The effects of irrigation water amounts and vegetative spraying some amino acids on and of banana plants yield and fruit ، growth water use efficiency under drip irrigation system in clay loam soils

By

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المستخلص :

تم إجراء تجربة حقلية في بستان موز خاص يقع في منطقة بدوي بمركز المنصورة بمحافظة الدقهلية ، وتم زراعة نباتات الموز علي مسافات ٣×٣.٥ م خلال موسمي ٢٠١٧/ ٢٠١٨ و ٢٠١٩/٢٠١٨ لدراسة تأثير كميات مياه الري المختلفة (من البخرنتح للمحصول) ١٠٠ و ٨٥ و ٧٠ ٪ من (ETc) ومعاملات رش الأوراق باستخدام بعض الأحماض الأمينية وهي(جلايسين بيتاين و البرولين و جلايسين بيتاين + البرولين) إضافة إلي معامله كنترول تحت نظام الري بالتنقيط في التربة الطينية وتاثيرها على قياسات النمو الخضري و وزن السوباطة و المحصول و جودة الثمار وكفاءة استخدام المياه ، في الخلف الأولى والثانية من نبات الموز صنف جرند نان.

يمكن تلخيص أهم النتائج على النحو التالي: سجلت معنويا مياه الري المضافة قيمة (٧٠٥٥ ، ٥٩٩٤ و ٤٩٣٩ م ٣ / فدان) في الموسم الأول و قيم (٧٥١٧ ، ٦٣٩٠ و ٥٢٦٢ م ٣ / فدان) في الموسم الثاني على التوالي. و أدت زيادة كمية مياه الري إلي زيادة النمو الخضري للموزفي كلا الموسمين. أدى كتا من جلايسين بيتاين + البرولين والبرولين إلى زيادة كبيرة في معظم صفات النمو الخضري مقارنة بالكنترول وحقق المستوى الأول من الري ا (١٠٠٪ من ETc مع الرش بالجلايسين بيتاين + البرولين أفضل تأثيرعلي معظم صفات النمو الخضري

في كلا الموسمين و لم توجد اختلافات كبيرة في طول الإصابع أو طول السوباطة بينمستويات مياه الري المختلفة في كلا الموسمين. و وجدت اختلافات كبيرة و زيادة في إجمالي االمحصول / فدان. عند الري ٨٥ ٪ من ETc في كلا الموسمين. زاد الرش بالأحماض الأمينية بشكل ملحوظ في طول الإصابع ، وطول السوباطة ، ووزن السوباطة ، والمحصول للطن / الفدان. مقارنة مع الكنترول في كلا الموسمين.
و تم الحصول علي اعلي انتاج للمحصول طن / للفدان عليه عند معاملة نباتات الموز بالرش جلايسين بيتاين + البرولين تحت المستوى الثاني من الري ٨٥٪ ETc بالمقارنة مع المعاملات الأخرى. أيضا ، ارتفع متوسط كفاءة استخدام المياه (WUtE) باستخدام ٨٥مستوي الري ٪ من ETc المسجلة (٢.٩٦ و ٣.١٩ كجم / م ٣) ، تليها المستوي ٧٠٪ من ETc 2,42 و ٢.٧٥ كجم / م ٣) ، ثم المستوي ١١٠٠ ٪ من ETc 2,26 و ٢.٤٥ كجم / م ٣) في كلا الموسمين ، على التوالي.
بشكل عام ، يمكن أن نستنتج أن الرش بالجلايسين بيتاين + البرولين تحت كمية المياه بنسبة ٨٥ ٪ من ETc كان أفضل معاملة لإنتاج الموز مع تحقيق أقصى كفاءة لإستخدام المياه تحت ظروف هذة الدراسة.

Abstract:

The present work was conducted in a private banana orchard located at Badawi district ،Mansoura Center, Dakahlia Governorate ،banana plants were cultivated٣ x3.5 m during 2017/2018 and 2018/2019 growing seasons to study the effect of different irrigation water amount at either 100, 85 and 70% of crop evapotranspiration (ETc (and foliar spray with (glycine-betaine, proline; glycine-betaine + proline) under drip irrigation system in clay loam soils on vegetative growth measurements, bunch weight, yield, fruit quality and water use efficiency ،of first and second ratoons of Grand Nain banana plant . The most important results can be summarized as follows: Applied irrigation water registered (7055, 5994 and 4939 m/٣fed(in the first season and (7517, 6390 and 5262 m/٣fed(in the second one, respectively. Increasing irrigation water quantity increased banana growth characters of both seasons. Glycine-betaine + proline and proline led to significant incremnts in most vegetative growth traits compared to control. First level of water irrigation (100 % of ETc) with application of glycine-betaine +

proline had the most significant effect on most vegetative growth characters, in both seasons of study. No significant differences were defected in finger length or bunch length between different irrigation water regemes in both seasons. Significant differences were found total yield lfed was increasedas aresalt of water regeme at 85% of ETe in both seasons.

Application of amino acids was significantly increased as a finger length , bunch length ،weight bunch and yield ton/fed . compared with the control in both seasons .

The maximum value of total yield ton/fed. was obtained when banana plants treated with glycine-betaine + proline under the 2nd level of irrigation (85 % ETc) in comparison with other treatments.

Also, average water utilization efficiency (WUtE) increased by using 85 % of ETc recorded (2.96 and 3.19 kg/m ،(٣followed by 70 % of ETc 2.42) and 2.75 kg/m ،(3and 100 % of ETc treatments (2.26 and 2.45 kg/m (3in both seasons, respectively.

Generally, it could be concluded that glycine-betaine + proline application under water quantity of 85% of ETc was the best combination for high banana production and maximum water use efficiency in this study.

.Key words :Banana, irrigation amounts, drip irrigation, amino acids, vegetative growth, yield and fruit quality.

