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ORIGINAL ARTICLES

The Respone Of Banana Production And Fruit Quality To Shading Nets

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ABSTRACT

Grand Nain banana (*Musa Cavendishii*) plantation at Bossaily Protected Cultivation, El-Behira Governorate, Egypt, was covered with red or black insect-proof nets that gave 30 and 45% lower light intensity, respectively as compared with the uncovered bananas in order to investigate the effect of shading on water-use efficiency, vegetative growth and bunch yield. During hot summer days, the covered plantations provided with wind protection had higher air relative humidity, lower air temperature, plants grew faster, producing shoots and harvested earlier with bunch weight heavier than the control. Water applied to the shaded bananas during the season was 40 % (521.8 mm) less than the control (740.3 mm) meanwhile water use efficiency (production per unit of water) was higher 73.9 and 87.0% for red nets and 44.9 and 55.2% for black nets than the uncovered for both seasons, respectively.

Key word: Water requirements, crop yield, net colour, shade screen colours.

Introduction

The bananas (*Musa Cavendishii*) are native to Southeast Asia where this crop have been cultivated thousands years ago and believed to be introduced to Africa in prehistoric times. Susceptibility to frost keeps the banana from spreading beyond the tropics and the worm subtropical areas. Bananas are grown inside plastic or glass covered structures and show wide adaptability to a range of environments. Areas between 20° and a little beyond 30° N and S latitude like Egypt are considered under the subtropics (Simmonds and Stover, 1987). Nevertheless, the establishment of bananas in these diverse environments (temperature, radiation and humidity) has often led to the adoption of unique cultural practices that modify the impact of adverse environment on the developed plant (Bruce and Peter, 1994). Planting bananas under shading house may overcome the unsuitable environmental conditions. Growing plants in greenhouses is a common practice in the Mediterranean zone and in the Canary Islands (Galan-Sauco *et al.,* 1992 and Ecksttiens *et al.,* 1998). In Egypt, banana under plastic-covered greenhouses failed to give positive results (Saleh, 2005) due to hot and dry summer (average maximum temperature about 39°c during July and August) which converted the greenhouse air to excessive hot condition especially at the leaf level. The high temperatures cause marginal leaf desiccation, leaf deformations beside bunch and fruit malformations. On the other hand, dust accumulations on the plastic cover during the summer reduce light transmission and limit photosynthetic activity.

The main purpose of this study is to protect the banana against winter low temperature and wind damage which in turn will usually give higher yields and better fruit quality. Therefore, the plastic covers on shade houses gave positive effect that was already documented and assured (Israeli *et al.*, 1995). However, bananas grow under black or red-coloured nets could benefit the protection against wind damage and excessive irradiation which overcome the reduction of photosynthetic activity. This process improve microclimatic conditions in terms of radiation, air temperature, relative humidity and effectively reduce water consumption.

Materials And Methods

This investigation was carried out at the Protected Cultivation Experimental farm in El_Bossaily site El_Behara Governorate (30° 35` N Latitude and 30° 36` E Longitude). A two-year field experiment was carried out in order to test black and red colored insect-proof nets in comparison with the uncovered treatment. Each colored net covered 1200 m^2 of the shade house. The initial shading of the net was 25% shade percentage which has been gradually increased due to dust adherence.

The treatments were arranged in a complete randomized plot design with three replicates (Each replicate had one plant in a soil Lysimeter container of 1.25 m^3 and was used to estimate the amount of water consumed

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within the active root zones). A Piezometer tube was installed 1m below the soil in order to monitor and record water table level. The soil was sandy with pH 6.6 and reflect Field capacity13.4% and permanent wilting point 6.7%.

The Spanish top shade house style was constructed covering 2400 m^2 with 4m height using a combination of 4" and 2" wood poles connected and anchored to the ground with 3-5 mm steel cables at a distance of 5m between poles while perpendicular supporting wires were installed every 20m. The shading net was stretched over the wires covering the top and all sides of the house structure in order to optimize maximum wind protection.

Young Grand Nain banana plants produced from tissue culture technique were planted on 1^{st} of July 2009 at a distance of 2.5m between rows and 2.5m between plants within the row in the shade house and at the same time in the open field.

