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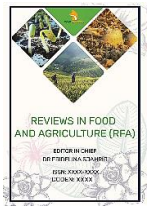

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RESEARCH ARTICLE

ECONOMICAL EVALUATION OF MANGO (CV. KEITT) TREES UNDER COLOURED SHADE NETS

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ABSTRACT

This study explored the economical viability of five different coloured shade nets (White, yellow, red, blue and black) on mango production (*Mangifera indica* L. cv. Keitt). This study investigated the climatic parameters in terms of light intensity, minimum and maximum air temperature, relative humidity and plant growth across 2019 and 2020 seasons. When compared to open field conditions, coloured shade nets resulted in higher maximum temperatures and relative humidity. The black net cover and open field treatments gave the lowest mango yield compared to all greenhouse net cover. When compared to the other treatments, the use of white or yellow nets resulted in a considerable increase in the number of fruits and total yield per plant. According to prevailed conditions, it could be concluded that optimum microclimate for growing mango in similar conditions could be obtained under white and yellow nets compared to the other net covers. Black greenhouse net cover gave the lowest productivity during the experimental duration. Production costs, total revenue, net return and ratio of total revenue to cost for Keitt mango in Egypt are presented in this study. The result shows that the net return for white net reached 15777 Egyptian pound (LE) and LE 15270 per m2 in 2019 and 2020 respectively, which was 2.63 times those grown in the open field (LE 5980 and LE 5081 per 2000 m^2) in 2019 and 2020 respectively. However, Revenue to cost ratio was found higher in white net in both seasons which were 1.9 and 1.8 respectively.

KEYWORDS

Keitt Mango, White, yellow, red, blue and black coloured shade nets, Net Return, Revenue to cost ratio, Cost per unit, Total Yield

1. INTRODUCTION

Total planted area of mango reached to 325.5 thousands acre representing about 18.9% of the total fruits area in 2020, with average yield of 4.31 tonnes per acre, and the total production was 1.2 million tonnes (MALR, 2021). The export value of Egyptian mango was $44.98 million; represented about 1.2% of global market. Top importer of Egyptian mangoes was Saudi Arabia followed by Jordan and United Arab Emirates with share in export of 31.06%, 15.49% and 13.91%, respectively (FAO, 2020). The rapid development of producing different fruit crops (orange, grape, mango etc.) under protected cultivation, particularly under net house, in order to increase yield (quantities and quality) while seeking to avoid impacts of climate change (high temperature, extreme weather events, lack of irrigation water etc.) has increased the investigations into the effects of the various net colours on the growth and yield of fruits. On the other side, the barren region between the rows and in-between during the initial years of fruit growth results are hence apparent in poor soil and water management. The bare land might be planted with various vegetable crops to improve food security, soil, water, fertiliser efficiency and minimise economic risk (Abul-Soud et al., 2014). Strong winds and intense sun radiation during the summer daytime are two elements that have a negative impact on mango growth, production and quality in hot climates. Excessive light, on the other hand, might have a detrimental impact on the look of the fruits (Jutamanee and Onnom, 2016). It is discovered that shading mango cv. Keitt trees with a white screen net improved fruit production in terms of yield kg/tree, fruit set, fruit number and weight, and this effect may be due to improving the microclimate under shading by lowering air temperature, increasing sun irradiance and decreasing relative humidity around the mango trees (Abdel-Sata et al., 2018). Photo-selective netting can also modify the growth and developmental cycle of fruits, such as fruit-set, harvest time, fruit yield, size and coloration, along with internal and external fruit attributes; hence, avoiding physiological problems (Racsko and Schrader, 2012). Extensive research has been conducted on the impact of photo-selective nets on agricultural plants, including ornamentals, vegetables, and fruits. The colour of such nets influence beneficial plant development features. For example, they increase the pace of vegetative growth and the vitality of foliage, especially when red and yellow nets are utilised. While blue nets have been known to produce dwarfing, grey nets have enhanced branching and bushiness while decreasing leaf area (Jokar et al., 2021). Nonetheless, it was proposed that in regions where trees frequently experience abiotic stress as a result of extreme solar radiation, netting can have a positive impact on fruit size by alleviating side effects and stress, thereby sustaining higher photosynthetic rates later in the day, as opposed to trees in full sun, where the photo-inhibition phenomenon is unavoidable (Mupambi et al., 2018). Fruit weight dropped in both fig varieties when exposed to colour shading nets, contradicting a prior result that showed an increase in high bush blueberry weight when plants were exposed to colour nets (Lobos et al., 2013). Shading could reduce the energy source of photosynthesis, cause the decrease of net photosynthetic rate and net carbon assimilation rate and lead to a decrease in dry weight and a reduction in yield. However, under strong light and high

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temperature stress, most crops show a clear "lunch break" phenomenon. Therefore, moderate shading at sunny noon in summer may improve photosynthesis and increase yield by improving the micro-meteorological environment of crop growth (Medany et al., 2009). Systems of permanent protection of the orchards, which have a more hybrid nature, such as shading nets or partial plastic covers, could be the most efficient solution to meet the mango growers' needs. Additionally, they can serve a double purpose which is partially protecting the plants from cold temperatures and mechanical damage during winter and reducing solar irradiation of fruits during summer to prevent sunburn (Dayioglu, and Hepaksoy, 2016). It was revealed that the development of architectures, technology and cultivation of net and plastic greenhouses with some fruit crops (such as navel orange and Keitt mango) happened, which generated a positive impact on the farmers' income compared to open field cultivation (Mohamed and Medany, 2015). Mohamed and Medany (2015) reached that the net income of Keitt mango under screen net is higher than in open field, despite the total production costs of screen net is higher than in open field.

