compared with those of 2 and 4 sprays in the first season and 2 sprays in the second one.

From the obtained data, it is evident that the increase or decrease in the height of pseudostem is proportional to the increase or decrease in girth except when plants treated with 2% urea, which caused a higher increase in diameter.

### **1-4- Number of green leaves:**

The data concerning the number of green leaves showed that, in both seasons, urea application significantly increased the number of green leaves as compared with the control. The highest number of leaves per plant was obtained when plants were sprayed with 2% urea solution. It produced an increment by about 60.21% over the control in the first season and 96.91% in the second one. In addition, the application of 4 and 6 sprays gave a significant increase in the number of leaves when compared with that of 2 sprays in the first season. Meanwhile, the leaves obtained from plants treated with different number of sprays did not differ significantly in the second season. Hossain and Haque (1988) and El-Gazzar (1993) obtained similar results. They reported that increasing the application of nitrogen fertilizer up to a certain rate caused a significant increase in the number of green leaves of banana plants, however, more increase in nitrogen induced insignificant increase in the number of green leaves per plant.

It was generally, noticed that spraying banana plants with urea increased the growth parameters as the concentration increased up to a certain limit (2%). Further increase in urea concentrations (3&4%) did not induce more increase in the vegetative growth parameters. This might be due to that the high urea concentrations were harmful for the vegetative growth of banana plants (Minessy and Baghdady. 1958), or it was probably due to that, these treatments (3&4%) did not significantly increase the leaf nitrogen content as compared with the treatment of 2% urea, especially N is considered an important element for plant growth.

### **2- Harvest index (maturity):**

The effect of spraying with different urea concentrations and number of sprays on the number of days from shooting stage until harvest is shown in tables (3&4). The obtained data indicated that, in both seasons, the maturity was delayed with increasing urea concentrations. The prolongation days for attaining maturity stage due to urea sprays were 32.03, 61.03, 64.07 and 69.70 days over the control (0% urea) for urea at 1, 2, 3 and 4%, respectively in the first season. The corresponding days for the second season were 23.66, 67.00, 70.66 and 82.93, respectively. On the other hand, the number of application did not affect the fruit maturity in both seasons. The effect of urea applications on delaying fruit maturity may be due to the effect of urea in increasing the period of vegetative growth, consequently fruit maturity was delayed. These findings are in harmony with those obtained by Gandhi (1984) who reported that the post shooting application of 1 and 2% urea delayed the maturity in Basrai banana. Likewise, Chattopadhyay and Bose (1986) found that nitrogen application hastened flowering and delayed fruit maturation of Dwarf Cavendish banana. In addition, Patel and Patel (1987) reported that 4% urea slightly delayed the harvest time, moreover, six sprays of urea significantly delayed fruit maturity of banana plants.

### **3- Yield and bunch characteristics:**

Data concerning yield and bunch characteristics are summarized in Tables 3 and 4 in both experimental seasons.

#### **3-1- Bunch weight:**

The data in both seasons showed that as the urea concentration increased in the spray solution, the bunch weight (yield) significantly increased up to 2% urea. Thereafter, the bunch weight was negatively decreased. It is also evident that the bunch weight obtained from the treatment, which was sprayed with the highest concentration (4%), did not differ significantly from that of the 1%. The increment percentages of bunch weight over the control were 47.98, 108.64, 78.31 and 36.16% for urea at 1, 2, 3 and 4%, respectively, in the first season. The corresponding values for the second season were 64.94, 176.24, 95.92 and 45.27%, respectively. The increment of the yield (as bunch weight) of Williams banana plants because of urea sprays could be attributed to the effect of N in improving plant growth and chlorophyll formation and consequently increasing photosynthesis. Such conditions could save a sufficient amount of carbohydrates and other assimilates which finally increase the yield. The decrease in bunch weight of plants treated with 4% as compared with those treated with 2% may be due to that the high urea rate was harmful to banana plants. These results are in accordance with those obtained by Mustafa (1988), Ghosh *et al* (1989), Hazarika and Mohan (1992) and Singh and Kashyap (1992). They reported that nitrogen applications increased the bunch weight of banana plants up to a certain limit. Moreover, Hedge and Srinivas (1991) found that increasing level of N fertilization had no significant effect on bunch weight of banana.

As for the effect of number of sprays on bunch weight, no significant differences were found between them in both seasons. Patel and Patel (1987) came to the same findings.

