Growth and Productivity of Mango Grown under Greenhouse Conditions

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Growth and Productivity of Mango Grown under Greenhouse Conditions

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THE SUITABILITY of white greenhouse net cover for growth of mango (*Mangifera indica*. L.) cv. Keitt cultivar was tested at the El-Bosaily governmental farm at the North West of the Nile Delta, Egypt. The treatments were cover the greenhouse by white net and conventional open field treatment (control). This study aims at investigating the effects of white net on the growth and production of mango trees from the interception of light, temperature, humidity and plant growth were evaluated over two seasons (from 2007 and 2008). The nets demonstrated their efficiency for orchard decrease maximum temperatures and increase minimum temperatures and relative humidity compared with open field treatment. The use of white net resulted in a significant increase of number of leaves, plant height and stem diameter per plant compared to open field orchard. The net was superior for plant growth, flowering and yield. Data revealed that microclimate under the white net make proper microclimate for tropical fruits under Egyptian conditions.

Keywords: Air temperature, Relative humidity, Microclimate, and Vegetative growth

Although screenhouses have been used for many years the recent upsurge in their popularity, which is largely due to the desire to reduce pesticide application, requires increased understanding of their climate. Little research on screenhouse climate and water use has been previously reported, and pressure on water resources makes this information timely. An early study of screenhouse climate (Ross and Gill, 1994) reported general features, but did not parameterize the house and screen structures, and therefore cannot be used to predict the behavior of modern screening materials and screenhouse structures, or the interaction of climate with screenhouses covering several thousand square meters of cultivated area (Desmarais, 1996).

It is the most demanding genus in terms of microclimate. The species and the hybrids from this genus do not tolerate wide thermic ranges and require different levels of solar radiation, temperature, and relative humidity, depending on the phenological phase of the plants (Lee & Lin, 1984, Wang, 1995 and Rajan, *et al*., 2006). The high temperatures determine the vegetative growth of the plants and damage their floral induction. Wang (1998) affirms that interactions between the temperature and the light are the key factors to plant growth. In order to relief the problems of high temperatures during the plant growth period, many growers greenhouse covered with shade net where the microclimate offers conditions closer to the ideal microclimate. There are growers that invest in more powerful climatized systems, such as, air conditioning, to transport these plants. Due to the fact that the tropical fruit trees need a appropriate micro-climate during all its phenological phases, modification of the microclimate by using shade net is necessary at least during part of spring, going through summer up to part of fall. For this reason, two types of shade net that modifies the solar spectrum transmitted was tested in this experiment, allowing their comparison with a white or black shade net, which is regularly used in this cultivation (Iglesias and Alegre, 2006).

Fouche *et al.* (1997) reported that the plants in a vegetative phase could grow with a photosinthetically active photon flow from 280 to 380. Lin and Hsu (2004) report that the leaves subjected to radiation levels higher than 200 suffer photo inhibition. Lin & Hsu (2004) and Saleh (2005) mention that, in case of regular commercial cultivation, the new leaves placed in the upper part of the plant can be subjected to photo-inhibition, whereas those placed in the lower portion of the plant, which are in the shadow, did not reach the ideal level of flow density of photosynthetically active photons (Lin and Hsu, 2004). Based on this fact, a higher amount of diffuse light in the environment could be thought, even if the total amount of radiation were kept in order to benefit the cultivation either by photo inhibition or by increasing the amount of photons received by the lower-positioned leaves (Konow & Wang, 2001 and Iglesias & Alegre, 2006). Due to the high microclimatic requirements of the culture, the installations for this kind of cultivation have a technically good level, varying the number of covering according to the local solar radiation (Iglesias and Alegre, 2006). It is preferred to cultivate this species in regions where mountains predominate, but as the market demand increases, the culture has been installed in places where the climate, at first, is inhospitable (Chaur, 2002). As a consequence to this fact, a higher investment in the microclimate is required. Among the problems that affect this cultivation, the low temperatures during the winter and the excess of temperature and solar radiation in summer (Saleh, 2005).

The aim of this study is to conditions were evaluate vegetative growth of mango grown under white net house comparing with open field conditions.

