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TRIALS FOR IMPROVING WATER USE EFFICIENCY AND IMPROVING PRODUCTIVITY IN WILLIAMS BANANA ORCHARDS BY SPRAYING SALICYLIC ACID

M. M. Al- Wasfy
Hort. Dept. Fac. of Agric. South Valley Univ. Qena, Egypt.

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ABSTRACT

During ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons, Williams banana plants were irrigated with eight levels of irrigation water (٥٨٧٥, ٧٠٥٠, ٨٢٢٥, ٩٤٠٠, ١٠٥٧٥, ١١٧٥٠, ١٢٩٢٥ and ١٤١٠٠ m٣/ fed./ year) in combined with spraying salicylic acid at ٠.٠, ١٢٥, ٢٥٠ and ٥٠٠ ppm.The trial was acheived as an attempt for saving water as well as promoting water use efficiency and production.

Results showed that irrigation with water at ٥٨٧٥ to ١٤١٠٠ m^3/ fed./ year in combined with spraying salicylic acid at ١٢٥ to ٥٠٠ ppm four times was very effective in enhancing growth, nutritional status of the plants, yield as well as physical and chemical characteristics of the fruits comparing with irrigation with water alone. Water use efficiency was remarkably improved with using salicylic acid in combined with irrigation water rather than using irrigation water alone. Supplying the plants with water at ١٠٥٧٥ m^3/ fed./ year and spraying salicylic acid at ٢٥٠ ppm effectively promoted water use efficiency instead of irrigation with water at ١١٧٥٠ to ١٤١٠٠ m^3/ fed./ year without the application of salicylic acid.

For saving irrigation water as well as promoting water use efficiency and production in Williams banana orchards, it advised to irrigate the plants with water at ١٠٥٧٥ m^3/ fed./ year in combined with using salicylic acid four times at ٢٥٠ ppm instead

of using irrigation water alone at ١٤١٠٠ m^3/ fed./ year. Under such promised treatment water saved reached ٣٥٢٥ m^3/ fed./ year.

INTRODUCTION

Banana is considered an important cash fruit crops in Egypt. It is required large quantities of well water in order to produce maximum productivity and improve fruit quality as well to ensure adequate sucker development (Goenaga *et al*., ١٩٩٣). With the shortage of the available water nowadays, any trial conducted to promote waters use efficiency is appreciated.

Previous studies showed that supplying different banana cvs with their requirements from water at the optimum amount had an obvious effect on promoting the yield quantitively and qualitatively (Asoegwu and Obiefuna, ١٩٨٧; Lahav and Kalmer, ١٩٨٨; Hedge and Srinivas, ١٩٩٠; Keller and Bliesner, ١٩٩٠; Ibrahim, ١٩٩٣; Goenago *et al*., ١٩٩٥; Sophocleous, ٢٠٠٤; Hasiao *et al*., ٢٠٠٧ and Pereira *et al*., ٢٠٠٩).

Salicylic acid (SA) (from Latin Salix willow tree, from the back of which the substance is obtained) is widely used in organic synthesis and function as a plant hormone. It is derived from the metabolism of salicin. It had the formula C_6H_4 (OH) COOH ($C_7H_6O_3$). It is a phenolic phytohormone and is found in plants with definite role in plant growth, development, photosynthesis as well as uptake and transport of nutrients (Reskin, ١٩٩٢a and ١٩٩٢b). SA also induces specific changes in leaf anatomy and chloroplast structure. It is involved in endogenous signaling mediating in plant defense against pathogens. It plays a role in the resistance to pathogens by inducing the production of pathogenesis- related. It is involved in the systemic acquired resistance in which a pathogenic attack one part of the plant induces resistance in other parts. The signal can also move to nearby plants by SA being converted to the volatile ester namely methyl salicylate. It is biosynthesized from the amino acid phenylalanine (Hayat and Ahmed, ٢٠٠٧; Taiz and Zeiger, ٢٠٠٢ and Van Huijsdijnen, ٢٠٠٩).

Early studies have described flower- inducing effects related to inhibiting or enhancing of ethylene synthesis (depends on concentrations) (Leslie and Romani, ١٩٨٦ and ١٩٨٨; Srivastava and

Dwivedi, ٢٠٠٠ and Zgang *et al*., ٢٠٠٣) and is involvement in heat production in plants (Raskin *et al*., ١٩٨٩). SA may affect the uptake of sugars and amino acids by indirect inhibition of the plasma membrane (Bourbouloux *et al*., ١٩٩٨).

Salicylic acid (SA) is an endogenous growth regular of phenolic nature, which participates in the regulation of physiological processes in plants. It plays an important role in the plant response to adverse environmental conditions as salinity. Meanwhile, soil salinity is a major constraint to food production because it limits crop yield and restricts use of land previously uncultivated. The SA plays an essential role in preventing oxidative damage in plants by detoxifying super oxide radicals, produced as a result of salinity (Pal *et al*., ٢٠٠٢). A review was highlighted the exogenous application of the lower concentrations of salicylic acid proved to be beneficial in enhancing the photosynthesis, growth and various other physiological and biochemical characteristics of plants (Lee *et al*., ١٩٩٥). Based on the morphology of the plants and parameters investigated, it was concluded that SA tolerant, made quicker response to a biotic stresses (Lee *et al*., ١٩٩٥; Pal *et al*., ٢٠٠٢ and Joseph *et al*., ٢٠١٠).

The beneficial effects of salicylic acid on fruiting of fruit crops were mentioned by many authors such as (Ahmed and Abd El-Hameed, ٢٠٠٤; Ibrahim- Asmaa, ٢٠٠٦; Imran *et al*., ٢٠٠٧; Ahmed *et al*., ٢٠١٠ and Shaaban *et al*., ٢٠١١).

The target of this study was testing the effect of using salicylic acid for saving water irrigation and increasing wafer use efficiency in Williams banana orchards. Yield and quality of the fruits in response to application of salicylic acid under different regimes of water irrigation were also investigated.

MATERIALS AND METHODS

This study was carried out during two successive seasons of ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ on third and fourth ratoons of Williams banana plants grown in a private banana orchard situated at Nagh Hamady district, Qena Governorate. Soil in clay loam in texture and well drained with a water table depth not less than two meters. The

plants are planted at ٣.٥ x ٣.٥ m apart. Surface irrigation system using Nile irrigation water was followed.

Table ١: Analysis of the tested soil:

Particle size distribution	Values
Sand %	٢٩.٠
Silt %	٣٠.٠
Clay %	٤١.٠
pH (١:٢.٥ extract)	٧.٨٥
EC (١: ٢.٥ extract) ppm	٣٠٠
O.M. %	١.٠٦
$CaCO_3$ %	١.١٩
Total N %	٠.٠٧
Available P (ppm)	٥.١
Available K (ppm)	٤٢٢.٠

Normal horticultural practices were carried out as usual except those dealing with irrigation water and application of any antioxidants.

This experiment included ٣٢ treatments from two factors (A& B). The first factor (A) included eight levels from various amounts of irrigation water (as m^3/ fed./ year) namely ٥٨٧٥, ٧٠٥٠, ٨٢٢٥, ٩٤٠٠, ١٠٥٧٥, ١١٧٥٠, ١٢٩٢٥ and ١٤١٠٠ m^3/ fed./ year (as a control). The second factor (B) contained four concentrations of salicylic acid (٠.٠, ١٢٥, ٢٥٠ and ٥٠٠ ppm). Each treatment was replicated three times, three stools per each. Each amount of water occupied the main plot (٢٨ m long and ١٠.٥ m width and contains ٣٦ stools). The total plots selected for achieving of the eight water amounts were eight. Each plot was divided into four rows each row contain nine stools. Each stool contained three plants for fruiting in the current season plus three suckers for fruiting in the following one. The eight amounts of water above mentioned were adjusted by using current meter which drained ٢٥ m^3 water/ hr. The details of wafer irrigation treatments are shown in Table (٢).

