Microclimate, in Relation to Productivity and Water Use Efficiency of Screenhouse Banana Crop cv. Grand Naine

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ABSTRACT

Screenhouses utilization is rapidly expanding nowadays; so in this investigation, the effect of screenhouse and its colors on banana cv. Grand Naine productivity, in relation to some microclimate elements (such as temperature, humidity, wind speed and light intensity inside the screenhouses) and the water use were recorded. Also, productivity parameters such as bunch weight, length, number of hands and number of fingers per hand were recorded. Water saving by using three different levels of irrigation was estimated. The obtained results revealed that, maximum temperature of screenhouses decreased by 1-2^{o}C, minimum temperature increased by approximately 1^{o}C , the intensity inside the screenhouses increased by approximately 30 % and about 40 % reduction in wind speed. Also humidity increased by 4-6 % and 30 % reduction in crop water use inside the screenhouses, without any significant reduction in productivity as compared to open field. The obtained results may be due to the reduction of evapotranspiration caused by screenhouse. Finally, we can recommend that: it is most importance to plant banana orchards into screen houses in order to minimize crop water use and enhance every the yield and fruit quality.

Key words: Banana, Screenhouses, Microclimate.

INTRODUCTION

Banana (*Musa spp*.) is one of the most important fruit crop in the world especially in the tropical and subtropical regions. Bananas are grown in 128 countries with a total cultivated area of about 5 million hectares and total world production of about 100 million metric tons. India ranked the first all over the world in banana production, which produces 27 million metric tons. In Egypt, bananas consider one of the most important economic fruit crops. It is covering about 64,000 feddan with a total production of about 1283644 metric tons (FAO STAT, 2014). Banana is a staple food across the Asian, African and American tropics, with the 15 % that is exported being important to many economies (Heslop and Schwarzacher, 2007). The use of screens and screenhouses is constantly increasing, especially in arid and semi-arid regions where their use is environmentally sound. This is due to several reasons: (i) the relatively low initial and maintenance costs, (ii) saving irrigation water – a crucial environmental issue, (iii) improved yield quality, (iv) reduction in pesticides application by using high mesh screens (Tanny *et al*., 2012). Screenhouses are used as a more economical choice for greenhouses to protect crops from wind, insects, hail and frost (Moller and Assouline, 2007). Greenhouse banana production can help to meet market needs as it allows for an increase above the existing outdoor production together with an extension of the production period. However, it is essential to know and understand both of the interaction occurring between the crop and its environment whereas there is little data on the microclimate of these structures (Demrati *et al*., 2007 and Santos *et al*., 2006). A spectrum of covered structures is used by growers, depending on the crop, the climatic region and the anticipated benefit. These structures can be generally classified into two categories: screen constructions and greenhouses. The former are covered by permeable porous screens while the latter by impermeable transparent plastic films or glass. The two groups can also be classified according to the nature of the internal climate control, passive for the screen constructions and active for the greenhouses, although sometimes a combination of both structures and/or climate control approaches is used. Passive climate control means that once the house is constructed, no actions are undertaken by the grower to artificially modify the microclimate. There is strong interaction between inside and outside conditions and exchange processes between the crop and the outside atmosphere are governed by system attributes. On the other hand, active climate control means that besides the structure and cover, systems are installed that enable manipulating of the inside microclimate. In greenhouse structures, the inside is more isolated from the outside, than in screen-constructions. The area of fruit orchards

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Received November 22,2017, Accepted December 30,, 2017

and vegetable crops grown in screenhouses has been increasing in recent years. The major agricultural objectives of screen houses are shading from supra-optimal solar radiation (Tanny *et al*., 2012). In addition to white or black screens for covering orchards and vegetable crops, the use of colored screens has expanded. Few investigations of the climatic performance of the Canarian type of plastic shelters under Mediterranean conditions have been undertaken (Demrati *et al.*, 2001).

Accordingly, this investigation aimed to estimate the effects of using screenhouse conditions and its color on microclimate parameters and different levels of irrigation water by bananas on its vegetative growth, flowering and productivity via improved screenhouses microclimate. Finally, detecting soma clonal variants of tissue cultured banana and its characterization at the molecular level.

MATERIALS AND METHODS

This investigation was carried out during two successive seasons of 2015/2016 on(Mother plant)-2016/2017 (First ratoon) of banana plants cv. Grand Naine Giant Cavendish (AAA) sub-group produced from tissue culture technique. This work was carried out at “Nabil Elwakkad” farm, Badr city, Beheira governorate, Egypt.

The present work was divided into seven parts:

1- Soil chemical and physical analysis and water analysis:

Soil chemical and physical analysis and water analyses were carried out to test the suitability of both soil and water for banana cultivation as shown in table 1and 2.

2- Construction of bunch support system and screenhouses:

Using steel wires and straight tree trunks 4.5 & 5 m, the bunch support system was made over rows in the orchard, strong steel wire extended from the start to the end of the row at 4.5 m height, every 20 m of the row there was a wooden support to carry 4 mm steel wire and subsequently carry the bunches. Two small concrete bases fixed at the start and the end of each row to keep the steel wire strait tensioned, also there were other steel wires fixed across the rows at each wooden support line to keep it rigid and stuck in its place. Three different colored (black, white and green) screen houses were constructed over the three 10 * 20 m plots.

3- Planting tissue cultured banana plants and application of three different levels of drip irrigation.

Each screenhouse consisted of three rows of ten banana trees. Field was prepared to banana planting according to farmer practice and drip irrigation system was applied. Planting distance was 2 m × 3 m. Applied irrigation program with recommended rates was estimated according to Penman-Monteith equation (Ibrahim, 2003) was shown in Table 3.

