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RESPONSE OF GROWTH, YIELD AND FRUIT QUALITY OF "ANNA" APPLE TREES TO FOLIAR SPRAY WITH SOME PLANT GROWTH PROMOTING RHIZOBACTERIA AS A SUBSTITUTE TO SYNTHETIC BIOSTIMULANTS

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ABSTRACT

Many synthetic biostimulants containing amino acids, macro- and micro-elements, humic acids and, sometimes, algae extracts have been used effectively for stimulating and increasing of fruit trees yield. The foliar spray with some PGPR (plant growth promoting rhizobacteria) has proved high potentiality in stimulating and increasing plant yield. The current study is concerned with the use of some PGPR types (*Azospirillum brasilense, Pseudomonas fluorescens and Bacillis polymyxa*) as an alternative to some commercial synthetic biostimulants i. e. Jisamar (J) and Furdos (F) in stimulating and improving yield of "Anna" apple trees.

The study field of apple trees (eight years old) was chosen at El-Bostan area, El-Behira Governorate, Egypt. The trees were sprayed twice with the different stimulators, the first was at fruit set and the second was done after ٣٠ days from fruit set. The control trees were sprayed with water.

The microorganisms which were used for spray were counted in the plant phyllosphere and they showed heavy increase in the phyllosphere of the treated plants. The spray with the synthetic biostimulants showed remarkable improvement to the plant morphological characteristics, e. g. shoot length, shoot diameter, leaf area, leaf dry weight and leaf content of chlorophyll a, b and total chlorophyll. While, specific leaf weight (SLW) did not significantly change. Likewise, the spray with bacterial biostimulants proved similar potentiality as synthetic ones, and even, sometimes, surpassed them. The spray with *Azospirillum brasilense* gave the highest fruit yield; ٤٥,١ and ٤١,٢ kg/tree versus ٣٣,٥ and ٣٢,٠ kg/tree for control treatment in ٢٠٠٩ and ٢٠١٠ seasons, respectively. The spray with Jisamar and Furdos gave ٣٧,٤ and ٣٣,٢ kg/tree and ٣٦,٥ and ٣٤,٧ kg/tree, respectively. The experimental treatments, raised the net return (£E/feddan) over that of control. *Azospirillum brasilense* spray attained the highest net return i. e. ٢١٥٩٥ versus ١٦٦٦٠, ١٦٨٧٠ and ١٥٦٥٠ £E/feddan for treatments of Jisamar, Fordose and control, respectively. Therefore, the substitution of synthetic biostimulant products with biological ones may be suitable for improving the plant growth, increasing productivity and raising the net return per feddan of Anna apple trees.

INTRODUCTION

The overwhelming increase of population and exacerbate of poverty and hungry problems in the world needs hard and continuous work to increase agricultural productivity. For a lot of reasons, horizontal expansion of agriculture represent a difficult equation for many countries of the world, therefore the vertical increase in plant productivity is the suitable solution.

Despite the balanced plant nutrition is of great importance for plant productivity, the application of some synthetic stimulants had the positive and

effective influence in increasing plant growth and productivity. Many of these stimulants contain amino acids, vitamins, humic acids, sea weeds extracts, plant phytohormones and sometimes microelements (Ferrini and Nicese, ٢٠٠٢). Spinelli *et al.* (٢٠١٠) treated the strawberry with "Actiwave" which is a product derived from the algae *Ascophyllum nodosum*. Spray with "Actiwave" enhanced the tree growth and yield and had a significant effect on reducing the negative effect of alternative bearing. They claimed that the biostimulant Actiwave may represent a promising strategy to reduce the use of phytochemicals in agriculture. They indicated that Actiwave application as a spray to the strawberry increased the mineral nutrient uptake, chlorophyll content and the abiotic stress tolerance.

Other authors found significant increase in plant growth and productivity due to spray with different types of PGPR cultures. Karakurt and Aslantas (٢٠١٠) demonstrated that the spray of apple tree with some PGPR (*Bacillus subtilis* OUS-١٤٢ and *Pseudomonas putida* BA-٨) enhanced tree growth and nutrient uptake. Erturk *et al.* (٢٠١١) observed that spray of hazelnut seedlings with *B. lentus*, *B. atrophaeus* and other types of PGPR significantly increased the plant growth parameters. The foliar spray of apple trees with three *Bacillus* sp. was also found by Ryu *et al*. (٢٠١١) to increase tree growth, fruit yield and quality.

The PGPR had multi-mechanisms for enhancing plant growth such as fixing atmospheric nitrogen (Saharan and Nehra, ٢٠١١); facilitate nutrient uptake (Martinez-Viveros *et al.,* ٢٠١٠); solubilizing phosphates (Oliveira *et al.,* ٢٠٠٩); producing plant phytohormones (Spaepen *et al.*, ٢٠٠٨); regulate plant ethylene level (Govidasamy *et al.,* ٢٠٠٨); resist plant pathogens (Van Loon, ٢٠٠٧) and produce antibiotics which reflected on plant growth, yield and quality (Esitken, ٢٠١١).

Therefore, the present investigation aimed to study the significance of spray of apple trees with some PGPR bacterial biostimulants as an alternative to synthetic biostimulants i. e. Jisamar and Furdose.

MATERIALS AND METHODS

Materials:

Microbial media:

١- *Azospirillum*: Semi solid Döbereiner medium (Döbereiner *et al*., ١٩٧٦) contained (g/liter of distilled water): Malic acid, ٥,٠; KH_2PO_4, ٠,٤; K_2HPO_4, ٠,١; $MgSO_4.7H_2O$, ٠,٢; NaCl, ٠,١; $CaCl_2.7H_2O$, ٠,٠٢; $FeCl_2.6H_2O$, ٠,٠١; $Na_2MoO_4.2H_2O$, ٠,٠٠٢; Agar, ١,٧٥.

٢- *Bacillus:* N-deficient medium for Bacilli (Hino and Wilson, ١٩٥٨) was composed of solution A: It contains (g/٥٠٠ ml distilled water): $MgSO_4.7H_2O$, ٠,٥; Sucrose, ٢٠,٠; NaCl, ٠,٠١; $FeSO_4$,٠,٠٢; $Na_2MoO_4.2H_2O$, ٠,٠٠٥; $CaCO_3$, ٠,٢ and solution B which contains Para amino benzoic acid, ١٠ µg; Biotin, ٥ µg ; K_2HPO_4, ٦,٨١ g ; KH_2PO_4, ١,٤٣ g ; distilled water ٥٠٠ ml. The two solutions were mixed after autoclaving at ١,٥ atm. for ١٥ minutes.