Table ٢: Schedules of irrigation during both seasons (٢٠٠٩/٢٠١٠ and ٢٠١٠/٢٠١١):

Month	Number of irrigation	Amounts of water (m^3)/ irrigation (A)							
		a_1 ١٢٥	a_2 ١٥٠	a_3 ١٧٥	a_4 ٢٠٠	a_5 ٢٢٥	a_6 ٢٥٠	a_7 ٢٧٥	a_8 ٣٠٠
		Amounts of water (m^3)/ month							
Feb.	٢	٢٥٠	٣٠٠	٣٥٠	٤٠٠	٤٥٠	٥٠٠	٥٥٠	٦٠٠
Mar.	٣	٣٧٥	٤٥٠	٥٢٥	٦٠٠	٦٧٥	٧٥٠	٨٢٥	٩٠٠
Apr.	٤	٥٠٠	٦٠٠	٧٠٠	٨٠٠	٩٠٠	١٠٠٠	١١٠٠	١٢٠٠
May.	٥	٦٢٥	٧٥٠	٨٧٥	١٠٠٠	١١٢٥	١٢٥٠	١٣٧٥	١٥٠٠
June	٦	٧٥٠	٩٠٠	١٠٥٠	١٢٠٠	١٣٥٠	١٥٠٠	١٦٥٠	١٨٠٠
July	٦	٧٥٠	٩٠٠	١٠٥٠	١٢٠٠	١٣٥٠	١٥٠٠	١٦٥٠	١٨٠٠
Aug.	٦	٧٥٠	٩٠٠	١٠٥٠	١٢٠٠	١٣٥٠	١٥٠٠	١٦٥٠	١٨٠٠
Sept.	٥	٦٢٥	٧٥٠	٨٧٥	١٠٠٠	١١٢٥	١٢٥٠	١٣٧٥	١٥٠٠
Oct.	٤	٥٠٠	٦٠٠	٧٠٠	٨٠٠	٩٠٠	١٠٠٠	١١٠٠	١٢٠٠
Nov.	٣	٣٧٥	٤٥٠	٥٢٥	٦٠٠	٦٧٥	٧٥٠	٨٢٥	٩٠٠
Dec.	٢	٢٥٠	٣٠٠	٣٥٠	٤٠٠	٤٥٠	٥٠٠	٥٥٠	٦٠٠
Jan.	١	١٢٥	١٥٠	١٧٥	٢٠٠	٢٢٥	٢٥٠	٢٧٥	٣٠٠
Total	٤٧	٥٨٧٥	٧٠٥٠	٨٢٢٥	٤٤٠٠	١٠٥٧٥	١١٧٥٠	١٢٩٢٥	١٤١٠٠
Treatment		a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8

Salicylic acid (soluble in Ethyl alcohol) at the above mentioned concentrations was sprayed four times started at the first week of May and at one month intervals. Triton B as a wetting agent was added to all solutions of salicylic acid before application.

This experiment was set up in completely randomized block design in split plot arrangement, where each treatment was replicated three times, three stools per each (٢٨٨ stools or ٨٦٤ plants for each season). The eight levels of water irrigation and the four concentrations of salicylic acid occupied the main and subplots, respectively.

After the emergence of the inflorescences of banana plants (early of Sept.), the following three growth characters were recorded:

١. Pseudostem height (cm.) from the soil surface up to the petiole of the last emerged leaf.
٢. Pseudostem girth (cm.) in the base, middle and top of the pseudostem, then the average was calculated.

٣. Total leaf area (m^2) was measured by multiplying the average leaf area by total number of green leaves per plant (Ahmed and Morsy, ١٩٩٩)

Leaf samples were taken from the third upper leaf in the descending leaves from the top of the plant after bunch shooting in Sept. during both seasons. A sample of ١٠ x ١٠ cm. area from the middle part of the leaf blades as recommended by Martin- Prevel (١٩٧٧) was taken for determining the percentages of N, P, K and Mg according to the procedures reported by Wilde *et al*., (١٩٨٥).

The bunches were picked at the mid. of Oct., during both seasons then bunch weight (kg.) was recorded. Six hands (from the base, middle and distal end of the bunch) were taken for measuring hand weight (kg.). After artificial ripening, fruit weight (g.), total soluble solids %, total and reducing sugars % and total acidity (as g. malic acid/ ١٠٠ g pulp) were determined according to methods stated by(A.O.A.C., ١٩٩٥).

Obtained data were tabulated and subjected to the proper statistical analysis and the differences between different treatment means were compared using new L.S.D test at ٥ % according to Mead *et al*., (١٩٩٣).

RESULTS AND DISCUSSION

١- Effect of water amounts and salicylic acid on height and girth of pseudostem as well as total surface area:

Data in Tables (٣& ٤) clearly showed that increasing amounts of irrigation water from ٥٨٧٥ to ١٤١٠٠ m^3/ fed./ year caused a gradual stimulation on the three growth characters namely height and girth of pseudostem and total leaf area. Significant differences on these growth traits were observed between most water levels except between amounts higher than ١٠٥٧٥ m^3/ fed/ year. Using irrigation water at amounts higher than ١٠٥٧٥ m^3/ fed/ year had a slight and unsignificant promotion on these growth characters.

It is clear from the obtained data that spraying salicylic acid at ١٢٥ to ٥٠٠ ppm was accompanied with enhancing all growth characters comparing with the control treatment.

Table ٣: Effect of water amounts, salicylic acid concentrations and their combinations on height and girth of pseudostem (cm.) of Williams bananas during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

Water amounts (m^3)/ fed/ year (A)	Pseudostem height (cm.)									
	٢٠٠٩/ ٢٠١٠					٢٠١٠/ ٢٠١١				
	Salicylic acid concentrations (B) ppm									
	b_1= ٠.٠	b_2= ١٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)	b_1= ٠.٠	b_2= ٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)
a_1 ٥٨٧٥ m^3/ fed/ year	١٧١.٠	١٧٤.٦	١٧٧.٩	١٧٨.٠	١٧٥.٢	١٧٣.٣	١٧٧.٩	١٨٢.٢	١٨٣.٠	١٧٩.١
a_2 ٧٠٥٠ m^3/ fed/ year	١٧٥.٥	١٨٠.٠	١٨٥.٠	١٨٥.٣	١٨١.٥	١٧٨.٠	١٨٣.٠	١٨٨.٠	١٨٨.٣	١٨٤.٣
a_3 ٨٢٢٥ m^3/ fed/ year	١٨٠.٠	١٨٧.٩	١٩٢.٠	١٩٢.٣	١٨٨.١	١٨٢.٦	١٩١.٩	١٩٥.٠	١٩٥.٥	١٩١.٢
a_4 ٩٤٠٠ m^3/ fed/ year	١٨٩.٠	١٩٦.٠	١٩٩.٠	١٩٩.٥	١٩٥.٩	١٩١.٧	١٩٨.٩	٢٠٤.٠	٢٠٥.٠	١٩٩.٩
a_5 ١٠٥٧٥ m^3/ fed/ year	١٩٧.٠	٢٠٧.٠	٢٠٩.٠	٢٠٩.٥	٢٠٥.٦	١٩٩.٦	٢١٠.٠	٢١٣.٠	٢١٣.٤	٢٠٩.٠
a_6 ١١٧٥٠ m^3/ fed/ year	٢٠٦.٣	٢٠٨.٠	٢٠٩.٥	٢١٠.٠	٢٠٨.٥	٢٠٨.٨	٢١٠.٥	٢١٣.٦	٢١٤.٠	٢١١.٧
a_7 ١٢٩٢٥ m^3/ fed/ year	٢٠٧.٠	٢٠٨.٢	٢١٠.٠	٢١٠.٠	٢٠٨.٨	٢٠٩.٥	٢١١.٠	٢١٤.٠	٢١٤.٥	٢١٢.٢
a_8 ١٤١٠٠ m^3/ fed/ year	٢٠٧.٦	٢٠٨.٦	٢١٠.٢	٢١٠.٥	٢٠٩.٢	٢١٠.٠	٢١١.٠	٢١٤.٠	٢١٤.٩	٢١٢.٤
Mean (B)	١٩١.٦	١٩٦.٢	١٩٩.١	١٩٩.٤		١٩٤.٢	١٩٩.٣	٢٠٢.٩	٢٠٣.٥	
New L.S.D at ٥ %	A: ٢.٩	B: ٢.٠	AB: ٥.٦			A: ٢.٨	B: ٢.٢	AB: ٦.٢		
Character	Pseudostem girth (cm.)									
a_1 ٥٨٧٥ m^3/ fed/ year	٦٠.٠	٦٢.٣	٦٥.٦	٦٦.٠	٦٣.٤	٦٠.٧	٦٤.٠	٦٧.٣	٦٧.٥	٦٠.٧
a_2 ٧٠٥٠ m^3/ fed/ year	٦٣.٣	٦٦.٠	٧١.٠	٧١.٢	٦٧.٨	٦٥.٠	٦٧.٧	٧٢.٨	٧٣.٠	٦٥.٠
a_3 ٨٢٢٥ m^3/ fed/ year	٦٦.٥	٧١.٠	٧٦.٠	٧٦.٣	٧٢.٤	٦٨.٢	٧٢.٧	٧٧.٨	٧٩.٠	٦٨.٢
a_4 ٩٤٠٠ m^3/ fed/ year	٧١.٠	٧٤.٠	٧٨.٩	٧٩.٠	٧٥.٧	٧٢.٧	٧٥.٨	٨٠.٧	٨١.٠	٧٢.٧
a_5 ١٠٥٧٥ m^3/ fed/ year	٧٤.٩	٧٩.٩	٨٢.٩	٨٣.٠	٨٠.٢	٧٦.٦	٨١.٦	٨٥.٠	٨٥.٥	٧٦.٦
a_6 ١١٧٥٠ m^3/ fed/ year	٧٧.٨	٨٠.٠	٨٣.٠	٨٣.٣	٨١.٠	٧٩.٥	٨١.٧	٨٥.٦	٨٦.٠	٧٩.٥
a_7 ١٢٩٢٥ m^3/ fed/ year	٧٨.٠	٨٠.١	٨٣.٢	٨٣.٤	٨١.٢	٨٠.٠	٨١.٨	٨٥.٨	٨٥.٦	٨٠.٠
a_8 ١٤١٠٠ m^3/ fed/ year	٧٨.٣	٨٠.٢	٨٣.٥	٨٣.٧	٨١.٤	٨٠.٠	٨٢.٠	٨٦.٠	٨٦.٠	٨٠.٠
Mean (B)	٧١.٢	٧٤.٢	٧٨.٠	٧٨.٢		٧٢.٨	٧٥.٩	٨٠.١	٨٠.٤	
New L.S.D at ٥ %	A: ١.٥	B: ١.٣	AB: ٣.٧			A: ١.٨	B: ١.٧	AB: ٤.٨		

