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Effect of Cobalt and some Vitamins as Foliar Application Treatments on Productivity and Quality of Williams Banana Cultivar

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ABSTRACT

This study was conducted during two successive seasons (2012/2013 first ratoon and 2013/2014 second ratoon) on Williams banana cultivar grown in clay loam soil under flood irrigation system in a private banana orchard located at El-Hagabey district, Meet Ghamr Dakahlia Governorate, at 3x3.5 m apart. Forty five stools/(mat) ,each containing two plants of Williams cultivar were chosen to evaluate the effect of foliar spray with Cobalt , Vit B_{12} and ascorbic acid (Vit C) singly, double or in triple combinations, beside control treatment on yield and fruit quality of the tested Williams banana cv. These treatments were arranged in a randomized complete blocks design with three replicates. The obtained results could be summarized as follows:Sprayed banana plants with the mixture of cobalt sulphate + Vit B_{12}+ Vit C at 50+50+500 ppm each (T_{14}) recorded increases in bunch weight, yield /fed. and number of fingers /bunch were about 63.34 , 65.49 and 15.22 % over control treatment, respectively. The plants which sprayed with the mixture of cobalt sulphate + Vit C at 100+1000 ppm each (T_{11}) gave the highest values of hand and finger weight and recorded increases about 54.00 and 62.82% over control treatment, respectively .The highest values of total sugars , SSC/TA and Vit.C were obtained by the plants which sprayed with cobalt sulphate + Vit B_{12}+ Vit C at 100+100+1000 ppm each (T_{15}) average two seasons and recorded the relative increases were about 24.62, 100.56 and 44.34% over control, respectively.

INTRODUCTION

Banana is one of the most important and popular fruit crops in Egypt for its high nutritive value, Banana fruits may be consumed either fresh or processed into juice, banana puree, flour, dried catsup, ships, alcohol, vinegar, beers, spirits and as a source of carbohydrate (Palmer, 1979).

Cobalt, a transition element, is an essential component of several enzymes and co-enzymes. It has a role in affecting growth and metabolism of plants in different stages, depending on the concentration and status of cobalt in rhizosphere and soil. Also, the beneficial effects of cobalt include retardation of senescence of leaf, increase in drought resistance in seeds, regulation of alkaloid accumulation in medicinal plants, and inhibition of ethylene biosynthesis (Palit and Sharma, 1994).

In this respect, Singh, and Agrez (2002) found that , foliar application of cobalt sulphate (200 mg/l) have been resulted in increasing fruit set and retention as well as fruit yield and TSS: acid and total sugars in mango than unsprayed trees. Aziz, *et al.* (2007) indicated that the application of Co at 20 mg/kg soil gave the highest yield of fresh and dry weight of roselle calyces than 40 mg/kg soil or untreated plants. Singh *et al.* (2008) sprayed mango trees with cobalt sulphates at 1000 ppm, pre flower bud differentiation in the first week of October, significantly increased the fruit yield by 35 to 37% as well as total and non reducing sugars in the fruit than other treatments Wahdan (2011) showed that foliar application of cobalt sulfate at 200 ppm were significantly reduced fruitlets abscission and increased the number and weight of harvested fruits per tree , SSC, SSC/ acid ratio, total sugars and vitamin C contents in mango fruits than untreated tress. Mansour and Mubarak (2014) found that fruit weight and fruit number as well as yield / feddan, TSS and TSS/ acid ratio were increased by spraying Navel orange trees with 20 ppm cobalt than other concentrations.

Recently, it was suggested that vitamins participate in plant growth and development indirectly by enhancing the endogenous levels of various growth factors such as cytokinins and gibberellins. Most vitamins are synthesized in the leaves and translocated in the pholem to the other organs. For more than two decades studying of the role of vitamins in plants attracted sporadic attraction. These studies indicated that various physiological process such as nutrient uptakes, absorption of water, translocation of organic foods, building of natural hormones, respiration, photosynthesis as well as chlorophyll and protein synthesis depended more or less on the availability of vitamins (Samiullah *et al*., 1988). Ascorbic acid (Vit. C) have catch all free radicals produced during plant metabolism, hence increasing plant resistance to stress. Moreover, they provide adequate protection against the deleterious effects of activated oxygen species (Alscher *et al*., 1997). Moreover, ascorbic acid has an auxinic action and synergistic effect on flowering and fruiting of fruit trees as well as, ascorbic acid is a natural and safety used instead of synthetic auxins. Ragab (2002) illustrated that three sprays of 200 ppm ascorbic acid were very effective in improving the yield of Washington Naval orange trees. Ahmed *et al.* (2003) reported that combined application of 1000 ppm ascorbic acid and 2000 ppm citric acid six times at the middle of April, May, June, July, August and September gave the best results with regard to yield of Williams banana cv. Ahmed and Abd-El-Hameed (2004) sprayed four antioxidants namely ascorbic acid (250-1000 ppm), citric acid (250-1000 ppm), vitamin B complex (250-1000 ppm), salicylic acid (250-1000 ppm), the treatments were replicated three times. Their results showed number of clusters per vine, yield per vine, berry weight, total soluble solids %, but total acidity were reduced these results confirmed the positive action