Material and Methods

The present investigation was carried out during three successive seasons from April, 2006 to October, 08 on mango plant (*Mangifera indica.* L.) cv. Keitt cultivar plants grown in El-Bosaily governmental farm at the North West of the Nile Delta, Behira governorate, Egypt. A completely randomized block design was used, with four blocks assigned to each of two treatments: white net and control. This design was used to control the effect due to the possible variations in tree vigor due to the effect of nets. Each treatment and block consisted of ten rows of 25 trees. Three trees per treatment were selected from the central row of each block based on uniform crop load and vigor. The plants were cultivated at the late Febraury of the first season, the distance between plants was 2.25 m and distance between rows is three meters. The rows were oriented from North to South. Samples of five plants of each experimental plot were taken to determine growth parameters at the end of season as follows (plant height, number of leaves per plant, number of branches, stem diameter, and total yield). The greenhouse area was 4200 m^2 (70 Length x 60 width). Greenhouse was covered by white screen net. The diameter of white net screen was 0.28 mm, and cell was size 3 x 7.4 mm. Sample of the soil was analyzed at the beginning of the experiment as shown in Table 1. In this respect, soil texture was sandy. All plants received the traditional and regular fertilization program, of which about 25 - 30 kg balady manure (farmyard manure) + 300 g super phosphate (15.5% P_2O_5)/plant/year added in December (winter additions), fertigation system were use to plant fertilization during the season. Drip irrigation system was installed to irrigate the plants under the greenhouse and open field. Plants either under white net or open field conditions were irrigated when the soil reached the field capacity. Total chlorophyll in the fresh leaves was determined as spad units (spad = 100 mg chlorophyll/g fresh weight) by using Minolta chlorophyll meter (spad, 501). Day light intensity, temperature and humidity were measured under white net and open field everyday. Data are subjected to statistical analysis according to Snedecor and Cochran (1980). The net characteristics were five-metre high poles were used to support the nets. The Estimated duration of white net cover is five years. For economical analysis, after considering the cost of organic materials application, the incomes from mango yield was used (CIMMYT, 1988) according to the formula: Net Income = value of obtained yield - cost of mineral/organic / biological nutrient sources; Value cost ratio (VC) = value of yield obtained / cost of mineral / organic/biological nutrient sources. Relative increase in income (RII) = (net income /income of control) x 100.

TABLE 1. Chemical and physical properties of the soil of the experiment analyzed before cultivation.

Chemical properties							
EC dS m^{-1}	pH	Ca^{++} meq/l	Mg^{++} meq/l	Na^{+} meq/l	K^{+} meq/l	HCO_3^{-} meq/l	Cl^{-} meq/l
3.11	6.55	18.32	12.84	13.51	1.34	7.45	12.4
Physical properties							
Sand %	Clay%	Silt%	Texture	FC %	PWP %	Bulk density g/cm^3	
95.28	4.32	0.40	Sandy	13.77	5.49	1.46	

Results and Discussion

Climatic data

Maximum, mean and minimum daily temperatures for the white shade net greenhouse and open field showed that the use of nets exerted a limited influence on orchard temperature (Fig. 1). Maximum temperatures tended to be lower under the nets (2°C), due to the interception of radiation which is greater than the gain of temperature caused by the use of nets due to their role in the interception of air circulation or "greenhouse effect". Bigger differences were recorded on the growing seasons. Minimum temperatures tended to be lower in the control by 1°C (Fig. 1) than in the nets because of the greenhouse effect and the low radiation at this time of the day. Similar results were reported by Vercammen (1999) and Rajan *et al*. (2006)**,** indicating that the influence of nets upon maximum orchard temperatures and their role in increasing minimum temperatures was not clearly demonstrated. Saleh (2005) found a moderate increase in maximum temperatures associated with the use of nets and Vaysse (1997) reported a moderate decrease (< 2 °C). Rajan *et al*. (2006) did not find any clear temperature effect associated with the use of nets and only noted that maximum.

Fig. 1. The average maximum and minimum temperatures under white net and control (open field) of the 2007 and 2008 seasons.