Table 1. Chemical and physical analysis of the tested soil

			Chemical analysis								
Depth	**pH**	**EC**	**Soluble salts (meq/l)**								**SAR**
cm		dS/m	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	
20	8.17	1.06	4.8	2.2	3.9	0.3	0.0	4.4	3.4	3.4	2.1

Depth	Available levels of nutrients (ppm)						OM %	$CaCO_3$ %
cm	P	K	Fe	Zn	Mn	Cu		
20	4.97	95.56	1.68	1.42	3.18	0.51	0.37	8.4

Depth	Physical analysis								
cm	Gravel	Sand	Silt	Clay	Texture	Sp%	FC%	WP%	Bulk density g/cm^3
20	11.2	90.8	3.6	5.6	Sand	26	13.47	5.53	1.53

Table 2.Chemical analysis of the tested irrigation water

		Chemical analysis									
pH	**EC**	**Soluble salts (meq/l)**								**SAR**	**TDS**
	dS/m	Ca	Mg	Na	K	CO_3	HCO	Cl	SO_4		
7.63	0.88	3.2	1.8	3.5	0.3	0.0	4.0	2.0	2.8	2.2	563
	Available levels of nutrients (ppm)										
	P	K	Fe	Zn	Mn	Cu					
	0.0	0.0	0.09	0.03	0.01	<0.01					

Table 3.Scheme of water frequency by drip irrigation system

Treatment / Month	ET_0	Amount of water applied (m^3/f)		
		***Recommended rate(Control)**	**15% Reduction of recommended rate**	**30% Reduction of recommended rate**
Feb.		337.5	286.87	236.25
Mar.		562.5	478.12	393.75
Apr.		750	637.5	525.0
May.		825	701.25	577.5
Jun.		975	828.75	682.5
Jul.		1125	956.25	787.5
Aug.		1125	956.25	787.5
Sep.		975	828.75	682.5
Oct.		900	765.0	630.0
Nov.		675	573.75	472.5
Dec.		487.5	414.38	341.25
Jan.		262.5	223.13	183.75
Total volume/fed/y		9000	7650	6300

The following parameters were used to evaluate the tested treatments:

a- Monitoring the microclimate parameters:

Minimum temperatures C° (HTC-1digital thermometer. China)**,** Maximum temperatures C°**,** Relative humidity % (KT-906 digital hygrometer. China), Light Intensity "lux" (LX1010B digital lux meter) and Wind speed "m/s" (JT-01A digital anemometer China).

b- **Monitoring the vegetative parameters**

Pseudo stem height (cm), pseudo stem girth (cm), leaf length (cm), leaf width (cm) and leaf area (cm^2) which, were calculated according to Obiefuna and Ndubizu (1979) equation as follows:

Leaf area (cm^2) = leaf length (cm) × leaf width (cm) × 0.86

Number of leaves per plant and assimilation area (m^2)/plant: According to Ibrahim (1993).

Assimilation area = leaf area × number of leaves.

c- Flowering (Bunch shooting) percentage:

Number of emerged, time to flowering, time to harvesting and cropping cycle.

d- Monitoring the productivity parameters:

Bunch weight (kg), bunch length (cm), bunch circumference (cm), number of hand per bunch, number of fingers per hands and number of fingers per bunch.

e- Water use efficiency (WUE) (kg./m^3):

WUE represents the quantity of banana fruit (Kg) that could be produced from one cubic meter of irrigation water, it was calculated by the following equation: according to Ibrahim *et al.,* (1988) and Al-adgham *et al.,* (1989).

$$\text{WUE (kg./m}^3\text{)} = \frac{\text{yield (kg/fed.)}}{\text{Irrigation Water (m}^3\text{/fed.)}}$$

4- Statistical analysis:

Data were subjected statistically to analysis of variance for factorial split plot design with (9) replicates in each treatment (Snedecor & Cochran, 1980). The means were compared by using the method of new least significant difference (New L.S.D at 0.05) described by Waller & Duncan (1969).

RERSULTS AND DISCUSSION

Monitoring the parameters of microclimate:

1- Minimum temperatures:

Minimum temperatures (Figures 1and 2) recorded during first and second seasons were higher inside the screenhouses than in the open field by 0.6-1.5^{O}C, that may relate to lower air velocity inside the screen houses than the wind speed outside, these results were in agreement with those obtained by Medany *et al.,* (2009). They reported that, minimum temperature tended to be lower in the control by 1°C than in the nets because of the greenhouse effect and the low radiation at this time of the day. On the other hand, Santos *et al.,* (2006) did not find any difference in minimum temperatures inside screen house and in the open field. Similar results were reported by Al-Mulla *et al.,* (2008) who reported that the average inside temperature was warmer than outside by 0.4-3 °C during January and February, but it colder than outside by 0.2-0.8 °C during March and April.

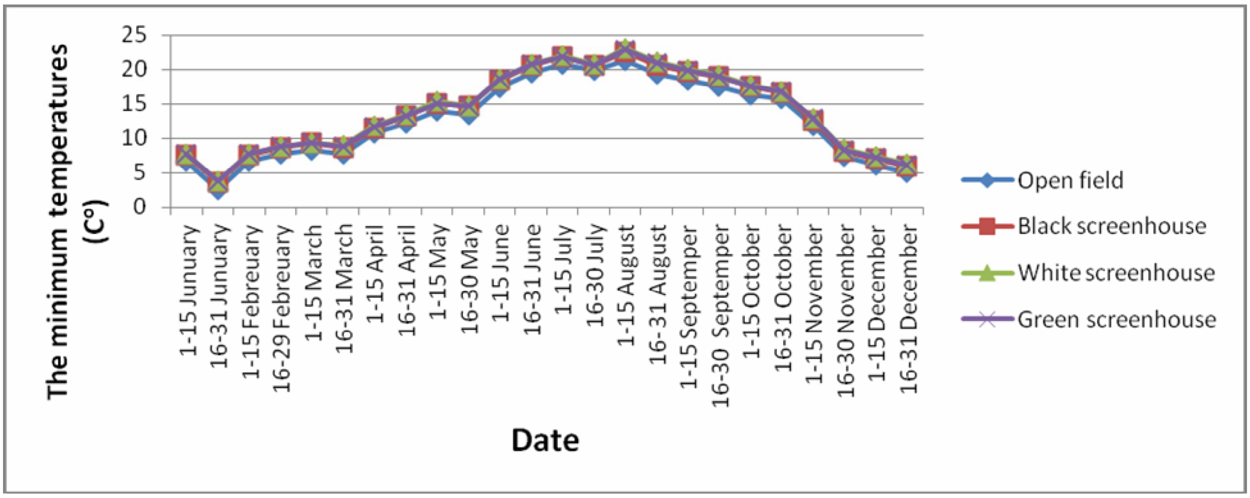

Figure 1.The average minimum temperature inside screenhouses and open field during first season