### **3-2- Stalk length:**

It can be noticed that, in the first season, the plants sprayed with urea at 2% had the highest stalk length. However, no significant differences in stalk length were found between plants sprayed with 2% or 3%. The stalk length of plants sprayed with the high concentration (4%) was nearly the same as that of the 1% and the control (0%). In the second season, the same trend was obtained, where, spraying with 2% resulted in a significant longer stalk length than those of the other treatments. The non-treated plants had the shortest stalk length followed by those sprayed with 4%. As for the effect of number of sprays, the stalk of plants received 2 sprays were slightly and significantly shorter than those of 4 and 6 sprays in the first and second season respectively.

### **3-3- Number of hands per bunch:**

With respect to the number of hands per bunch, the data revealed that, in general, the application of urea significantly increased the number of hands per bunch as compared with the non-treated plants. Moreover, plants sprayed with 2% urea yielded the highest significant number of hands as compared with the other concentrations. In the meantime, the number of hands per bunch for plants were sprayed 4 and 6 times were significantly more than those obtained when 2 sprays were applied in the first season. Meanwhile, number of sprays did not significantly affect number of hands in the second season. These results are in line with those obtained by Baghel *et al* (1987), Nair *et al* (1990) and Singh and Kashyap (1992). On the contrary, Corrales *et al* (1989) and Martinez *et al* (1997) found that nitrogen application had no effect on the number of hands per bunch.

### **3-4- Number of fingers per bunch:**

The data in Tables (3&4) revealed that, the maximum number of fingers was attained when the plants were treated with urea at 2%. The average number of fingers per bunch from plants treated with 2% urea was 122 fingers, while in the control was 73.22. The corresponding numbers for the second season were 175.22 and 78.56, respectively. At the concentrations of 1, 3 and 4% urea, the number of fingers per bunch was significantly lower than that in the treatment of 2% urea and higher than that in the control plants. The data also indicated that, in the first season, the application of 4 and 6 sprays caused a significant increase in the number of fingers than those of 2 sprays. No significant difference was found between the 4 and 6 sprays. Meanwhile, in the second season, the application of 6 sprays only caused a significant increase in the number of fingers than those of the 2 and 4 sprays which were the same. Similar results were previously found by Corrales *et al* (1989). Singh *et al* (1990), Singh and Kashyap (1992) and Martinez *et al*(1997). They all stated that N application significantly affected the number of fingers per bunch of banana plants.

**Table (3) : Effect of foliar sprays of urea on vegetative growth, harvest index, yield and bunch characteristics of Williams banana plants during 96/97 growing season.**

Treatments		Pseud- ostem height (cm)	Pseud- ostem girth (cm)	Pseud- ostem height / girth ratio	No. of green leaves/ plant	Harvest index (days)	Bunch Weight (kg)	Stalk length (cm)	No. of hands per bunch	No. of Finger s per bunch
Urea conc. %	No. of sprays									
0	2	181.00	54.67	3.31	8.67	120.00	5.67	49.00	6.00	73.00
	4	180.67	51.67	3.50	9.33	120.90	6.00	47.33	5.67	74.00
	6	188.00	53.67	3.51	8.00	120.00	5.33	51.00	6.33	72.67
1	2	218.33	57.67	3.79	11.67	145.00	7.67	53.67	6.00	76.00
	4	219.67	55.67	3.95	12.67	145.00	8.00	54.67	7.00	91.67
	6	224.33	56.33	3.98	12.67	167.00	9.50	55.00	7.00	95.33
2	2	255.00	66.33	3.84	11.33	181.00	10.50	60.67	9.00	109.30
	4	266.67	75.50	3.53	14.67	181.00	11.33	61.33	10.67	119.00
	6	274.67	81.00	3.39	14.67	182.00	13.67	64.67	11.00	137.70
3	2	245.00	63.67	3.85	11.33	185.00	9.67	55.00	7.00	97.33
	4	255.00	65.00	3.92	12.33	185.00	10.67	64.33	8.00	103.30
	6	234.33	59.67	3.94	12.33	185.00	10.00	64.67	7.67	94.67
4	2	200.33	54.67	3.66	9.67	190.00	8.00	54.67	7.00	72.67
	4	196.00	54.00	3.63	11.67	190.00	8.33	51.00	7.00	90.67
	6	228.67	49.67	4.61	10.67	190.00	8.63	49.33	7.00	89.33
Mean Effect of urea conc.	0	183.22	53.34	3.44	8.67	120.30	5.67	49.11	6.00	73.22
	1	220.78	56.56	3.91	12.34	152.33	8.39	54.45	6.67	87.67
	2	265.45	74.28	3.59	13.89	181.33	11.83	62.22	10.22	122.00
	3	244.78	62.78	3.90	12.00	185.00	10.11	61.33	7.56	98.43
	4	208.33	52.78	3.97	10.67	190.00	7.72	51.67	7.00	84.22
L.S.D 0.05		7.34	1.41	0.16	1.13	4.11	1.21	4.60	0.67	5.49
Mean Effect of No. of sprays	2	219.93	59.40	3.69	10.73	164.20	8.30	54.60	7.00	85.66
	4	223.60	60.37	3.71	12.13	164.38	8.87	55.73	7.67	95.73
	6	230.00	60.07	3.89	11.67	168.80	9.07	56.93	7.80	97.94
L.S.D 0.05		5.69	NS	0.13	0.87	NS	NS	NS	0.52	4.25
Conc. × No. of sprays L.S.D 0.05		12.70	6.23	0.48	3.10	6.50	NS	NS	NS	9.50

