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EFFECT OF FOLIAR APPLICATION OF SOME GROWTH PROMOTRES ON GROWTH, FRUITING AND FRUIT QUIALITY OF "SULTANI" FIG TREES

ABD-ELLA, EMAN*, E.K. AND WAFAA. A.A.Z. EL-SISI**

***Hort. Res. Station, Sabahia, Alex. **EL. Maamoura Botanical garden, Alex. Hort. Res. Inst., Agric. Res, Center, Egypt.**

ABSTRACT

This investigation was carried out during 2009 and 2010 growing seasons on ten years old Sultani fig trees, grown in a calcareous soil in a private farm in Burg El-Arab region, about 70 kilometers west of Alexandria in order to study the effect of foliar spray with different concentrations of some growth promoters i.e. EM (effective microorganisms) at 10%, 20% and 30% or GA_3 (growth regulator) at 10ppm,20ppm and 30ppm on vegetative growth, fruit set, yield, yield increment, fruit quality and leaf mineral content during both seasons of the study. Results showed that vegetative growth ,fruit set, yield as weight or number of fruits / tree as well as fruit quality (average fruit weight, diameter, length, TSS and total sugar) and leaf N, P and Fe content were generally, improved by increasing the concentration of both treatments as compared with control in both seasons while, slight effect on acidity was noticed. The studied treatments did not significantly affect leaf K, Mn, Zn and fruit vitamin C. in both seasons. The obtained results indicated that 30% of EM was the best concentration to increase all vegetative growth parameters, leaf chlorophyll, N, P and Fe as well as fruit set %, yield and its increment. Similar trend was attained by spraying trees with GA_3 at highest concentration (30ppm) on some fruit quality parameters (fruit

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weight, length, diameter and total sugar) in both seasons and for TSS in the 1st one. It is worthy to note that, spraying trees with highest concentration of EM (30%) had a similar effect to spraying trees with GA_3 at highest concentration (30 ppm). Hence, it could be concluded that spraying fig trees with EM at higher rate (30%) is a promising treatment under the same condition of our study as it is safe, natural, less polluting and recommended to produce highest yield with best fruit quality.

INTRODUCTION

In conventional agriculture, chemical fertilizers, pesticides and plant growth regulators are usually applied to increase the yield and quality of crops. However, frequent and excessive use of these chemicals has often resulted in adverse environmental effects, disturbing the ecological balance and making plants even more susceptible to pests and diseases (Bhanti and Taneja, 2007). There is a growing concern that food produced under such farm management may not be safe or of good quality. Public awareness to these problems has shifted the approach towards some alternative measures (Shaxson, 2006). In recent past, bio-product and microbial inoculants have been introduced to modern agriculture as a natural substances to produce food with good quality, and safety with minimize the bad effects of the former (Kannaiyan, 2002). A microbial inoculant containing many kinds of naturally occurring beneficial microorganisms (photosynthetic bacteria, lactic acid, actinomycetes, yeast and fungi) called Effective Microorganisms (EM) according to Higa, 1995 , produced by EMRO corporation, Okinawa Japan and locally marketed by the Ministry of Agric. and Land Reclamation, Egypt.

EM (Effective Microorganisms) has been used widely as inoculants to change the microbial diversity and interaction in soils and plants (Xu, 2000). In turn, EM has been shown to improve soil health, and the growth, yield and quality of crops over a wide range of agro-

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ecological conditions (Higa and Parr, 1994; Iwaishi, 2000 and Yamada et al., 2000). When EM cultures are applied to soil they stimulate the decomposition of organic wastes and thereby residues releasing inorganic nutrients for plant uptake.

Foliar application of EM appears to suppress the occurrence of plant diseases and facilitates the uptake of simple organic molecules that can increase plant growth and yield in relatively short time (Wididana and Higa, 1998). Many countries around the world such as Indonesia have come to consider EM in the same way they would apply any foliar fertilizer, especially micronutrients which responded to foliar application of micronutrients much greater than soil application, and believe that foliar application is more efficient (Javaid, 2010). Furthermore, in China, using EM as a foliar application improved the quality and enhanced yield of tea, cabbage and sugar corn (Xiaohou *et al.*, 2001) .Moreover, foliar application of EM results in a large number of beneficial microorganisms at the leaf surface, or phyllosphere. It is believed that certain microorganisms in the EM culture including photosynthetic bacteria and N-fixing bacteria, can enhance the plant's photosynthetic rate and efficiency and its N-fixing capacity as well (Pati and Chandra, 1981). Through foliar application, microorganisms in EM appear to suppress the development of harmful plant pathogens at the surface, thereby providing a measure of plant protection through biocontrol. Another example of the beneficial effect of phyllosphere microorganisms was reported by Atlas and Bartha (1981).They found that pigmented yeast and bacteria that colonized on the leaf surfaces could afford some protection to the plant from excessive exposure to direct sunlight. Chamberlain and Daly (2005) reported that the metabolites developed by micro-organisms are directly absorbed into plant surface. In addition photosynthetic bacteria play the leading role in the activity of EM. They synthesize useful substances and increase the number of other bacteria and act as nitrogen binders.