٣- *Pseudomonas*: King □s medium (King et al., ١٩٥٤) was composed of (g/liter distilled water): sucrose, ٢٠,٠ g ; peptone, ٥,٠ g ; $K_٢HPO_٤$, ٠,٥ g ; Agar , ٢٠,٠ g ; distilled water ١٠٠٠ ml, pH, ٧,٢ (٠,١N KOH).

Jisamar: is a commercial synthetic biostimulant contains seaweed extract (٢٠,٥٪), free amino acids (٦,٥٪), total nitrogen (٥,٨٪), phosphorus (٣٪), boron (٠,١٧٪) and potassium (٤,٦٪).

Furdose: : is a commercial synthetic biostimulant contains humic and vulvic acids (٢٢٪), natural and organic substances (٤٠٪), free amino acids (١٤,٦٪), N, (٤,٥٪), P (٣,٨), K (٥٪), Ca (٠,٤٪), Mg (٠,٤٪), Fe (٠,١٪), Mn (١٥ ppm), Zn (٢٠ ppm), Cu (١٥ ppm).

This study has been carried out on eight years old "Anna" apple trees budded on Malus rootstock during ٢٠٠٩ and ٢٠١٠. Trees were grown at Elbostan region of Elbehira Governorate. Drip fertigation system was applied for irrigation and fertilization. The experimental soil analysis is shown below in Table ١.

Table ١: Some chemical and physical analysis characteristics of the experimental soil

Sand %	Silt %	Clay %	Texture	O.M %	pH	EC ($ds.m^{-١}$)
٨٠,٢	٨,٥	١١,٣	Sandy clay loam	٠,٦٣	٨,١	١,١٧

Cations (mg./L)			Anions (mg./L)				Macro-nutrient (ppm)		
Na^{+}	Ca^{++}	Mg^{++}	$CO_٣^{--}$	$HCO_٣^{-}$	Cl^{-}	$SO_٤^{--}$	N	P	K
٥,٨٩	١٠,٤٢	٣,٩١	-	١,٣٧	١٢,٤١	٦,٧٢	١٣٩	٧	٨٦

Methods:

Treatments were arranged in a random order on the selected trees. Single tree plot with ٣ replicates for each treatment was arranged in random complete blocks design.

All trees were subjected with common regional horticultural practices, while treatments were applied as follows:

(A): Trees were sprayed with a suspension of *Azospirillum brasilense.*

(P): Trees were sprayed with a suspension of *Pseudomonas fluorescens*.

(B): Trees were sprayed with a suspension of *Bacillus polymyxa*

(J): Trees were sprayed with a suspension of Jisamar.

(F): Trees were sprayed with a suspension of Furdose.

(A+J): Trees were sprayed with a suspension of *Azospirillum brasilense* and Jisamar.

(A+F): Trees were sprayed with a suspension of *Azospirillum brasilense* and Furdose.

(P+J): Trees were sprayed with a suspension of *Pseudomonas fluorescens* and Jisamar

(P+F): Trees were sprayed with a suspension of *Pseudomonas fluorescens* and Furdose.

(B+J): Trees were sprayed with a suspension of *Bacillus polymyxa* and Jisamar.

(B+F): Trees were sprayed with a suspension of *Bacillus polymyxa* and Furdose.
(M): Trees were sprayed with a suspension of the bacterial mixture.
(M+J): Trees were sprayed with a suspension of the bacterial mixture and Jisamar.
(M+F): Trees were sprayed with a suspension of the bacterial mixture and Furdose.
(C): Control trees sprayed with tap water

The Microbial inoculants were prepared and provided by Biofertilizers Production Unit, Soil, Water and Environment Research Institute, ARC, Egypt. Bacterial suspensions were diluted by mixing of ٤٠٠ ml of bacterial stocks with ٩ L of water per ٣ trees of each treatment. Each of the used bacterial species was grown on its specific medium. *Bacillus polymyxa* was grown up on liquid medium of Hino and Wilson (١٩٥٨) for ٣ days at ٣٠^{o}C. *Azospirillum brasilense* was grown up for ٣ days at ٣٠^{o}C on semi solid Döbereiner medium (Döbereiner *et al*., ١٩٧٦) and *Pseudomonas fluorescense* was grown up for ٣ days at ٣٠^{o}C on King s medium (King *et al.*, ١٩٥٤). Each tree was sprayed twice, at fruit sitting and ٣٠ days later for both seasons.

Viable counts of *P. fluorescense, A. brasilense* and *B. polymyxa*:

P. fluorescense, A. brasilense and B. polymyxa viable count in the phylosphere of apple tree were determined, ٣٠ days before fruit maturity at the second season, using respective media.

Estimation of plant growth promoting substances by bacteria:

Bacterial strains were tested for their capability to produce indole acetic acid (IAA) (Bric et al., ١٩٩١), were grown on Tryptone Soya Agar Medium (TSA) (Difco, ١٩٨٤). Quantitative determination of IAA was performed according to Glickmann and Dessoux (١٩٩٥). Total gibberellins were measured by the procedure of Udagwa and Kinoshita (١٩٦١).

Three branches, five years old, in different directions on each tree were selected and labeled to estimate growth parameters. All current shoots developed on these branches were measured to get shoot length (cm). Li-Core-٣١٠٠ Areameter was used to measure detached leaves of nine shoots (three shoots per branch) to get area per leaf (cm^{٢}). Leaves were dried at ٧٠°C and weighted to get dry weight (mg.) and then specific leaf weight (SLW) was calculated as (mg /cm^{٢}) according to Ferree and Forshey (١٩٨٨).

Spectrophotometer was used to estimate chlorophyll a and chlorophyll b which extracted from fresh leaves with di-methyl formamide (DMF) as described by Rami and Porath (١٩٨٠). The concentration of chlorophyll a and chlorophyll b and its total value were calculated by Rami's formulas as (µg / ml) (Rami ١٩٨٢) while results were presented as (mg /cm^{٢}).