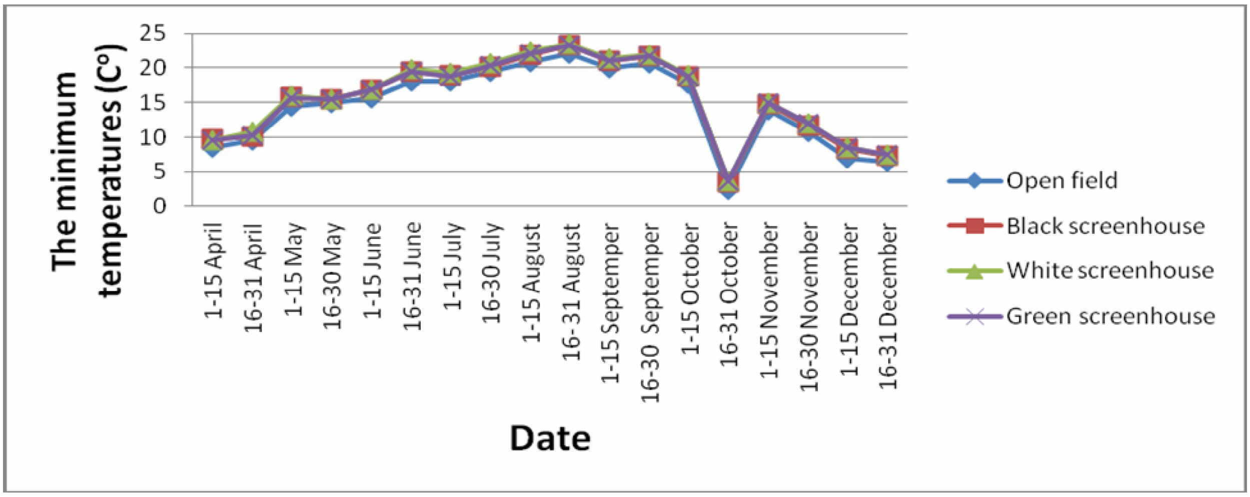

Figure 2.The average minimum temperature inside the screenhouses and open field during second season

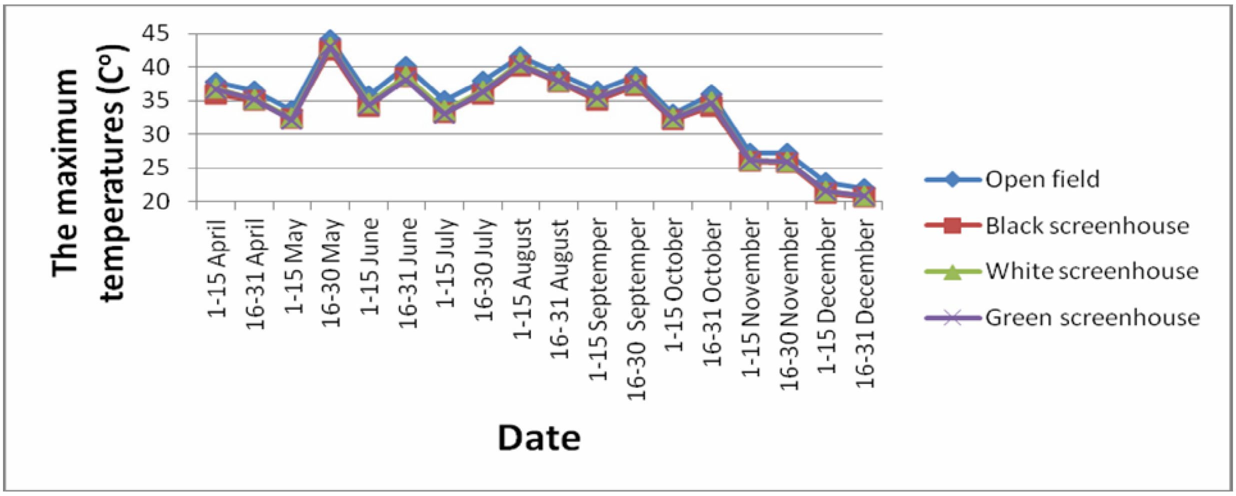

Figure 3.The average maximum temperature inside the screenhouses and open field during first season

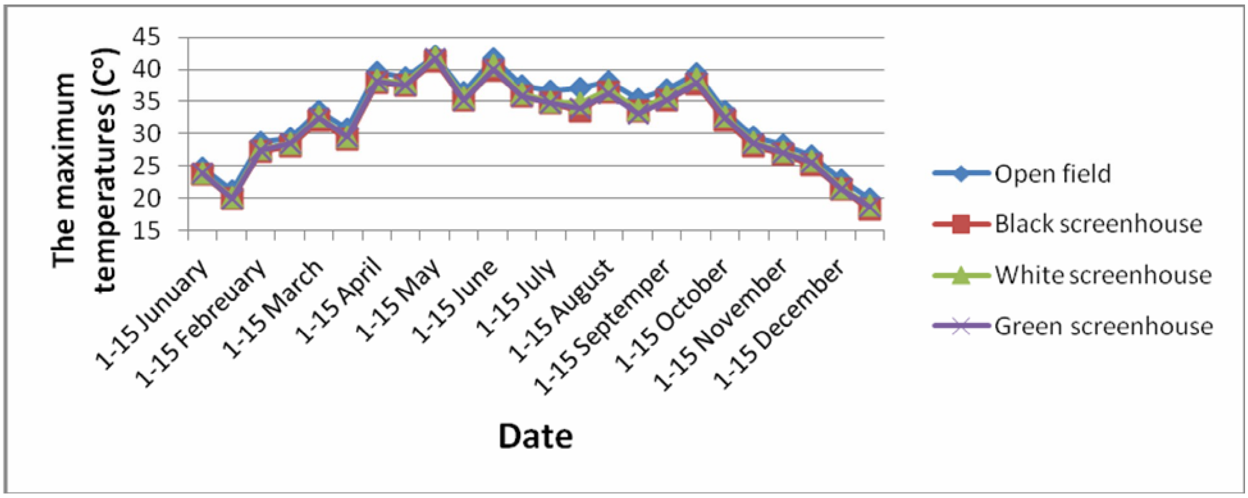

Figure 4.The average maximum temperature inside the screenhouses and open field during second season