Average relative humidity increased by the use of white net by 4-8% compared with open field (Fig. 2). These results were in line with those reported by Iglesias and Alegre, (2006), indicating a 2-6% increase in humidity associated with the use of nets. These authors also reported a decrease in evaporation associated with the use of nets and a significant reduction in wind speed. Campen and Bot (2003) explained the ventilation phenomenon. The pressure difference over the openings was one of the driving forces for ventilation, which could be either due to the wind outside the greenhouse or due to the temperature difference over the openings. At lower wind speed, which was true under present case, mainly the buoyancy effect contributes in ventilation.

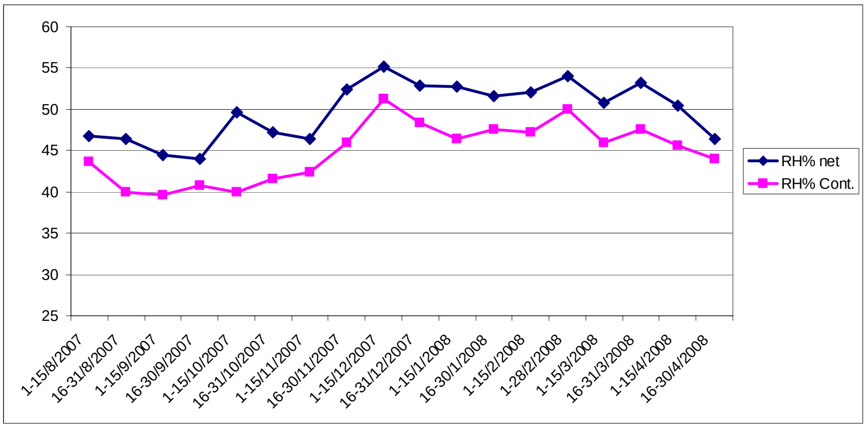

Fig. 2. The average means relative humidity under white net and control (open field) of the 2007 and 2008 seasons.

Vegetative growth

The effect of white net condition on vegetative growth of mango trees are shown in Fig. (3-6) as follows: As for plant height, data showed that plant height mango significantly affect by covering the greenhouse with white net, plants under white net were taller than those grown under open field condition during the two tested seasons.

As for plant height, number of leaves, number of branches per plant and main stem diameter per plant it was significantly reduced under open field comparing with covered greenhouse with white net. This was true in the first and second seasons.

Regarding number of leaves per plant, white net condition significantly increased number of green leaves in both seasons, number of total leaves was also significantly increased in the both season. Similar results was found by Abou-Hadid *et al*. (1992) and Saleh (2005) who found that vegetative growth of the plants under white net cover were bigger than those plants grow under higher open field conditions. The improved vegetative growth evidenced as plant height, number of leaves, and stem diameter per plant under the greenhouse levels may be due to the favorable weather conditions, *i.e*., increase in relative humidity, lower maximum temperature and light irradiance, higher minimum temperature and finally lower wind speed in comparison with open field conditions (Lin & Hsu, 2004 and Iglesias & Alegre, 2006). Other possibility was increasing plant ability to uptake water and nutrients which ultimately accelerated the rate of vegetative growth under greenhouse conditions.

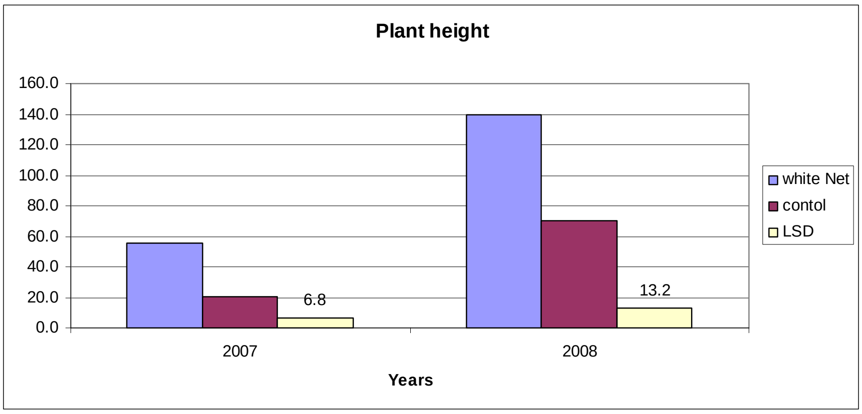

Fig. 3. Plant height (cm) under white net and control (open field) of the 2007 and 2008 seasons.