In Egypt, growers sprayed some growth hormones to induce growth and increase fruit set and yield. Gibberellin (GA_3 i.e. Berlex) is the most isomer widely used. They regulate growth and influence various developmental processes, including stem elongation, germination,

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flowering, sex expression, enzyme induction and leaf and fruit senescence (Donald et al., 2001). The effect of GA_3 has at least three important actions, intensifies an organ ability to function as a nutrient sink, ability to increase the synthesis of IAA in plant tissues and involves synthesis acceleration of hydrolytic enzymes as amylase and other hydrolytic enzymes in aleurone cells (Addicott and Addicott, 1982). As the effect of growth regulator spray, many investigations on some fruits were accepted from Abd-Ella and El-sisi (2006) on figs and Malaka (2008) on pears.

The objective of the present investigation was to study the effect of foliar applications of EM as a natural stimulator and GA_3 as a growth regulator on fruit set, yield, fruit quality and leaf mineral content of Sultani fig trees.

MATERIALS AND METHODS

This investigation was carried out through two successive seasons 2009 and 2010 on about ten years old Sultani fig trees, grown in a calcareous soil in Burg El Arab region ,about 70 kilometers west of Alex. and spaced at 5x5 apart meters under drip irrigation. Some physical and chemical properties of such soil are listed in Table (1).

The trees in this orchard were annually fertilized with 15 m^3/ feddan of organic manure in December of each year and 1.5 Kg of calcium super phosphate (15.5% P_2O_5).Moreover, 3.0 Kg ammonium sulphate (20.5% N) and 1.5 Kg of potassium sulphate (48% K_2O) per tree were added as soil application in three equal doses at March, April and June. The selected trees were nearly similar in vigor and free from visible pathogens. The trees were sprayed with different treatments in the two seasons as follow:

T_1: Foliar spray with water only (control).
T_2: Foliar spray with EM at 10%.
T_3: Foliar spray with EM at 20%.
T_4: Foliar spray with EM at 30%.
T_5: Foliar spray with GA_3 at 10ppm.
T_6: Foliar spray with GA_3 at 20ppm.
T_7: Foliar sprat with GA_3 at 30ppm.

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Trees were sprayed with the above treatments, three times at full bloom (March), after fruit set (fruit diameter about 2mm) at May and after one month of fruit set (July). Foliar sprays were applied using a hand pressure sprayer. Triton B emulsifier at rate of 0.2% was as a surfactant. Each tree received 5 liters spraying solution. Microbiological and chemical analysis of Effective Microorganisms (EM) is listed in Table (2).

Table(2) Microbiological and chemical analysis of EM:

Microbiological Analysis	Population (CFU ml^{-1})	Chemical Analysis	Chemical Content
Total plate count	$1.2x10^9$	N	0.47%
E Coli	0	P	<0.1ppm
Other coliforms	0	K	0.22ppm
Salmonella sp.	0	B	<0.57ppm
Staphylococcus sp.	0	S	<0.1ppm
Clostridium spp.	0	Fe	51ppm
Enterobacter	0	Cu	1ppm
N-fixing bacteria		Mo	<0.03ppm
a. Azospirillum sp.	0	Co	<0.2ppm
b. Azotobacter sp.	0		
c. Rhizobium sp.	0		
P-Solubilizing bacteria	$2.0x10^3$		
Lactobacillus spp.	$2.0x10^6$		
Yeast	$6.2x10^5$		
Fungi	70		
Celluloytic bacteria	$4.3x10^3$		
Streptomyces sp.	$8.6x10^3$		

CFU = Colony Forming Unit

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Treatments were arranged in a Randomized Complete Block Design with three replications for each treatment using three trees as a single replicate (7 treatments x 3 replicates x 3 trees= 63 trees).The following parameters were determined in the two successive seasons:

1. **Vegetative growth**:

At the beginning of both growing seasons, on mid March, eight main branches well distributed around periphery of each replicate tree were randomly selected and tabulated (2 branches toward each direction). Number of the current shoot per selected branches was counted, their lengths and diameters were measured (cm) when the growth was ceased (October 30). Five leaves were collected randomly from the first fully mature leaves from the tip of the previously tagged branches and their areas (cm^2) were measured.