The banana plants in all plots under shade were irrigated and fertilized by a drip irrigation system using two lines of laterals on every row. The Reference evapotranspiration (ET_o) utilizing the modified FAO "Penman" equation was applied for soil properties and calculation of the interval between irrigations. The crop coefficient (K_c) was determined from the relationship between ET_c and ET_o. Water flow meters were installed in each treatment to measure the amounts of irrigation water. Water use efficiency (WUE) for each treatment was calculated as bunch yield divided by seasonal $ET_{c.}$

The recorded data were done on 1. Mean air and soil temperatures, wind speed, relative humidity and net radiation which were recorded daily under the net colours and the open field using Campbell Scientific Ltd, CR10X automatic weather station. The climatic data was used to calculate the ET_o and ET_c which was determined by using the Lysimeter container. 2. Determination on the plant characteristics took place on the vegetation parameters including stem circumference, stem height, total leaf number, bunch stalk circumference and days from shooting to harvest. The yield quantity which confined the bunch number of hands, number of fingers and weight as well as the quality that embraced finger circumference and length were estimated.

The results were statistically analyzed using F-value test and the means were compared by the L.S.D at the level of 5% probability. MSTATC was the computer program that used to calculate the obtained results and statistical analysis.

Results And Discussion

A. Effect of coloured nets on microclimate and water relations:

a. *Microclimate:*

The results of microclimatic conditions during this study are shown in Figure (1) including mean air and soil temperatures, wind speed, relative humidity and net radiation in the two seasons from July 2009 to December 2011.

The shading nets of black colour reduced air temperature and wind speed especially during the hot hours of the summer days and increased relative humidity followed by red shading nets and open field, respectively. Consequently, the radiation was reduced by the shading of black colour net which reflects that the soil received a fairly low amount of solar radiation as compared with the red net and the open field, in respective order.

b. Evapotranspiration (ET_o):

The daily climatic data were used for estimating the daily reference evapotranspiration (ET_o) according to the "modified Penman" equation from July 2009 to December 2011. The data in Figure (2) present the daily reference evapotranspiration (ET_o) during the two growing seasons. The total reference evapotranspiration (ET_o) values in the two seasons for the black, red nets and uncovered treatment were 521.8, 634.6 and 740.3 mm, respectively. The highest values were obtained in June 2010 and 2011 at 5.2 and 5.3 mm day^{-1} from the uncovered treatment meanwhile the lowest values were 0.32 and 0.35 mm day^{-1} from black net colour in December 2009 and 2010 respectively. The values were gradually increased with the progress in plant development during hot dry summer climate.

c. Water requirements:

Water requirements were affected by both plant developmental stages and climatic conditions. The effect of both cover colours on water requirements (Figure 2) exhibit that this item was gradually increased with the progress of the plant age till a top was reached at June from the mid stage of then turned to decrease slightly till the end of the growing season. It is obvious that the minimum values were found after the start of planting. This trend may be related to the continuous gradual increase in the water consumptive use with the progress of plant growth till the end of development. However, in descending order the arrangement of the water requirements