of antioxidants instead of using auxins in producing organic fruits from Botany grapevines. Mostafa (2004) showed that bunch weight, finger weight and early bunch shooting were achieved by ascorbic acid at 2000 ppm or vitamin B_1 at 2000 ppm on Graud Nain banana plants. Fayed (2010) found that foliar application of triple combined antioxidants (thiamin+ ascorbic acid + citric acid) gave higher yield (kg/vine) and bunch weight than other antioxidants treatments and control vines of Thompson seedless grapevine. Al- Wasfy (2013) tested the effect of spraying royal jelly at 0.025 to 0.1 %, potassium silicate at 0.05 to 0.2 % and vitamins B (B_1 at 250 ppm + B_6 at 100 ppm and B_{12} at 250 ppm) either singly or in all possible combinations of Sakkoti date palm fruits. Who found that treating Sakkoti date palms with vitamins B significantly resulted in improving bunch weight and yield per palm in relative to untreating the palms. Faissal *et al*. (2014) indicated that application of vitamins K, E, P, A and B complex in combinations gave the best results for increasing fruit weight and yield / tree than application alone or untreated trees of Balady mandarin. and Wassel *et al*. (2015) showed that using a mixture of amino acids at 250 ppm, vitamins B at 50 ppm and potassium silicate at 0.1% increased the primary and finally fruit set, number of fruits/tree, yield/tree (Kg), weight per fruit (g) ,TSS and reducing sugars as well the lowest values of acidity in fruits on wonderful pomegranate.

The main target of this study is to evaluate the response of using cobalt and some vitamins such as vitamin B_{12} and vitamin C as foliar application to obtain high yield and best fruit quality of Williams banana cultivar.

MATERIALS AND METHODS

This study was conducted during two successive seasons (2012/2013 first ratoon and 2013/2014 second ratoon) on Williams banana (Giant Cavendish AAA sub-group) plants grown in clay loam soil under flood irrigation system in a private banana orchard located at El-Hagabey district, Meet Ghamr Dakahlia Governorate, at 3x3.5 m apart. Forty five stools/(mat) ,each containing two plants of Williams cultivar were chosen to evaluate the effect of cobalt , Vit B_{12} and ascorbic acid (Vit C.) on yield and fruit quality of the tested banana cv.

The experiment contained 15 treatments as follows:

T1- Control (foliar spray with tap water only)
T2- Cobalt at 50 ppm
T3- Cobalt at 100 ppm
T4- Vit B_{12} at 50 ppm
T5- Vit B_{12} at 100 ppm
T6- Ascorbic acid (Vit C) at 500 ppm
T7- Ascorbic acid (Vit C) at 1000 ppm
T8- Cobalt + Vit B_{12} at 50 ppm each
T9- Cobalt + Vit B_{12} at 100 ppm each
T10- Cobalt + Vit C at 50+500 ppm
T11- Cobalt + Vit C at 100+1000 ppm
T12- Vit B_{12} + Vit C at 50 +500 ppm
T13- Vit B_{12} + Vit C at 100 +1000 ppm
T14- Cobalt + Vit B_{12}+ Vit C at 50+50+500 ppm
T15- Cobalt + Vit B_{12}+ Vit C. at 100+100+1000 ppm

These treatments were arranged in a randomized complete blocks design with three replicates. Each replicate was represented by one stool, which contains two plants for yielding in the current season and two emerged suckers for yielding in the following season.

Plants were sprayed with cobalt sulphate as the source of cobalt and vitamins (B and C) twice , the first one on May and the second one on July. Then the fruit harvested at November. Each plant was sprayed by three liters. Super film as a wetting agent at 0.5 cm^3/ L was added to all solutions.

All plants under investigation received the traditional and regular fertilization program applied in that location, which comprised of about 560 g N in the form of ammonium sulphate (20.6 %) , 250 g superphosphate (15.5 % P_2O_5)/ plant/year in March +500 g potassium sulphate (48 % K_2O) / plant/year added in two equal application in April and July. Plants were irrigated at 10-15 days intervals according to the climatic conditions. The other agricultural practices (weed and pests control ….etc.) were the same for all plants under investigation.

The obtained data were used for calculating the following parameters

1. Yield and fruit quality

Bunches of banana were picked during the common date of harvesting starting from November to January in both considered seasons which the bunch (or fruits) were suitable (when fingers attained full stage) for harvesting Yield

Average bunch weight (w) in Kgs as well as number of bunch as per fed. (N) were calculated as follows

Yield = Wx N

Also, hand weight (kg), number of hands/bunch, number of fingers/bunch and bunch length (cm) as well as average finger weight (g), were recorded. Two hands were taken from the base, middle and distal end of each bunch as sample for each replicate.

2. Fruit quality of finger at harvest date

Total soluble sugar : It was determined according to the method described by **Dubios *et al*. (1956).**

Total soluble solids to titratable acidity ratio (SSC/TA): The calculations were based on the values of TSS and total titratable acidity percent.

Ascorbic acid (Vit. C mg/100 ml juice) : it was determined in pulp juice using 2, 6, dichlorophenol indophenols dye as indicator (AOAC, 1990)

*Relative increases over control percentage (RI): was calculated to the following equation

$$RI = \frac{\text{Treatment value - control value}}{\text{Control value}} \times 100$$

Statistical analysis:

The obtained data were subjected to statistical analysis of variance according to Snedecor and Cochran (1980), and means separation was done according to (Duncan multiple Range test ,1958) at 0.05 levels of probability**.**

RESULTS AND DISCUSSION

Yield and its component's

Bunch weight

There were significant differences between all tested treatments comparing with control regarding bunch weight in both seasons (Table 1). Treated banana plants with T15 gave the highest bunch weight (32.05 kg) without significant differences with T11, T13 and T14 in the 1st season and T14 (33.70 kg) without significant differences with T13 and T15 in the 2nd season. While, the lowest bunch weight was recorded with control treatment T1 (20.43 and 19.67 kg) in the 1st and 2nd seasons, respectively. In the average two season, T14 produced the highest values (32.75 kg/), followed by T15, T13 and T11. In this regard sprayed banana plants with T14 recorded increases in bunch weight about 63.34 % over control treatment.