**Table (4) : Effect of foliar sprays of urea on vegetative growth harvest index yield and bunch characteristics of Williams banana plants during 97/98 growing season.**

Treatments		Pseud- ostem height (cm)	Pseud- ostem girth (cm)	Pseud- ostem height/ girth ratio	No. of green leaves/ plant	Harvest index (days)	Bunch weight (kg)	Stalk length (cm)	No. of Hands per bunch	No. of fingers per Bunch
Urea conc. %	No. of sprays									
0	2	175.67	52.67	3.34	7.00	128.00	4.50	40.00	6.00	79.00
	4	178.00	52.33	3.40	7.00	126.00	6.00	43.67	6.00	77.67
	6	175.00	53.67	3.26	7.33	123.00	5.67	46.00	6.00	79.00
1	2	209.33	57.00	3.68	8.67	132.00	8.00	53.33	7.00	102.67
	4	239.33	57.67	4.15	11.33	158.00	8.33	64.33	7.00	103.67
	6	244.33	60.67	4.03	11.33	158.00	10.33	64.33	8.00	131.00
2	2	274.33	72.33	3.79	12.00	186.00	14.00	68.33	11.00	156.00
	4	277.00	76.33	3.63	14.67	196.00	14.33	75.00	12.00	184.67
	6	289.33	78.83	3.67	15.33	196.00	16.33	81.00	12.00	185.00
3	2	255.33	66.33	3.85	11.67	196.00	11.00	64.00	10.00	131.70
	4	259.00	65.33	3.96	11.00	195.90	10.67	64.33	8.00	103.30
	6	249.00	65.83	3.78	9.00	197.00	10.00	64.67	7.67	94.67
4	2	255.67	60.33	4.24	11.67	204.90	8.33	53.00	7.00	91.33
	4	246.33	56.33	4.38	10.33	210.00	8.33	51.00	7.00	90.67
	6	241.33	49.33	4.89	10.00	210.90	6.83	49.33	7.00	89.33
Mean effect of urea conc.	0	176.22	52.89	3.33	7.11	125.67	5.39	43.22	6.00	78.56
	1	231.00	58.45	3.95	10.44	149.33	8.89	60.66	7.33	112.45
	2	280.22	75.83	3.70	14.00	192.67	14.89	74.78	11.67	175.22
	3	254.44	65.83	3.86	10.56	196.33	10.56	64.33	8.56	109.89
4	247.78	55.53	4.50	10.67	208.60	7.83	51.11	7.00	90.44	
L.S.D 0.05		8.34	1.56	0.18	1.25	3.03	1.51	3.81	0.76	3.01
Mean effect of No. of sprays	2	234.07	61.73	3.78	12.20	169.38	9.17	55.73	8.20	112.14
	4	239.93	61.60	3.90	10.87	177.18	9.53	59.67	8.00	112.00
	6	239.8	61.67	3.93	10.67	177.00	9.83	61.07	8.13	115.80
L.S.D 0.05		5.46	NS	0.14	NS	NS	NS	2.95	NS	2.33
Conc. × No. of sprays L.S.D 0.05		14.50	5.40	0.90	4.70	7.55	NS	12.40	NS	12.50

**4- Finger characteristics:**

The data concerning the effect of urea applications on the characteristics of ripened fruits in both seasons are shown in Tables (5&6).