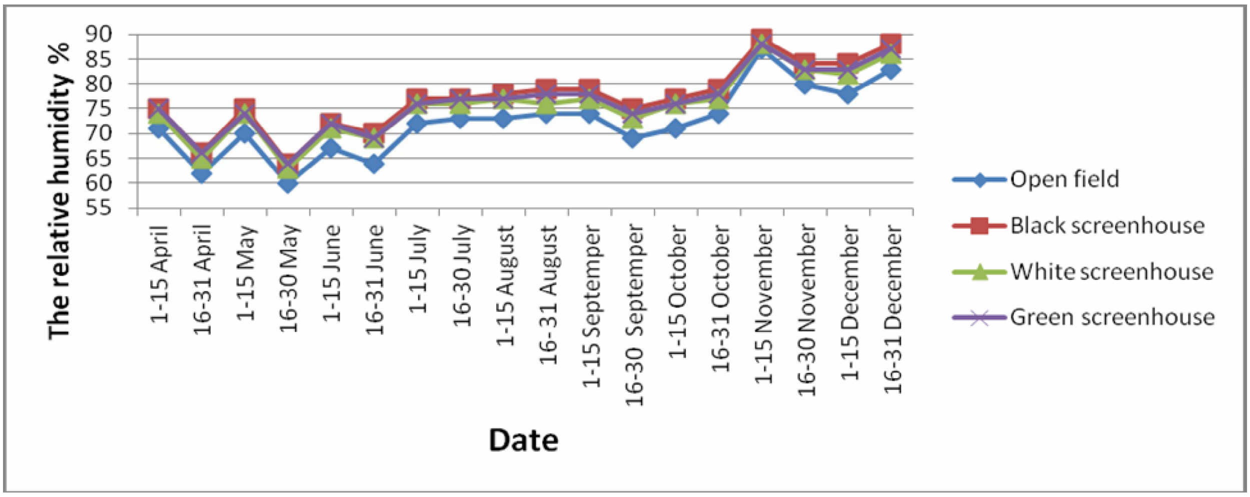

Figure 5.The average relative humidity inside the screenhouses and open field during first season

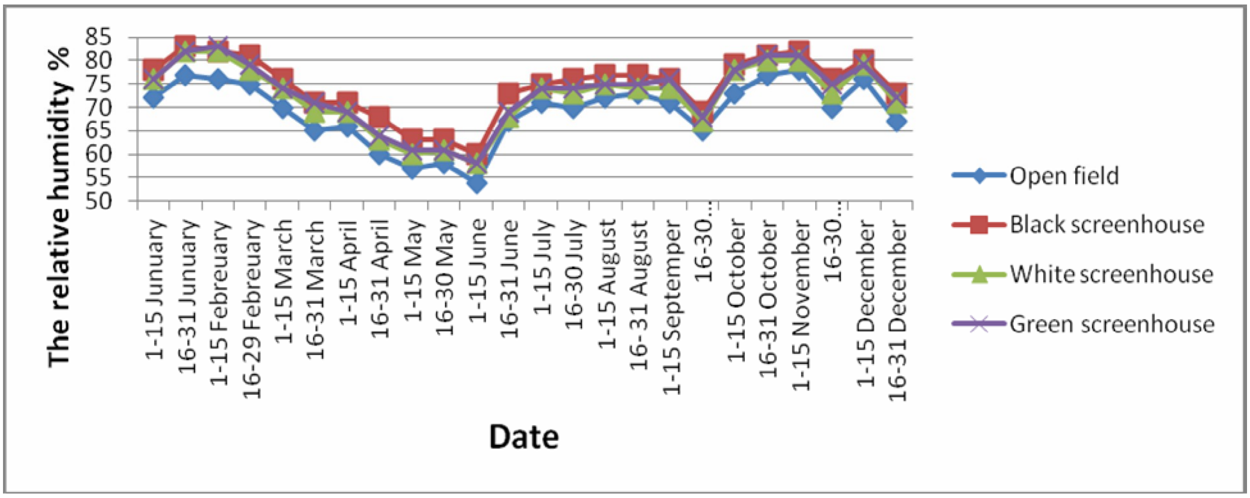

Figure 6. The average relative humidity inside the screenhouses and open field during second season

2- Maximum temperatures:

Maximum temperatures (Figures 3 and 4) recorded during first and second seasons tended to be lower inside the screenhouses than in the open field by 0.5-2^{O}C, that may related to shading effect inside the screen houses than the outside. These results were in agreement with those obtained by Medany *et al.* (2009).They reported that maximum temperatures tended to be lower under the nets (2^{o}C) due to the interception of radiation which is greater than the gain of temperatures caused by the use of nets due to their role in the interception of air circulation or greenhouse effect. However, Moller and Assouline (2007) found that screen did not significantly modify maximum temperature.

3- Relative humidity:

The relative humidity (Table 5and 6) increased by about 4-6% inside screenhouses especially black one as compared to open field. High relative humidity seemed to be suitable for banana vegetative growth subsequently enhances the productivity. Likewise, Medany *et al*.(2009) found that average relative humidity increased by the use of net by 4-8% compared to open field. Also Liu *et al.*(2015) reported that, relative humidity increased by 8% relative to an external meteorological station. These results were in line with those reported by Al-Mulla *et al.*(2008) indicating relative humidity, was always higher (max. by 5%) than on the screen house. Moreover, Al-Mulla *et al.*(2011) indicating relative humidity, with an average of 55.5%, was also uniformly distributed inside the screenhouse and it was more humid than outside by 7.3.

4- Light Intensity:

The light intensity reduced significantly inside screenhouses especially black one as compared to open field (Figure 7 and 8). In that concern, Tanny (2013) and Tanny *et al*. (2014) reported that, screens are mainly used to reduce high radiation loads and wind speed. Also, Santos *et al*. (2006) reported that radiation measurements showed that radiation under screen was 30% (clean screens)-50% (dust, dirty screens) lower than external values. Moreover, M?ller and Assouline (2007) stated that shading reduced mean global radiation by more than 40%. In the same trend, Liu *et al.*(2015) reported that the clear polyethylene screen reduced radiation by between 8 and 25% depending on dust accumulation and aging. Also Liu *et al*.(2009) showed that reductions in banana transpiration inside the screen house were mainly due to the decrease in net radiation and wind speed. However, Moller *et al.* (2003) found that radiation load under the screen was reduced to almost half of its external value.