INTRODUCTION:

The water wealth of natural resources that are related to the existence of life and preservation has become vitally important . Agriculture is the sector where the main consumer of this resource in most countries of the world (In Arab countries ،90 % of the water available(

Banana belongs to the genus Musa of the family Musaceae .Its cultivation is distributed throughout the warmer countries and is confined to regions between 30°N and 30°S of equator. Together, bananas and plantains ،are the fourth most important food crop in the world after rice, wheat and maize (Salvador et al. (2007(

Banana and plantains (Musa Cavindishii Lamb(are today grown in many regions and constitute the highest fruit crop production in the world, following the 4th after grapes, citrus and apple. In Egypt, the total planted area of banana increased to reach 25073 hectare in 2012 season ،producing1.129 million tons 20) tons/feddan (according to the FAO latest statistics (FAO , 2 0 1 2(

The major hurdle in banana production quality is the lack of professional outlook towards its production and the mismanagement of the available natural resources. Water is one of the most important constraints which significantly influence itis quality and productivity .Banana is a tropical plant that requires an ample and frequent supply of water .Many earlier workers have reported that water deficit adversely affects the crop growth and yield (Mahmoud, 2006(

Generally, the banana in Egypt is irrigated by surface irrigation in in the old cultivated lands. There are several problems in surface irrigation caused by accumulation of salts ،increased level of tail water loss through evaporation and leaching, difficulties in moving of farm equipment, added expenses and time to make extra tillage practice (furrow construction), an increase in the erosive potential of the flow ، requires a lot of water, does not work well on sandy soils, and irrigated area needs to be relatively flat. Also, it may add too much water near the inlet and not enough water at the edges. Generally, furrow systems are more difficult to automate particularly with regard to regulating an equal discharge in each furrow and losing too much water to deep drainage or runoff (Walker, 1989(

Banana plants require large quantities of water to maintain high production with good

fruit quality (Van Vosselen et al. (2005(

Water deficit is a major problem in banana grown under arid regions climatic conditions. It affects plant growth and development and ultimately leads to a

considerable bunch yield reduction or crop failure Ahmed et al. (2013) Consequently ،researchers pay attention to improve deficit irrigation strategies to decrease irrigation water requirements (Lu et al. (2002(

Water is increasingly becoming a scarce resource and the areas requiring irrigation are very extensive and encompass portions of every continent of the world (Israelsen and Hansen(1972 An earlier estimate made by (FAO, 1993. for average irrigation water utilization showed that farm distribution losses constitute 15% of irrigation water; while field application system losses constitute 25%, irrigation system losses 15% and the water effectively used by crops constitutes only about 45% .

In Egypt , prpirrigation was c0mmonly used in sandy soils but not in old clay soils.

The present work used drip irrigation system as a tool and newtechnique for irrigation banana in oid clay soils.

Drip irrigation (trickle or micro irrigation (is a promising system for

economizing the available irrigation water. It is also necessary to manage the

available water efficiently for maximum crop production. Drip irrigation can apply water both precisely and uniformly at a high irrigation frequency compared with furrow and sprinkler irrigation (Hanson and May, 2007(Drip irrigation systems are well suited to fertigation because of their frequency of operation and because water application can be easily controlled by the manager (Brad Lewis, 2001(

Glycine betaine (GB (is an organic compound that occurs in plants ،it is an amphoteric quaternary amine, plays an important role as a compatible solute in plants under various types of environmental stress, such as high levels of salts and high or low temperature (Sakamoto A .and Murata N., 2002(

Furthermore, because some of these solutes also protect cellular components from dehydration injury ،they are commonly referred to as osmo-protectants. These solutes include proline ،sucrose ،polyols ،trehalose and quaternary ammonium compounds (QACs) such as glycine betaine, alanine betaine, proline betaine, choline

O-sulfate ،hydroxyl proline betaine ،and pipecolate betaine (Rhodes and Hanson, 1993(

Proline is the most important amino acids that accumulate in various tissues of the plant ،particularly in the Leaves Because the effect of water stress .And that the accumulation of this amino acid has a role in the regulation of osmosis in the cell As the proline is concentrated in the cytoplasm to counterbalance effort osmosis Cell sap .Also ، proline protects enzymes under conditions of water stress (Meister 2012(

As well as The Proline is indicators of drought and an increase in the leaf proof that the plant suffered water stress also Is one of the ways the plant resistance to water stress The accumulation of proline in the leaf appearance adaptation in times of drought to save the best percentage of water in the plant (Tarighaleslami, Zarghami et al. 2012)

The objectives of the study were -١ :change the surface irrigation systems to drip irrigation system irrigation methods for banana production under clay loam soil in terms of yield and yield components, quantities of water applied ، irrigation water productivity and economic analysis. 2- finds ways to cope with scarcity of water ،taking place in many countries of the world using glycine-betaine and the amino acid proline and understand some of the effects and physiological adaptations to drought.

MATERIALS AND METHODS

This study was conducted during two successive seasons 2017/2018 first ratoon and 2018/2019 second ratoon for banana (Musa AAA) cv. Grand Nain produced through tissue culture. Banana plants grown in clay loam soil under drip irrigation system in a private banana orchard located at Badaway district ،Mansoura Center, Dakahlia Governorate ، banana plants were cultivated٣ x3.5 m apart, similar in growth, free from diseases and received the same horticultural managements . .Forty five stools/(mat، (each containing two plants of Grand Nain cultivar were chosen to evaluate the effect of irrigation water amounts and spraying some amino acids on yield and fruit quality ،some vegetative growth measurements and water use efficiency under drip irrigation system in clay loam soil .One metre gap was provided between each plot to avoid effect of irrigation treatment.

Forty five of Grand Nain banana plants each in separate mat, were chosen and arranged in split plot on fifteen interaction treatments with three replications. In the first season, each mat yielded three suckers. Also ،in the second season, each mat yielded three suckers .

Field capacity, permanent wilting point, the available water and bulk density were determined as well as soil physical parameters and listed in Table (1(Meteorological data of the Agricultural Research Station are shown in Table (2)

Irrigation started on January i.e ،.irrigation was done when moisture reached the relevant level to determine available soil water retained in the soil .

Table 1: Physical properties of the orchard soil .

Parameter				Value
Particle size distribution:(%)				
Clay%				39.6
Silt%				38.3
Fine sand%				21.1
Coarse sand%				1.0
Texture class				Clay loam
Water parameters and bulk density				
epth	Field capacity (FC) % (w/w)	Wilting Point (WP) % (w/w)	Available water (AW) % (w/w(	Bulk density (BD) gm./cm٣
0-15	39.90	18.52	21.38	1.19
15-30	37.65	17.68	19.97	1.23
30-45	35.86	16.76	19.10	1.25
45-60	32.15	16.46	15.69	1.28

Table 2 : Meteorological data in 2017/18 and 2018/19 seasons.