Table 1. Effect of foliar application with cobalt and some antioxidants on bunch weight (kg) of Williams banana plants (2012/2013 and 2013/2014 seasons)

No	Treatments	Bunch weight (kg)			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	20.43 f	19.67 f	20.05i	0.00
T2	Cobalt at 50 ppm	24.23 c-e	21.61 e	22.92gh	14.31
T3	Cobalt at 100 ppm	23.20 e	21.92 e	22.56h	12.52
T4	Vit B_{12} at 50 ppm	23.92de	21.82 e	22.87h	14.06
T5	Vit B_{12} at 100 ppm	25.46c	22.61 e	24.03j	19.85
T6	Vit C at 500 ppm	23.96 c-e	26.51 d	25.23f	25.84
T7	Vit C at 1000 ppm	24.71 c-e	29.43 c	27.07e	35.01
T8	Cobalt + Vit B_{12} at 50ppm each	23.58 e	28.73 c	26.15ef	30.42
T9	Cobalt + Vit B_{12} at 100 each	25.20 cd	28.49 c	26.84e	33.87
T10	Cobalt at 50 ppm + Vit C 500 ppm	27.12 b	29.54 c	28.32d	41.25
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	30.62 a	31.84 b	31.23b	55.76
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	27.27 b	31.72 b	29.49c	47.08
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	31.98 a	32.30 ab	32.14ab	60.30
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	31.80 a	33.70 a	32.75a	63.34
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	32.05 a	32.98 ab	32.51a	62.14

Values in the same column followed by different letter(s) are significantly differ using Duncan multiple range test at probability of 5%
R_1= first ratoon , R_2= second ratoon

In this regard, sprayed banana plants recorded values of bunch weight ranged 12.52 to 35.01 % , 30.42 to 60.30 % and 62.14-63.34 % regarding singly , double and triple treatments than control treatments (average two seasons), respectively.

Data in Table, 2 indicate that yield /fed. of banana plants significantly increased by different treatments as foliar application than control treatment in both seasons, except T2 in the 2nd season only. The values ranged from 15.52 to 24.37 and 14.95 to 26.28 ton/fed. in the first and second seasons, respectively.

Table 2. Effect of foliar application with cobalt and some antioxidants on yield (ton/fed.) of Williams banana plants (2012/2013 and 2013/2014 seasons)

No	Treatments	Yield (ton/fed.)			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	15.52e	14.95e	15.24f	0.00
T2	Cobalt at 50 ppm	18.41cd	16.42de	17.42e	14.30
T3	Cobalt at 100 ppm	17.63d	16.67d	17.15e	12.53
T4	Vit B_{12} at 50 ppm	18.17ce	16.58d	17.38e	14.04
T5	Vit B_{12} at 100 ppm	19.35bc	17.19d	18.27e	19.88
T6	Vit C at 500 ppm	18.21cd	17.87d	18.04e	18.37
T7	Vit C at 1000 ppm	18.78cd	22.37c	20.57cd	34.97
T8	Cobalt + Vit B_{12} at 50ppm each	17.93cd	21.84c	19.88d	30.45
T9	Cobalt + Vit B_{12} at 100 each	19.15bd	21.65c	20.40d	33.86
T10	Cobalt at 50 ppm + Vit C 500 ppm	20.61b	22.45c	21.53bc	41.27
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	24.70a	24.20b	24.45a	60.43
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	20.72b	24.11b	22.41b	47.05
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	24.31a	24.55b	24.43a	60.30
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	24.17a	26.28a	25.22a	65.49
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	24.37a	25.07ab	24.72a	62.20

Values in the same column followed by different letter(s)are significantly differ using Duncan multiple range test at probability of 5%
R_1= first ratoon , R_2= second ratoon

The highest yield/fed. (24.70 ton) was obtained with T11 without significant differences with T13, T14 and T15 in the 1st season. While in the 2nd season and average two seasons the maximum yield (26.28 ton) and (25.22 ton) were recorded when sprayed banana plants with T14 .

The relative increases in total yield/fed. due to the application of T14 was about 65.49 % over control treatment , followed by the plants which sprayed with T15 and T13 (62.20 and 60.30 % over control treatment, respectively.

Moreover, sprayed banana plants with different treatments singly , double and triple recorded values

of yield/fed. ranged 12.53 to 34.97 % , 30.45 to 60.43 % and 62.20 to 65.49 % than control treatments (average two seasons), respectively.

Bunching characteristics

Bunch length

The values of bunch length ranged from 87.33 to 109.33 and 89.67 to 102.67 cm in the 1st and 2nd seasons, respectively (Table, 3).

Table 3. Effect of foliar application with cobalt and some antioxidants on bunch length (cm) of Williams banana plants (2012/2013 and 2013/2014 seasons)

No	Treatments	Bunch length (cm)			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	87.33 i	89.67 fg	88.50 g	0.00
T2	Cobalt at 50 ppm	94.33 e-i	92.33 e-g	93.33 d-g	5.46
T3	Cobalt at 100 ppm	101.67 a-e	96.33 b-e	99.00 b-d	11.86
T4	Vit B_{12} at 50 ppm	105.33 ab	101.00 a-c	103.17 ab	16.58
T5	Vit B_{12} at 100 ppm	99.33 b-f	96.00 b-e	97.67 b-e	10.36
T6	Vit C at 500 ppm	89.00 hi	92.33 e-g	90.67 fg	2.45
T7	Vit C at 1000 ppm	98.00 b-g	95.33 c-f	96.67 c-f	9.23
T8	Cobalt + Vit B_{12} at 50ppm each	91.00 g-i	92.00 e-g	91.50 e-g	3.39
T9	Cobalt + Vit B_{12} at 100 each	92.67f-i	89.00 g	90.83 fg	2.63
T10	Cobalt at 50 ppm + Vit C 500 ppm	104.33 a-c	102.00 ab	103.17 ab	16.58
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	96.67 c-h	95.67 c-f	96.17 c-f	8.67
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	93.00 f-i	93.33 d-g	93.17 d-g	5.28
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	96.00 d-h	94.33 d-g	95.17c-f	7.54
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	102.67 a-d	99.33 a-d	101.00 a-c	14.12
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	109.33 a	102.67 a	106.00 a	19.77