Fruits were picked at maturity stage and weighted and counted. Fruit pulp texture (firmness) was recorded by using Lfra texture analyzer instrument. The results were expressed as a resistance force of the fruit to the penetrating tester (g/cm^{٢}) according to Harold (١٩٨٥). Fruit skin color measurements (a*, b*, L* & H°) were determined using Minolta colorimeter (Minolta Co. Ltd., Japan). The instrument estimated skin color of fruits with color metric CIE Lab method where L* measure lightness scale readings and

the two coordinates a * and b* included. Positive values of a* is a measure of redness and becomes greenish measure when values changed into negative, while b* of yellowness and blueness (- b*) on the Hue circle. The Hue angle [H° = arc tan (b*/a*)] describe the relative amounts of redness and yellowness where point at ٠°/٣٦٠° is defined for red/magenta, ٩٠° yellow, ١٨٠° for green and ٢٧٠° for blue color (McGuire, ١٩٩٢ and Voss, ١٩٩٢). Soluble solids content (SSC) was determined by using a hand refractometer and total acidity percentage was estimated in filtered juice according to A.O.A.C. (١٩٩٠).

Statistical analysis:

Data obtained were subjected to the analysis of variance and treatment means were compared using the L.S.D methods according to Steel and Torrie (١٩٨٠).

RESULTS AND DISCUSSION

The synthetic and/or bacterial biostimulants foliar spray treatments had an effective role in increasing shoot length of apple trees (Table ٢). At the first season, Jisamar treatment attained the highest and significant increase (٦٤,٨٣ cm) followed by the treatment of *P. fluorescens* which gave, a significant increase of ٦٤,٦٣ cm compared to water spray (control) treatment (٥٦,٣٦ cm). The second season trend was similar to that of the first one. The studied treatments exhibited not significant increments in shoot diameter. The spray with Furdose, Jisamar and bacterial inoculants and their mixtures with PGPR biostimulants had a great effect in increasing leaf area and dry weight. In most cases, the treatments achieved consistent, remarkable and significant increases over control. Specific leaf weight (SLW) data did not show significant differences.

Spray of fruit trees with compounds containing amino acids, plant phytohormones, humate, N,P,K and some microelements contribute in improving tree growth, promote flowering process and fruit setting, which consequently, reflected positively on the fruit yield (Eissa, ٢٠٠٣). Likewise, foliar application with some PGPR types (*Azotobacter chroococcum*) gave results similar to the action of these treatments (Nour El-Din, ٢٠٠٦). The results of the present study showed that foliar spray with some synthetic plant stimulants (Furdose and Jisamar) which contain sea weeds extracts, amino acids, low percentages of N, P and K with microelements had the positive effect on shoot length, stem diameter, leaf area and leaf dry weight. The spray with the varied PGPR types alone or mixed with the synthetic biostimulants, similarly, increased these characteristics of apple trees, in some cases surpassed synthetic ones. This promoting influence is attributed to the plant phytohormones, amino acids, vitamins and macro and microelements contained in bacterial biostimulants. Fathi *et al.* (٢٠٠٢) found that spray with $GA_٣$, K-humate and ascorbic acid significantly increased shoot length, leaf area of "Desert Red" peach and increased leaf area and leaf dry weight of "Anna" apple. Esitken *et al.* (٢٠٠٤), also, reported that spray

with *Bacillus* OSU١٤٢ at full bloom, ٣٠ and ٦٠ days after blooming increased shoot length and growth of apricot tree especially when sprayed at full bloom.

Table ٢: Effect of spray with some synthetic and some bacterial biostimulants (PGPR cultures) on "Anna" apple vegetative characteristics

Treatments	Shoot length (cm)		Shoot Diameter (cm)		Leaf dry weight (g)		Leaf area (cm^2)		(SLW) (mg cm^2)	
	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠
A	٦١,٢ abc	٥٨,٤٣ abc	١,٥٩ ab	١,٥٣ ab	٠,٣٧٠ bcd	٠,٣٤٣ abc	٣٣,٩٣ abc	٣٠,٦٣ bcd	١٠,٨٤ bcd	١١,١٦ b-e
A+J	٥٧,٥٦ bc	٥٥,٥٧c	١,٦٢ ab	١,٥٧ ab	٠,٣٦٣c d	٠,٣٣٣b c	٣٤,٨ abc	٣٢,٤٣a bc	١٠,٣٨d	١٠,٣٧d -e
A+F	٦٠,١٦ abc	٥٧,١٧b c	١,٦٩ ab	١,٥٧ ab	٠,٣٩ abc	٠,٣٧٧a b	٣٧,٠٦a	٣٤,١٣a b	١٠,٦٦c d	١٠,٨٦b e
B	٦١,٩٣ ab	٥٣,٧٣a bc	١,٧٥ a	١,٦٤ a	٠,٣٤٧d	٠,٣٢٠c d	٣٢,٢٣a -d	٢٨,٧٣c -f	١٠,٧١c d	١١,١١b -e
B+J	٥٦,١ c	٥٧,٤٧b c	١,٦٣ ab	١,٥١ ab	٠,٣٤٧d	٠,٣١٧c d	٣١,٤٦a -d	٢٨,٧٣c -f	١١,٠٠b cd	١٠,٠٩e
B+F	٦١,٠٦ abc	٥٥,٤٣c	١,٦٩ ab	١,٥٦ ab	٠,٣٩ abc	٠,٣٧٣a b	٣١,٧ a-d	٢٩,٣ b-e	١٢,٠٤a d	١٢,٨٨a bc
P	٦٤,٦٣ a	٦٠,٨ ab	١,٦٦ ab	١,٥٧ ab	٠,٣٩٧a bc	٠,٣٧٠a b	٣٥,٩٦a	٣٦,٠٧a	١١,٢٤b cd	١٠,٣٤d e
P+J	٦٠,٢ abc	٥٦,٦٧b c	١,٧٣ ab	١.٦٠ a	٠,٣٧٠b cd	٠,٣٥٠a bc	٣٦,١ a	٣٣,١٠a bc	١٠,٢٩d	١٠,٥٦c de
P+F	٦١,٦ abc	٥٥,٨٣c	١,٦٥ ab	١,٥٢ ab	٠,٤١٠a b	٠,٣٨٧a	٣٥,٢٦a b	٣٥,٥٧a	١١,٧٠b cd	١٠,٩١b -e
M	٥٨,٥٣ bc	٥٤,٢ c	١,٥٨ ab	١,٥ ab	٠,٣٣٧d e	٠,٣٠ cd	٢٦,٣ de	٢٤,٠ fg	١٢,٨٤a bc	١٢,٩٥a bc
M+J	٥٧,٦٣ bc	٥٥,٠ c	١,٥٨٠a b	١,٤٦ ab	٠,٣٤٣d e	٠,٣١٧c d	٢٦,٥٣d e	٢٤,١٧f g	١٢,٩٧a bc	١٣,٠١a b
M+F	٥٨,١٦ bc	٥٥,٨ c	١,٦٣ ab	١,٥٥ ab	٠,٣٤٧d	٠,٣٢٠c d	٢٦,٦٣d e	٢٤,٣٧e fg	١٣,١٠ a b	١٣,١٧a b
J	٦٤,٨٣ a	٥٧,٣ bc	١,٦٩ ab	١,٥٦ ab	٠,٤١٧a	٠,٣٣٣b c	٢٩,٠٦c de	٢٦,١٣d -g	١٤,٣٧a	١٢,٧٨a bc
F	٦٠,٤ abc	٦١,٩٧a	١,٦٦ ab	١,٦٢ a	٠.٣٦ cd	٠,٣٨ a	٢٩,٢ bc	٢٦,٩٣d -g	١٢,٤٤ a-d	١٤,٤٢a
C	٥٦,٣٦ bc	٥٣,٩٧c	١,٥٣ ab	١,٤٠ b	٠,٣٠٣e	٠,٢٨٣d	٢٤,٤٦e	٢٢,٣ g	١٢,٠٥ a-d	١٢,٥٥a -d