The promotion was associated with increasing concentrations of salicylic acid from ٠.٠ to ٥٠٠ ppm. Increasing concentrations from ٢٥٠ to ٥٠٠ ppm failed to show significant stimulation on these growth characters.

Table ٤: Effect of water amounts, salicylic acid concentrations and their combinations on the total surface area (m^2) and percentage of N in the leaves of Williams bananas during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

Water amounts (m^3)/ fed/ year (A)	Total leaf area/ plant (m^2)									
	٢٠٠٩/ ٢٠١٠					٢٠١٠/ ٢٠١١				
	Salicylic acid concentrations (B) ppm									
	b_1= ٠.٠	b_2= ١٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)	b_1= ٠.٠	b_2= ٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)
a_1 ٥٨٧٥ m^3/ fed/ year	٢٦.٠	٢٧.٤	٢٨.٩	٢٩.٠	٢٧.٨	٢٦.٩	٢٨.٣	٣٠.٠	٣٠.١	٢٨.٨
a_2 ٧٠٥٠ m^3/ fed/ year	٢٦.٨	٢٨.٢	٢٩.٨	٢٩.٩	٢٨.٧	٢٧.٧	٢٩.١	٣١.٠	٣١.٢	٢٩.٨
a_3 ٨٢٢٥ m^3/ fed/ year	٢٧.٧	٢٩.١	٣٠.٦	٣٠.٦	٢٩.٥	٢٨.٥	٣٠.٠	٣١.٨	٣٢.٠	٣٠.٦
a_4 ٩٤٠٠ m^3/ fed/ year	٢٨.٥	٢٩.٩	٣١.٩	٣٢.٠	٣٠.٦	٢٩.٤	٣٠.٨	٣٣.٠	٣٣.٣	٣١.٦
a_5 ١٠٥٧٥ m^3/ fed/ year	٢٩.٣	٣٢.٠	٣٥.٩	٣٦.٠	٣٣.٣	٣٠.٣	٣٢.٩	٣٧.٥	٣٧.٦	٣٤.٦
a_6 ١١٧٥٠ m^3/ fed/ year	٣٠.٣	٣٢.٥	٣٦.٠	٣٦.٣	٣٣.٨	٣١.٢	٣٣.٣	٣٧.٦	٣٧.٨	٣٥.٠
a_7 ١٢٩٢٥ m^3/ fed/ year	٣٠.٥	٣٢.٦	٣٦.٣	٣٦.٥	٣٤.٠	٣١.٣	٣٣.٤	٣٧.٦	٣٧.٩	٣٥.١
a_8 ١٤١٠٠ m^3/ fed/ year	٣٠.٦	٣٢.٦	٣٦.٣	٣٦.٧	٣٤.٠	٣١.٤	٣٣.٦	٣٧.٨	٣٧.٩	٣٥.٢
Mean (B)	٢٨.٧	٣٠.٥	٣٣.٢	٣٣.٤		٢٩.٦	٣١.٤	٣٤.٥	٣٤.٦	
New L.S.D at ٥ %	A		B		AB	A		B		AB
	٠.٧		٠.٧		١.٠	٠.٧		٠.٦		١.٠
Character	Leaf N %									
a_1 ٥٨٧٥ m^3/ fed/ year	١.٦٦	١.٧١	١.٨١	١.٨٢	١.٧٥	١.٧٧	١.٨٥	١.٩٥	١.٩٦	١.٨٨
a_2 ٧٠٥٠ m^3/ fed/ year	١.٧٣	١.٨٠	١.٩١	١.٩٢	١.٨٤	١.٨٤	١.٩٥	٢.٠٦	٢.٠٨	١.٩٨
a_3 ٨٢٢٥ m^3/ fed/ year	١.٨٠	١.٩١	٢.٠٤	٢.٠٣	١.٩٤	١.٩١	٢.٠٧	٢.١٨	٢.٢٠	٢.٠٩
a_4 ٩٤٠٠ m^3/ fed/ year	١.٨٨	١.٩٩	٢.١١	٢.١٢	٢.٠٢	١.٩٩	٢.٢١	٢.٣٣	٢.٣٤	٢.٢٢
a_5 ١٠٥٧٥ m^3/ fed/ year	١.٩٦	٢.١٨	٢.٢٧	٢.٢٨	٢.١٧	٢.٠٧	٢.٣٠	٢.٤١	٢.٤٢	٢.٢٦
a_6 ١١٧٥٠ m^3/ fed/ year	٢.٠٥	٢.١٩	٢.٢٨	٢.٢٩	٢.٢٠	٢.١٦	٢.٣١	٢.٤٢	٢.٤٣	٢.٣٣
a_7 ١٢٩٢٥ m^3/ fed/ year	٢.٠٦	٢.٢٠	٢.٢٩	٢.٣٠	٢.٢١	٢.١٧	٢.٣٢	٢.٤٢	٢.٤٣	٢.٣٤
a_8 ١٤١٠٠ m^3/ fed/ year	٢.٠٧	٢.٢١	٢.٣٠	٢.٣١	٢.٢٢	٢.١٧	٢.٣٣	٢.٤٣	٢.٤٤	٢.٣٤
Mean (B)	١.٩٠	٢.٠٢	٢.١٢	٢.١٣		٢.٠١	٢.١٦	٢.٢٧	٢.٢٨	
New L.S.D at ٥ %	A		B		AB	A		B		AB

	٠.٠٥	٠.٠٤	٠.١١	٠.٠٥	٠.٠٤	٠.١١

The significant effect on these growth characters may be attribut to the interaction between water amounts and salicylic acid concentrations since using salicylic acid at ١٢٥ to ٥٠٠ ppm beside irrigation with water at ٥٨٧٥ to ١٤١٠٠ m^3/ fed/ year was significantly enhanced growth characters rather than irrigation with water alone. With using salicylic acid at various concentrations, the amount of irrigation water (m^3/ fed/ year) required for plant growth was significantly declined. The reduction on irrigation water was associated with increasing salicylic acid concentrations. Irrigation with water at ١٠٥٧٥ m^3/ fed/ year in combined with spraying salicylic acid at ٢٥٠ ppm gave satisfactory promotion on these growth characters. Using higher amounts of water (from ١١٧٥٠ to ١٤١٠٠ m^3/ fed/ year) and spraying ٥٠٠ ppm salicylic acid caused unsignificant promotion on these growth characters comparing with using the lower levels. These results were similar during both seasons.

These results regarding the effect of irrigation are in harmony with those obtained by Ibrahim (١٩٩٣) and Pereira *et al*., (٢٠٠٩). Similar trend regarding the effect of fertilization of salicylic acid was declared by Ahmed *et al*., (٢٠١٠) and Shaaban *et al*., (٢٠١١).