**Table (5) : Physical and chemical properties of fingers of Williams banana plants as influenced by urea foliar sprays during 96/97 growing sea son**

Treatments	Finger	Finger	Finger	Pulp	Peel	Pulp/	TSS	Acidity
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Urea conc. %	No. of Sprays	length (cm)	girth (cm)	weight (g)	weight (g)	weight (g)	peel ratio	(%)	(%)
0	2	12.50	9.33	56.43	37.43	19.00	1.98	19.33	0.17
	4	12.67	8.50	56.33	35.83	20.50	1.76	19.33	0.18
	6	12.67	10.33	55.17	34.57	20.26	1.70	21.33	0.17
1	2	13.00	10.50	65.03	45.07	19.97	2.27	18.00	0.18
	4	13.76	8.83	64.33	42.55	21.78	1.95	20.67	0.26
	6	13.67	10.50	65.37	45.60	20.13	2.29	22.00	0.25
2	2	15.67	11.50	84.37	61.12	23.25	2.68	18.67	0.27
	4	17.67	11.83	85.00	62.87	22.13	2.87	21.33	0.25
	6	18.67	12.17	87.37	66.13	21.23	3.20	21.33	0.25
3	2	13.33	10.50	65.43	45.73	19.70	2.33	18.67	0.28
	4	13.00	12.17	67.87	48.23	19.63	2.47	20.67	0.27
	6	13.00	12.67	69.97	49.40	20.57	2.48	22.00	0.25
4	2	12.33	10.33	58.00	35.60	22.40	1.59	20.00	0.28
	4	12.33	13.33	67.08	44.94	22.13	2.10	22.00	0.28
	6	12.33	13.50	67.33	46.93	20.40	2.32	22.00	0.29
Mean effect of urea conc.	0	12.61	9.39	55.98	35.94	20.03	1.81	20.00	0.17
	1	13.45	9.94	65.03	44.41	20.63	2.17	20.22	0.23
	2	17.34	11.83	85.58	63.37	22.20	2.92	20.44	0.26
	3	13.11	11.78	67.76	47.79	19.97	2.43	20.45	0.27
	4	12.33	12.39	64.14	42.49	21.64	2.00	21.33	0.28
L.S.D 0.05		0.79	0.65	2.59	3.14	NS	0.30	0.99	0.02
Mean Effect of No. of Sprays	2	13.37	10.43	65.85	44.99	20.86	2.17	18.93	0.24
	4	13.87	10.93	68.12	46.88	21.23	2.23	20.80	0.25
	6	14.07	11.83	69.11	48.53	20.59	2.40	21.73	0.24
L.S.D 0.05		0.61	0.51	2.01	2.43	NS	NS	0.77	0.01
Conc. × No. of sprays		NS	0.90	8.90	13.40	NS	NS	NS	NS
L.S.D 0.05									

**4-1- Finger length:**

It was quite apparent from the data that the maximum length of ripened fingers in the two seasons was obtained when the plants treated with 2% urea. The data also showed that, in the first season, no differences were noticed between urea at 1 or 3%. In addition, urea at 4% slightly reduced finger length as compared with the control, although they were statistically the same. Meanwhile, in the second season, it can be noticed that at the concentrations of 3 and 4% the finger length, however, was significantly less than that obtained from 1 and 3% urea. With respect to number of sprays, the data showed that in the first season, six-urea sprays markedly increased finger length as compared with two sprays. Although the differences between number of sprays were not significantly different in the second season. Such results are in line with those found by Corrales *et al* (1989).

**4-2- Finger girth:**

The obtained data indicated that, in the first season, spraying banana plants with 2% urea or more (3 and 4%) significantly increased finger girth as compared with control or 1% urea, although they were statistically the same.

Meanwhile, in the second season, urea at 1, 2 and 3 % produced fingers with higher girth than those of control and 4% urea.

The application of 6 urea sprays significantly increased the fingers girth than those of 2 or 4 sprays in the first season. Nevertheless, increasing number of urea sprays did not affect fingers girth in the second one.

#### **4-3- Finger, pulp and peel weights:**

From the data in Tables (5&6) it can be noticed that, in both seasons, the application of 2% urea resulted in significant higher finger and pulp weights as compared with the control and other urea concentrations. Moreover, increasing the number of sprays significantly increased both finger and pulp weights in the first season, but did not affect them in the second one. With respect to peel weight, the data indicated that neither urea concentrations nor number of sprays affect peel weight in both the experimental seasons.

#### **4-4- Pulp / peel ratio:**

The data concerning the pulp/peel ratio of the ripened fruits obtained from the different treatments clearly indicated that, in both seasons, urea at 2% significantly increased pulp/peel ratio as compared with the control or other urea concentrations. For the number of urea sprays, the differences in the pulp/peel ratio from the different sprays (2, 4 and 6 sprays) were so small to be statistically significant. Similarly, Hedge and Srinivas (1991) reported that the pulp/peel ratio was not affected by nitrogen fertilization.