Season	2017 / 2018						2018 / 2019					
Month	T.max	T.min.	W.S	R.H	S.S	R.F	T.max	T.min	W.S	R.H	S.S	R.F
ebruary	21.3	12.1	2.7	67.0	8.2	41.6	19.7	10.0	3.4	63.6	8.3	12.3
March	22.6	12.5	3.5	60.8	8.5	0.4	26.1	13.7	3.1	53.3	8.4	2.2
April	25.9	14.2	3.5	57.7	9.3	30.6	27.9	15.6	3.3	53.9	9.5	5.6
May	30.9	18.4	3.5	50.8	10.5	14.7	32.1	20.0	3.7	52.5	10.4	3.4
June	33.7	21.5	3.4	51.7	11.8	0.0	33.8	22.3	3.5	50.5	11.2	0.0
July	35.9	24.0	3.4	53.8	12.0	0.0	35.1	23.8	3.6	55.3	12.4	0.0
August	34.9	24.4	3.2	56.4	11.9	0.0	34.4	24.3	3.4	58.2	11.8	0.0
September	32.9	22.3	3.3	57.4	11.0	0.0	33.4	23.4	3.2	57.7	11.1	0.0
October	28.3	19.3	3.3	62.4	10.2	0.0	29.6	21.0	3.3	59.3	10.3	0.0
November	23.9	15.9	2.9	64.4	9.1	20.5	25.3	17.5	2.9	62.1	9.3	22.6
December	21.3	14.0	3.2	68.9	8.6	6.3	20.2	13.3	3.7	66.9	8.5	23.6
January	18.9	11.3	3.9	68.9	8.1	33.6	18.2	8.8	4.0	60.2	8.2	13.9

where: T.max., T.min.= maximum and minimum temperatures °C; W.S = wind speed (m/ sec); R.H.= relative humidity (%); S.S= actual sun shine (hour (and RF = rainfall (mm / month(] Data were obtained from the agrometeorological Unit at SWERI, ARC

Table 3 Penman- Monteith formulae in 2017/18 and 2018/19 seasons .

Season		Penman- Monteith			
		2017 / 2018		2018 / 2019	
Month	Kc	mm/day	mm/month	mm/day	mm/month
February	0.75	3.60	100.8	3.24	90.7
March	0.80	4.12	127.7	4.70	145.7
April	0.81	5.19	155.7	5.64	169.2
May	0.81	6.86	212.7	7.07	219.2
June	1.03	7.61	228.3	7.69	230.7
July	1.18	8.66	268.5	8.00	248.0
August	1.17	7.41	229.7	7.30	226.3
September	0.93	6.44	193.2	6.43	192.9
October	0.96	4.77	147.9	5.12	158.7
November	0.92	3.30	99.0	3.59	107.7
December	0.87	2.63	81.5	2.82	87.4

January	0.76	3.13	97.0	2.81	87.1
Seasonal (mm(			1942		1964

Soil moisture was determined grave metrically on oven dry basis of soil samples taken from depths of 15 cm. up to 60 cm. Water consumption use was calculated as the differences of soil moisture content in soil samples taken before irrigation and field capacity.

Experimental design and treatment

Split plot design with three replicates was adopted .

Irrigation treatments (main plots)

Three amounts of applied irrigation water based dy Penman-Monteith equation were tested in this experiment. The irrigation treatments were as follow:

I_1:Irrigation with amount of water equals 100 % of potential evapotranspiration (ETc)

I_2: Irrigation with amount of water equals 85 % of ETc .

I_3: Irrigation with amount of water equals 70 % of ETc .

Foliar applications (sub-plots)

Co : Foliar spray with water (control)..

GB : Foliar spray with glycine-betaine at the rate of 250 ppm .

Pr : Foliar spray with proline at the rate of 250 ppm .

GB+ Pr: Foliar spray with glycine-betaine + proline (1:1 ratio) at the rate of 250 ppm.

Calculation of crop coefficient and evapotranspiration

The actual evapotranspiration (ETa) or water consumption is a key parameter in the water balance, describing the processes within the soil–water–atmosphere–plan environment and is an important parameter for irrigation scheduling. The methods available for the calculation of the ETa vary from very simple, more empirically based approaches to complex, more physically based approaches. A first approach is based on the calculation of a reference evapotranspiration (ETo) and subsequent calculation of the crop evapotranspiration (ETc) by multiplying ETo with a crop factor kc. For the calculation of ETo, several methods are available, going from more simple to more complex **.**

Reference evapotranspiration (ETo)

Reference evapotranspiration (ETo) was calculated using the meteorological data using formulae as cited by **Allen *et al.*, (1998)** as follows:

Penman- Monteith equation

For estimating potential evapotranspiration of Penman Monteith, it was applied by using CROP WAT model **(Smith 1991)** as follows :

$$ETo = \frac{0.408\,\Delta(Rn - G) + \gamma\,[900/(T + 273]\,U_2\,(e_s - e_a)}{\Delta + \gamma\,(1 + 0.34\,U_2)}$$

ETo: reference evapotranspiration, mm/day

Rn: net radiation (MJm-2d-1)

G: soil heat flux (MJm-2d-1)

Δ: slope vapor pressure and temperature curve (kPa°C-1)

γ : psychrometric constant (kPa °C-1).

U2:= wind speed at 2 m height (ms-1).

es-ea: vapor pressure deficit (kPa).

T : mean daily air temperature at 2 m height (°C).

<u>Soil water relations:</u>

<u>1- Amount of applied irrigation water (AIW):</u>

The amount of applied water was measured by a flow meter and was calculated according to the following equation **(FAO, 1984):**

$$AIW = \frac{Sp\ X\ S_l\ X\ ETo\ X\ Kc\ X\ Kr\ X\ I\,\text{int}\,erval}{Ea} + LR$$

where:

AIW = applied irrigation water depth (liters/day).

Sp = distance between plants in the same line (m).

S_l = distance between lines (m).

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ET_o = potential evapotranspiration (mm/day) values obtained by Penman- Monteith equation .

K_c = crop coefficient.