Values in the same column followed by different letter(s)are significantly differ using Duncan multiple range test at probability of 5%
R_1= first ratoon , R_2= second ratoon

The uppermost values of bunch length were obtained by treated banana plants with T15 (109.33 and 102.67 cm) in the 1st and 2nd seasons, respectively without significant differences with T3, T4, T10 and T14 in the 1st season and T4, T10 and T14 in the 2nd season. On the other hand, control treatment gave the lowest bunch length (87.33 and 89.67 cm 0 in the 1st and 2nd seasons, respectively. Generally, the highest bunch length (average two seasons) was obtained by T15 and recorded increase in bunch length equal 19.77 % than control treatment.

At the same time, sprayed banana plants with different treatments recorded values of bunch length ranged 2.45 to 16.58 % ,2.63 to 16.58 % and 14.12 to 19.77 % regarding singly , double and triple treatments than control treatments (average two seasons), respectively.

Number of hand / bunch

Sprayed banana plants with T13 or T14 has significant effect on number of hand/ bunch comparing with control treatment in both seasons. The increases in number of hand/ bunch due to the application of the two treatments were bout 10 % over control treatment (average two seasons) (Table 4).

Table 4. Effect of foliar application with cobalt and some antioxidants on number of hands/ bunch of Williams banana plants (2012/2013 and 2013/2014 seasons)

No	Treatments	Number of hands/ bunch			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	10.54 c	10.66 ab	10.61 c	0.00
T2	Cobalt at 50 ppm	10.92 bc	10.66 ab	10.79 bc	1.70
T3	Cobalt at 100 ppm	11.30 a-c	10.66 ab	10.98 a-c	3.49
T4	Vit B_{12} at 50 ppm	11.30 a-c	10.66 ab	10.98 a-c	3.49
T5	Vit B_{12} at 100 ppm	11.67 ab	10.33 b	11.00 a-c	3.68
T6	Vit C at 500 ppm	11.67 ab	10.66 ab	11.17 a-c	5.28
T7	Vit C at 1000 ppm	11.67 ab	10.33 b	11.00 a-c	3.68
T8	Cobalt + Vit B_{12} at 50ppm each	11.67 ab	11.00 ab	11.34 a-c	6.88
T9	Cobalt + Vit B_{12} at 100 each	12.05 a	11.00 ab	11.53 ab	8.67
T10	Cobalt at 50 ppm + Vit C 500 ppm	11.67 ab	10.66 ab	11.17 a-c	5.28
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	11.67 ab	10.66 ab	11.17 a-c	5.28
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	11.67 ab	11.00 ab	11.34 a-c	6.88
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	12.05 a	11.33 a	11.69 a	10.18
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	12.05 a	11.33 a	11.69 a	10.18
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	11.67ab	11.33 a	11.50 ab	8.39

Values in the same column followed by different letter(s)are significantly differ using Duncan multiple range test at probability of 5%
R_1= first ratoon , R_2= second ratoon

The relative increases in number of hand / bunch regarding T13 were about 10.18 % than control treatment. In this regard, the plants which received cobalt sulpaht, Vit. B_{12} and Vit. C singly , double and triple treatments recorded values ranged 1.70 to 5.28 % , 5.28 to 10.18 % and 8.39 to 10.18 % than control treatments, respectively (average two seasons),.

Number of finger / bunch

Data in Table, 5 clear that foliar application with CS and some vitamins (B_{12} and Vit.C) singly or in combination had significantly effect on number of finger / bunch of banana during 2012/2013 and 2013/2014.

Table 5. Effect of foliar application with cobalt and some antioxidants on number of fingers/ bunch of Williams banana plants (2012/2013 and 2013/2014 seasons)

No	Treatments	Number of fingers/ bunch			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	199.26 f	189.33 i	194.30 h	0.00
T2	Cobalt at 50 ppm	207.17 ef	195.67 g-i	201.42 gh	3.66
T3	Cobalt at 100 ppm	211.31 d-f	195.67 g-i	203.49 fg	4.73
T4	Vit B_{12} at 50 ppm	207.17 ef	193.00 hi	200.09 gh	2.98
T5	Vit B_{12} at 100 ppm	218.09 b-e	194.67 g-i	206.38 e-g	6.22
T6	Vit C at 500 ppm	214.70 c-e	197.33 f-h	206.02 e-g	6.03
T7	Vit C at 1000 ppm	222.23 a-d	197.67 e-h	209.95 d-f	8.05
T8	Cobalt + Vit B_{12} at 50ppm each	218.47 b-e	203.67 d-f	211.07 c-f	8.63
T9	Cobalt + Vit B_{12} at 100 each	222.61 a-d	201.67 d-g	212.14 c-e	9.18
T10	Cobalt at 50 ppm + Vit C 500 ppm	225.25 a-c	205.00 c-e	215.12 b-d	10.72
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	228.64 ab	207.67 b-d	218.15 a-c	12.27
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	228.26 ab	212.00 a-c	220.13 ab	13.29
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	229.01 ab	212.67 ab	220.84 ab	13.66
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	232.40 a	215.33 a	223.87 a	15.22
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	228.64 ab	217.67 a	223.16 a	14.85

Values in the same column followed by different letter(s) are significantly differ using Duncan multiple range test at probability of 5%

R_1= first ratoon , R_2= second ratoon

The values ranged from 199.26 to 228.64 and 189.33 to 217.66 finger/ bunch in the first and second seasons, respectively.