5. Wind speed:

Reduction in air velocity (Figure 9and10) inside the screenhouse reaches 50%; this reduction directly affects the evapotranspiration and relative humidity. These results were in agreement with those obtained by M?ller and Assouline (2007). They stated that wind speed inside the screen house was reduced by more than 50%. No significant difference was observed among the three screen houses in terms of wind speed reduction. In that concern, Santos *et al*. (2006) reported that screenhouses are used mainly as wind protection. In the same trend, Tanny *et al.*(2006) reported that a good correlation was found between inside air velocity and outside wind speed as expected. Also, Liu *et al.*(2015) reported that in the screenhouse, wind speed, global radiation and air temperature were reduced by more than 60, 20 and 1%, respectively. In terms of the distribution of air velocity inside the screen house, Teitel *et al.*(2014) revealed that the resistance of the screens to airflow is high and ventilation rate is strongly reduced in comparison to the open field.

The effect of screenhouse color and irrigation regime on productivity of banana plants cv. Grand Naine.

1- Bunch weight (Kg):

Bunch weight (Table 4) significantly varied in response to screenhouse color and irrigation water treatments. In this respect, the heaviest bunches (31.82and 34.96 Kg) were obtained from plants in white screen house while the lightest bunches (21.25 and 21.92 Kg) were obtained from plants in the open field, in both tested seasons. In terms of irrigation treatments, recommended rate (9000 m^3/Fed./year) was superior to other treatments (28.16 and 29.91 Kg) followed by 15% reduction from recommended rate (7650 m^3/Fed./year), (25.62 and 27.31 Kg). Bunch weight significantly increased by increasing water amounts within each screen house color. Interaction studies between the main factors were statistically significant which refer to screenhouse color and amount of water act dependently in this concern. For example the heaviest bunches were obtained from plants received high amount of water under any screenhouse color. The highest values of bunch weight (33.11, 31.48, and 30.88 Kg and 36.66, 34.77 and 33.44 Kg) were obtained in white screenhouse by using recommended rate (9000 m^3/Fed./year). Fifteen persent reduction from recommended rate (7650 m^3/Fed./year) and thirty persent reduction from recommended rate (6300 m^3/Fed./year)in the first season (mother plant) and second season (first ratoon), respectively.

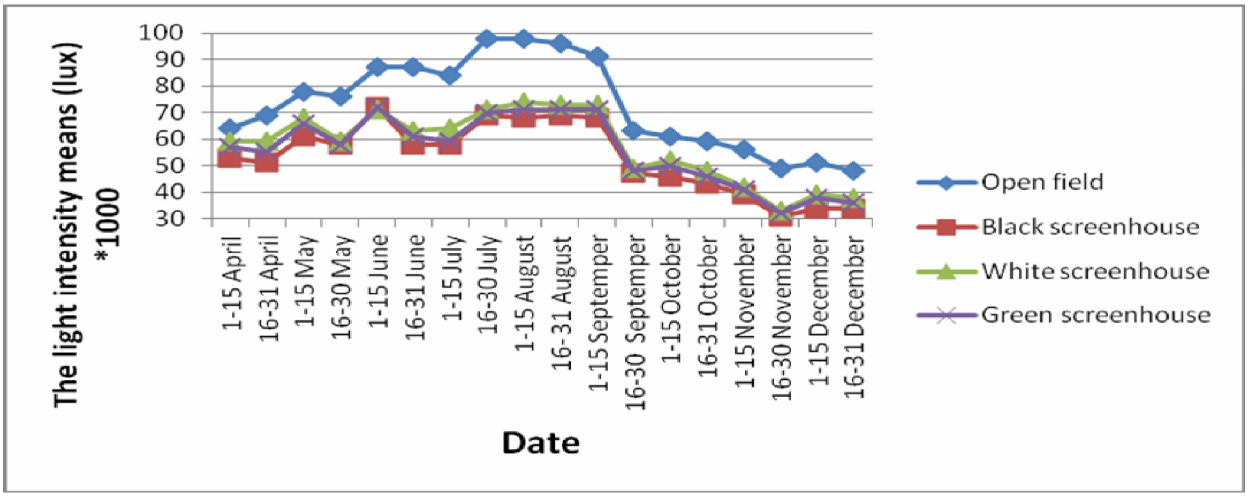

Figure 7.The average intensity inside the screenhouses and open field during first season

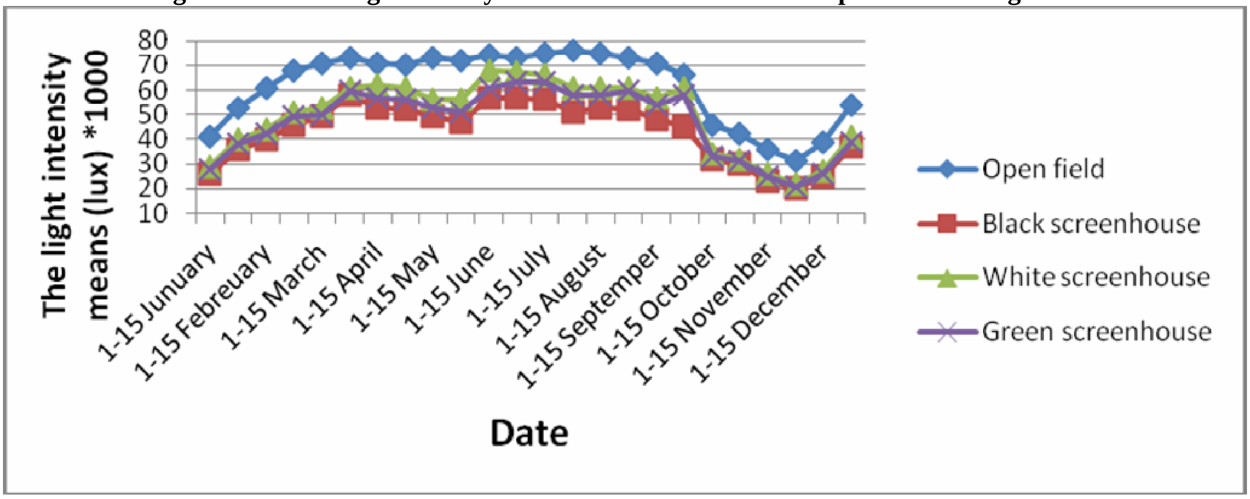

Figure 8. The average intensity inside the screenhouses and open field during second season