K_r = reduction factor that depends on ground cover. It equals 0.7 for mature trees **(FAO, 1979).**

E_a = irrigation efficiency = K_1 x K_2 = 0.80

where:

K_1 = emitter uniformity coefficient = 0.90 for the experimental site.

K_2 = drip irrigation system efficiency = 0.89 for the experimental site.

$I_{interval}$ = irrigation intervals (days) = 1 day for the experimental site.

LR = leaching requirements **(FAO, 1977)** = $\frac{EC_w}{2MaxEC_e}$

where:

EC_w = electrical conductivity of the irrigation water (1.2 dS/m).

Max EC_e = maximum tolerable electrical conductivity of the soil saturation extract for banana crop (5 dS/m).

Water utilization efficiency (W.Ut.E): Applied irrigation water is used to describe the relationship between production and the amount of water applied. It was determined according to the following equation **(Jensen 1983)**:

$$W.Ut.E = \frac{\text{Fruits yield (kg)/feddan}}{\text{Seasonal AIW (m}^3\text{ water applied/feddan)}}$$

Soil physical analysis:

Particle size distribution was conducted using the pipette method and bulk density according to **Klute (1986).** Soil moisture constant was determined using the pressure membrane apparatus, considering the saturation percent (SP) at KPa tension. Field capacity (FC) and wilting point (WP) at 0.33 and 15 bar, respectively. Available water is the difference between FC and WP **(Stackman, 1966).**

Vegetative growth:

Morphological measurements were done at bunch shooting stage via the following parameters: Pseudostem height (cm.), pseudostem circumference (cm) and number of leaves/plant. Flowering: 1) Time to flowering: The period from sucker emergence to bunch shooting (in days) date was calculated in the tested seasons.

2 Time to harvesting: the period from bunch shooting to the date of harvesting (in days) was calculated in the two seasons

Yield, bunch weight and finger properties:

At time of harvesting, bunch weight in Kg, finger weight (g), finger length and diameter in cm were measured and recorded.

Statistical analysis:

The experimental data were tabulated and statistically analyzed according to **Snedecor and Cochran (1980)** and the differences between the means of various treatments were compared according to Duncan's Multiple Range Test at 0.5 level of probability **(Duncan, 1955.(**

RESULTS AND DISCUSSION

1- <u>water relations:</u>

1.1. <u>Applied irrigation water (AIW):</u>

The effect of tested irrigation treatments on applied irrigation water expressed as liters/hole/day, m^3/fed/month, and m^3/fed/year for the 2017/2018 and 2018/2019 growing seasons is presented in Table 4. Results show that amounts of applied irrigation water were 7055, 5997 and 4939 m^3/fed./yr in first season and 7517, 6390 and 5262 m^3/fed./yr in second season for the I_1 (100 % ETc), I_2 (85 % ETc) and I_3 (70 % ETc) irrigation treatments, respectively. The obtained amounts equal 1735, 1475 and 1214 mm/fed/yr for the same respective treatments. The values showed that seasonal water applied by banana are higher in the second than in the first season. Such results are mainly due to differences in climatic factors.

The obtained result was within the irrigation requirements for banana crop reported by **FAO (1979).** They stated that the water requirements per year vary between 1200mm in the humid tropics to 2200mm in the dry tropics. **Narayanamoorthy (2003)** reported that the water saving due to drip method of irrigation is about 47% for sugarcane and nearly 30% for banana. Moreover, **Sharmasarkar et al. (2001)** reported that the amount of applied irrigation water with the drip system was lower than that applied by surface irrigation. **Aujla et al. (2007)** reported a saving of 25% water on drip irrigation compared with furrow irrigation. All in all, the results of this study indicated that drip irrigation can safe water, time and energy.

Table 4. Effect of irrigation treatments on the amounts of applied irrigation water for the 2017/2018 and 2018/2019 growing seasons.

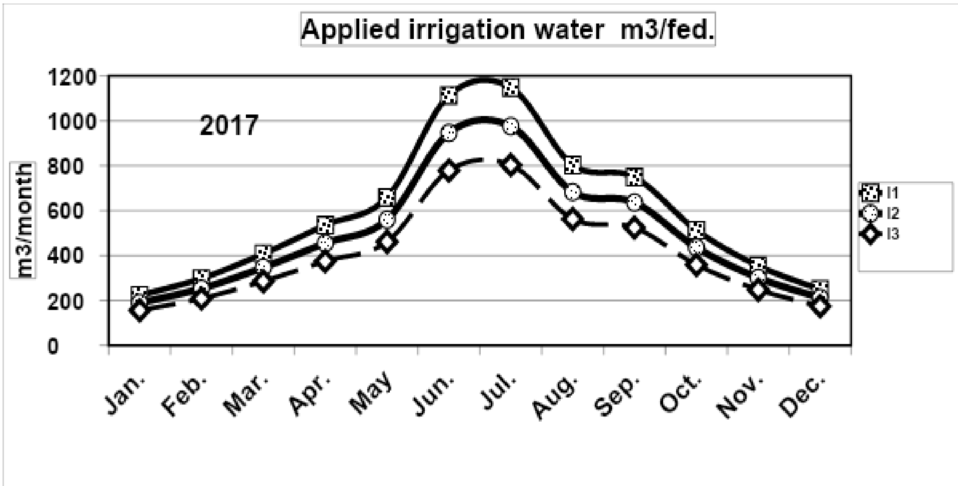
Month	AIW	2017/2018			2018/2019		
		I_1	I_2	I_3	I_1	I_2	I_3
Feb.	L/hole/day	25	21	17	25	21	19
	m^3/fed/month	298	253	209	306	260	235
Mar.	L/hole/day	30	26	21	34	29	26
	m^3/fed/month	408	347	286	455	387	351
Apr.	L/hole/day	41	35	29	43	37	33
	m^3/fed/month	535	455	375	564	480	435
May	L/hole/day	49	42	34	65	55	50
	m^3/fed/month	659	560	461	869	739	669
Jun.	L/hole/day	86	73	60	86	73	66
	m^3/fed/month	1113	946	779	1119	951	862