#### **4-5- Total soluble solids (TSS):**

It was quite apparent from the data presented in Tables (5&6) that increasing urea concentration and number of sprays increased the total soluble solids of ripened fruits in both seasons. Such increment was significant for urea at 4% in the first season, and for urea at 2, 3 and 4% in the second one as compared with the control. . Moreover, four or six urea sprays markedly increased fruit TSS as compared with the two sprays in both seasons. Such increment in fruit TSS due to urea treatments may be attributed to the effect of N in increasing chlorophyll formation (through increasing vegetative growth, Tables 2&3) and consequently more carbohydrates were accumulated. Similar observations were reported by Patel and Patel (1987) who mentioned that spraying banana plants four times with urea gave significantly more TSS as compared with two sprays. Likewise, Hedge and Srinivas (1991) found that increasing nitrogen application increased TSS in banana fruits.

**Table (6) : Physical and chemical properties of fingers of Williams banana plants as influenced by urea foliar sprays during 97/98 growing season.**

Treatments		Finger length (cm)	Finger girth (cm)	Finger weight (g)	Pulp weight (g)	Peel Weight (g)	Pulp/peel ratio	TSS (%)	Acidity (%)	
Urea Conc. %	No. of Sprays									
0	2	14.00	10.33	58.37	37.98	20.38	1.88	18.00	0.18	
	4	13.67	9.17	57.17	34.73	22.43	1.57	19.33	0.18	
	6	13.67	10.50	58.00	37.26	20.74	1.82	20.67	0.17	
1	2	14.33	11.33	68.97	47.92	21.05	2.30	18.67	0.18	
	4	15.17	11.33	69.53	47.10	22.43	2.10	19.33	0.28	
	6	15.33	11.67	69.97	49.00	20.97	2.35	21.33	0.25	
2	2	16.00	11.33	86.53	64.53	22.00	3.12	18.67	0.27	
	4	17.83	11.67	88.67	65.08	23.58	2.86	20.67	0.26	
	6	18.33	11.83	89.29	65.49	23.80	2.82	22.00	0.27	
3	2	13.00	11.00	71.00	48.10	22.90	2.10	18.67	0.28	
	4	13.00	11.33	67.87	46.77	21.10	2.23	20.67	0.27	
	6	13.00	10.67	69.97	49.09	20.88	2.40	22.00	0.28	
4	2	12.83	10.00	68.23	46.22	22.01	2.10	22.00	0.27	
	4	12.33	9.67	67.08	45.44	21.63	2.10	22.00	0.25	
	6	12.33	9.50	67.33	46.29	21.05	2.21	20.67	0.25	
Mean Effect of urea conc.	0	13.78	10.00	57.85	36.66	21.18	1.76	19.33	0.18	
	1	14.94	11.44	69.49	48.01	21.48	2.25	19.78	0.23	
	2	17.39	11.61	88.16	65.03	23.13	2.93	20.45	0.27	
	3	13.00	11.00	69.61	47.99	21.63	2.24	20.45	0.28	
L.S.D 0.05	4	12.50	9.72	67.55	45.98	21.56	2.14	21.56	0.26	
	L.S.D 0.05		0.70	0.69	2.29	4.02	NS	0.44	1.12	0.04
	Mean Effect of No. of Sprays	2	14.03	10.80	70.62	48.95	21.67	2.30	19.20	0.24
		4	14.40	10.63	70.06	47.82	22.23	2.17	20.40	0.24
6		14.53	10.83	70.91	49.43	21.49	2.32	21.33	0.24	
L.S.D 0.05		NS	NS	NS	NS	NS	NS	0.86	NS	
Conc. × No. of sprays		NS	NS	NS	NS	NS	NS	1.90	NS	
L.S.D 0.05										

#### 4-6- Acidity:

The mean values of acidity percent of the ripened banana fruits increased in the treated plants than those of the control (0% urea). In the first season, the average of acidity percent in fruits for the concentrations 2, 3 and 4% were significantly than that of 1%, whereas, the differences between 3% and each of 2 and 4% was not significant. Moreover, the application of 4 urea sprays markedly increased the fruit acidity than those of 2 and 6 sprays. In the second season, the data obtained were almost the same in the first one. Maximum acidity was obtained with the concentration of 3%, which did not significantly differ from the 2 and 4% urea. The latter 2 concentrations (2 and 4%) not differ significantly with the 15 urea. Regarding the number of application, the 2, 4 and 6 sprays, produced the same fruit acidity percent.