٢- Effect of water amounts and salicylic acid on the percentages of N, P, K and Mg in the leaves:

It is clear from the data in Tables (٤& ٥& ٦) that increasing water amounts from ٥٨٧٥ to ١٤١٠٠ m^3/ fed/ year caused a gradual increase on the percentages of the four major nutrients namely N, P, K and Mg. Significant differences on these nutrients were observed with applying water amounts till ١٠٥٧٥ m^3/ fed/ year and afterwards the promotion was slight.

Spraying salicylic acid at ١٢٥ to ٥٠٠ ppm was followed by significant promotion on these elements comparing with those treatments having no salicylic acid. The stimulation was associated with increasing salicylic acid concentrations. Significant differences on these nutrients were observed between all salicylic acid

concentrations except between the higher two concentrations namely ٢٥٠ and ٥٠٠ ppm.

Significant differences of levels of the four macronutrients may be due to the interaction between water irrigation and salicylic acid concentrations. Irrigation accompanied with using salicylic acid significantly enhanced these nutrients comparing with using irrigation water alone. The maximum percentages of these nutrients were observed with using ١١٧٥٠ m^3/ fed/ year without applications of salicylic acid, but with using salicylic acid the amount of water that responsible to maximize these nutrients was ١٠٥٧٥ m^3/ fed/ year. Generally, application of salicylic acid with irrigation water significantly enhanced percentages of these nutrients in the leaves comparing with using water alone..

Table ٥: Effect of water amounts, salicylic acid concentrations and their combinations on the percentages of P and K in the leaves of Williams bananas during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

Water amounts (m^3)/ fed/ year (A)	Leaf P %									
	٢٠٠٩/ ٢٠١٠					٢٠١٠/ ٢٠١١				
	Salicylic acid concentrations (B) ppm									
	b_1= ٠	b_2= ١٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)	B_1= ٠	b_2= ٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)
a_1 ٥٨٧٥ m^3/ fed/ year	٠.١٤	٠.١٧	٠.٢٠	٠.٢١	٠.١٨	٠.١٦	٠.١٩	٠.٢٣	٠.٢٤	٠.٢٠
a_2 ٧٠٥٠ m^3/ fed/ year	٠.١٦	٠.١٩	٠.٢٢	٠.٢٢	٠.١٩	٠.١٩	٠.٢٢	٠.٢٦	٠.٢٧	٠.٢٣
a_3 ٨٢٢٥ m^3/ fed/ year	٠.١٨	٠.٢٢	٠.٢٦	٠.٢٧	٠.٢٣	٠.٢٢	٠.٢٧	٠.٣١	٠.٣٢	٠.٢٨
a_4 ٩٤٠٠ m^3/ fed/ year	٠.٢١	٠.٢٦	٠.٣٠	٠.٣١	٠.٢٧	٠.٢٦	٠.٣١	٠.٣٥	٠.٣٦	٠.٣٢
a_5 ١٠٥٧٥ m^3/ fed/ year	٠.٢٣	٠.٢٩	٠.٣٣	٠.٣٣	٠.٢٩	٠.٣٠	٠.٣٥	٠.٤٠	٠.٤١	٠.٣٦
a_6 ١١٧٥٠ m^3/ fed/ year	٠.٢٥	٠.٣٠	٠.٣٤	٠.٣٥	٠.٣١	٠.٣٣	٠.٣٥	٠.٤٠	٠.٤١	٠.٣٧
a_7 ١٢٩٢٥ m^3/ fed/ year	٠.٢٦	٠.٣٠	٠.٣٥	٠.٣٦	٠.٣٢	٠.٣٤	٠.٣٥	٠.٤١	٠.٤١	٠.٣٧
a_8 ١٤١٠٠ m^3/ fed/ year	٠.٢٦	٠.٣٠	٠.٣٦	٠.٣٦	٠.٣٢	٠.٣٤	٠.٣٦	٠.٤١	٠.٤١	٠.٣٨
Mean (B)	٠.٢١	٠.٢٥	٠.٢٩	٠.٣٠		٠.٢٦	٠.٣٠	٠.٣٤	٠.٣٥	
New L.S.D at ٥ %	A	B	AB			A	B	AB		
	٠.٠٢	٠.٠٢	٠.٠٦			٠.٠٢	٠.٠٢	٠.٠٦		
Character	Leaf K %									
a_1 ٥٨٧٥ m^3/ fed/ year	١.٥١	١.٥٦	١.٦٣	١.٦٤	١.٥٨	١.٦٠	١.٦٦	١.٧٤	١.٧٥	١.٦٠
a_2 ٧٠٥٠ m^3/ fed/ year	١.٥٦	١.٦٢	١.٧١	١.٧١	١.٦٥	١.٦٧	١.٧٤	١.٨٢	١.٨٤	١.٦٧

a_3 ٨٢٢٥ m³/ fed/ year	١.٦٣	١.٧١	١.٨٠	١.٨١	١.٧٣	١.٧٥	١.٨٣	١.٩١	١.٩٢	١.٧٥
a_4 ٩٤٠٠ m³/ fed/ year	١.٧١	١.٨١	١.٩١	١.٩٢	١.٨٣	١.٨٣	١.٩٠	١.٩٩	١.٩٩	١.٨٣
a_5 ١٠٥٧٥ m³/ fed/ year	١.٨٢	١.٩٢	٢.٠٢	٢.٠٣	١.٩٤	١.٩٠	١.٩٧	٢.٠٦	٢.٠٧	١.٩٠
a_6 ١١٧٥٠ m³/ fed/ year	١.٩١	١.٩٩	٢.١١	٢.١٢	٢.٠٣	١.٩٨	٢.١١	٢.٢٢	٢.٢٣	١.٩٨
a_7 ١٢٩٢٥ m³/ fed/ year	١.٩١	١.٩٩	٢.١٢	٢.١٣	٢.٠٣	٢.٠١	٢.١٢	٢.٢٣	٢.٢٤	٢.٠١
a_8 ١٤١٠٠ m³/ fed/ year	١.٩٢	٢.٠٠	٢.١٢	٢.١٣	٢.٠٤	٢.٠٢	٢.١٣	٢.٢٤	٢.٢٥	٢.٠٢
Mean (B)	١.٧٤	١.٨٢	١.٩٢	١.٩٣		١.٨٤	١.٨٤	١.٨٤	١.٨٤	
New L.S.D at ٥ %	A		B		AB	A		B		AB
	٠.٠٥		٠.٠٤		٠.١١	٠.٠٥		٠.٠٤		٠.١١

Spraying salicylic acid for improving water use efficiency and productivity in williams banana

Table ٦: Effect of water amounts, salicylic acid concentrations and their combinations on the percentage of magnesium in the leaves and bunch weight (kg.) of Williams bananas during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