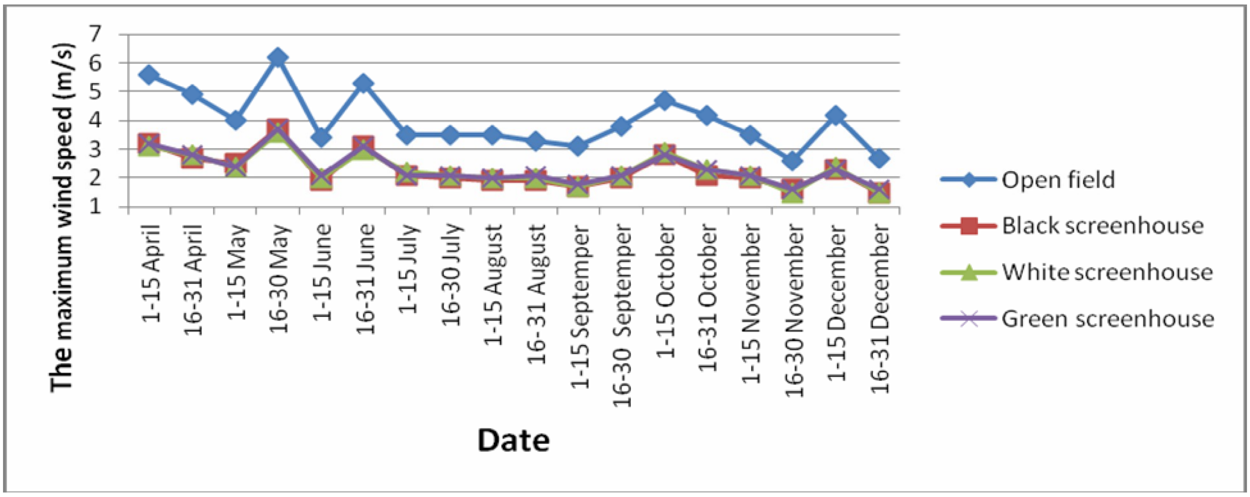

Figure 9.The average intensity inside the screenhouses and open field during second season

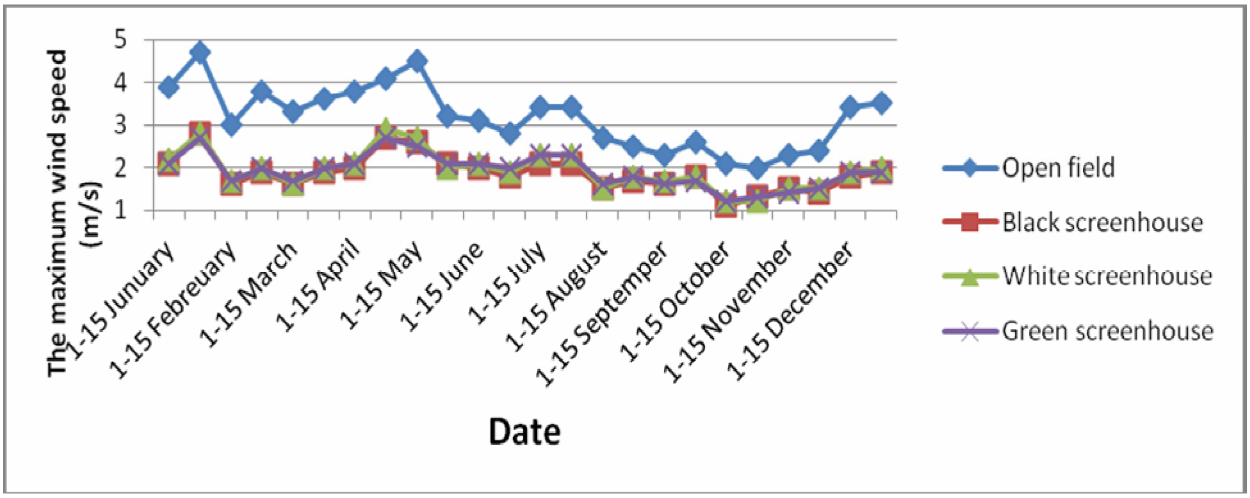

Figure 10.The average wind speed inside the screenhouses and open field during second season

Table 4.The effect of screenhouse color and irrigation water treatments on bunch weight (Kg) of banana plants cv. Grand Naine

Water regime	Bunch weight(Kg) of mother plants (First season)					Bunch weight(Kg) of first ratoon (Second season)				
	Open field	Black screen house	White screen house	Green screen house	Means	Open field	Black screen house	White screen house	Green screen house	Means
Recommended rate	26.66	24.11	33.11	28.77	28.16	27.78	25.77	36.66	29.11	29.91
15% reduction of R.r.	20.33	23.44	31.48	27.22	25.62	19.44	24.88	34.77	30.11	27.31
30% reduction of R.r	16.77	20.88	30.88	26.29	23.71	18.55	22.88	33.44	29.33	26.05
Means	21.25	22.81	31.82	27.43		21.92	24.51	34.96	29.52	
New L.S.D. at 0.05										
Screenhouse	2.75					1.90				
water regime	2.24					1.64				
interaction	4.49					3.28				

2 - Bunch height (cm):

Data in Table 5 showed that the highest mean values of bunch height (101.1 and 107.4 cm) were obtained from White screenhouse (WSH) treatments in the first and the second seasons, respectively. On the other hand, the lowest values of bunch height (81.51 and 88.36 cm) were obtained from the open field treatments in the first and the second season, respectively. Considering the effect of water treatments, data in Table 5 showed that the highest mean values (97.42 and 101.8 cm) were obtained from recommended rate (9000 m^3/Fed./year) in the first and the second seasons ,respectively. On the other hand, the lowest values of bunch height (88.22 and 94.92 cm) were obtained from the 30% water reduction from recommended rate (6300 m^3/Fed./year)in the first and the second seasons, respectively. In terms of the interaction between the two factors tested, the highest significant value of bunch height (102.4 and 109.2 cm) occurred in WSH treatment with recommended rate (9000 m^3/Fed./year) in the first and the second seasons, respectively; while the lowest mean values (69.55 and 78.11cm) occurred in the open field with 30 % reduction from recommended rate (6300 m^3/Fed./year)in the first and the second seasons, respectively.