The uppermost values of number of finger/ bunch (232.40 and 217.67) came from T14 in the 1st season and T15 in the 2nd season, respectively). While the lowest values of number of finger /bunch was obtained by control treatment (199.26 and 189.33) in the 1st and 2nd seasons, respectively.

On the other side, the maximum number of finger/ bunch (average two seasons) was obtained by T14 (223.87). The increases in number of finger / bunch due to the application of the same treatments was about 15.22 % over control treatment , followed by the plants which sprayed with T15 (14.85% over control treatment (average two seasons).

However, treated banana plants recorded values of number of finger/ bunch ranged 2.98 to 8.05 % , 8.63 to 13.66 % and 14.85-15.22 % regarding singly , double and triple treatments than control treatments Table 5 (average two seasons), respectively.

Hand weight

Data in Table, 6 indicate that hand weight / bunch of banana was affected significantly by different treatments as foliar application than control treatment in both seasons, except T2 in the 2nd season only.

Table 6. Effect of foliar application with cobalt and some antioxidants on hand weight (kg) of Williams banana plants (2012/2013 and 2013/2014 seasons)

No	Treatments	Hand weight (kg)			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	2.160 f	2.023 g	2.090 h	0.00
T2	Cobalt at 50 ppm	2.333 de	2.169 fg	2.250 g	7.66
T3	Cobalt at 100 ppm	2.313 e	2.236 ef	2.276 g	8.90
T4	Vit B_{12} at 50 ppm	2.380 de	2.181ef	2.280 g	9.09
T5	Vit B_{12} at 100 ppm	2.473 cd	2.330 e	2.403 f	14.98
T6	Vit C at 500 ppm	2.366 de	2.320 ef	2.343 fg	12.11
T7	Vit C at 1000 ppm	2.410 de	2.800d	2.606 e	24.69
T8	Cobalt + Vit B_{12} at 50ppm each	2.286 ef	2.870 cd	2.580 e	23.44
T9	Cobalt + Vit B_{12} at 100 each	2.343 de	2.840 cd	2.593 e	24.07
T10	Cobalt at 50 ppm + Vit C 500 ppm	2.563 c	2.977 c	2.770d	32.54
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	3.230 a	3.218 ab	3.226 a	54.35
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	2.606 c	3.220 ab	2.913 c	39.38
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	2.933 b	3.191 b	3.060 b	46.41
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	2.936 b	3.369 a	3.150 ab	50.72
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	3.056 b	3.275ab	3.166 ab	51.48

Values in the same column followed by different letter(s)are significantly differ using Duncan multiple range test at probability of 5%

R_1= first ratoon , R_2= second ratoon

The values ranged from 2.160 to 3.230 and 2.023 to 3.369 kg/ hand in the first and second seasons, respectively.

Sprayed banana plants with T11 recorded the highest hand weight (3.230 kg) in the 1st season, while T14 recorded the maximum (3.369 kg) in the 2nd season. On the other hand, the lowest hand weight was obtained with control treatment (2.160 and 2.023 kg/ hand) in the 1st and 2nd seasons, respectively.

On the other side, the highest weight of hand (average two seasons) was obtained when sprayed plants with T11 (3.226 kg). The relative increases in hand weight due to the application of T11 was about 54 % over control treatment , followed by the plants which sprayed with T15 (51.48% over control treatment (average two seasons).

Sprayed banana plants recorded values of number of finger/ bunch ranged 7.66 to 24.69 % , 23.44 to 54.35 % and 50.72- 51.48 % regarding singly , double and triple treatments than control treatments (average two seasons), respectively.

Finger weight

All treatments foliar spray singly or in combination had significantly increased finger weight of banana than control treatment in both seasons (Table 7).

Table 7. Effect of foliar application with cobalt and some antioxidants on finger weight (g) of Williams banana plants (2012/2013 and 2013/2014 seasons)

No	Treatments	Finger weight (g)			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	98.36 i	88.20 g	93.29 i	0.00
T2	Cobalt at 50 ppm	117.59 c	98.50 f	108.05 g	15.82
T3	Cobalt at 100 ppm	103.66 gh	101.76 f	102.71 h	10.10
T4	Vit B_{12} at 50 ppm	108.69 ef	97.51 f	103.10 h	10.52
T5	Vit B_{12} at 100 ppm	111.46 de	102.24 f	106.85 g	14.54
T6	Vit C at 500 ppm	106.84 e-g	109.12 e	107.98 g	15.75
T7	Vit C at 1000 ppm	104.19 f-h	149.06 bc	126.63 de	35.74
T8	Cobalt + Vit B_{12} at 50ppm each	99.77 hi	141.06 d	120.42 f	29.08
T9	Cobalt + Vit B_{12} at 100 each	105.84 fg	141.70 d	123.78 ef	32.68
T10	Cobalt at 50 ppm + Vit C 500 ppm	110.99 de	144.12 cd	127.56 d	36.73
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	149.13 a	153.27 ab	151.20 a	62.08
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	115.22 cd	149.40 bc	132.31 c	41.83
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	136.45 b	152.02 ab	144.24 b	54.61
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	133.05 b	156.30 a	144.67 b	55.08
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	133.19 b	151.78 ab	142.48 b	52.73

Values in the same column followed by different letter(s) are significantly differ using Duncan multiple range test at probability of 5%

R_1= first ratoon , R_2= second ratoon

The uppermost values of finger weight (149.13 and 156.30 g) came from T11 in the 1st season and T14 in the 2nd season, respectively). While the lowest values of finger weight was obtained by control treatment.