Water amounts (m^3)/ fed/ year (A)	Leaf Mg %									
	٢٠٠٩/ ٢٠١٠					٢٠١٠/ ٢٠١١				
	Salicylic acid concentrations (B) ppm									
	b_1= ٠.٠	b_2= ١٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)	b_1= ٠.٠	b_2= ٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)
a_1 ٥٨٧٥ m^3/ fed/ year	٠.٣١	٠.٣٥	٠.٤٠	٠.٤١	٠.٣٦	٠.٣٣	٠.٣٧	٠.٤٢	٠.٤٣	٠.٣٨
a_2 ٧٠٥٠ m^3/ fed/ year	٠.٣٦	٠.٤١	٠.٤٦	٠.٤٨	٠.٤٢	٠.٣٨	٠.٤٢	٠.٤٨	٠.٥٠	٠.٤٤
a_3 ٨٢٢٥ m^3/ fed/ year	٠.٤٢	٠.٤٨	٠.٥٤	٠.٥٥	٠.٤٩	٠.٤٤	٠.٥٠	٠.٥٥	٠.٥٥	٠.٥١
a_4 ٩٤٠٠ m^3/ fed/ year	٠.٥١	٠.٥٧	٠.٦٤	٠.٦٥	٠.٥٩	٠.٥٣	٠.٦٠	٠.٦٥	٠.٦٦	٠.٦١
a_5 ١٠٥٧٥ m^3/ fed/ year	٠.٦١	٠.٧١	٠.٧٩	٠.٨٠	٠.٧٢	٠.٦٣	٠.٧٤	٠.٨٠	٠.٨١	٠.٧٤
a_6 ١١٧٥٠ m^3/ fed/ year	٠.٧١	٠.٨٣	٠.٨٨	٠.٨٨	٠.٨٢	٠.٧٣	٠.٨٥	٠.٨٩	٠.٩٠	٠.٨٤
a_7 ١٢٩٢٥ m^3/ fed/ year	٠.٧١	٠.٨٣	٠.٨٨	٠.٨٩	٠.٨٢	٠.٧٤	٠.٨٥	٠.٩٠	٠.٩٠	٠.٨٤
a_8 ١٤١٠٠ m^3/ fed/ year	٠.٧٢	٠.٨٤	٠.٨٨	٠.٨٩	٠.٨٣	٠.٧٤	٠.٨٦	٠.٩٠	٠.٩٠	٠.٨٥
Mean (B)	٠.٥٤	٠.٦٢	٠.٦٨	٠.٦٩		٠.٥٦	٠.٦٤	٠.٦٩	٠.٧٠	
New L.S.D at ٥ %	A	B	AB			A	B	AB		
	٠.٠٤	٠.٠٣	٠.٠٨			٠.٠٤	٠.٠٣	٠.٠٨		
Character	Bunch weight (kg.)/ fed.									
a_1 ٥٨٧٥ m^3/ fed/ year	١٨.٠	١٩.٦	٢١.٢	٢١.٥	٢٠.١	١٨.٩	٢٠.٧	٢٢.٢	٢٢.٤	٢١.١
a_2 ٧٠٥٠ m^3/ fed/ year	١٩.٠	٢٠.٧	٢٢.٣	٢٢.٥	٢١.١	٢٠.٠	٢١.٨	٢٣.٥	٢٣.٦	٢٢.٢
a_3 ٨٢٢٥ m^3/ fed/ year	٢٠.٥	٢٢.٢	٢٤.٢	٢٤.٢	٢٢.٧	٢١.٥	٢٣.٣	٢٥.٥	٢٥.٦	٢٣.٩
a_4 ٩٤٠٠ m^3/ fed/ year	٢٢.٠	٢٣.٦	٢٥.٩	٢٦.٠	٢٤.٣	٢٣.٢	٢٤.٧	٢٦.٩	٢٧.٠	٢٥.٤
a_5 ١٠٥٧٥ m^3/ fed/ year	٢٤.٠	٢٥.٩	٢٨.٠	٢٨.٠	٢٦.٤	٢٥.١	٢٧.٠	٢٩.٠	٢٩.٠	٢٧.٥
a_6 ١١٧٥٠ m^3/ fed/ year	٢٥.٩	٢٦.٠	٢٨.٢	٢٨.٢	٢٧.١	٢٧.٠	٢٧.٥	٢٩.٥	٢٩.٥	٢٨.٣
a_7 ١٢٩٢٥ m^3/ fed/ year	٢٦.٠	٢٦.٠	٢٨.٣	٢٨.٥	٢٧.٢	٢٧.٠	٢٧.٦	٢٩.٦	٢٩.٧	٢٨.٤
a_8 ١٤١٠٠ m^3/ fed/ year	٢٦.٠	٢٦.٥	٢٨.٥	٢٨.٦	٢٧.٤	٢٧.٢	٢٧.٨	٢٩.٧	٢٩.٩	٢٨.٦
Mean (B)	٢٢.٦	٢٣.٨	٢٥.٨	٢٥.٩		٢٣.٧	٢٥.١	٢٦.٩	٢٧.١	
New L.S.D at ٥ %	A	B	AB			A	B	AB		

	٠.٨	٠.٥	١.٤	٠.٩	٠.٥	١.٤

The maximum values from economically point of view were obtained with supplying the plants with water at ١٠٥٧٥ m^3/ fed/ year in combined with using salicylic acid at ٢٥٠ ppm. Similar results were obtained during both seasons.

These results regarding the effect of irrigation are in conformity with those obtained by Ibrahim (١٩٩٣) and Pereira *et al*., (٢٠٠٩).

The beneficial effect of salicylic acid on enhancing nutrients was supported by the results of Ahmed *et al*., (٢٠١٠) and Shaaban *et al*., (٢٠١١).

٣- Effect of water amounts and salicylic acid on weights of bunch and hand:

Data in Tables (٦& ٧) clearly showed that varying amounts of water from ٥٨٧٥ to ١١٧٥٠ m^3/ fed/ year without using salicylic acid and from ٥٨٧٥ to ١٠٥٧٥ m^3/ fed/ year with the application had significant differences on the weights of bunch and hand. Unsignificant variation on the weights of bunch and hand was observed among the higher levels. From statistical analysis point of view, supplying the plant with water at ١٠٥٧٥ to ١١٧٥٠ m^3/ fed/ year gave the best results with regarding to weights of bunch and hand.

Foliar application of salicylic acid at ١٢٥ to ٥٠٠ ppm significantly promoted weights of bunch and hand rather than non-application. The promotion on weights of bunch and hand was associated with increasing salicylic acid concentrations from ٠.٠ to ٥٠٠ ppm. Increasing concentrations of salicylic acid from ٢٥٠ to ٥٠٠ ppm failed to enhance the weights of bunch and hand by a significant level. Therefore, the recommended concentration from economical point of view was ٢٥٠ ppm.

The interaction between water amounts and salicylic acid showed a significant effect on the weights of bunch and hand, supplying the plants with water at ١٠٥٧٥ m^3/ fed/ year with spraying salicylic acid at ٢٥٠ ppm gave the best results with regard to bunch weight from economical point of view. Under such promised treatment, bunch weight in both seasons (٢٠٠٩/٢٠١٠ and ٢٠١٠/٢٠١١) reached ٢٨ and ٢٩ kg, respectively comparing with bunch weight that reached ٢٦ and ٢٧.٢ kg in the plants that received water at ١٤١٠٠ m^3/ fed/ year without salicylic acid application. This means that application of salicylic acid at ٢٥٠ ppm saved water amount reached about ٣٥٢٥ m^3/ fed/ year. The same results were similar during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

Table ٧: Effect of water amounts, salicylic acid concentrations and their combinations on the weights of hand (kg.) and finger (g.) of Williams bananas during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