3- Number of hands per bunch:

Data in Table 6 showed that, the highest mean values of number of hands per bunch (9.63 and 11.14) obtained from WSH treatments in the first and the second season, respectively. On the other hand, the lowest values of number of hands per bunch (9.15 and 9.15) were obtained from the Black screenhouse (BSH) treatment in the first and the second seasons, respectively. Considering the effect of water treatments, data in Table 6 showed that the highest mean values of number of hands per bunch (9.74 and 10.58) obtained from recommended rate (9000 m^3/Fed./year) in the first and the second season, respectively. Opposite data revealed that, the lowest values of number of hands per bunch (8.94 and 9.33) were obtained from the 30% reduction from recommended rate (6300 m^3/Fed./year) in the first and the second seasons, respectively. In terms of the interaction between the two factors tested, the highest significant value of number of hands per bunch (9.85 and 11.88) occurred in Open field (O.F.) and WSH treatments with recommended rate (9000 m^3/Fed./year)in the first and the second seasons, respectively. Meanwhile the lowest mean values number of hands per bunch (8.22 and 8.44) occurred in the BSH and open field with 30% reduction from recommended rate (6300 m^3/Fed./year)in the first and the second seasons, respectively.

Table 5.The effect of screenhouse color and irrigation water treatments on bunch height (cm) of banana plants cv. Grand Naine

Water regime	Bunch height (cm) of mother plants (First season)					Bunch height (cm) of first ratoon (Second season)				
	Open field	Black screen house	White screen house	Green screen house	Means	Open field	Black screen house	White screen house	Green screen house	Means
Recommended rate	89.21	97.66	102.4	100.4	97.42	97.41	101.7	109.2	99.00	101.8
15% reduction of R.r.	85.77	95.44	101.1	94.78	94.27	89.55	100.5	106.5	99.64	99.06
30% reduction of R.r	69.55	88.00	99.78	95.57	88.22	78.11	97.43	106.4	97.75	94.92
Means	81.51	93.70	101.1	96.92		88.36	99.89	107.4	98.80	
New L.S.D. at 0.05										
Screenhouse			4.33					4.28		
water regime			5.05					4.17		
interaction			7.50					7.34		

Table 6. The effect of screenhouse color and irrigation water treatments on number of hands per Bunch of banana plants cv. Grand Naine

Water regime	Number of hands per bunch of mother plants (First season)					Number of hands per bunch of first ratoon (Second season)				
	Open field	Black screen house	White screen house	Green screen house	Means	Open field	Black screen house	White screen house	Green screen house	Means
Recommended rate	9.85	9.78	9.78	9.55	9.74	10.44	9.55	11.88	10.44	10.58
5% reduction of R.r.	9.33	9.44	9.66	9.44	9.47	9.22	9.00	10.88	10.44	9.89
30% reduction of R.	8.88	8.22	9.44	9.22	8.94	8.44	8.89	10.66	9.33	9.33
Means	9.36	9.15	9.63	9.41		9.37	9.15	11.14	10.07	
New L.S.D. at 0.05										
Screenhouse			0.05					0.21		
water regime			0.07					0.19		
interaction			0.08					0.37		

4- Number of fingers per hand:

Considering the effect of screenhouse colors, data in Table 7 showed that the highest mean values of number of fingers per hand were 24.59 and 25.0 in the first and the second season respectively, obtained from BSH &WSH treatments. On the other hand, the lowest values of number of fingers per hand were 22.11 and 22.89 in the first and the second seasons, respectively, obtained from the O.F. & G.S.H. treatments. Considering the effect of water treatments, data in Table 7 showed that the highest mean values of number of fingers per hand were 23.94 and 24.86 in the first and the second seasons, respectively, obtained from recommended rate (9000 m^3/Fed./year). On the other hand, the lowest values of number of fingers per hand were 22.64 and 23.08 in the first and the second seasons, respectively, obtained from the 30% reduction from recommended rate (6300 m^3/Fed./year). In terms of the interaction between the two factors tested, the highest significant value of number of fingers per hand were 24.88 and 25.66 in the first and the second seasons, respectively, occurred in B.S.H. and O.F. treatments with recommended rate (9000 m^3/Fed./year). Meanwhile, the lowest mean values number of fingers per hand were 20.66 and 21.66 in the first and the second seasons, respectively, occurred in the open field with 30% reduction from recommended rate (6300 m^3/Fed./year).

In terms of the effect of screenhouse and irrigation on banana productivity, the herein results were in line with those obtained by Kittas *et al.*(2012)who reported that shading increased the number of fruits per plant, and the total fresh yield of tomato. Shading reduced losses and thus increased the marketable fruit yield compared to growth under non-shaded conditions. Likewise, Pirkner *et al.* (2014) showed that estimated reference evapotrans - pirations were lower under the screenhouse. However, the horticultural measures of fruit yield characteristics were the higher under screen house, and hence, their results suggested a potential increase in productivity under the screenhouse. Likewise, Altinkaya *et al.* (2016) recorded yield components (number of hands, number of fingers, finger circumference and length, and bunch weight) and fruit quality attributes (peel thickness, the peel and pulp ratio, soluble solids content) after ripening which were significantly higher under shading conditions.

Water use efficiency (kg/m^3):

Water Use Efficiency (WUE) represents the quantity of fruit (Kg) that could be produced from one cubic meter of irrigation water. Data in Table 8 showed that the highest mean values of WUE considering the effect of screenhouse colors, obtained from WSH treatment during the two seasons were 2.96 and 5.57 Kg/m^3 , respectively. On the other hand, the lowest values of WUE obtained from the open field treatments during the two seasons were 1.93 and 3.43 Kg/m^3, respectively.