On the other side, the maximum finger weight (average two seasons was obtained when sprayed plants with T11 (151.20 g). The increases in finger weight due to the application of the same treatments was about 62.82 % in finger weight over control treatment , followed by the plants which sprayed with T13 (55% over control treatment (average two seasons).

In this connection, the plants which received cobalt sulpaht, Vit. B_{12} and Vit. C singly , double and triple treatments recorded values of finger weight ranged 10.10 to 36.73 % , 29.08 to 62.08 % and 52.73 to 55.08 % than control treatments (average two seasons), respectively.

Regarding the effect of cobalt , the results are in harmony with those obtained with Singh, and Agrez, (2002) found that , foliar application of cobalt sulphate (200 mg/l) have been resulted in increasing fruit set and retention as well as fruit yield in many mango cultivars than unsprayed trees. Aziz, *et al.* (2007) showed that the application of Co at 20 mg/kg soil gave the highest effect on fresh and dry weight of roselle calyces. Singh et al. (2008) indicated that cobalt sulphate at 1000 ppm significantly reduced floral malformation of mango by 65 to 71% and increased the fruit yield by 35 to 37%. Wahdan (2011) found that foliar application of cobalt sulphate at different concentrations increased the number and weight of harvested mango fruits per tree than untreated ones. Moreover , the highest values of these parameters were obtained by spraying trees with 200 ppm Cobalt Sulfate. Mansour and Mubarak (2014) found fruit weight and fruit number as well as yield/feddan were increased by spraying Navel orange trees with 20 ppm cobalt than other concentrations. Gad (2015) found that all cobalt treatments significantly increased total fresh yield and dry matter percentage of Moringa herb. The highest values of N, P and K content were obtained by cobalt at 10 ppm .

As for, the response of banana plants to spraying trees with some vitamins. Ahmed *et al.* (2003) on Williams banana cv. , Ahmed and Abd-El-Hameed (2004) on Botany grapevines, Mostafa (2004) on Graud Nain banana plants , Mansour *et al.* (2008) on Le-Conte pear trees. , Maksoud *et al.* (2009) on olive trees. , Fayed (2010) on Thompson seedless grapevine , Kassem *et al.* (2010) on Costata persimmon trees , Al-Douri and Al-A'areji (2012) on pomegranate trees . Samra *et al.* (2012) on mandarin trees, Al- Wasfy (2013) on Sakkoti date palms , El-Badawy (2013) on Canino apricot trees, Al- Khawaga (2014) on

grapevine, El-Sayed *et* al. (2014) on Manzanillo olive, Faissal *et al*. (2014) on Balady mandarin and Wassel *et al*. (2015) on pomegranate wonderful cv. They found that spraying fruit tree with different concentration of vitamins B_{12} or C singly or in combination increased yield and its components than unsprayed trees.

Fruit chemical characteristics

Total sugars (%)

All foliar spray treatments had significantly increased total sugar (%) in Williams banana fruits and ranged from 11.96 to 15.23 in the first season and from 11.51 to 14.04 in the second season (Table 8) .

Table 8. Effect of foliar application with cobalt and some antioxidants on total sugars (%) in fruits of Williams banana (2012/2013 and 2013/2014 seasons)

No	Treatments	Total sugars (%)			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	11.96k	11.51n	11.74n	0.00
T2	Cobalt at 50 ppm	12.56i	11.72m	12.14l	3.41
T3	Cobalt at 100 ppm	12.19j	11.86l	12.02m	2.39
T4	Vit B_{12} at 50 ppm	12.99h	11.96k	12.48k	6.30
T5	Vit B_{12} at 100 ppm	12.95h	12.08j	12.52jk	6.64
T6	Vit C at 500 ppm	13.43g	12.48h	12.95i	10.31
T7	Vit C at 1000 ppm	12.90h	12.19i	12.55j	6.90
T8	Cobalt + Vit B_{12} at 50ppm each	13.67f	12.65g	13.16h	12.10
T9	Cobalt + Vit B_{12} at 100 each	13.75f	13.01f	13.38g	13.97
T10	Cobalt at 50 ppm + Vit C 500 ppm	14.15e	13.07ef	13.61f	15.93
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	14.22e	13.15e	13.68e	16.52
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	14.32d	13.24d	13.79d	17.46
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	14.56c	13.45c	14.00c	19.25
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	15.05b	13.89b	14.47b	23.25
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	15.23a	14.04a	14.63a	24.62

Values in the same column followed by different letter(s)are significantly differ using Duncan multiple range test at probability of 5%
R_1= first ratoon , R_2= second ratoon

The higher values of total sugar in fruit (%) were recorded with T15 (15.23 , 14.04 and 14.63), followed by T14 (15.05, 13.89 and 14.47 %) in the 1st, 2nd and average two seasons, respectively. On the other hand, the lowest total sugar percentage i.e., (11.96 , 11.51 and 11.74 %) in the 1st, 2nd and average two seasons, respectively were obtained with T1 control treatment.

The relative increases in total sugars due to treated banana plants with T15 were about 24.62 % , followed by T14 (23.25%) over control treatment.

However, the plants which sprayed with singly, double and triple treatments recorded values of Total sugars ranged 2.39 to 10.31 % , 12.10 to 19.25 % and 23.25 to 24.62 % than control treatments (average two seasons), respectively.

SSC/ acid ratio

Results in Table, 9 elucidate that, there were a significant differences between all treatments on SSC/ acid ratio in banana fruits , the values of SSC acid ratio ranged 52.02 to 106.18, 54.36 to 107.17 and 53.19 to 106.68 % in the 1st , 2nd and average two seasons.