Water amounts (m^3)/ fed/ year (A)	Hand weight (kg.)									
	٢٠٠٩/ ٢٠١٠					٢٠١٠/ ٢٠١١				
	Salicylic acid concentrations (B) ppm									
	b_1= ٠.٠	b_2= ١٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)	b_1= ٠.٠	b_2= ٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)
a_1 ٥٨٧٥ m^3/ fed/ year	١.٨٠	١.٩٥	٢.١١	٢.١٢	١.٩٩	١.٩١	٢.٠٥	٢.٢٠	٢.٢٢	١.٩١
a_2 ٧٠٥٠ m^3/ fed/ year	١.٩٢	٢.٠٥	٢.٢٥	٢.٢٦	٢.١٢	٢.٠٤	٢.١٦	٢.٤٠	٢.٤١	٢.٠٤
a_3 ٨٢٢٥ m^3/ fed/ year	٢.٠٢	٢.٢٠	٢.٤٠	٢.٤١	٢.٢٥	٢.١٤	٢.٣٣	٢.٥١	٢.٥٥	٢.١٤
a_4 ٩٤٠٠ m^3/ fed/ year	٢.٢٠	٢.٣٦	٢.٦٠	٢.٦١	٢.٤٤	٢.٣١	٢.٤٥	٢.٦٩	٢.٧٠	٢.٣١
a_5 ١٠٥٧٥ m^3/ fed/ year	٢.٣١	٢.٦٠	٢.٩٢	٢.٩٣	٢.٦٩	٢.٤٤	٢.٦٨	٢.٨١	٢.٨٢	٢.٤٤
a_6 ١١٧٥٠ m^3/ fed/ year	٢.٤١	٢.٦١	٢.٩٢	٢.٩٥	٢.٧٢	٢.٥٥	٢.٦٩	٢.٨٢	٢.٨٣	٢.٥٥
a_7 ١٢٩٢٥ m^3/ fed/ year	٢.٤٢	٢.٦١	٢.٩٣	٢.٩٥	٢.٧٢	٢.٥٦	٢.٧٠	٢.٨٢	٢.٨٥	٢.٥٦
a_8 ١٤١٠٠ m^3/ fed/ year	٢.٤٤	٢.٦٢	٢.٩٤	٢.٩٥	٢.٧٣	٢.٥٦	٢.٧٠	٢.٨٢	٢.٨٥	٢.٥٦
Mean (B)	٢.١٩	٢.٣٧	٢.٦٣	٢.٦٤		٢.٣١	٢.٣١	٢.٣١	٢.٣١	
New L.S.D at ٥ %	A		B		AB	A		B		AB
	٠.٠٧		٠.٠٦		٠.١٧	٠.٠٧		٠.٠٦		٠.١٧
Character	Finger weight (g.)									
a_1 ٥٨٧٥ m^3/ fed/ year	٩٧.٠	١٠١.٠	١٠٦.٠	١٠٦.٥	١٠٢.٦	٩٨.٣	١٠٢.٥	١٠٧.٥	١٠٧.٨	١٠٤.٠
a_2 ٧٠٥٠ m^3/ fed/ year	١٠٠.٠	١٠٥.٠	١١٠.٠	١١٠.٥	١٠٦.٣	١٠١.٤	١٠٦.٣	١١١.٥	١١١.٦	١٠٧.٧
a_3 ٨٢٢٥ m^3/ fed/ year	١٠٤.٠	١١٠.٠	١١٤.٩	١١٥.٠	١١٠.٩	١٠٥.٣	١١١.٤	١١٦.٣	١١٦.٧	١١٢.٤
a_4 ٩٤٠٠ m^3/ fed/ year	١٠٩.٩	١١٥.٠	١٢٠.٠	١٢٠.٥	١١٦.٣	١١١.٣	١١٦.٥	١٢٢.٥	١٢٢.٩	١١٨.٣
a_5 ١٠٥٧٥ m^3/ fed/ year	١١٢.٠	١١٩.٠	١٢٥.٠	١٢٥.٥	١٢٠.٣	١١٣.٥	١٢٠.٥	١٢٦.٠	١٢٦.٤	١٢١.٦
a_6 ١١٧٥٠ m^3/ fed/ year	١١٤.٨	١١٩.٥	١٢٦.٠	١٢٦.٣	١٢١.٦	١١٥.٠	١٢١.٠	١٢٦.٥	١٢٦.٧	١٢٢.٣
a_7 ١٢٩٢٥ m^3/ fed/ year	١١٥.٠	١١٩.٩	١٢٦.٠	١٢٦.٤	١٢١.٨	١١٥.٠	١٢١.٠	١٢٦.٩	١٢٧.٠	١٢٢.٤
a_8 ١٤١٠٠ m^3/ fed/ year	١١٥.٠	١٢٠.٠	١٢٦.٠	١٢٦.٥	١٢١.٨	١١٥.٥	١٢١.٥	١٢٧.٠	١٢٧.٦	١٢٢.٩
Mean (B)	١٠٨.٤	١١٣.٦	١١٩.٢	١١٩.٦		١٠٩.٤	١١٥.١	١٢٠.٥	١٢٠.٨	
New L.S.D at ٥ %	A		B		AB	A		B		AB

	٢.٠	١.٩	٥.٤	٢.٢	٢.٠	٥.٦

These results regarding the effect of water irrigation are in harmony with those obtained by Ibrahim (١٩٩٣) and Pereira *et al*., (٢٠٠٩).

The promoting effect of salicylic acid on the yield was emphasized by the results of Ahmed *et al*., (٢٠١٠) and Shaaban *et al*., (٢٠١١).

٤- Effect of water amounts and salicylic acid on some physical and chemical characteristics of the fruits:

It is obvious from the data in Tables (from ٧ to ١٠) that increasing water amounts from ٥٧٨٧ to ١٠٥٧٥ m^3/ fed/ year caused a gradual promotion on fruit quality expressed in enhancing finger weight, pulp/ peel, T.S.S % as well as total and reducing sugars %. However, reducing total acidity %. However, the higher levels of water amounts (١١٧٥٠, ١٢٩٢٥ and ١٤١٠٠ m^3/ fed/ year) caused a significant reduction on T.S.S % as well as total and reducing sugars %, while promoted total acidity %. The best results with regard to quality of the fruits were recoded when the plants received water at ١٠٥٧٥ m^3/ fed/ year.

Results regarding the effect of salicylic acid concentrations on fruit quality, clearly showed that spraying salicylic acid at ١٢٥ to ٥٠٠ ppm significantly improved both physical and chemical characteristics of the fruits comparing with the control treatment. Improving the fruit quality was associated with increasing salicylic acid concentrations. Significant differences were observed among different treatments of salicylic acid concentrations except between the higher two concentrations namely ٢٥٠ and ٥٠٠ ppm.

The best results with regard to fruit quality were obtained with supplying the plants with water at ١٠٥٧٥ m^3/ fed/ year along with spraying salicylic acid at ٢٥٠ ppm. Using the higher amounts of water under non- application of salicylic acid gave unsatisfactory effects on chemical characteristics of the fruits. Similar trend was observed during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

These results regarding the promoting effect of water when applied at the optimum level on fruit quality are in harmony with those obtained by Ibrahim (١٩٩٣) and Pereira *et al*., (٢٠٠٩).

Similar trend regarding the beneficial effect of salicylic acid on fruit quality was revealed by Ahmed *et al*., (٢٠١٠) and Shaaban *et al*., (٢٠١١).

٥- Effect of water amounts and salicylic acid on water use efficiency:

Data in Table (١٠) clearly showed that water use efficiency was significantly varied among different water irrigation treatments. There was a gradual and significant reduction on water use efficiency with increasing the amounts of water from ٥٨٧٥ to ١٤١٠٠ m^3/ fed/ year. The maximum values were recorded on the plants that irrigated with water at ٥٨٧٥ m^3/ fed/ year. Watering of plants with water at ١٤١٠٠ m^3/ fed/ year gave the lowest values.

Foliar application of salicylic acid at ١٢٥ to ٥٠٠ ppm was significantly responsible for improving water use efficiency rather than non- application. Improving water efficiency was associated with increasing the concentrations of salicylic acid. No significant increase on water use efficiency was observed with increasing salicylic acid concentrations from ٢٥٠ to ٥٠٠ ppm.

Significant differences on water use efficiency may be due to the interaction between water amounts and salicylic acid concentrations. Irrigation with water along with foliar application of salicylic acid was significantly very effective in enhancing water use efficiency comparing with carrying out irrigation without spraying salicylic acid. These results were similar during both seasons.

These results with regard to water amounts are in agreement with those obtained by Ibrahim (١٩٩٣) and Pereira *et al*., (٢٠٠٩).

The promoting effect of salicylic acid on water use efficiency was supported by the results of Ahmed *et al*., (٢٠١٠) and Shaaban *et al*., (٢٠١١).

The positive action of water when applied at the optimum rate on fruiting of Williams bananas might be attributed to the beneficial role of water on stimulating cell division, biosynthesis of carbohydrates,

absorption of most nutrients, activation of all enzymes and translocation of organic foods (Goenaga *et al*., ١٩٩٥).

The essential roles of salicylic acid on photosynthesis, uptake and transport of nutrients and counteracting the adverse effects of stress conditions on fruiting of fruit crops (Bourbouloux *et al*., ١٩٩٨) could explain the present results.

As a conclusion, it is beneficial for improving the yield quantitively and qualitatively of Williams bananas through supplying the plants with water at ١٠٥٧٥ m^3/ fed/ year in combined with spraying the plants four times with salicylic acid at ٢٥٠ ppm.

Table ٨: Effect of water amounts, salicylic acid concentrations and their combinations on pulp/ peel and the percentage of total soluble solids in the fruits of Williams bananas during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