The highest mean values of WUE considering the effect of water treatments, obtained from 30% reduction from recommended rate (6300 m^3/Fed./year) during the two seasons were 2.63 and 4.97 Kg/m^3, respectively. On the other hand, the lowest values of WUE obtained from the recommended rate (9000 m^3/Fed./year) during the two seasons were 2.19 and 3.98 Kg/m^3, respectively. In terms of the interaction between the two factors tested, in the first season, the highest significant value of WUE was 3.43 Kg/m^3 occurred in WSH treatment with 30% reduction recommended rate (6300 m^3/Fed./year), while the lowest one was 1.86 Kg/m^3 occurred in the open field 15% , 30% reduction from recommended rate were 7650 and 6300 m^3/Fed./year, respectively. In the second season, the highest significant value of WUE was 6.38 Kg/m^3 occurred also in WSH treatment with 30% reduction from recommended rate (6300 m^3/Fed./year). The lowest mean value of WUE was 3.05Kg/m^3 occurred in the second season at open field with 15% reduction from recommended rate (7650 m^3/Fed./year). These results indicated that we can plant bananas under white screenhouse with 30% reduction from recommended rate (6300 m^3/Fed./year) with the highest WUE. These results were in agreement with those obtained by Tanny *et al.* (2012). They reported that in the Jordan Valley water savings can reach 20-30% with the same and even better yield. Likewise, Ibrahim *et al*. (2012) in the same concern, found that drip irrigation system gave the highest values concerning WUE. In other words improvement of WUE may be attributed with available water formed in the root zone but not the amount of applied water. In that concern, Tanny *et al.* (2010) reported that screenhouses save water and improve fruit quality. Water savings can reach 20-30% thus, (WUE) is increased. These results were in agreement with those obtained by Pirkner *et al*. (2014) whey showed that, the horticultural measures of flowering and fruit yield characteristics were the higher under screenhouse; hence, their results suggest a potential increase in water use efficiency under the screenhouse.

Table 7. The effect of screenhouse color and irrigation water treatments on number of fingers per hand of banana plants cv. Grand Naine

Water regime	Number of fingers per hand of Mother plant (First season)					Number of fingers per hand of first ratoon (Second season)				
	Open field	Black screen house	White screen house	Green screen house	Means	Open field	Black screen house	White screen house	Green screen house	Means
Recommended rate	23.11	24.88	24.66	23.11	23.94	25.66	25.44	25.11	23.22	24.86
15% reduction of R.r.	22.55	24.66	24.55	22.77	23.63	24.11	24.11	25.22	23.44	24.22
30% reduction of R.r.	20.66	24.22	23.00	22.66	22.64	21.66	24.00	24.66	22.00	23.08
Means	22.11	24.59	24.07	22.85		23.81	24.52	25.00	22.89	
New L.S.D. at 0.05										
Screenhouse			0.66					0.24		
water regime			0.41					0.32		
interaction			0.83					0.55		

Table 8. The effect of screenhouse treatments and irrigation water regime on water use efficiency (WUE) of banana plants cv. Grand Naine

Water regime	Water use efficiency(WUE) of mother plant (First season)					Water use efficiency (WUE) of ratoon (Second season)				
	Open field	Black screen house	White screen house	Green screen house	Means	Open field	Black screen house	White screen house	Green screen house	Means
Recommended rate	2.07	1.87	2.57	2.24	2.19	3.70	3.43	4.89	3.87	3.98
15% reduction of R.r.	1.86	2.14	2.88	2.49	2.34	3.05	3.91	5.45	4.73	4.29
30% reduction of R.r.	1.86	2.32	3.43	2.92	2.63	3.53	4.35	6.38	5.59	4.97
Means	1.93	2.11	2.96	2.55		3.43	3.89	5.57	4.73	
New L.S.D. at 0.05										
Screenhouse			0.19					0.17		
water regime			0.16					0.15		
interaction			0.33					0.30		

CONCLUSION

Screenhouse utilization became utmost important in banana cultivation as it could modify the microclimate to make it proper for banana plants cultivation. In case of water scarcity, it can maximize water savings up to 30% without significant reduction in the production. Screenhouses promoted the vegetative growth and subsequently enhanced the productivity. Also, screenhouses could alleviate all negative effects and protect banana crop from biotic and abiotic stresses such as super optimal solar radiation, wind damage, insect damage, viral infection and chilling damage. The protection from all these stresses provided by screenhouses ensures or even enhances fruit quality.

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الملخص العربي

المناخ الدقيق وعلاقته بالإنتاجية وكفاءة استخدام المياه لمحصول الموز صنف"جراندنان" بالبيوت الشبكية

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يزداد استخدام البيوت الشبكية بسرعة كبيرة في الوقت الحاضر؛ لذلك فإنه في هذه الدراسة،تم تسجيل تأثير البيت الشبكي وألوانه على إنتاجية الموز صنف"جراندنان"،وعلاقته ببعض العناصر المناخية الدقيقة(درجة حرارة التظليل،الرطوبة وسرعة الرياح والكثافة الضوئية)وكذلك استخدام المياه. تم تسجيل مكونات الإنتاج مثل:وزن السباطة،وطولها،وعدد الكفوف وعدد الأصابع في الكف. وقد تم تقدير توفير المياه باستخدام ثلاثة مستويات مختلفة من الري ومقارنة كل ذلك بالحقل المكشوف. وأظهرت النتائج المتحصل عليها انخفاضا لدرجة الحرارة القصوى للبيوت الشبكية بمقدار ١-٢^{o}م ، وزيادة درجة الحرارة الدنيا بمقدار ١^{o}م تقريبا، وزيادة الكثافة بنحو٣٠٪ تقريبا، وانخفاضا في سرعة الرياح بحوالي٤٠٪، وارتفاعا للرطوبة بنسبة ٤-٦٪،وانخفاضا لاستخدام المياه المحصولية داخل البيوت الشبكية بنسبة٣٠٪، وذلك بدون أي انخفاض معنوي في الإنتاجية بالمقارنة مع الحقل المكشوف؛ وقد يرجع هذا إلى الحد من البخر الناتج عن البيت الشبكي. ويمكن التوصية بزراعة الموز داخل البيوت الشبكية من أجل تقليل استخدام المياه المحصولية إلى أدنى حد، وتحسين كل من كمية المحصول وجودة الثمار.