Table 9. Effect of foliar application with cobalt and some antioxidants on SSC/ acid ratio in fruits of Williams banana plants (2012/2013 and 2013/2014 seasons)

No	Treatments	SSC/ acid ratio			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	52.02 k	54.36 l	53.19 n	0.00
T2	Cobalt at 50 ppm	58.46 j	56.23 l	57.35 m	7.82
T3	Cobalt at 100 ppm	62.32 i	63.82 j	63.07 k	18.57
T4	Vit B_{12} at 50 ppm	73.68 g	75.81 g	74.74 h	40.52
T5	Vit B_{12} at 100 ppm	60.86 i	60.89 k	60.87 l	14.44
T6	Vit C at 500 ppm	73.02 g	70.95 h	71.98 i	35.33
T7	Vit C at 1000 ppm	72.02 g	66.54 i	69.28 j	30.25
T8	Cobalt + Vit B_{12} at 50ppm each	78.49 f	76.98 fg	77.74 g	46.16
T9	Cobalt + Vit B_{12} at 100 each	67.47 h	70.29 h	68.88 j	29.50
T10	Cobalt at 50 ppm + Vit C 500 ppm	79.95 f	79.03 f	79.49 f	49.45
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	88.52 e	83.82 e	86.17 e	62.00
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	92.71d	87.36 d	90.04 d	69.28
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	97.71 c	95.75 c	96.73 c	81.86
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	100.96 b	102.56 b	101.76 b	91.31
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	106.18 a	107.17 a	106.68 a	100.56

Values in the same column followed by different letter(s)are significantly differ using Duncan multiple range test at probability of 5%
R_1= first ratoon , R_2= second ratoon

Plants which sprayed with T15 gave significantly highest SSC/ acid ratio in fruits, i.e., 106.18, 107.17 and 106.68 in the 1st , 2nd and the average two seasons, respectively, followed by T14 in both seasons.

The relative increases in SSC/ acid ratio regarding spraying plants with T15 were about 100.56% followed by T14 (91.31%) than control treatment. In this regard, sprayed banana plants with the other treatments recorded values of SSC/ acid ratio ranged 7.82 to 40.52 % , 29.50 to 81.86 % and 91.31-101.56 % regarding singly , double and triple treatments than control treatments (average two seasons), respectively.

Vit. C content

Data in Table, 10 showed that , the effect of different foliar spray treatments on the content of Vit. C in banana fruit in both seasons. The values ranged 6.69 to 9.43, 6.21 to 9.18 and 6.45 to 9.31 mg/100 ml) in the 1st , 2nd and average two seasons, respectively. Spraying banana trees with T15 significantly achieved the highest Vit. C content (9.43, 9.18 and 9.31 mg/100 ml) in the 1st, 2nd and the average two seasons, respectively. On the other hand, control treatment gave the lowest Vit. C. content i.e., (6.69, 6.21 and 6.45 mg/100 ml) in the first, second and average two seasons, respectively.

The relative increases in Vit. C. content in fruits regarding spraying plants with T15 were about 44.34% followed by T14 (41.71%) than control treatment. In this concern, the plants which sprayed with different treatments recorded values of Vit C. ranged 4.65 to 21.86 % , 22.79 to 37.98 % and 41.71 to 44.34 % regarding singly, double and triple treatments than control treatments (average two seasons), respectively.

As for the effect of cobalt , results are in line with those reported by Singh, and Agrez, (2002) who found that , foliar application of cobalt sulphate (200 mg/l) have been resulted in increasing TSS: acid ratio and total sugars in many mango cultivars than unsprayed trees. Singh *et al.* (2008) found that total and non reducing sugars in the fruit were adversely affected by the higher rates of cobalt. Gad and Abd El-Moez (2011) found that TSS, protein, sugars, phenoles as well as vitamin "A" and "C" of broccoli plants increased with treated plants with cobalt at 6ppm than other concentration (0, 3, 9 and 12 ppm), Wahdan (2011) indicated that SSC, SSC/ acid ratio, total sugars and vitamin C in mango cv. succary were increased with addition of 200 ppm cobalt sulpahe to tress as foliar spray. Mansour and Mubarak (2014) showed that TSS and TSS/ acid ratio of Graind Nain banana were increased by spraying trees with 20 ppm cobalt than other concentrations. While vitamin C was increased by application of cobalt at 10 ppm of Navel orange fruit

Table (10) : Effect of foliar application with cobalt and some antioxidants on vitamin C (mg/g juice) in fruits of Williams banana plants (2012/2013 and 2013/2014 seasons)

No	Treatments	Vitamin C (mg/g juice)			
		1st season (R_1)	2nd season (R_2)	Average two seasons	Relative increases over control (%)
T1	Control (foliar spray with tap water)	6.69 j	6.21 o	6.45 l	0.00
T2	Cobalt at 50 ppm	7.08 hi	6.42 n	6.75 k	4.65
T3	Cobalt at 100 ppm	7.01 i	6.57 m	6.79 k	5.27
T4	Vit B_{12} at 50 ppm	7.13 hi	6.76 l	6.95 j	7.75
T5	Vit B_{12} at 100 ppm	7.22 h	6.98 k	7.10 i	10.08
T6	Vit C at 500 ppm	7.75 g	7.48 j	7.62 h	18.14
T7	Vit C at 1000 ppm	7.85 g	7.86 i	7.86 g	21.86
T8	Cobalt + Vit B_{12} at 50ppm each	7.88 g	7.95 h	7.92 g	22.79
T9	Cobalt + Vit B_{12} at 100 each	8.07 f	8.09 g	8.08 f	25.27
T10	Cobalt at 50 ppm + Vit C 500 ppm	8.73 e	8.38 f	8.56 e	32.71
T11	Cobalt at 100 ppm + Vit C at 1000 ppm	8.94 cd	8.52 e	8.73 d	35.35
T12	Vit B_{12} at 50 ppm + Vit C +500 ppm	9.02 c	8.78 d	8.90 c	37.98
T13	Vit B_{12} at 100 ppm + Vit C +1000 ppm	8.85de	8.93c	8.89 c	37.83
T14	Cobalt + Vit B_{12} at 50 ppm each + Vit C at 500 ppm	9.22 b	9.06 b	9.14 b	41.71
T15	Cobalt + Vit B_{12} at 100 ppm each + Vit C at 1000 ppm	9.43 a	9.18 a	9.31 a	44.34