Water amounts (m^3)/ fed/ year (A)	Pulp/ peel									
	٢٠٠٩/ ٢٠١٠					٢٠١٠/ ٢٠١١				
	Salicylic acid concentrations (B) ppm									
	b_1= ٠.٠	b_2= ١٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)	b_1= ٠.٠	b_2= ٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)
a_1 ٥٨٧٥ m^3/ fed/ year	١.١٨	١.٢٥	١.٣٣	١.٣٤	١.٢٧	١.٢٠	١.٢٧	١.٣٦	١.٣٧	١.٣٠
a_2 ٧٠٥٠ m^3/ fed/ year	١.٢٥	١.٣٣	١.٤٣	١.٤٤	١.٣٦	١.٢٦	١.٣٤	١.٤٣	١.٤٤	١.٣٦
a_3 ٨٢٢٥ m^3/ fed/ year	١.٣٢	١.٤٢	١.٥١	١.٥٢	١.٤٤	١.٣٣	١.٤٤	١.٥٢	١.٥٢	١.٤٥
a_4 ٩٤٠٠ m^3/ fed/ year	١.٤١	١.٥٠	١.٧٠	١.٧١	١.٥٨	١.٤٢	١.٥١	١.٦٠	١.٦١	١.٥٣
a_5 ١٠٥٧٥ m^3/ fed/ year	١.٥٠	١.٦٩	١.٧٩	١.٨٠	١.٦٩	١.٥٥	١.٧٠	١.٨٢	١.٨٣	١.٧٢
a_6 ١١٧٥٠ m^3/ fed/ year	١.٥٦	١.٧٠	١.٨٠	١.٨١	١.٧١	١.٦٠	١.٧١	١.٨٣	١.٨٥	١.٧٤
a_7 ١٢٩٢٥ m^3/ fed/ year	١.٥٧	١.٧١	١.٨١	١.٨٢	١.٧٢	١.٦١	١.٧١	١.٨٥	١.٨٦	١.٧٥
a_8 ١٤١٠٠ m^3/ fed/ year	١.٥٧	١.٧٢	١.٨٢	١.٨٢	١.٧٣	١.٦١	١.٧٢	١.٨٥	١.٨٧	١.٧٦
Mean (B)	١.٤٢	١.٥٤	١.٦٤	١.٦٥		١.٤٤	١.٥٥	١.٦٥	١.٦٦	
New L.S.D at ٥ %	A		B		AB	A		B		AB
	٠.٠٥		٠.٠٤		٠.١١	٠.٠٥		٠.٠٤		٠.١١
Character	Total soluble solids %									
a_1 ٥٨٧٥ m^3/ fed/ year	١٨.٠	١٨.٤	١٩.٠	١٩.٠	١٨.٦	١٨.٢	١٨.٦	١٩.٣	١٩.٤	١٨.٨

a_2 ٧٠٥٠ m³/ fed/ year	١٨.٤	١٨.٨	١٩.٤	١٩.٥	١٩.٠	١٨.٦	١٩.٠	١٩.٧	١٩.٨	١٩.٢
a_3 ٨٢٢٥ m³/ fed/ year	١٨.٨	١٩.٢	٢٠.١	٢٠.٢	١٩.٥	١٨.٩	١٩.٤	٢٠.٤	٢٠.٥	١٩.٨
a_4 ٩٤٠٠ m³/ fed/ year	١٩.٠	١٩.٤	٢٠.٤	٢٠.٥	١٩.٨	١٩.١	١٩.٦	٢٠.٨	٢٠.٩	٢٠.١
a_5 ١٠٥٧٥ m³/ fed/ year	١٩.٣	١٩.٧	٢٠.٨	٢٠.٨	٢٠.١	١٩.٥	١٩.٩	٢١.٢	٢١.٤	٢٠.٥
a_6 ١١٧٥٠ m³/ fed/ year	١٩.٠	١٩.٤	٢٠.٤	٢٠.٥	١٩.٨	١٩.١	١٩.٦	٢٠.٦	٢٠.٧	٢٠.٠
a_7 ١٢٩٢٥ m³/ fed/ year	١٨.٦	١٩.٠	٢٠.٢	٢٠.٣	١٩.٥	١٨.٧	١٩.٢	٢٠.٤	٢٠.٥	١٩.٧
a_8 ١٤١٠٠ m³/ fed/ year	١٨.٥	١٨.٩	٢٠.١	٢٠.٢	١٩.٤	١٨.٥	١٩.٠	٢٠.٢	٢٠.٣	١٩.٥
Mean (B)	١٨.٧	١٩.١	٢٠.١	٢٠.١		١٨.٨	١٩.٢	٢٠.٣	٢٠.٤	
New L.S.D at ٥ %	A		B		AB	A		B		AB
	٠.٣		٠.٢		٠.٦	٠.٣		٠.٢		٠.٦

Spraying salicylic acid for improving water use efficiency and productivity in williams banana

Table ٩: Effect of water amounts, salicylic acid concentrations and their combinations on the percentages of total and reducing sugars in the fruits of Williams bananas during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

Water amounts (m^3)/ fed/ year (A)	Total sugars %									
	٢٠٠٩/ ٢٠١٠					٢٠١٠/ ٢٠١١				
	Salicylic acid concentrations (B) ppm									
	b_1= ٠.٠	b_2= ١٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)	b_1= ٠.٠	b_2= ٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)
a_1 ٥٨٧٥ m^3/ fed/ year	١٣.٠٠	١٣.٣٠	١٣.٦٠	١٣.٨٠	١٣.٤٢	١٣.٠٩	١٣.٤١	١٣.٧١	١٣.٨٠	١٣.٥٠
a_2 ٧٠٥٠ m^3/ fed/ year	١٣.٣٠	١٣.٥٠	١٣.٧٥	١٣.٩٢	١٣.٦١٧	١٣.٤٠	١٣.٦٠	١٣.٨٦	١٣.٩٠	١٣.٦٩
a_3 ٨٢٢٥ m^3/ fed/ year	١٣.٥٠	١٣.٦٩	١٣.٨٦	١٤.١١	١٣.٧٩	١٣.٦٠	١٣.٨٠	١٣.٩٦	١٣.٩٩	١٣.٨٣
a_4 ٩٤٠٠ m^3/ fed/ year	١٣.٦٦	١٣.٨٥	١٣.٩٩	١٤.٢٢	١٣.٩٣	١٣.٧٦	١٣.٩٥	١٤.١١	١٤.١٥	١٣.٩٩
a_5 ١٠٥٧٥ m^3/ fed/ year	١٣.٨٠	١٣.٩٦	١٤.١١	١٤.٣٢	١٤.٠٤	١٣.٩٠	١٤.٠٦	١٤.٢٢	١٤.٢٥	١٤.١٠
a_6 ١١٧٥٠ m^3/ fed/ year	١٣.٦٠	١٣.٨٠	١٤.٠٠	١٤.٢٢	١٣.٩٠	١٣.٧١	١٣.٩٠	١٤.١١	١٤.١٥	١٣.٩٦
a_7 ١٢٩٢٥ m^3/ fed/ year	١٣.٥٠	١٣.٧١	١٣.٨٠	١٤.١١	١٣.٧٨	١٣.٦٠	١٣.٨١	١٣.٩٠	١٣.٩٥	١٣.٨١
a_8 ١٤١٠٠ m^3/ fed/ year	١٣.٤٠	١٣.٦١	١٣.٦٠	١٤.٠٦	١٣.٦٦	١٣.٥٠	١٣.٧١	١٣.٧١	١٣.٧٥	١٣.٦٦
Mean (B)	١٣.٤٧	١٣.٦٧	١٣.٨٣	١٤.٠٩		١٣.٥٧	١٣.٧٨	١٣.٩٤	١٣.٩٩	
New L.S.D at ٥ %	A	B	AB			A	B	AB		
	٠.١٠	٠.٠٩	٠.٢٥			٠.١٠	٠.٠٩	٠.٢٥		
Character	Reducing sugars %									
a_1 ٥٨٧٥ m^3/ fed/ year	٤.٤	٤.٧	٥.٢	٥.٣	٤.٩	٤.٦	٤.٩	٥.٥	٥.٦	٥.١
a_2 ٧٠٥٠ m^3/ fed/ year	٤.٧	٥.١	٥.٦	٥.٧	٥.٢	٤.٩	٥.٣	٦.٠	٦.١	٥.٥
a_3 ٨٢٢٥ m^3/ fed/ year	٥.٠	٥.٤	٦.٠	٦.١	٥.٦	٥.٢	٥.٦	٦.٣	٦.٥	٥.٩
a_4 ٩٤٠٠ m^3/ fed/ year	٥.٢	٥.٨	٦.٣	٦.٥	٥.٩	٥.٥	٦.٠	٦.٦	٦.٧	٦.٢
a_5 ١٠٥٧٥ m^3/ fed/ year	٥.٥	٦.١	٦.٦	٦.٧	٦.٢	٥.٦	٦.٣	٦.٩	٧.٠	٦.٤
a_6 ١١٧٥٠ m^3/ fed/ year	٥.٢	٥.٨	٦.٤	٦.٥	٥.٩	٥.٣	٥.٩	٦.٥	٦.٥	٦.١
a_7 ١٢٩٢٥ m^3/ fed/ year	٤.٩	٥.٦	٦.٠	٦.١	٥.٦	٤.٩	٥.٧	٦.٣	٦.٤	٥.٨
a_8 ١٤١٠٠ m^3/ fed/ year	٤.٧	٥.٤	٥.٨	٥.٩	٥.٤	٤.٧	٥.٥	٦.٠	٦.١	٥.٥
Mean (B)	٤.٩	٥.٤	٥.٩	٦.١		٥.١	٥.٦	٦.٣	٦.٤	

New L.S.D at ٥ %	A	B	AB	A	B	AB
	٠.٣	٠.٣	٠.٦	٠.٣	٠.٢	٠.٦

Spraying salicylic acid for improving water use efficiency and productivity in williams banana

Table ١٠: Effect of water amounts, salicylic acid concentrations and their combinations on the percentage of total acidity in the fruits and water use efficiency of Williams bananas during ٢٠٠٩/ ٢٠١٠ and ٢٠١٠/ ٢٠١١ seasons.