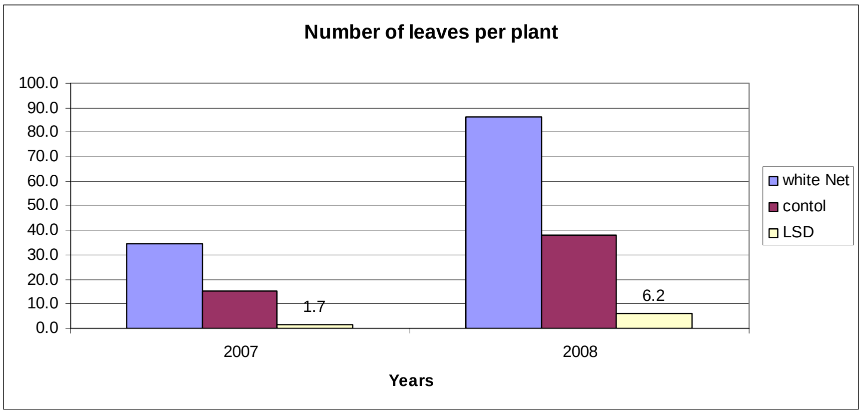

Fig. 4. Number of leaves per plant under white net and control (open field) of the 2007 and 2008 seasons.

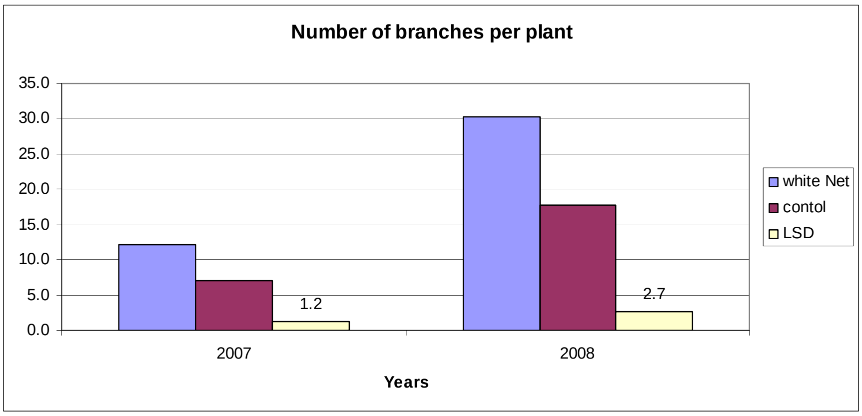

Fig. 5. Number of branches per plant under white net and control (open field) of the 2007 and 2008 seasons.

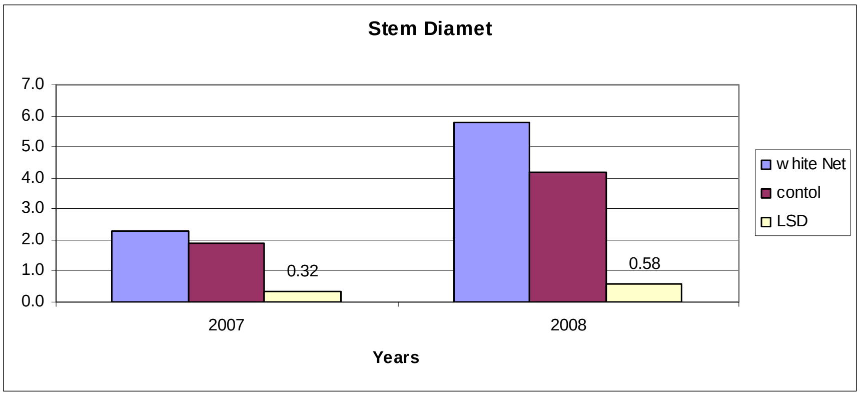

Fig. 6. Number of stem diameter (cm) under white net and control (open field) of the 2007 and 2008 seasons.