Jul.	**L/hole/day**	86	73	60	86	73	66
	m^3/fed/month	1149	976	804	1154	981	889
Aug.	**L/hole/day**	60	51	42	60	51	47
	m^3/fed/month	804	683	563	811	690	625
Sep.	**L/hole/day**	58	49	40	59	50	45
	m^3/fed/month	749	637	525	764	649	588
Oct.	**L/hole/day**	38	32	27	42	36	32
	m^3/fed/month	513	436	359	565	481	435
Nov.	**L/hole/day**	27	23	19	30	25	23
	m^3/fed/month	354	301	248	389	331	300
Dec.	**L/hole/day**	19	16	13	20	17	15
	m^3/fed/month	249	212	175	266	226	205
Jan	**L/hole/day**	17	14	12	19	16	14
	m^3/fed/month	223	190	156	252	214	194
Total	**m^3/fed/year**	**7055**	**5997**	**4939**	**7517**	**6390**	**5262**

1.2. Monthly applied irrigation water:

Monthly applied irrigation water Fig. 1 was low at the beginning of the growth season . This can be related to less transpiring surface leaves during the period of first growth. Potential evapotranspiration was low through this period Table 4, then increased gradually as the green cover increased with increases in air temperature and solar radiation. The highest applied irrigation water occurred during July reflecting: expansion of the leaf system, growth of fruit on a volume basis and high solar radiation and air temperature. The July values for the treatments averaged 1152, 949 and 847 m^3/fed. for I_1,I_2 and I_3 (means of the 2 seasons), respectively.

Thereafter, evapotranspiration rate decline to reach its minimum value from October to December as the plants were approaching period harvest. Such results can be attributed to high evaporation than transpiration early in the season as plants intercepts little of net radiation. Later, as the green cover expanded, transpiration was greater than evaporation. Thus, the increase in evapotranspiration from the beginning of the growth season till fruit maturity can be explained on the basis of the cover. **Ibrahim (1981)** concluded that the increase in evapotranspiration by maintaining soil moisture at a high level is attributed to excess available water in the root zone.



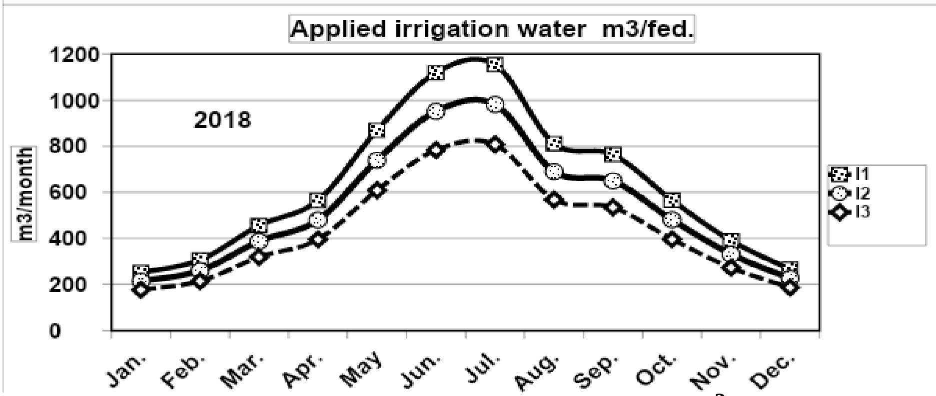


Fig. 1: Monthly applied irrigation water m^3/month for banana plants as affected by different irrigation treatments during 2017/18 and 2018/19 seasons.

1.3. Water utilization efficiency (W.Ut.E):

Water utilization efficiency (Fig. 2) is represented here as the amount of yield produced by one cubic meter of irrigation water used by crop. The main effect of irrigation treatments shows that I_2 gave the highest W.Ut.E and values were as follows: I_2 = 3.10, I_3 = 2.59 and I_1 = 2.36 kg fruit / m^3 water(means of the 2 seasons), . Thus I_2 and I_3 gave 31.4 and 9.7 % more efficiency than I_1 respectively. Considering the interactions caused by foliar spray with amino acids affecting the comparative response to irrigation, the superiority of I_3 over I_1 and I_2, was particularly significant under condition of foliar spray with glycine-betaine + proline exhibiting a 2-factor interaction.

The main effect of foliar spray with amino acids shows that all spray with amino acids increased WUtE as compared with the spray with water treatments. The highest WUtE among spray with amino acids treatments was that of glycine-betaine + proline, and the lowest was that of proline. Mean values were as follows: 2.68, 2.48 and 3.33 kg fruit/m^3 water (means of the 2 seasons), by spraying glycine-betaine, proline and glycine-betaine + proline respectively. There was an interaction caused by amino acids; under I_1 conditions of glycine-betaine was superiority to proline and glycine-betaine + proline with Water utilization efficiency. These results are in agreement with those reported by **Hassanli et al. (2009)** who stated that the maximum irrigation water use efficiency was obtained with the drip irrigation and the minimum was obtained with the furrow method. The most economical deficit irrigation level depends on the uniformity of application of the irrigation water and the associated cost of the irrigation water, any cost of remediation treatment on the drainage water, and the value of a unit of the crop **(Al-Jamal et al. 2001). Zeng et al. (2009)** found that the lower the amount of irrigation water applied, the higher the irrigation water use efficiency obtained.