2. Leaf chemical components:

-Leaf chlorophyll reading was recorded using Minolta Chlorophyll Meter Spad-502 (Minolta Camera Co., LTD Japan) in the field at the end of July. The average of ten readings was taken on the middle of leaves from all the tree canopy.

-Leaf mineral content was determined at the end of July of both seasons. Sample of ten leaves was randomly selected from the middle part of non fruiting shoots of each replicate tree in both seasons. Leaf samples were washed with tap water, rinsed with distilled water and oven dried at 70 °C to a constant weight and then ground. The ground samples were digested with sulphuric acid and hydrogen peroxide according to Evenhuis and DeWaard (1980). Suitable aliquots were taken for determination of N, P, K. Nitrogen and phosphorous were determined colorimetrically according to Evenhuis (1976) and Murphy and Riley (1962), respectively. Potassium content was determined against a standard by a Flame photometer according to Chapman and Pratt (1961) while, iron, zinc and manganese by a Perkin Elmer Atomic Absorption Spectrophotometer. The concentrations of N, P and K were expressed as percent, while those of Fe, Zn and Mn were expressed as parts per million, on dry weight basis.

Data were statistically analyzed according to Snedecor and Cochran (1990) and L.S.D test at 0.05 levels was used for comparison between means of various treatments.

3. Fruit set percentage and yield:

The total numbers of buds were recorded and then numbers of syconia on the selected shoots were counted to calculate the percentage of fruit set. Total yield (Kg) of each replicate tree was calculated using average fruit weight (gm) and the total number of fruits per tree. On mid July in both seasons, number of fruits per each experimental tree was counted. Increment percentage compared with the control was also calculated by using the following equation:

$$\frac{\text{Yield (Kg)/ treatment t- yield (Kg)/ control}}{\text{Yield (Kg)/ control}} \times 100$$

4. Fruit quality:

At harvesting time, 1st August, of both seasons, ten fruits were taken at random from each replicate tree to determine fruit quality (average fruit weight (gm), diameter (cm) and length (cm)).In juice of each fruit sample, total soluble solids (TSS) percentage was determined by a hand refractometer and the percentage of acidity was measured according to A.O.A.C. (1995).Vitamin C was determined by titration with dichlorophenol endophenol blue dye and expressed as mg vitamin C / 100 ml juice. Total sugars in fruit pulp tissues were determined by phenol sulfuric method according to (Dubois *et al*., 1956)

RESULTS AND DISCUSSION

1-Vegetative growth characters:

The data representing the effect of foliar application of different concentrations with EM (Effective Microorganisms) and GA_3 (Gibberellic Acid) promoters on vegetative growth parameters were listed in Table (3). In general, the results indicated that, both types of growth promoters either EM or GA_3 was predominant to the control, of all the

evaluated vegetative growth parameters, i.e., number of new shoots per main branch, new shoot length, shoot diameter and leaf area in both seasons. In other words, a gradual increase in the studied growth parameters of “Sultani” fig tree was quite obvious with increasing the concentrations of both EM and GA_3.

It was clear that foliar application of EM at the highest concentration (30%) was superior and associated with highest value of all previously mentioned characters. The enhancement of plant growth by the EM biostimulant application may be attributed to the profound effect of natural plant growth regulator substances produced by the effective microorganisms (bacteria, fungi, and yeast)as reported by Joo, *et al.,(*1999). Natural hormones like cytokinin which enhance cell division and cell enlargement so far increasing the extension of leaf surface area as well as enhancing the accumulation of soluble metabolites (Ferguson *et al.,* 1987). Moreover, Higa and Wididana (1999) reported that when EM applied to soil or plant leaf surface, the population of photosynthetic bacteria and nitrogen fixing bacteria dramatically increased. This phenomenon was associated with the growth of more vigorous plants and enhanced the plant’s photosynthetic rate, efficiency and it’s nitrogen fixing capacity. In this regard Ruinen (1970) was among the first to investigate the occurrence of nitrogen fixing bacteria on leaf surfaces. The present results were in harmony with those reported by Sangakkara and Marambe (1998) on tomato and french beans and Desoky *et al*., (2001) on Papaya , who found that trees became more vigorous when subjected to different rates and application methods of foliar sprays with EM .Similarly, Piotr and Zofia(2008) found that apple rootstocks gave significantly greater mass and length of lateral shoots as well as enhanced their diameter and number when sprayed with EM in comparison with water only. While, Javaid and Shah (2010) found that EM foliar application didn’t affect various growth parameters of wheat plants.