The data of the present investigation agreed with those obtained by Patel and Patel (1987) who mentioned that the concentration of urea, in general, increased the acidity of banana fruits: but it failed to achieve the level of significance. In addition, Singh *et al* (1992) found that the higher fruit acidity was obtained when banana plants were sprayed with urea at the

concentration of 2%. Meanwhile, Agrawal *et al* (1997) concluded that acidity was not influenced by nitrogen fertilizer treatments.

**5- Leaf mineral contents:**

The effect of urea sprays on leaf mineral contents of Williams banana plants are shown in Tables (7&8) in both seasons.

**Table (7) : Effect of foliar sprays of urea on leaf elemental composition of Williams banana plants during 96/97 growing season.**

Treatments		% dry weight						mg/kg dry weight			
Urea Conc. %	No. of Sprays	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
0	2	1.29	0.23	2.53	1.15	0.56	0.10	89.20	28.40	18.20	9.30
	4	1.39	0.21	2.43	0.98	0.56	0.10	91.40	25.80	18.00	9.70
	6	1.53	0.23	2.34	0.97	0.51	0.10	86.20	27.60	18.00	10.50
1	2	2.42	0.22	2.54	1.56	0.61	0.06	88.40	22.80	18.40	10.10
	4	2.52	0.22	2.58	1.55	0.69	0.09	88.10	24.80	17.70	10.60
	6	2.56	0.22	2.57	1.31	0.58	0.10	92.30	24.20	18.10	9.80
2	2	2.66	0.24	2.48	1.43	0.60	0.09	91.00	24.80	18.60	8.90
	4	2.67	0.26	2.59	1.42	0.59	0.12	88.50	23.80	18.30	10.40
	6	2.66	0.29	2.68	1.27	0.61	0.08	88.70	26.40	17.50	10.40
3	2	2.58	0.23	2.63	1.35	0.62	0.07	90.00	25.00	18.60	9.80
	4	2.72	0.25	2.61	1.36	0.63	0.09	92.10	24.90	17.00	8.40
	6	2.49	0.22	2.58	1.35	0.61	0.10	91.00	26.00	18.40	9.80
4	2	2.69	0.23	2.50	1.37	0.63	0.12	89.20	25.70	17.90	9.10
	4	2.62	0.20	2.65	1.30	0.68	0.13	90.10	25.30	18.10	10.20
	6	2.59	0.26	2.54	1.48	0.67	0.09	89.00	27.10	17.90	10.10
Mean Effect of Urea Conc.	0	1.40	0.22	2.43	1.03	0.54	0.10	89.60	27.27	18.07	9.83
	1	2.50	0.22	2.56	1.47	0.63	0.08	89.60	23.93	18.07	10.17
	2	2.66	0.26	2.58	1.37	0.60	0.10	89.40	25.00	18.13	9.90
	3	2.60	0.23	2.61	1.35	0.62	0.09	91.03	25.30	18.00	9.33
4	2.63	0.23	2.56	1.38	0.66	0.11	89.43	26.03	17.97	9.80	
<b>L.S.D 0.05</b>		0.14	NS	0.12	0.09	0.60	NS	NS	NS	NS	NS
Mean Effect of No. of Sprays	2	2.33	0.23	2.45	1.37	0.60	0.09	89.56	25.34	18.34	9.44
	4	2.38	0.23	2.57	1.32	0.11	0.63	90.04	24.92	17.82	9.68
	6	2.37	0.24	2.54	1.28	0.09	0.60	89.84	26.26	17.98	10.12
<b>L.S.D 0.05</b>		NS	NS	NS	0.07	NS	NS	NS	NS	NS	NS
<b>Conc. × No. of sprays</b>		NS	NS	NS	0.30	NS	NS	NS	NS	NS	NS
<b>L.S.D 0.05</b>											

**5-1- Macronutrientents**

It can be clearly noticed that, in both seasons, the N content markedly increased in leaves of sprayed plants as compared with that of control. The highest leaf N content was obtained by urea at 2% through four applications in the first season. Meanwhile, in the second one the highest leaf N content was gained by spraying urea at 4% through 6 sprays. Similar results were reported by Arunachalam *et al* (1976), Behairy and zeinb (1978), Abou-Aziz

*et al* (1987) and Hedge and Srinivas (1991). They all found that N content in banana leaves was increased with N application.