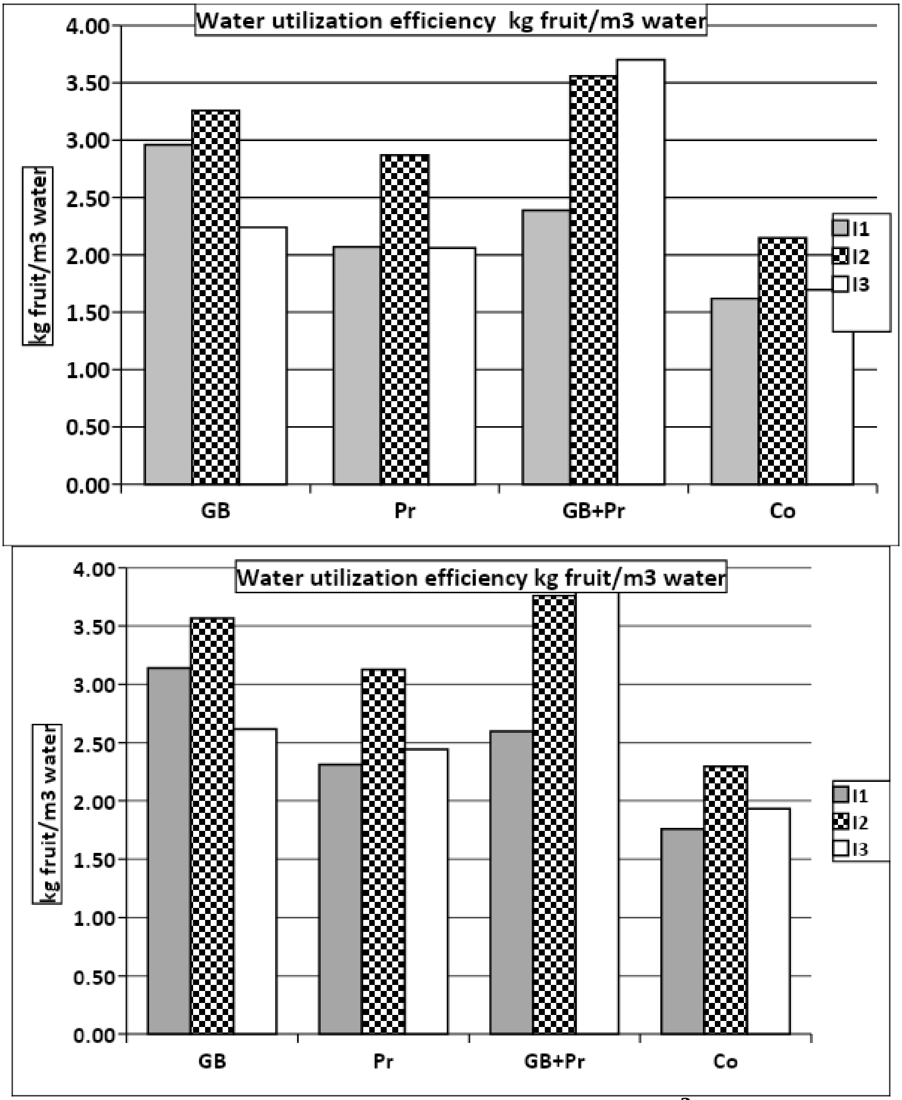


Fig. 2: Water utilization efficiency kg fruit/m^3 water for banana plant as affected by the amounts of applied irrigation water and different amino acids treatments.

2. **Some vegetative growth measurements:**

Data represented in Table 6 showed the effects of water irrigation amounts, amino acids and their interaction on some vegetative growth parameters i.e; Psedostem length (cm), Psedostem circum (cm) and number of leaves per plant. The main effect of irrigation treatments shows that Psedostem length (cm) and Psedostem circum (cm) due to I_1, I_2 and I_3 treatments averaged (241, 224 and 226 cm) and (72.3, 65.4 and 63.6) (means of the 2 seasons), respectively. There was an interaction caused by amino acids; under conditions of glycine-betaine, I_3 was superiority to I_1 and I_2 with Psedostem length (cm).

Obtained results disclosed clearly that an obvious significantly increased in three growth parameters was generally exhibited with all foliar spray with treatments as compared to the control in the two seasons of study.

However, the foliar spray with proline (pr) treatment gave the highest significant values in Psedostem length (cm) . There was an interaction caused by irrigation treatments superiority glycine-betaine + proline under 100% of ETc . While foliar spray with glycine-betaine + proline treatment gave the highest significant values in Psedostem circum (cm) and number of leaves/plant gave the highest under glycine-betaine of banana plant (246 & 251 cm), (71.4 & 73.9 cm) and (11.6 & 14.6) in both 2017/18 and 2018/19 seasons, respectively. These results are in agreement with those of **Hegde and Srinivas (1991)** who reported that the plants were 3% taller under the drip irrigation than the basin irrigation. The results under drip irrigation treatments indicated that application of water up to the optimum crop water requirement may promote plant growth parameters (Table 6). These results are in agreement with those of **Goenagea and Irizarry (2000)** who reported that irrigation according to increasing pan factors from 0.25 to 1.25 resulted in increase in the number of functional leaves at flowering of banana.

Table 6. Effect of water irrigation amounts, amino acids and their interaction on psedostem length (cm), psedostem circum. (cm) and No. leave /plant of Grand Nain banana plants during 2017/2018 and 2018/2019 seasons.

Psedostem length (cm)										
Irrigation treatments	2017/2018					2018/2019				
	Amino acids									
	GB	Pr	GB+Pr	Co	Mean	GB	Pr	GB+Pr	Co	Mean
I1	224 d	259 b	267 a	211 efg	**240 b**	218 E	263 b	270 a	213 g	**241 b**
I2	212 ef	255 b	216 e	203 g	**221 c**	216 G	261 b	221 f	206 h	**226 c**
I3	233 c	223 d	231 c	206 fg	**223 c**	241 c	228 e	234 d	207.3 h	**228 c**
Mean	**223 d**	**246 b**	**238 c**	**207 e**		**225 d**	**251 b**	**242 c**	**209 e**	
Psedostem circum. (cm)										
Irrigation treatments	2017/2018					2018/2019				
	Amino acids									
	GB	Pr	GB+Pr	Co	Mean	GB	Pr	GB+Pr	Co	Mean
I1	70.3 bc	71.5 b	77.7 a	60.2 d	**69.9 b**	81.1 a	75.3 b	81.2 a	61.2 d	**74.7 b**
I2	70.7 bc	67.7bc	68.2 bc	49.7 e	**64.1 c**	74.3 b	70.3 bc	70.2 bc	51.7 e	**66.6 c**
I3	64.7 c	66.3 bc	68.2 bc	51.1 e	**62.6 c**	66.7 c	67.7 c	70.3 bc	53.3 e	**64.5 c**
Mean	**68.6 c**	**68.5 c**	**71.4 b**	**53.7d**		**74.0b**	**71.1 b**	**73.9 b**	**55.4 c**	
No. leave /plant										
Irrigation treatments	2017/2018					2018/2019				
	Amino acids									
	GB	Pr	GB+Pr	Co	Mean	GB	Pr	GB+Pr	Co	Mean
I1	10.3 b	11.2 ab	11.2 ab	7.7 c	**10.1 b**	13.1 bc	12.3 c	13.7 abc	8.7 d	**12.0 b**
I2	12.1 ab	11.3 ab	12.7 a	8.3 c	**11.1 b**	15.3 a	13.3 bc	15.3 ab	9.3 d	**13.3 b**
I3	12.3 ab	10.7 ab	11.1 ab	8.3 c	**10.6 b**	15.3 a	13.7 abc	14.3 abc	9.3 d	**13.2 b**
Mean	**11.6b**	**11.1 b**	**11.7 b**	**8.1 c**		**14.6b**	**13.1 c**	**14.4 c**	**9.1 d**	