Data also indicated that foliar application of GA_3 at higher concentration had similar effect on improving some growth parameters (leaf area and shoot diameter). However, the differences between higher concentrations of both promoters were not big enough to be significant. It is well known that foliar application of GA_3 has the ability to stimulate plant growth and development in a variety of test systems. GA_3 increased plant size as a result of increased photosynthetic rates or due to more efficient utilization of photosynthetic products (Erkan and Bangerth, 1980). El-Sabagh and Mostafa (2003) revealed that an increase in total area of leaves in response to foliar spray of GA_3. The results were in agreement with some investigators who worked on the effect of GA_3 on apple trees; Grochowska *et al.*, (1995), Callejas-R *et al*., (1998) and El-Sabagh and Mostafa (2003).

2- Leaf chemical components:

The results presented in Table (4), clearly, indicated that leaf chlorophyll, N, P and Fe were increased by foliar application of EM (commercial bio stimulant) or GA_3 compared to the control in both seasons, while, leaf K, Mn and Zn were not significantly affected. In general, it was noticed that the highest levels of leaf chlorophyll, N, P and Fe were obtained from trees sprayed with highest concentration of EM (30%) in both seasons. The promoting effect of natural bio stimulant on the nutritional status of the leaves could be related to the role of the effective microorganisms in improving the availability of nutrients. Similar findings were recorded by Sangakkara and Nissanka *(*1998) who found that foliar application of EM significantly increased leaf chlorophyll content and enhanced yield of beans due to greater rates of photosynthesis.

3-Fruit set percentage and yield:

The results of foliar treatments of EM (natural stimulant) and GA_3 (growth promoter) on fruit set and yield of Sultani fig trees were shown in Table (5). It was clear that fruit set and yield as number or weight (Kg/tree)of fruits were significantly increased with increasing the concentration of both EM and GA_3. Data in the same table indicated that all treatments had a highly significant effect on percentage of yield increment as compared to untreated trees (control) in both seasons. However, spraying trees with EM at high concentration (30%) gave

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significantly the highest fruit set. Similarly, spraying trees with high concentration of GA_3 (30 ppm) gave almost the same effect as high concentration of EM on number of fruits / tree in the 2^{nd} season and on other fruiting aspects in the 1^{st} one. These results reflect similar trends to those of plant growth and mineral content of leaves as previously mentioned. Therefore, increasing Sultani fig yield might be attributed to the increments in the amounts of metabolites synthesized by the plant which, in turn accelerated plant growth and resulted in improving total yield. These results can be explained as the EM biostimulant contains more than 60 strains of microorganisms as bacteria, yeast, actinomycetes and various fungi. The high contents of minerals and vitamins as well as the cytokinin contents in yeast might play a role in the orientation and translocation of metabolites from leaves into the productive organs (Nagodawithana,1991). Similar results were recorded by Wididiana and Higa (1998), Sangakkara and Marambe (1998) and Xiaohou *et al*., (2001) on various vegetables crops , Yousaf *et al.*, (2000) on groundnut and Desoky *et al*., (2001)on papaya , they clearly indicated that foliar solution of EM at certain concentrations and time intervals caused significant increase in yield . Additionally, EM can be used as a regulation substance to improve metabolism of crop plants for yield promotion and quality improvement. Also, these results may be due to spraying trees with plant hormones (GA_3 at 30ppm) which may stimulate shoot growth and there is a strong competition and relationship between the developing fruitlets and rapidly growing shoot tips (El-Sabagh and Mostafa,2003). GA_3 plays a major role in enlarging fruit size (Wiltank and Krezdorn, 1969). These results are in harmony with those obtained by Abd-Ella and El-Sisi (2006) on fig and Malaka (2008) on pear.