With respect to phosphorous, The mean values of leaf P content indicated that the both urea concentrations and number of sprays did not significantly affect leaf P content. These findings agreed with those obtained by Abou-Aziz *et al* (1991), Gubbuk *et al* (1991) and Hazarika and Mohan (1992), who found that increasing N fertilizer rates did not affect the leaf P percentages.

The effect of urea on leaf k content revealed an adverse trend in both experimental seasons. In the first one, urea sprays markedly increased leaf K content in comparison with the control without significant differences between the concentrations 1, 2, 3 and 4%. Whereas, in the second season, the differences between all concentrations and the control were not high enough to be significant, although urea at 2% produced high leaf K content. Moreover, the number of urea sprays had no effect in leaf K content.

As for leaf Ca content, urea application resulted in an increase in leaf Ca as compared with the control in both seasons. In addition, the application of six urea sprays reduced the leaf Ca content when compared with those of two and four applications.

The data concerning leaf Mg content was in harmony with those of leaf Ca content, where Mg content was significantly increased by treating banana plants with different urea concentrations as compared with the control. Moreover, the number of sprays did not affect leaf Ca content.

The increase in leaf K, Ca and Mg contents as a result of urea treatments may be due to the effect of N application in improving vegetative and root growth which meaning more absorption of nutrients from the soil, thereby increasing leaf mineral content. The mentioned above results are in agreement with those found by Arunachalam *et al* (1976), Gubbuk *et al* (1991) and Sharaf *et al* (1994). They reported that N application increased leaf contents of K, Ca and Mg.

With respect to leaf Na content, it can be concluded that urea treatments did not significantly affect leaf Na content in both seasons. Although no significant differences were found between urea concentrations, the plants sprayed with urea at 4% had higher Na content in their leaves than control or other urea concentrations.

**5-2-**

**Micronutrients:**

The data presented in Tables (7&8) clearly indicated that increasing urea concentrations did not affect the leaf contents of Fe, Mn and Cu in both seasons. Moreover, the number of urea sprays had the same effect, where the differences between 2, 4 and 6 sprays were not big enough to be significant. On the other hand, spraying Williams banana plants with urea at 1, 2, 3 and 4% markedly increased leaf Zn content as compared with the control in the second season only. Nevertheless, the number of sprays did not affect leaf Zn content in both seasons. These findings are in accordance with those obtained by Gubbuk *et al* (1991) who reported that increasing the rates of N did not show significant effect on the leaf content of Zn, Mn and Cu in banana plants. Likewise, Labanauskas and Puffer (1963) found no significant differences in the leaf Zn, Cu and Fe contents of Valencia orange

trees treated with urea foliar application. In the same line, Salem *et al* (1994) stated that spraying Balady mandarin trees with urea did not affect leaf Fe, Mn and Zn contents.

Generally, from the data obtained, it can be recommended the application of urea foliar spray at 2% through two sprays (due to the lack of significance between the number of urea sprays in most cases) to obtain suitable growth, yield, fruit quality and leaf mineral status of Williams banana plants under the similar conditions of this experiment.

**Table (8) : Effect of foliar sprays of urea on leaf elemental composition of Williams banana plants during 97/98 growing season.**