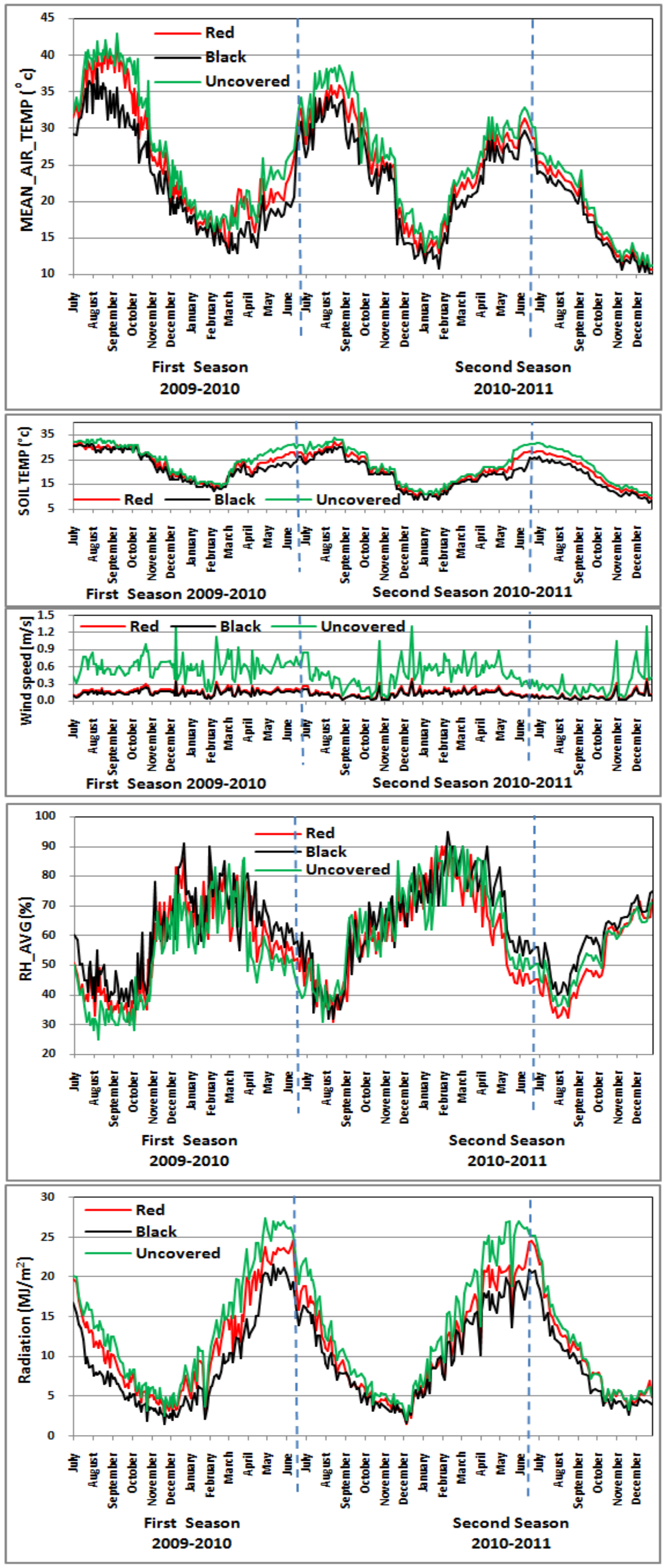

Fig. 1: Daily climatic conditions (Mean air and soil temperature °c, Wind speed m/s, Average relative humidity % and Radiation Mj/m2) of Grand Nane banana growth under different net sheet colours from July 2009 up to December 2011.

values began with black and red nets then was followed by the open field. This result may be attributed to that nettings may reduce wind speeds and wind run which can affect temperatures, relative humidities, and gas concentrations resulting from reductions in air mixing (Robert,2009). These changes can affect transpiration, photosynthesis, respiration, and other processes which reflect on water consumptive use. (Doorenbous & Pruitt, 1984 and Hane & Pumphrey, 1984).

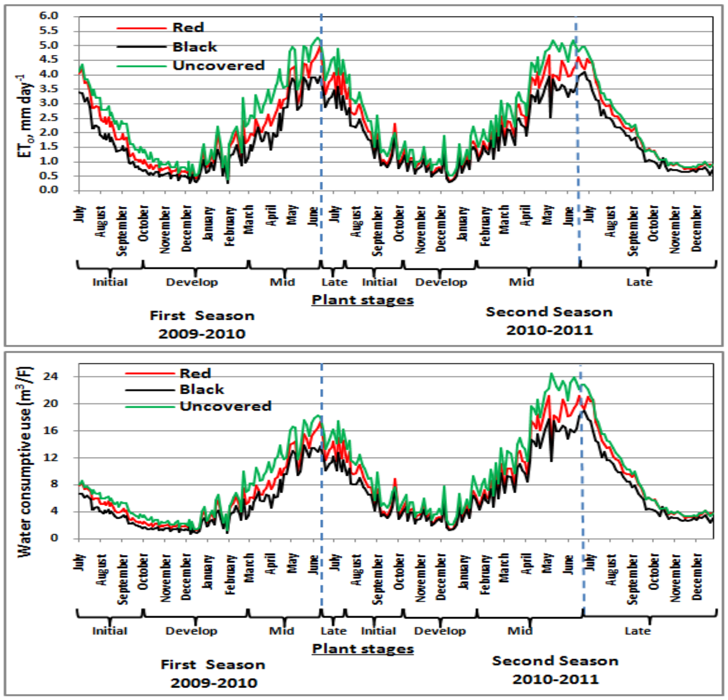

Fig. 2: Daily reference evapotranspiration (ETo, mm day-1) and water consumptive use (m3/F) of Grand Nane banana under various treatments from July 2009 up to December 2011.

d. Crop coefficient (K_c):

Determination of crop coefficient (K_c) value depends on planting time, stage of crop development, climatic conditions and soil moisture which usually expressed as a function of time (days after planting). In the present investigation, the values of K_c were calculated by using actual evapotranspiration (ET_c) which was measured by volumetric method (lysimeter container) under the various shading cover colours that nominated as a function of days after planting (Fig. 3). The values of K_c were increased gradually and reached the maximum at the mid season for the black shading colour meanwhile this maximum was shifted 10 days later for the red one and 20 days for the open field then all of them decreased gradually till the end of the growing season. The black and red shading colours were harvested 35 and 25 days earlier than the open field cultivation and the Kc values were the maximum with the optimum amounts of irrigation water with the black shading followed by the red one then the open field treatment.

e. Drainage Water:

Drainage water (Liter/plant) of banana was measured by lysimeter container which gave indication about soil water balance in the active root zoon. The results in Fig. 4 of drainage water pointed that the black net shading colour losses more water in the deep percolation than the red and uncovered ones especially in the initial stages of banana growth. These results explain why shading banana perform well under lower irrigation rates (Doorenbos & Kassam, 1986 and Refaie, 2003).