Water amounts (m^3)/ fed/ year (A)	Total acidity %									
	٢٠٠٩/ ٢٠١٠					٢٠١٠/ ٢٠١١				
	Salicylic acid concentrations (B) ppm									
	b_1= ٠.٠	b_2= ١٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)	b_1= ٠.٠	b_2= ٢٥	b_3= ٢٥٠	b_4= ٥٠٠	Mean (A)
a_1 ٥٨٧٥ m^3/ fed/ year	٠.٣٤٥	٠.٣٢٠	٠.٢٩٥	٠.٢٩٤	٠.٣١٣	٠.٣٤٤	٠.٣١٨	٠.٢٩٣	٠.٢٩١	٠.٣٤٤
a_2 ٧٠٥٠ m^3/ fed/ year	٠.٣٢٠	٠.٢٩٥	٠.٢٦٩	٠.٢٦٦	٠.٢٨٧	٠.٣١٨	٠.٢٩٣	٠.٢٦٠	٠.٢٥٩	٠.٣١٨
a_3 ٨٢٢٥ m^3/ fed/ year	٠.٢٩٥	٠.٢٦٩	٠.٢٣٠	٠.٢٢٨	٠.٢٥٥	٠.٢٩٤	٠.٢٦٧	٠.٢٥٣	٠.٢٥٢	٠.٢٩٤
a_4 ٩٤٠٠ m^3/ fed/ year	٠.٢٧٠	٠.٢٣٩	٠.٢٠٠	٠.١٩٩	٠.٢٢٧	٠.٢٦٩	٠.٢٣٧	٠.٢١٧	٠.٢١٦	٠.٢٦٩
a_5 ١٠٥٧٥ m^3/ fed/ year	٠.٢٤٠	٠.٢١٩	٠.١٨٠	٠.١٧٩	٠.٢٠٤	٠.٢٣٩	٠.٢١٧	٠.١٩٥	٠.١٩٤	٠.٢٣٩
a_6 ١١٧٥٠ m^3/ fed/ year	٠.٢٦٦	٠.٢٤٦	٠.٢١١	٠.٢٠٩	٠.٢٣٣	٠.٢٤٧	٠.٢٣٦	٠.٢١١	٠.٢١٠	٠.٢٤٧
a_7 ١٢٩٢٥ m^3/ fed/ year	٠.٢٨٦	٠.٢٦٦	٠.٢٤١	٠.٢٤٠	٠.٢٥٨	٠.٢٨٨	٠.٢٤٧	٠.٢٣١	٠.٢٣٠	٠.٢٨٨
a_8 ١٤١٠٠ m^3/ fed/ year	٠.٣١١	٠.٢٩٥	٠.٢٦٦	٠.٢٦٤	٠.٢٨٤	٠.٣١١	٠.٢٦٦	٠.٢٥٥	٠.٢٥٣	٠.٣١١
Mean (B)	٠.٢٩١	٠.٢٦٨	٠.٢٣٦	٠.٢٣٤		٠.٢٨٨	٠.٢٨٨	٠.٢٨٨	٠.٢٨٨	٠.٢٩١
New L.S.D at ٥ %	A		B		AB	A		B		AB
	٠.٠٢٢		٠.٠٢١		٠.٠٥٩	٠.٠٢٢		٠.٠٢٠		٠.٠٥٦
Character	Water use efficiency (WUE) (kg fruits/ m^3 water)									
a_1 ٥٨٧٥ m^3/ fed/ year	٣.١	٣.٣	٣.٦	٣.٧	٣.١	٣.٢	٣.٥	٣.٨	٣.٨	٣.٦
a_2 ٧٠٥٠ m^3/ fed/ year	٢.٧	٢.٩	٣.٢	٣.٢	٢.٧	٢.٨	٣.١	٣.٣	٣.٣	٣.١
a_3 ٨٢٢٥ m^3/ fed/ year	٢.٥	٢.٧	٢.٩	٢.٩	٢.٥	٢.٦	٢.٨	٣.١	٣.١	٢.٩
a_4 ٩٤٠٠ m^3/ fed/ year	٢.٣	٢.٥	٢.٨	٢.٨	٢.٣	٢.٥	٢.٣	٢.٩	٢.٩	٢.٧
a_5 ١٠٥٧٥ m^3/ fed/ year	٢.٣	٢.٤	٢.٦	٢.٦	٢.٣	٢.٤	٢.٦	٢.٧	٢.٧	٢.٦
a_6 ١١٧٥٠ m^3/ fed/ year	٢.٢	٢.٢	٢.٤	٢.٤	٢.٢	٢.٣	٢.٣	٢.٥	٢.٥	٢.٤
a_7 ١٢٩٢٥ m^3/ fed/ year	٢.٠	٢.٠	٢.٢	٢.٢	٢.٠	٢.١	٢.١	٢.٣	٢.٣	٢.٢
a_8 ١٤١٠٠ m^3/ fed/ year	١.٨	١.٩	٢.٠	٢.٠	١.٨	١.٩	٢.٠	٢.١	٢.١	٢.٠
Mean (B)	٢.٤	٢.٥	٢.٧	٢.٧		٢.٥	٢.٦	٢.٨	٢.٨	

New L.S.D at ٥ %	A	B	AB	A	B	AB
	٠.٢	٠.٢	٠.٦	٠.٢	٠.٢	٠.٦

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محاولات لتحسين كفاءة استخدام ماء الري وتحسين الإنتاجية في بساتين الموز الوليامز عن طريق رش حامض السلسليك

مؤمن محمد الوصفي

قسم البساتين – كلية الزراعة – جامعة جنوب الوادي – قنا – مصر.

تمت الدراسة خلال موسمي ٢٠٠٩/ ٢٠١٠، ٢٠١٠/ ٢٠١١ حيث تم ري نباتات الموز الوليامز بثمانية معدلات من مياه الري هي ٥٨٧٥، ٧٠٥٠، ٨٢٢٥، ٩٤٠٠، ١٠٥٧٥، ١١٧٥٠، ١٢٩٢٥، ١٤١٠٠ متر مكعب مياه للفدان في العام جنبا الي جنب مع رش حامض السلسليك بتركيز صفر، ١٢٥، ٢٥٠، ٥٠٠ جزء في المليون وذلك كمحاولة لتوفير وتحسين كفاءة استخدام مياه الري والإنتاجية.

أشارت نتائج الدراسة إلي أن الري بالماء بكميات من ٥٨٧٥ إلي ١٤١٠٠ متر مكعب للفدان في العام جنبا الي جنب مع رش حامض السلسليك بتركيز ما بين ١٢٥ إلي ٥٠٠ جزء في المليون كان فعالا جدا في تحسين النمو والحالة الغذائية للنباتات والمحصول وكذلك الخصائص الطبيعية والكيميائية للثمار وذلك بالمقارنة بالري بدون استخدام حامض السلسليك وكان هناك تحسن واضح في كفاءة استخدام مياه الري مع استخدام حامض السلسليك مع مياه الري وذلك بالمقارنة بالري فقط. إن ري النباتات بمعدل ١٠٥٧٥ متر مكعب للفدان جنبا إلي جنب مع رش حامض السلسليك بتركيز ٢٥٠ جزء في المليون يؤدي إلي تحسين كفاءة استخدام مياه الري بدلا من استخدام مياه الري بكمية مقدارها ١٤١٠٠ متر مكعب للفدان في العام بدون استخدام حامض السلسليك.

لأجل توفير مياه الري وتحسين كفاءة استخدام مياه الري والإنتاجية في بساتين الموز الوليامز فإنه ينصح بري النباتات بالماء بمعدل ١٠٥٧٥ متر مكعب للفدان في العام مع رش حامض السلسليك أربعة مرات بتركيز ٢٥٠ جزء في المليون بدلا من الري بمعدل ١٤١٠٠ متر مكعب للفدان/ العام (معاملة الكونترول) وعدم استخدام حامض السلسليك حيث يصل معدل توفير الماء إلي ٣٥٢٥ متر مكعب للفدان/ **العام.**