3. Effect of irrigation treatments on yield and yield components

3.1. Bunch weight (kg)

Data averaged in Table (7) showed the bunch weight (kg/plant) with respect to the effect of some foliar spray amino acids treatments of Grand Nain banana plant. There were significant effects between the irrigation treatments (100, 85 and 70 % of ETc) on the bunch weight in both seasons of study. The bunch weight (kg) highest was given by I_2 (85 % of ETc) and the lowest was by I_3. Mean values were as follows: I_2 gave the highest bunch weight of (19.7 and 22.6) followed by I_1 which gave (17.7 and 20.5), then I_3 which gave (13.3 and 16.1) kg/plant both season, respectively. . There was interaction due to amino acids affecting bunch weight per plant under foliar spray with glycine-betaine + proline, I_3 (70 % of ETc) was superiority to I_1 (100 % of ETc) with bunch weight.

Moreover, both amino acids treatments (glycine-betaine + proline and glycine-betaine only) gave the superior results of bunch weight during the two seasons. In addition, the interaction treatments indicated that using either glycine-betaine with irrigation amount at 100 % of ETc was significantly superior than using other treatment in improving weight of bunch under the same conditions of study.

These results were in agreement with those of **Cevik et al. (1985)** who compared drip and basin methods of irrigation in banana crop. **Hegde and Srinivas) 1991)** indicated an increase in the banana yield under drip irrigation compared to the basin irrigation. The highest bunch weight was obtained with 120 % of ETc while the lowest bunch weight was obtained on 40% and 60% of ETc under drip irrigation system because the water stress affected yield negatively.

3.2. Total yield

Data averaged in Table (7) showed the yield (ton/fed) with respect to the effect of some foliar spray amino acids

treatments of Grand Nain banana plant. The main effect of irrigation treatments shows that the yield (ton/fed) was highest by I_1, followed by I_2, and the lowest was that of I_3. Mean values of yield ton/fed (means of the 2 seasons) were as follows: 19.04, 17.19 and 13.23 ton/fed respectively. Therefore I_2 and I_1 showed increases over I_3 of 43.9 and 29.9 % respectively.
There was an interaction caused by foliar spray amino acids ; under conditions of glycine-betaine + proline, I_1 was similar to I_3 also with a glycine-betaine there was no superiority of the I_2 irrigation over the I_1 irrigation.

The main effect of foliar spray amino acids shows that all spray amino acids increased the yield ton per fed. as compared with the spray water treatment only. The highest yield among the amino acids treatments was that of glycine-betaine + proline, and the lowest was that of proline. Mean values (means of the 2 seasons) were as follows 18.6, 15.36, 20.16 and 11.79 ton / fed by spraying GB, Pr, GB+Pr and Co respectively.There was an interaction caused by irrigation: under conditions of I_3, glycine-betaine similar in effect with proline; also under condition of I_1 of the glycine-betaine superiority over other treatments. These results revealed that higher yields were produced under drip irrigation than the surface irrigation. **Shashidhara et al. (2007)** reported that drip irrigation increased yield of banana to the extent of 5.94% and 3.54%, respectively as compared to surface irrigation. **El-Sayed et al. (2002)** stated that yield efficiency tended to increase as quantity of applied irrigation water increased**. Goenaga *et al.* (1993)** conducted an experiment to determine the optimum water requirement of drip-irrigated banana grown under semiarid conditions. Results showed that, all yield components were significantly affected by the amount of water applied. Highest marketable yield (33.9 t/ha) was obtained with the application of a pan factor treatment of 1.25.

Table 7. Effect of water irrigation amounts, amino acids and their interaction on bunch weight/ plant (kg) and yield (ton) / fed. of Grand Nain banana plants during 2017/2018 and 2018/2019 seasons.

Bunch weight/ plant (kg)										
Irrigation treatments	2017/2018					2018/2019				
	Amino acids									
	GB	Pr	GB+Pr	Co	Mean	GB	Pr	GB+Pr	Co	Mean
I_1	23.2 ab	16.2 d	18.7 c	12.7 F	**17.7 c**	26.2 a	19.3 c	21.7 b	14.7 d	**20.5 c**
I_2	21.7 b	19.1 c	23.7 a	14. 3 E	**19.7 b**	25.3 a	22.2 b	26.7 a	16.3 d	**22.6 b**
I_3	12.3 f	11.3 f	20.3 c	9. 3 g	**13.3 d**	15.3 d	14.3 d	23.3 b	11.3 e	**16.1 d**
Mean	**19.1 a**	**15.5b**	**20.9 a**	**12.1c**		**22.3 a**	**18.6 b**	**23.9 a**	**14.1 c**	
Yield (ton) / fed.										
Irrigation treatments	2017/2018					2018/2019				
	Amino acids									
	GB	Pr	GB+Pr	Co	Mean	GB	Pr	GB+Pr	Co	Mean
I_1	20.88 ab	14.58d	16.83 c	11.43 f	**15.93 c**	23.58a	17.37 c	19.53 b	13.23 d	**18.45 c**
I_2	19.53 b	17.19c	21.33 a	12.87 e	**17.73 b**	22.77a	19.98 b	24.03 a	14.67 d	**20.34 b**
I_3	11.07 f	10.17 f	18.27 c	8.37 g	**11.97 d**	13.77d	12.87 d	20.97 b	10.17 e	**14.49 d**
Mean	**17.16 a**	**13.98 b**	**18.81 a**	**10.89 c**		**20.04a**	**16.74 b**	**21.51 a**	**12.69 c**	

3.3. Finger length and Length bunch (cm).

Data averaged in Table 8 showed the finger length or length bunch with respect to he effect of some amino acids treatments of Grand Nain banana plant. There were no significant effects between the three irrigation water amunt (100. 85 and 70 % of ETc) on the finger length or length bunch in both seasons of study.