4-Fruit quality:

The results in Table(6) showed gradual and significant increase of fruit physical and chemical properties i.e. fruit weight, diameter, length ,TSS and total sugar % with increasing the concentration of both EM and GA_3 treatments as compared with control. Acidity, however showed an opposite trend, whereas, V.C. was not significantly affected.

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It is noteworthy to mention that the effect of spraying trees with GA_3 at higher concentration (30ppm) was more pronounced than other treatments followed by 30 % of EM. However, the trees sprayed with tap water were the lowest .In addition, the response of fig trees to high concentration of GA_3 was almost as like as that of high concentration of EM on fruit juice V.C., besides decreasing acidity. Significant differences were found between the effects of the highest two concentrations of GA_3 and EM on fruit weight in the 2nd season and fruit length and diameter in both seasons of study. In the meantime, the differences between the two growth promoters at higher concentration were too few to be significant in TSS and total sugar during both seasons. Apparently, the gibberellins affect cell elongation and cell division, therefore GA_3 plays a major role in enlarging fruit size. The results were in line with those obtained by El-Sabagh and Ahmed *(*2004) on apple, Abd-Ella and El-Sisi (2006) on fig and Malaka (2008) on pear. The above mentioned results of EM on fruit quality was due to its content of bacteria and yeast which, via its cytokinin content might play a role in the synthesis of protein and nucleic acids and minimized their degradation (Legocka,1987). Likewise, Wood *et al.,* (1997) reported that foliar spray with EM produced plant hormones, beneficial bioactive substances, and antioxidants which solubilize nutrients. Similarly, Shou-Song *et al*., (2002) suggested that EM can be used as a regulation substance to improve metabolism of crop plants for yield promotion and quality improvement. These results are in line with those obtained by Higa and Wididana (1999) on green pepper and turnip and Desoky *et al.,* (2001) on papaya. They found that foliar application with EM improved fruit quality through increasing flesh TSS percent, and contents of V. C. and sugars.

CONCLUSION

In conclusion this study demonstrated that spraying the bio stimulant EM 30% had a similar effect to that of spraying with GA_3 at rate 30 ppm and a beneficial effect on growth and fruit set which had an impact on yield and fruit quality. Such approach is highly recommended in confirming the need for safe food and sound environment in the light of an increasing demand for organic food.

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الملخص العربي

تأثيرالرش ببعض منشطات النموعلي نمو وإثماروجودة ثمارأشجار التين السلطاني

ايمان السيد كامل عبد اللاه[1] – وفاء على السيسى[2]
1- محطة بحوث البساتين بالصبحية - إسكندرية
2- الحديقة النباتية بالمعمورة - إسكندرية

أجري هدا البحث عامي 2009-2010 علي أشجار تين صنف سلطاني عمرها 10 أعوام ونامية في أرض جيرية بمنطقة برج العرب (حوا لي 70 كم غرب الإسكندرية) لدراسة تأثير الرش بمنشط النموالحيوي (EM) بتركيزات 10،20،30 % وكذلك منظم النمو حامض الجبريلك (GA_3)بتركيزات10، 20،30 جزء في المليون علي النمو الخضري ونسبة عقد الثماروالمحصول وصفات جودة الثمار.

أوضحت النتائج عامة فى كلا موسمى الدراسة أن جميع المعاملات لكل من المنشط الحيوى EM و GA_3 ادت الى زيادة معنوية فى النمو الخضرى معبرا عنه بعدد النموات الحديثة وطول وقطر هذه النموات ومساحة الورقة وايضا نسبة العقد والمحصول(عدد ، وزن الثمار/ شجرة) ومواصفات جودة الثمار (وزن وطول وقطرالثمرة ،المواد الصلبة الذائبة، والسكريات الكلية) مقارنة بالاشجارالغيرمعاملة. ولم يكن للمعاملات أي تاثير علي محتوى الثمار من فيتامين ج .

واوضحت النتائج ان التركيز الاعلى لكل منEM وGA_3 أعطى أفضل النتائج لجميع مواصفات النمو الخضرى وأيضا نسبة العقد والمحصول.

وتحت ظروف هذه الدراسه يمكن التوصية باستخدام الEM رشا على اشجار التين بتركيز 30% لانتاج اعلى محصول مع افضل مواصفات جودة للثمار و كبديل امن عن استخدام منظم النمو حمض الجبريليك GA_3.

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