***J: Jisamar; F: Furdos; A: *Azospirillum brasilense*; B: *Bacillus polymyxa*; P: *Pseudomonas fluorescens*; M: microbial mixture, SLW : Specific leaf weight.**

****Means with different letters within the same column differ significantly at P < ٠,٠٥.**

The results presented in Table ٣ showed an increase in chlorophyll content of leaf as a result of treatment with Jisamar and Furdos synthetic biostimulants as will as spray with PGPR biostimulants. The first season results showed significant increments in chlorophyll a resulted from spray with each of *A. brasilense*, *B. polymyxa and P. fluorescen*s alone, while, the mixture of them did not give significant difference. However, a significant increase was observed due to application with Furdose compared to control.

The treatment with *P. fluorescens* + Jisamar recorded ٥,٠٤ and ٤,٨٩ mg/cm^{٢} at first and second seasons, respectively. The trend of the second season results was similar to that of the first one. The spray with PGPR bacteria as will as PGPR with F or J potentially increased fruit production per tree, The spray with *Azospirillum brasilense* culture gave the highest results for both studied seasons, which attained ٤٥,١٦ and ٤١,٢٠ kg/tree at ٢٠٠٩ and ٢٠١٠ seasons, respectively, followed by the spray with *Azospirillum brasilense* + Jisamar which achieved production averaged ٤٣,٨٦ and ٤٠.٧٣ kg/tree for both seasons compared to ٣٣,٥٣ and ٣٢,٠٧ kg/tree for control treatment at the seasons ٢٠٠٩ and ٢٠١٠, respectively. The differences than control were significant. Likewise, number of fruits per tree was positively affected by the different spray treatments, although, the most differences were not significant except the treatment of spray with *Azospirillum brasilense* or *Azospirillum brasilense* with F or J as will as *B. polymyxa or B. polymyxa* with F or J which attained significant differences at both seasons. The treatment of *Azospirillum brasilense* spray recorded the highest fruit number / tree at ٢٠٠٩ and ٢٠١٠ seasons (٣٤٦,٣ and ٣١٤,٠, respectively).

The increase of leaves chlorophyll content resulted from spray with synthetic or bacterial biostimulants is due to the stimulation and nutrientive effect on the plant. Gisamar and Furdose contains nutrients and stimulating compounds like short chain amino acids, plant phytohormones, vitamins and some macro- and micro-elements. Maini (٢٠٠٠) reported that the biostimulants (Siapton) which based on short chain amino acids increased the chlorophyll content for wheat plant. Also, Ferrini and Nicese (٢٠٠٢) sprayed Oak plants with two types of biostimulants; WPth which composed of humic acid, seaweeds extract, Yucca extracts, vitamins and nitrogen fixing bacteria, and DP^{TM} compound which composed of indo and ecto mycorrhiza, biostimulant bacteria, humic acids, carbohydrate, vitamins and Yucca extract. They claimed that photosynthesis and chlorophyll content were enhanced. The spray with Furdose and Jisamar, in the present study, stimulated the growth and increased fruit yield, but the spray with bacterial biostimulants had a strong influence than the synthetic biostimulants, and the treatment of *Azospirillum brasilense* foliar spray was the best in this concern. The mechanisms of bacterial biostimulants action may be summarized as follow:

١- Increase of number and size of plant cells due to the function of plant phytohormones like IAA, cytokinens and gebrillins (Iqbal *et al*., ٢٠١١).
٢- The polyamines contained in the synthetic biostimulants and these released by bacterial biostimulants regulate many growth processes; differentiation, formation of embryo, setting and ripening of fruits (Taha and Eid, ٢٠١١).
٣- Stimulate production of antioxidants, therefore, decrease free radicals or reactive oxygen molecules leads to improvement of plant growth especially at biotic and abiotic stress like salinity, dryness and high exposure to UV. Most importantly, they provide essential information on cellular redox state, and regulate gene expression associated with biotic and abiotic stress responses to optimize defense and survival (Shao *et al*., ٢٠٠٨).

٤- These stimulants contained some macro and micro-elements which enhance plant growth (Maini, ٢٠٠٠).

٥- The bacterial biostimulants release plant phytohormones, amino acids, antioxidants, siderofores and antibiotics in addition to fixing atmospheric nitrogen in the rhizosphere or phyllosphere (Martinez-Viveros *et al*., ٢٠١٠).