Moreover, both foliar spray amino acids treatments (+ proline and glycine-betaine + proline gave the superior results of finger length and length bunch during the two seasons. In addition, the interaction treatments indicated that using either glycine-betaine + proline with irrigation water amount at 70 % of ETc was significantly superior than using other treatment in improving weight of finger length and length bunch under the same conditions of study. These results are in agreement with those of **Shashidhara et al. (2007)** who reported higher length of fruit and fruit thickness of banana under drip irrigation compared to surface irrigation. **Goenagea and Irizarry (2000)** found that irrigation according to increasing class A pan factors increased fruit length, diameter and weight.

Table 8. Effect of water irrigation amounts, amino acids and their interaction on Finger length (cm) and length bunch (cm) of Grand Nain banana plants during 2017/2018 and 2018/2019 seasons

Finger length (cm)										
Irrigation treatments	**2017/2018**					**2018/2019**				
	Amino acids									
	GB	**Pr**	**GB+Pr**	**Co**	**Mean**	**GB**	**Pr**	**GB+Pr**	**Co**	**Mean**
I_1	17.3 c	26.1 a	18.1 c	11.3 d	**18.2 c**	19.3 f	28.3 a	20.1 ef	12.3 g	**20.0 d**
I_2	22.3 b	20.1 bc	18.3 c	13.1 d	**18.5 c**	25.7 b	22.7 cd	20.7 def	14.1 g	**20.8 d**
I_3	20 bc	19.6 bc	22.1 b	13.3 d	**18.8 c**	23.1 cd	22.3 cde	24.3 bc	14.3 g	**21.0 d**
Mean	**19.9 bc**	**21.9 b**	**19.5 c**	**12.6 d**		**22.7b**	**24.4 b**	**21.7 c**	**13.6** g	
bunch Length (cm)										
Irrigation treatments	**2017/2018**					**2018/2019**				
	Amino acids									
	GB	**Pr**	**GB+ Pr**	**Co**	**Mean**	**GB**	**Pr**	**GB+Pr**	**Co**	**Mean**

I_1	95.1 a	97.2 a	75.3 c	65.3 d	**83.2 a**	97.7 b	99.3 b	77.7 d	66. 7 f	**91.6 a**
I_2	84.3 b	84.7 b	81.7 bc	70.5d	**80.3 a**	87.2 c	88.3 c	85.3 c	70.7 e	**82.9 b**
I_3	75.1 c	101.3 a	98.3 a	62.3 d	**84.3 a**	78.3 d	105.1 a	101. 7 ab	64.7 f	**82.7 b**
Mean	**84.8 b**	**94.4 a**	**85.1 b**	**66.0c**		**87.7 b**	**97.6 a**	**88.2 b**	**67.4 c**	

3.4. Number of hands and fingers per bunch:

The main effect of irrigation treatments shows that insignificant in the number of hands per bunch of the both season Table 9 . There was interaction due to amino acids affecting number of hands per bunch under foliar spray with glycine-betaine + proline, I_3 was superiority to I_1 and I_2 with number of hands per bunch and superiority I_2 over on I_3 under foliar spray with glycine-betaine only. All treatments foliar spray with amino acids exceeded the foliar spray with water . While the main effect of foliar spray with amino acids shows that insignificant in the number of hands per bunch of the both season . There was interaction due to irrigation under I_3 glycine-betaine + proline, was superiority to glycine-betaine and proline with number of hands per bunch .

On the other hand, the main effect of irrigation treatments shows that the number of fingers per bunch was highest by I_3, followed by I_2, and the lowest was that of I_1 . The also it was found that the most superor intraction treatment was of foliar spray of glycinebetaine I2 in both seasons Furthermore, all treatments of foliar spray with amino acids exceeded the foliar spray with water. The foliar spray with glycine-betaine + proline and proline treatment gave the highest significant values in number of fingers per bunch.. Similar results were reported by **Shashidhara et al. (2007)** who reported that drip irrigation system had more number of hands per bunch and fingers per bunch of banana compared to surface irrigation.

Bhella (1985) found that drip irrigation increased fruit size when compared with no irrigation.

Table 9: Effect of water irrigation amounts, amino acids and their interaction on No. of hands per bunch and No. of fingers per bunch of Grand Nain banana plants during 2017/2018 and 2018/2019 seasons.

No. of hands per bunch										
Irrigation treatments	**2017/2018**					**2018/2019**				
	Amino acids									
	GB	**Pr**	**GB+Pr**	**Co**	**Mean**	**GB**	**Pr**	**GB+Pr**	**Co**	**Mean**
I_1	10.2 ab	9. 7 ab	9.7 ab	7.7 bc	**9.3 b**	11.3 b	10.7 bc	10.7 bc	8.7 cd	**10.4 b**
I_2	10.3 ab	10.2 ab	9.2 b	6.7 cd	**9.1 b**	12.2 ab	12.0 ab	11.2 b	7.7 de	**10.8 b**
I_3	8.3 bc	10.3 ab	11.7 a	8.3 bc	**9.7 b**	10.3 bc	12.3 ab	13.7 a	6.7 e	**10.8 b**
Mean	**9.6 b**	**10.1 b**	**10.2 b**	**7.6 c**		**11.3 b**	**11.7 b**	**11.9 b**	**7.7 c**	

No. of fingers per bunch										
Irrigation treatments	**2017/2018**					**2018/2019**				
	Amino acids									
	GB	**Pr**	**GB+Pr**	**Co**	**Mean**	**GB**	**Pr**	**GB+Pr**	**Co**	**Mean**
I_1	14.2 c	15.1 c	20.3 b	9.7 d	**14.8 c**	16.1 c	17.1 c	22.3 b	10.7 d	**16.6 c**
I_2	24.7 a	18.7 b	15.3 c	11.3 d	**17.5 b**	26.7a	20.7 b	17.3 c	12.3 d	**19.3 b**
I_3	14.3 c	24.7 a	23.7 a	10.7 d	**18.4 b**	16.3 c	26.7 a	26.1 a	11.7 d	**20.2 b**
Mean	**17.7 c**	**19.5b**	**19.8 b**	**10.6 d**		**19.7c**	**21.5 b**	**21.9 b**	**11.6 d**	

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