Yield

The effect of covered greenhouse with white net condition on fruit yield of mango trees is shown in Table 2. The higher mango yield associated with the use of the white net in comparison with open field conditions. The reduction of radiation is responsible for down-regulation of photosynthetic capacity of leaves and consequently a lower light saturated photosynthetic rate compared to the control (Gindaba and Wand, 2007).

Economic consideration

Annual costs of using nets (nets, installation, structure, rented machinery, labour, fold and unfold the nets each year, etc.) were 3650 L. E. per feddan, for white nets, (Table 2). We consider a lifespan for the support structure (poles, support cables) of 20 years, and white net of 5 years. The cost of installation of nets resulted in annual recurring cost. Both factors are considered to evaluate the effect of the nets on the gross income without considering the other costs of production -labour, inputs, irrigation, etc.-, because these are the same for the two treatments (Under white net and open field) of one feddan of mango. Considering the same yield for the two treatments and based on the mean data corresponding to the 2007 -2008 period, shown in Table 2. Compared to the control, the benefits (total gross profit) of using white net was higher than cultivate in open field. White net was superior of fruiting by two years comparing with control treatment, and the total benefit during the first two years after cultivation was 19160 L. E. (without considering production costs (labor, inputs, irrigation, etc.). In case of using white net cover the benefit increased compared to the control which is nowadays used in the main areas of fruit production in Egypt.

Table 2. Mango fruit weight and differences on gross profit due to the use of White net and control (without nets), over a one feddan.

Concept per fed.	Treatment	
	Control	White net
Income		
First year	0.0	370
Second year	0.0	1520
Total yield (kg fed.)	0.0	1890
Average Price (L.E/ kg)	14	14
Total fruit income for the two years (L.E/fed.)	0.0	26460
Cost		
Total nets cost (L.E/fed.) (Life period 5 years)	0.0	12500
Nets cost (L.E/fed./ year)	0.0	-2500
Total Greenhouse Structure Cost (L.E/fed.) (Life period 10 years)	0.0	11500
Structure coverage (L.E/fed./year)	0.0	-1150
Total net cost of coverage for the two year (L.E/fed.)	0.0	-7300
Profit		
Total gross profit for two years (L.E/fed.)	0.0	19160

Data mean fruit grower prices from 2007 to 2008. (yr): without considering production costs (labor, inputs, irrigation, etc.).

Conclusion

On the basis of the results presented, we can conclude that the system evaluated was very effective at protecting mango fruit trees (Iglesias and Alegre, 2006). It would therefore a divisible to use white nets in warm arid areas with cv. keitt cultivar. It would also be interesting to study the effect of using nets on plant water needs and their influence upon tree vigor. These are considerations of potential interest due to the effects of nets on radiation, humidity, evapotranspiration and temperature.

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نمو وإنتاجية نباتات المانجو المنزرعة تحت الصوب

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تم إختبار قابلية زراعة المانجو تحت الغطاء الشبكي الأبيض صنف كيت بمزرعة البوصيلي شمال الدلتا – مصر ، تشتمل المعاملات على تغطية الصوب بالشبك الأبيض ومقارنتها بالزراعه بالحقل المفتوح (معاملة المقارنه) ، يهدف البحث إلى تقييم تغطية الصوب بالشبك الأبيض وتأثيره على نمو وإنتاجية نباتات المانجو من خلال تأثيره على شدة الإضاءة ، درجة الحرارة والرطوبة خلال موسمي ٢٠٠٧ و ٢٠٠٨. أدى استخدام الشبك الأبيض إلى تقليل الحرارة العظمى وارتفاع درجة الحرارة الصغرى والرطوبة النسبية مقارنتا بالحقل المفتوح . كما أدى إستخدام التغطية بالشبك الأبيض إلى زيادة عدد الاوراق ، طول النبات وقطر الساق مقارنتا بالحقل المفتوح. ادى إستخدام الشبك الابيض إلى تفوق النباتات في النمو، الإزهار والمحصول. تشير النتائج إلى أن التغطية بالشبك الأبيض أدى إلى توفير مناخ دقيق ملائم لنمو نباتات المانجو تحت الظروف المصرية.