The daily actual water values varied with the change in climatic conditions and plant growth. At the initial stages of growth the rate of actual water use was low which was followed by increases to reach the maximum value at the end of the developmental stages. At the mid-season the rate of actual water use declined from full development up till harvest.

The actual water use was decreased with the increase of soil water stress and this reduction can be attributed to the shortage of available water in the root zoon which resulted from the low amounts of added water under shading covers.

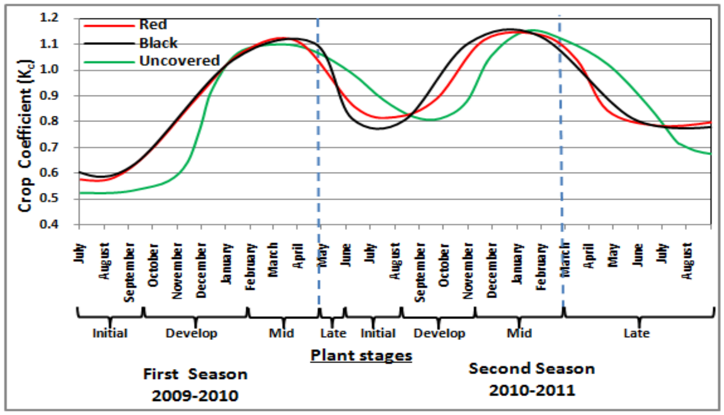

Fig. 3: The crop coefficient (Kc) of Grand Nane banana growth under various net sheet colours from July 2009 up to December 2011.

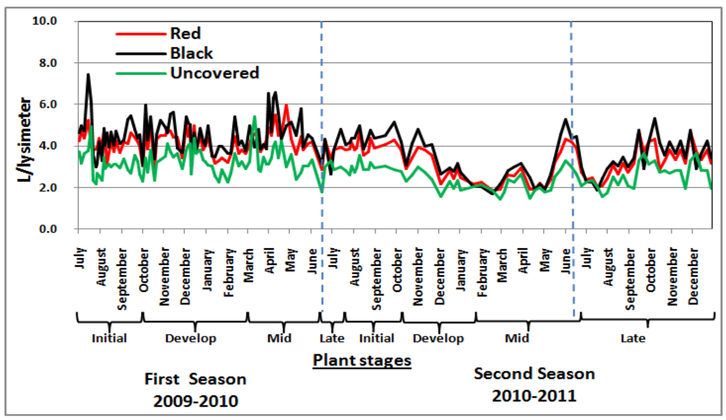

Fig. 4: Drainage Water (L/lysimeter) of Grand Nane banana growth under various net sheet colours from July 2009 up to December 2011.

B. *Effect of coloured nets on plant growth and development:*

The growth of plants was found fast (Table 2) represented early shooting, coming in advance in date of Sucker emergence to bunch shoot by 55 days and froming sucker emergence to bunch harvest by about 90 days earlier than the unshaded control (Table 2). Shade house gave rise to early shooting bigger bunches weight, more number of fingers per bunch, heavier finger and hand weights than the unshaded control (Table 3).

a. *Vegetative growth:*

The effect of shading treatments on the vegetative growth of plants is shown in Table (1). As for plant length and girth of pseudostem, the obtained data show that the length of pseudostem did not significantly affect by net colours. The girth of pseudostem was significantly reduced under open field comparing with shading colours but this characteristic was significant by red and black net in the second season only.

Regarding the number of total leaves and suckers per plant (Table 1), it was shown that covering with the red and black nets increased significantly these characteristics over the open field in both seasons but there was no significant difference between the two net colours.

The results illustrated in Table (2) show the effect of shading conditions on the periods from sucker emergence to bunch shooting, bunch shooting to bunch harvesting and sucker emergence to bunch harvesting. These parameters were significantly elongated under the open field conditions than the shading treatments. On the other hand, the characteristics of the period from sucker emergence to bunch shoot and from sucker emergence to bunch harvest were significantly decreased with the application of the red net in the second season only.

Table 1: Effect of various net sheet colours on some vegetative growth characteristics of Grand Nane banana during 2009-2010 and 2010-2011 seasons.