Table ٣: Effect of spray with some synthetic and some bacterial biostimulants (PGPR cultures) on chlorophyll content and fruit yield of "Anna" apple trees

Treatments	Chlorophyll a (mg/cm^2)		Chlorophyll b (mg/cm^2)		Total chlorophyll (mg/cm^2)		Fruit weight (Kg/tree)		Fruit number	
	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠
A	٤,٦٤ cd	٤,٤٤ cd	٢,٥٦ ab	٢,٤٢ ab	٧,٢٠ bc	٦,٨٦ cde	٤٥,١٦ a	٤١,٢٠ a	٣٤٦,٣a	٣١٤,٠ a
A+J	٤,٦٩ bcd	٤,٥٢ bc	٢,٥١ ab	٢,٣٩ ab	٧,٢٠ bc	٦,٩١ bcd	٤٣,٨٦ ab	٤٠,٧٣ ab	٣٣٠,٠ ab	٣٠٠,٣ abc
A+F	٤,٥٦ de	٤,١٣ cde	٢,٤٧ abc	٢,٣٧ abc	٧,٠٣ cd	٦,٧٦ def	٤٢,٤٦ abc	٣٩,١٠ abc	٣١٢,٠ abc	٢٧٤,٣ cde
B	٤,٤٠٧ d-g	٤,٢٣ de	٢,٣٢ bcd	٢,٢٠ bcd	٦,٧٣ def	٦,٤٣ fg	٤٢,٩٦ ab	٣٩,٤٠ abc	٣٢٧,٦ ab	٢٩٨,٠ a-d
B+J	٤,٥٥ de	٤,٣٢ cde	٢,٢٩ bcd	٢,١٨ bcd	٦,٠٨ c-f	٦,٥٠ fg	٤٠,٩٣ a-d	٣٧,٥٣ a-d	٣١٨,٣ abc	٢٩٥,٣ a-d
B+F	٤,٤٤ def	٤,٢٥ de	٢,٣٩ a-d	٢,٢٩ a-d	٦,٨٤ c-f	٦,٥٤ efg	٤٠,٨٣ a-d	٣٧,٢٣ a-d	٣٢٨,٠ ab	٣٠٤,٦ ab
P	٤,٩١ abc	٤,٧٢ ab	٢,٦١ a	٢,٤٩ a	٧,٥٣ ab	٧,٢١ ab	٣٩,٢٣b cd	٣٦,١٠b -e	٣١٦,٦a bc	٢٨٣,٣b -e
P+J	٥,٠٤ a	٤,٨٩ a	٢,٦٠ a	٢,٤٩ a	٧,٦٦ a	٧,٣٩ a	٣٧,٤ cde	٣٤,٩٧c -f	٣٠٦,٣b c	٢٧٨,٠ b-e
P+F	٤,٩٣ ab	٤,٧٣ ab	٢,٥٣ ab	٢,٤٢ ab	٧,٤٧ ab	٧,١٥ abc	٣٧,٠٣c de	٣٣,٩٣d ef	٣٢١,٠a bc	٢٩٦,٠a -d
M	٤,١٥ g	٣,٩٦ f	٢,١٦ d	٢,٠٥ d	٦,٣١ g	٦,٠١ h	٣٣,٤٣e	٣٠,٥٠f	٢٨٧,٦c	٢٦٣,٣e
M+J	٤,٤١ d-g	٤,١٦ ef	٢,٢٠ cd	٢,٠٩ d	٦,٦٢ efg	٦,٢٥ gh	٣٧,٢٣c de	٣٤,٣٧c -f	٣٠٠,٦b c	٢٦٢,٠e
M+F	٤,٢٥ fg	٤,٠٧ ef	٢,٣٢ bcd	٢,١٩ bcd	٦,٥٧ fg	٦,٢٦ gh	٣٨,٥b-e	٣٦,٢٠b -e	٣٠٣,٦b c	٢٦٩,٧d e
J	٤,٨٩ abc	٤,١٧ ef	٢,٥٣ ab	٢,٤١ ab	٧,٤٢ ab	٦,٥٩d-g	٣٧,٤cd e	٣٣,٢٧d ef	٣١٥,٠a bc	٢٨٥,٦a -e
F	٤,٤٢٧d -g	٤,٧١ ab	٢,٥٦ ab	٢,٤١ ab	٦,٩٣ cde	٧,١١ abc	٣٦,٥٣d e	٣٤,٧٧c -f	٣١٣,٣a bc	٢٨٧,٦a -e
C	٤,٢٩ efg	٤,٠٩ ef	٢,٢٣٠c d	٢,١٤ cd	٦,٥٢ fg	٦,٢٣ gh	٣٣,٥٣e	٣٢,٠٧e f	٢٩٢,٠c	٢٦٦,٠e

***J: Jisamar; F: Furdos; A: *Azospirillum brasilense*; B: *Bacillus polymyxa*; P: *Pseudomonas fluorescens*; M: microbial mixture.**

****Means with different letters within the same column differ significantly at P < ٠,٠٥.**

Data of Table ٤, some important quality parameters of the fruits were determined like soluble solid content (SSC), acidity, firmness and color. The values of SSC through the two studying seasons were generally lowered due to spraying with stimulants whether were synthetic or biological, but the

differences from the control did not usually reach to significance. While acidity of the fruits, in general, increased by the sprayed treatments especially with bacterial biostimulants in both seasons. The foliar spray with the studied bacterial biostimulants, generally, led to significant increases in firmness values of the fruit, at the second season only. The treatments of synthetic or biological decreased the color degree of the fruits and this effect was clear for results of the second season where all differences than control treatment were significant. The control values recorded ٩٤,٨٤ and ٩٠,٣٤ for seasons ٢٠٠٩ and ٢٠١٠ compared to values ranged from ٦٥,٠٢ to ٨٣.٨٤ at season ٢٠٠٩ and from ٧٠,٦٣ to ٨٢,٢٥ at season ٢٠١٠.