Values in the same column followed by different letter(s)are significantly differ using Duncan multiple range test at probability of 5%
R_1= first ratoon , R_2= second ratoon

Concerning the effect of antioxidants, results are in harmony with those reported by Ahmed *et al.* (2003) found that combined application of 1000 ppm ascorbic acid and 2000 ppm citric acid six times at the middle of April, May, June, July, August and September clearly improved fruit quality of Williams banana cv. Fayed (2010) found that foliar application of triple combined antioxidants (thiamin+ ascorbic acid + citric acid) increased TSS/ acid ratio and berry total soluble sugars and firmness than other antioxidants treatments and control vines .Samra *et al.* (2012) revealed that sprayed mandarin trees with ascorbic acid at 500 ppm increased average fruit weight, SSC/acid ratio and vitamin C content in fruit juice than the control or 1000 ppm of Balady mandarin fruits. El-Badawy (2013) found that the heaviest fruit weight (g) and the highest T.S.S. %, V.C (mg/100 ml juice), total sugars % and fruit firmness ($lb/inch^2$) values as well as the lowest value of total acidity % were scored by the high level of antioxidants.Al- Khawaga (2014) showed that sprays

of vitamins B & C and/ or glutamic acid with or without using silicon significantly was very effective in improving quality of the berries in terms of increasing berry weight and dimensions, TSS %, TSS/ acid and reducing sugars % and decreasing total acidity % relative to the check treatment. Faissal *et al*. (2014) indicated that application of vitamins K, E, P, A and B complex in combinations recorded the highest values of TSS , TSS/ acid ratio , reducing and total sugars as well as vitamin C in fruit than application alone or untreated trees of Balady mandarin, and Wassel *et al*. (2015) showed that sprayed pomegranate trees with the mixture of amino acids at 250 ppm, vitamins B at 50 ppm and potassium silicate at 0.1% recorded the highest values of TSS and reducing sugars as well as the lowest values of acidity in fruits.

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تأثير معاملات الرش الورقى بالكوبالت وبعض الفيتامينات على انتاجية وجودة الموز صنف ويليامز

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*** قسم فاكهه جامعه المنصوره**

**** مركز البحوث الزراعيه**

اجري هذا البحث خلال الموسمين المتتالين ٢٠١٢ / ٢٠١٣ خلفه اولي موسم اول ,٢٠١٣/٢٠١٤ علي خلفه ثانيه موسم ثاني علي الموز صنف وليامز النامي بالارض الطمييه الخفيفه تحت نظام الري بالغمر وذلك بمزرعه موز خاصه بقريه الحاجبي بمدينه ميت غمر محافظه الدقهليه والتي زرعت علي مسافه ٣.٥x٣ م علي ٤٥ جوره كل جوره تحتوي علي خلفتين تقريبا من الموز صنف الوليامز والتي اختيرت متقاربه لتقيم تأثيرالرش الورقي بكل من الكوبلت ة وفيتامين ب١٢ والاسكوربيك اسيد (فيتامين س) في صوره منفرده او موزدوج او في صوره توليفات ثلاثيه ذلك بالاضافه الي معامله الكنترول (بدون) علي انتاجيه المحصول وجوده الثمار وصفاتها الكيميائيه علي صنف الموز وليامز .وقد وزعت المعاملات في صوره قطاعات كامله العشوائيه ١٥ معامله في ٣ مكررات ولخصت النتائج كما يلي.ادي رش نباتات الموز بمخلوط من سلفات الكوبلت + فيتامين ب١٢ + فيتامين س بمعدل ٥٠+٥٠+٥٠٠ جزء في المليون لكل منهم علي التوالي (معامله ١٤) وقد سجلت زياده في وزن السباطه , المحصول للفدان , عدد الاصابع بالسباطه , قدرها ٦٣.٣٤ % , ٦٥.٤٩ % , ١٥.٢٢ % علي التوالي عن المعامله بالكنترول .كما سجلت النباتات التي رشت بمخلوط من سلفات الكوبلت + فيتامين س بمعدل ١٠٠+١٠٠٠ جزء في المليون لكلا منهما علي التوالي (معامله١١) والتي اعطت اعلي قيم وزياده لكل من وزن الكف , ووزن الاصبع , وسجلت زيادات مقدارها ٥٤.٠٠ % , ٦٢.٨٢ % عن الكنترول علي التوالي . اما اعلي القيم لكل من السكريات الكليه , المواد الصلبه الزائبه / الحموضه الكليه وفيتامين ج قد لوحظت مع النباتات التي رشت بمخلوط سلفات الكوبلت + فيتامين ب١٢ + فيتامين ج بمعدل ١٠٠+١٠٠+١٠٠٠ جزء في المليون لكل منهم علي التوالي (معامله ١٥) وسجلت زيادات نسبيه مقدارها ٢٤.٦٢ % , ١٠٠.٥٦ % ,٤٤.٣٤ % علي التوالي عن الكنترول خلال متوسط الموسمين علي التوالي .