Treatments		% dry weight						mg/kg dry weight				
Urea conc. %	No. of Sprays	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	
0	2	1.69	0.24	2.58	1.16	0.59	0.06	91.30	24.60	17.50	8.60	
	4	1.79	0.22	2.68	1.23	0.60	0.06	89.00	25.20	18.20	10.10	
	6	1.93	0.18	2.56	1.00	0.52	0.06	88.10	23.30	17.70	9.40	
1	2	2.36	0.21	2.49	1.38	0.69	0.10	92.00	23.70	18.40	9.50	
	4	2.45	0.22	2.57	1.34	0.60	0.11	91.00	29.20	18.40	7.20	
	6	2.65	0.20	2.58	1.28	0.71	0.10	89.00	25.20	18.50	10.50	
2	2	2.41	0.20	2.61	1.58	0.59	0.09	87.40	27.00	18.00	10.30	
	4	2.59	0.21	2.63	1.29	0.62	0.07	87.20	26.50	18.20	9.20	
	6	2.89	0.23	2.72	1.40	0.57	0.11	87.00	24.60	17.80	10.00	
3	2	2.54	0.22	2.52	1.15	0.63	0.08	91.10	27.20	18.90	9.80	
	4	2.55	0.24	2.50	1.49	0.63	0.07	85.00	26.00	19.20	8.50	
	6	2.81	0.23	2.54	1.36	0.62	0.10	88.00	26.60	18.90	7.60	
4	2	2.54	0.22	2.63	1.33	0.67	0.13	86.00	23.40	19.20	10.40	
	4	2.56	0.23	2.32	1.39	0.61	0.11	85.00	27.10	17.90	9.40	
	6	2.90	0.26	2.58	1.53	0.64	0.08	87.30	26.40	18.20	9.80	
Mean Effect of Urea Conc.	0	1.80	0.21	2.61	1.13	0.57	0.06	89.74	24.37	17.80	9.37	
	1	2.49	0.21	2.55	1.33	0.67	0.10	90.67	26.03	18.43	9.07	
	2	2.63	0.21	2.56	1.42	0.59	0.09	87.20	26.03	18.00	9.83	
	3	2.63	0.23	2.52	1.33	0.63	0.08	88.03	26.60	19.00	8.63	
L.S.D 0.05	4	2.67	0.24	2.51	1.42	0.64	0.11	86.10	25.63	18.43	9.87	
	0.05	0.12	NS	0.13	0.17	0.05	NS	NS	NS	0.66	NS	
	Mean Effect of No. of Sprays	2	2.31	0.22	2.57	1.32	0.63	0.09	89.56	25.81	18.40	9.72
		4	2.39	0.22	2.54	1.35	0.61	0.08	87.44	26.80	18.38	8.88
6		2.64	0.22	2.60	1.31	0.61	0.09	87.88	25.22	18.22	9.46	
L.S.D 0.05	0.05	0.09	NS	NS	NS	NS	NS	NS	NS	NS	NS	
	Conc. × No. of sprays	NS	NS	0.20	NS	NS	NS	NS	NS	NS	NS	
L.S.D 0.05												

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تأثير الرش باليوريا على النمو الخضري و المحصول و جوده الثمار و المحتوى  
المعدني لأوراق نباتات الموز صنف وليامز

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أجريت تجربته حقلية خلال موسمى النمو 1997/1996 و 1998/1997 على نباتات الموز صنف وليامز، وذلك لدراسة تأثير الرش باليوريا بتركيزات صفر% و 1% و 2% و 3% و 4% بعدد رشات 2 و 4 و 6 مرات على النمو الخضري و موعد اكتمال نمو الثمار و كميته المحصول و جوده الثمار المحتوى المعدني للأوراق. وبصفه عامه فقد أوضحت نتائج التجربة أن الرش باليوريا سبب زيادة النمو الخضري ( طول و محيط الساق الكاذبة ، نسبه طول الساق الكاذبة إلى محيطها و عدد الأوراق الخضراء) مقارنة بالنباتات الغير معاملة باليوريا. رش نباتات الموز باليوريا بتركيز 2% أدى إلى زيادة نمو الساق الكاذب فى الطول و القطر و كذلك أنتج أكبر عدد من الأوراق ، فى حين أدى هذا التركيز إلى خفض نسبه طول الساق الكاذبة إلى محيطها و ذلك مقارنة بالتركيزات الأخرى. وبصفه عامه فقد أدت زيادة عدد مرات الرش إلى زيادة نمو نباتات الموز. كما عملت زيادة تركيزات اليوريا فى محلول الرش على تأخر موعد اكتمال نمو الثمار بصوره مؤكدة فى كلا الموسمين ، فى حين أن زيادة عدد مرات الرش باليوريا سببت تأخير فى موعد اكتمال نمو الثمار فى الموسم الثانى فقط. المعاملة باليوريا إلى زيادة مؤكدة فى المحصول (وزن السوياطه) و طول الحامل الثمرى و عدد الكفوف و الأصابع فى السوياطه و كان التركيز 2% متفوقا على باقى التركيزات. وكذلك فان زيادة عدد مرات الرش سببت زيادة بسيطة فى وزن السوياطه و زيادة مؤكدة فى بقيه الخصائص. وبصفه علمه فقد أدت المعاملة باليوريا إلى زيادة طول ووزن و عرض الثمار (الأصابع) و وزن اللب و القشرة ، و نسبه وزن اللب إلى القشرة و المواد الصليه الذائبة الكليه و حموضة عصير الثمار. زيادة تركيز اليوريا فى محلول الرش أدى إلى زيادة محتوى الأوراق من عناصر النتروجين و البوتاسيوم و الكالسيوم و الماغنسيوم و الزنك ، فى حين لم يتأثر كل من الفوسفور و الصوديوم و الحديد و المنجنيز النحاس. و لم يكن هناك اتجاه واضح لتأثير عدد مرات الرش على المحتوى المعدنى للأوراق.