Table ٤: Effect of spray with some synthetic and some bacterial biostimulants (PGPR cultures) on some fruit quality characters of "Anna" apple trees

	SSC		Acidity		Firmness		Color	
Treatments	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠	٢٠٠٩	٢٠١٠
A	١٣,٢٠ a	١٣,٣٣a	٠,٨٢ab	٠,٨٦bc	٢٢٦,٠ab	٢٦٣,٣b	٧٩,٢٣a	٧٧,٦٨bcd
A+J	١٢,٩٣abc	١٣,١٦ab	٠,٨٥b	٠,٨٦bc	٢٦٠,٠a	٢٦٣,٠b	٧٤,١٧a	٧٥,٠١bcd
A+F	١٣,٠٦ab	١٣,٢٦a	٠,٨٤b	٠,٨٧c	٢٣٧,٦a	٢٤٥,٣c	٧٦,١٧a	٧٧,٨٥bcd
B	١٢,٦٠bcd	١٢,٩٨abc	٠,٨٢bc	٠,٧٨ef	٢٦٧,٦a	٢٨٠,٠a	٧٣,٠٢a	٧٥,٦٢bcd
B+J	١٢,٤٠cd	١٢,٢٦d	٠,٩٤a	٠,٩٢ab	٢١٥,٦ab	٢٨٥,٦a	٧٢,٩٦a	٧٥,٣٧bcd
B+F	١٢,٢٣d	١٢,٨٣abc	٠,٩٤a	٠,٩٣ab	٢٨٠,٠a	٢٨٣,٦a	٧١,١١a	٧٥,٢٦bcd
P	١٢,٤٣cd	١٢,٦٣bcd	٠,٨٤b	٠,٨٦bcd	٢٦٩,٠a	٢٧٧,٦a	٧٢,١٠a	٧٥,٥١bcd
P+J	١٢,٤٠cd	١٢,٦٦bcd	٠.٨٢bc	٠,٧٧ef	٢٨٦,٣a	٢٨٤,٦a	٦٥,٠٢a	٧٠,٦٣d
P+F	١٢,٤٣cd	١٢,٦٣bcd	٠,٩٧a	٠,٩٦a	٢٨٦,٣a	٢٨٦,٣a	٦٦,٢٩a	٧٠,٢٦d
M	١٣,١٣ab	١٣,٣٠a	٠,٨٠bc	٠,٧٧ef	٢٢١,٠ab	٢٢٩,٠d	٧١,٨١a	٧٣,٨٤cd
M+J	١٢,٤٣cd	١٢,٦٠cd	٠,٨٢bc	٠,٨١cde	٢٢١,٠ab	٢٢٧,٠d	٧٣,٧٣a	٧٥,٣٢bcd
M+F	١٢,٦٠bcd	١٢,٨٦abc	٠.٨١bc	٠,٧٩def	٢٢٠,٠ab	٢٢٩,٠d	٧٣,٨٣a	٧٥,٢٩bcd
J	١٢,٦٦a-d	١٢,٨٣abc	٠,٧٤cd	٠,٧٢fg	٢٢٢,٠ab	٢٣٢,٦cd	٨٣,٨٤a	٨١,٥٤bc
F	١٢,٨٨abc	١٣,٠٠abc	٠,٧٤cd	٠,٧٠g	٢٢٣,٠ab	٢٣٤,٦cd	٨٢,٣٠a	٨٢,٢٥b
C	١٣,٠٦ab	١٣,٠٣abc	٠,٦٩d	٠,٧٧ef	٢٠٧,٠ab	٢٢٠,٦d	٩٤,٨٤a	٩٠,٣٤a

***J: Jisamar; F: Furdos; A: *Azospirillum brasilense*; B: *Bacillus polymyxa*; P: *Pseudomonas fluorescens*; M: microbial mixture.**

****Means with different letters within the same column differ significantly at P < ٠,٠٥.**

The spray with gibberellic acid ($GA_٣$) showed improvement for fruit quality of jambu madu (Moneruzzaman *et al*, ٢٠١١), apple fruits (Ryu *et al*., ٢٠١١). At the same time Pirlak and Köse (٢٠٠٩) claimed that the spray of strawberry with *Pseudomonas* BA-٨ and other PGPR bacteria increased TSS and acidity of the fruits. The spray with synthetic or bacterial biostimulants lead to decrease of SSC values and color of fruits but increased acidity and firmness, however, most variations were not significant. Sahain *et al*. (٢٠٠٧) reported different results, whereas, they showed that spray of apple trees with EM biostimulant (composed of fluorescent bacteria and fermentative fungi) increased TSS and decreased acidity and firmness of the fruits, the difference in the influence may be due to the variation in the microbial composition between EM and the present used PGPR bacteria. Results of Esitken *et al.* (٢٠٠٩) were similar to our findings as they sprayed the trees with some PGPR types.

Viable counts (Table ٥) of the used microorganisms as foliar spray notably increased in the phyllosphere of the plant. The counts of *Azospirillum brasilense* appeared very high due to spray with the liquid culture of *Azospirillum brasilense*, this effect clearly appeared after spray with *Azospirillum brasilense* alone or mixing with Jismar or Furdos. The spray with the mixture of *Azospirillum brasilense* and Jismar attained the highest average number of *Azospirillum* evaluated ٢٤٠ x ١٠^{٢} cfu/cm^{٢} of leaf. Likewise, the spray with *B. polymyxa* culture alone or mixed with Jisamar had potential effect in increasing its numbers in the phyllosphere, which represented ٤٥ x ١٠^{٢} and ٤٠ x ١٠^{٢} cfu/cm^{٢} of leaf, respectively. Similar results happened with the spray with *P. fluorescens* which caused clear increase of the applied microbe in the phyllosphere area, the counts were ٥ x ١٠^{٢}, ٣٠ x ١٠^{٢} and ٢٥ x ١٠^{٢} cfu/cm^{٢} of leaf due to spray with *P. fluorescens* only, *P. fluorescens* + J and *P. fluorescens* + F, respectively. The spray with the mixture of the three microorganisms only or mixed with J or F attained increments over that of the control, but these increments were lower than these caused by spray with each microbe alone. The counts of the tested baceria of control treatment averaged ٠,١ x ١٠^{٢}, ٠,٠٥ x ١٠^{٢} and ٠,٠٤ x ١٠^{٢} cfu/cm^{٢} of leaf due to the spraying with *Azospirillum brasilense*, *B. polymyxa* and *P. fluorescenc*, respectively.

Table ٥: Effect of spray with some synthetic and some bacterial biostimulants (PGPR cultures) on the counts of the used PGPR bacterial cells in the phyllosphere of "Anna" apple trees at ٢٠١٠ season.