Net sheet colour	Pseudo stem				No. of total leaves		No. of suckers/plant	
	Length (cm)		Girth (cm)					
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Red	298.0	312.0	76.0	79.0	48.8	49.4	4.2	4.8
Black	302.0	320.0	72.0	74.0	46.9	48.2	3.9	4.0
Open field	276.0	282.0	65.0	67.0	39.6	38.7	3.0	3.2
LSD at 0.05	14.2	10.0	7.2	4.3	4.3	3.3	1.1	0.9

Table 2: Effect of various net sheet colours on the period from sucker emergence to bunch shoot, from bunch shoot to bunch harvest and from sucker emergence to bunch harvest of Grand Nane banana during 2009-2010 and 2010-2011 seasons.

Net sheet colour	From sucker emergence to bunch shoot		From bunch shoot to bunch harvest		From sucker emergence to bunch harvest	
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Red	346.0	340.0	102.0	104.0	448.0	444.0
Black	360.0	364.0	112.0	110.0	472.0	474.0
Open field	430.0	436.0	122.0	125.0	552.0	561.0
LSD at 0.05	24.2	22.6	17.4	14.6	35.5	27.4

b. Yield and fruit quality:

It is clear that the parameters of bunch weight, number of fingers per bunch and number of hands per bunch increased under the shading conditions than the open field (Table 3). The results indicate that there are significant increase by using red and black nets in the yield and quality with the superiority of the red net over the black one. On the other hand, the results of finger and hand weights reflect that there was no significant differences between the red and black nets in all the studied characteristics.

Table 3: Effect of various net sheet colours on yield and fruit quality of Grand Nane banana during 2009-2010 and 2010-2011 seasons.

Net sheet colour	Bunch weight (k.g)		No. of Fingers/Bunch		No. of Hands/Bunch		Finger weight(gm)		Hand weight (kg)	
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Red	18.7	18.2	249.9	234.2	13.2	13.4	75.0	77.8	1.4	1.4
Black	15.6	15.1	221.6	208.7	12.0	12.2	70.4	72.5	1.3	1.2
Open field	10.8	9.7	185.7	163.6	9.8	9.9	58.0	59.3	1.1	1.0
LSD at 0.05	3.0	2.3	19.7	21.1	0.9	0.8	12.2	11.2	0.3	0.4

C. Water use efficiency (WUE):

Data on water use efficiency (WUE) are presented in Fig 5. The highest significant value of WUE was obtained from plants grown under the red nets in the two seasons. Plants grown under red shade gave 73.9 and 87.0% production per unit of water while black nets gave 44.9 and 55.2% higher than the uncovered treatment in both seasons respectively. Such results recommend the utilization of red nets over banana plantation especially in the newly reclaimed lands to save water.

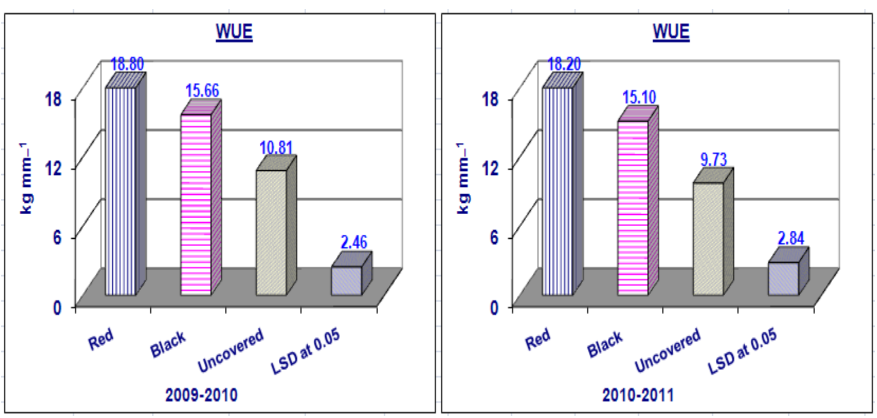

Fig. 5: Water use efficiency (WUE) (kg mm^{-1}) of Grand Nane banana growth under various net sheet colours from July 2009 up to December 2011.

Conclusion:

All the previous results pointed that the main limiting factors for Grand Nain banana production are heat, wind and water stress. Therefore, the meteorological elements governing growth, development, production and quality of Grand Nain banana at a given site are basically air and soil temperatures, solar radiation, soil moisture and crop water use or evapotranspiration (ET_o). The obtained results provided a comprehensive account to recommend the application of the shade cover especially the red one which is the most suitable cover for Grand Nain banana growth, yield and fruit quality.

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