Treatment	*Azospirillum* x١٠^{٢}	*B. polymyxa* x١٠^{٢}	*P. fluorescens* x١٠^{٢}
A	٣٤,٠	٠,١	٠,٤
A+J	٢٤٠,٠	٠,٢	٠,٣
A+F	٤,٠	٠,١	٠,٣
B	٠,٢	٤٥,٠	٠,٣
B+J	٠,٢	٤٠,٠	٠,٥
B+F	٠,٢	٦,٠	٠,٥
P	٠,٣	٠,٢	٥,٠
P+J	٠,٣	٠,١١	٣٠,٠
P+F	٠,٥	٠,٣	٢٥,٠
M	٢,٠	٠,٣	٠,٥
M+J	٥,٠	٢,٠	٠,٣
M+F	٧,٠	٠,٤	١,٠
J	٠,٥	٠,٠٢	٠,٠٥
F	١,٠	٠,٤	١,٠
C	٠,١	٠,٠٥	٠,٠٤

***J: Jisamar; F: Furdos; A: *Azospirillum brasilense*; B: *Bacillus polymyxa*; P: *Pseudomonas fluorescens*; M: microbial mixture.**

Spray of plant phyllosphere with PGPR bacteria resulted in increased counts of these bacteria in the phyllosphere, our results confirmed those of Kim *et al.* (٢٠١١) as they reported effective colonization of the used PGPR bacteria in the phyllosphere of pepper plants compared to control plants.

They, also, noted that most of the fluorescent bacterial cells were localized near the stomata and throughout the blade part of the inoculated leaves.

Readings of Table ٦ show the productivity of apple fruits (tons/fed.), costs of production, total and net return (LE/fed). The fixed costs (land rent, labors, fertilizers, pesticides, hoeing and pruning) reached about ٥٠٠٠ **£** E/fed. Changed costs include chemical or biological stimulators, rent of spray machine and spray labor reached ٦٠٠ **£** E/fed. The price of apple fruits evaluated ٣٥٠٠ **£** E/ton.

Table ٦: Economic evaluation of apple trees spray with some synthetic and some bacterial biostimulants (PGPR cultures)

Treatments	Fixed costs (£.E/fed.)	Changed costs (£.E/fed.)	Total costs (£.E/fed.)	Total yield (Ton/ fed.)	Value (£.E/fed.)	Net return (£.E/ fed.)	Increase / decrease in return than control
A	٥٠٠٠	٦٠٠	٥٦٠٠	٧,٧٧	٢٧١٩٥	٢١٥٩٥	٥٩٤٥
A+J	٥٠٠٠	٦٠٠	٥٦٠٠	٧,٦١	٢٦٦٣٥	٢١٠٣٥	٥٣٨٥
A+F	٥٠٠٠	٦٠٠	٥٦٠٠	٧,٣٤	٢٥٦٩٠	٢٠٠٩٠	٤٤٤٠
B	٥٠٠٠	٦٠٠	٥٦٠٠	٧,٤١	٢٥٩٣٥	٢٠٣٣٥	٤٦٨٥
B+J	٥٠٠٠	٦٠٠	٥٦٠٠	٧,٠٦	٢٤٧١٠	١٩١١٠	٣٤٦٠
B+F	٥٠٠٠	٦٠٠	٥٦٠٠	٧,٠٣	٢٤٦٠٥	١٩٠٠٥	٣٣٥٥
P	٥٠٠٠	٦٠٠	٥٦٠٠	٦,٧٨	٢٣٧٣٠	١٨١٣٠	٢٤٨٠
P+J	٥٠٠٠	٦٠٠	٥٦٠٠	٦,٥١	٢٢٧٨٥	١٧١٨٥	١٥٣٥
P+F	٥٠٠٠	٦٠٠	٥٦٠٠	٦,٣٩	٢٢٣٦٥	١٦٧٦٥	١١١٥
M	٥٠٠٠	٦٠٠	٥٦٠٠	٥,٧٥	٢٠١٢٥	١٤٥٢٥	-١١٢٥
M+J	٥٠٠٠	٦٠٠	٥٦٠٠	٦,٤٤	٢٢٥٤٠	١٦٩٤٠	١٢٩٠
M+F	٥٠٠٠	٦٠٠	٥٦٠٠	٦,٧٢	٢٣٥٢٠	١٧٩٢٠	٢٢٧٠
J	٥٠٠٠	٦٠٠	٥٦٠٠	٦,٣٦	٢٢٢٦٠	١٦٦٦٠	١٠١٠
F	٥٠٠٠	٦٠٠	٥٦٠٠	٦,٤٢	٢٢٤٧٠	١٦٨٧٠	١٢٢٠
C	٥٠٠٠	٠,٠	٥٠٠٠	٥,٩٠	٢٠٦٥٠	١٥٦٥٠	-

J: Jisamar; F: Furdos; A: *Azospirillum brasilense*; B: *Bacillus polymyxa*; P: *Pseudomonas fluorescens*; M: microbial mixture.

The calculations of net return per feddan exhibited that the application of treatments of Jisamar and Furdose attained net return over the treatment of control by about ١٠١٠ and ١٢٢٠ **£** E/fed, respectively. The application of bacterial biostimulants alone or mixed with Jisamar or Furdose, however, attained net return much higher than both the control and synthetic stimulators. The highest obtained increase in net return over control treatment was attained by spray with *Azospirillum brasilense* (٥٩٤٥ **£** E/fed) followed by treatment of *Azospirillum brasilense* +J which achieved ٥٣٨٥ **£** E/fed. An increase reached ٤٦٨٥ **£** E/fed due to spray with *B. polymixa*. Otherwise, the only treatment that exhibited decrease than control was the spray with the mixture of the microorganisms.

Finally, from the economic evaluation for the influence of synthetic and bacterial biostimulants, it could be conclude that these compounds increased plant growth and yield without a notable increase in costs because

of the lower price of these compounds. Thus, the net return was positive, whereas, the spray with *Azospirillum brasilense* liquid culture gave the highest net return (٥٩٤٥ **£** E/feddan), and the net return of bacterial biostimulants was much larger than those of synthetic biostimulants. Therefore, we recommend the spray of apple trees twice with liquid cultures of effective *Azospirillum brasilense* cultures by the rate of ٢٠ L per feddan as alternative to the application of synthetic biostimulants.

Table (٧): Production of indole acetic acid (IAA) and total gibberellins by the used bacterial strains.

Strain	G.P.S*(mg/l)	
	IAA	GA
Pseudomonas fluorescense	١٦٠,٠	٤٨٥,٠
Bacillus polymyxa	١٥٧,٠	٥٧٤,٥
Azospirillum brasilense	١٠١,٤	٦٠٤,٣

G.P.S.* Growth Promoting Substances

The different bacterial isolates produced different amounts of IAA and GA (Table ٧). However, *Azospirillum brasilense* release the highest amounts of GA (٦٠٤,٣ mg/l) compared to ٤٨٥ and ٥٧٤.٥ mg/l for *Pseudomonas fluorescence* and *Bacillus polymyxa* respectively. *Pseudomonas fluorescence* attained the highest IAA amount (١٦٠ mg/l) compared to ١٥٧ and ١٠١,٤ mg/l for *Bacillus polymyxa* and *Azospirillum brasilense*, respectively.

Yicheng Tu (٢٠٠٠) reviewed that gibberellins(GA) were first discovered by Japanese scientists studying a rice disease characterized by excessive stem elongation named “bakenae” (foolish seedling). The symptom was found to be stimulated by compound(s) released by a fungus *Gibberella fujikuroi*. In ١٩٣٥, the compound was isolated and named after the fungus as “Gibberellin”. Further experiments showed that GA not only occurred in plants but also played a key role in various aspects of plant growth and development. GAs were found to promote cell expansion and perhaps cell division that led to elongation of shoot tissues and development of a number of other morphological structures such as inflorescences and fruit.

The effects of plant growth promoting rhizobacteria (PGPR) on the rooting and root growth of semi-hardwood and hardwood kiwifruit stem cuttings were investigated by Martínez-Viveros (٢٠١٠). The PGPR used were *Bacillus* RC٢٣, *Paenibacillus polymyxa* RC٠٥*, Bacillus subtilis* OSU١٤٢, *Bacillus* RC٠٣, *Comamonas acidovorans* RC٤١, *Bacillus megaterium* RC٠١ and *Bacillus simplex* RC١٩. All the bacteria showed indole-٣-acetic acid (IAA) producing capacity. Among the PGPR used, the highest rooting ratios were obtained at ٤٧,٥٠٪ for semi-hardwood stem cuttings from Bacillus RC٠٣ and Bacillus simplex RC١٩ treatments and ٤٢,٥٠٪ for hardwood stem cuttings from *Bacillus* RC٠٣. As well, *Comamonas acidovorans* RC٤١ inoculations indicated higher value than control treatments. The results suggest that these PGPR can be used in organic nursery material production and point to the feasibility of synthetic auxin (IBA) replacement by organic management based on PGPR. While Anwar (٢٠٠٧) found that *Azospirillum* K-I produced higher amount of GA (١٠ ug/ml) which decreased in later growth stages. This

decrease in GA might be due to its hydrolysis by bacterial strain. *Azoarcus* K-I and *Azospirillum* ER-٢ and ER- ٢٠ also produced indole, acetamide as identified by HPLC. These strains were also useful for increasing rice biomass, N-uptake and fertilizer-N use efficiency. In green house experiments, inoculation of rice with PGPR increased chlorophyll, leaf area, tiller number, plant height, root shoot biomass and grain yield in rice. Soil, root, leaf and stem inoculation methods were equally useful for plant growth improvement

CONCLUSION

The spray of Anna apple trees with synthetic biostimulants (Jisamar and Furdose) resulted in an increase in growth and yield of apple trees and did not significantly affected the quality of the resulted fruits, but leads to increase of fruit weight. The spray with bacterial biostimulants, however, gave best results and the application of *Azospirillum brasilense* surpassed the other bacterial biostimulants. The single spray with bacterial biostimulant showed best results than their mixture with Jisamar or Furdose. Thus, the spray with *Azospirillum brasilense* was the best which may be safely used as an alternative to the chemical synthetic biostimulants.

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إستجابة نمو و محصول و جودة ثمار أشجار التفاح "أنا" للرش الورقي ببعض الميكروبات المنتجة لمنظمات النمو كبديل عن الرش بمنشطات النمو الكيماوية

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تم مقارنة الرش بالمركبات الكيماوية بالرش بالمزارع الميكروبية و الخلط بينهم لتحديد كفاءتها و إمكانية استبدال هذه المركبات الحيوية الطبيعية بتلك الكيماوية.

تم اختيار حقل منزرع بأشجار التفاح صنف "أنا" عمر ثماني سنوات و تم تحديد عدد ثلاثة أشجار لكل معاملة ثم رشت الأشجار بالمعاملات المختلفة مرتين الأولى عند الإزهار و الأخرى بعد عقد الثمار بالمقارنة بالرش بالماء كمعاملة مقارنة.

حققت معاملة الرش بالمنشطات الكيماوية تحسنا ملحوظا في خواص النبات الظاهرية مثل طول الفروع، قطر الفروع، مساحة الورقة، الوزن الجاف للورقة و محتوى الورقة من كلوروفيل أ و ب و الكلوروفيل الكلي، فيما لم يتغير الوزن النوعي للورقة معنويا. أظهرت معاملات الرش بالمنشطات الحيوية تأثيرا مماثلا للمنشطات الكيماوية (الجيسمار و الفردوس) بل تفوقت عليها في بعض الحالات. كما أظهرت أعداد الميكروبات التي تم الرش بها أعدادا كبيرة بمنطقة الفيلوسفير. على الرغم من زيادة إنتاجية ثمار التفاح بسبب الرش بالمحفزات الحيوية و الكيماوية، فان الرش بالمحفزات الحيوية تفوقت و بدرجة عالية على تأثير الرش الكيماوي، حيث حققت معاملة الرش بالازوسبيرليم أعلى إنتاجية و هي٤٥،١٦ و ٤١،٢ كيلوجرام/شجرة لموسمي ٢٠٠٩ و ٢٠١٠ في مقابل ٣٣،٥٣ و ٣٢،٠٧ على التوالي لمعاملة الكنترول و أعطى الرش بالجيسمار ٣٧،٤ و٣٣،٢٧ و بالفردوس ٣٦،٥٣ و ٣٤،٧٧ كيلوجرام/شجرة على التوالي. كما حققت معاملة الرش بالازوسبيرليم أعلى صافي عائد بالجنيه المصري وهو٢١٥٩٥ في مقابل ١٦٦٦٠ و ١٦٨٧٠ و ١٥٦٥٠ لمعاملات الجيسمار والفردوس والكنترول على التوالي. لذلك فمن المناسب استبدال الرش بالمحفزات الحيوية مثل مزارع الازوسبيرليم المخففة لهذه المنشطات الكيماوية لكفاءتها في تحسين نمو الأشجار و زيادة الإنتاجية مع تحسين العائد الاقتصادي للفدان.

قام بتحكيم البحث

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