The current investigation aimed to study the effect of different coloured shade nets on Keitt mango yields, in addition to estimating the economical viability of different treatments.

2. Materials and Methods

2.1 Greenhouse Infrastructure

Mango seedlings (*Mangifera indica*) CV. Keitt cultivars were planted in the "multi-tunnel" greenhouse with an area of 10000 m^2 (80 Length X 125 width) in June 2009. The greenhouse was covered by five sequential coloured shade net sections (white, yellow, red, blue and black). Each section covered 80 m long (North- South direction) and about 25 m wide (East- West direction) with a total area 2000 m^2. The number of trees per treatment was 333 trees/ 2000 m^2. Mango seedlings (one and half year of age) were provided by the Central Laboratory for Agricultural Climate farm in El-Behaira Governorate, Egypt. Keitt mango trees were planted at 3 X 2 m^2. In this respect, the soil texture was sandy. Different coloured shade nets were 50 mesh.

2.2 Experimental Location and Design

The study was carried out in multi- tunnel greenhouse at the Agricultural Research Centre farms in 2019 and 2020. It is located in Km 80 Cairo–Alexandria Desert Road, in El- Behira Governorate, Egypt.

Experimental design was complete randomized blocks with four replicates. The experimental plot was 60 m^2 10 meters length and 6 meters width. The average number of fruits and yield per plant was recorded for each replicate under different greenhouse cover net treatments. In this respect, the soil texture was sandy. Different coloured shade nets were 50 mesh.

2.3 Orchard Management

Trees were irrigated by a drip irrigation system. The amount of water supplied to the trees was determined according to the reference crop evapotranspiration (ET_0) (mm/day) and which was calculated using the methodologies of Penman-Monteith (Allen et al., 1998) using daily weather data from the automatic weather station inside the farm with the following equations

$ETc = ETo \times Kc$

Where ETc = crop evapotranspiration, ETo = reference crop evapotranspiration, and Kc= single crop coefficient.

Mango trees under greenhouse were fertilised with 10 tonnes of compost, each tonne of compost mixed with 100 kg ammonium sulfate and 50 kg sulfate during land preparation and after the harvesting of fruit. On the other hand mango trees under open field were fertilized with 2 tonnes of compost each tonne of compost needs 100 kg ammonium sulfate and 50 kg sulfate during land preparation and after the harvesting of fruit. For each treatment, the same amount of fertilizer (N, P_2O_5 and K_2O) was applied with the irrigation two times per week during both cropping seasons.

2.4 Statistical Analysis

Statistical analysis was determined by computer, using SAS program using SAS 9.4 software. The differences among means for all traits were tested for significance at 5% level according to the procedure described by (Snedicor and Cochran, 1981).

3. Result and Discussion

3.1 Climatic Data

Average monthly minimum and maximum temperatures under different coloured shade nets as well as opened field during experimental seasons showed that the use of different nets affected the air temperature under multi- tunnel greenhouse (Figures 1 and 2). The highest air temperature was recorded by the open field treatment followed by red net; white net came in the third order, while the lowest maximum air temperature was gained by black net. Maximum temperatures tended to be lower under the black net by 2- 3°C in comparison to open field. This finding may be due to more interception of solar radiation which is greater than the gain of temperature caused by the use of colour nets due to their role in the interception of air circulation or "greenhouse effect". Bigger differences were recorded on the growing seasons i.e. the air temperature decreased during the growing season of December, January and February in comparison to autumn months (September, October and November) and summer months (June, July and August). Similar results were reported indicating the influence of nets upon maximum temperatures under different net cover, which found black and blue net decreased the air temperature under greenhouse in comparison to open field or white net by (Elad et al., 2007; Perez et al., 2006; Retamales et al., 2008).

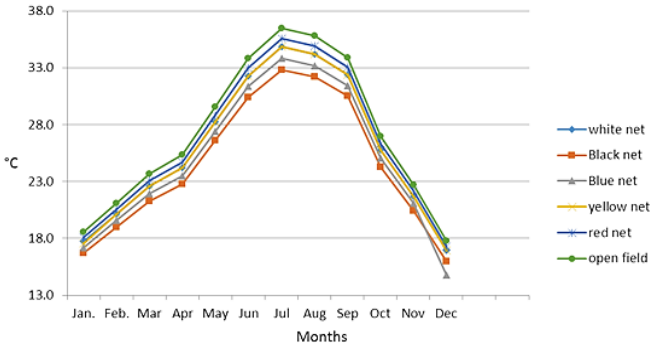

Figure 1: Average monthly maximum air temperature under different shade net covers compared to open field during 2019 and 2020

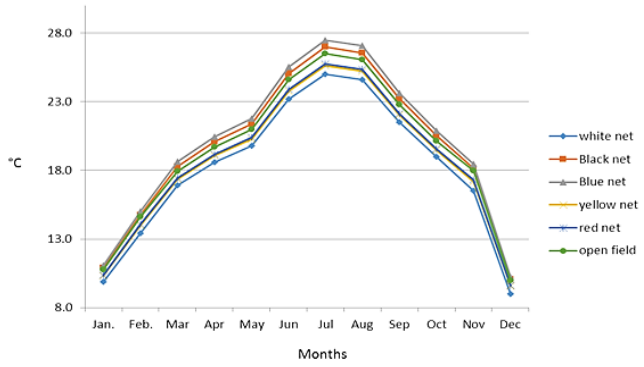

Figure 2: Average monthly minimum air temperature under different shade net covers compared to open field during 2019 and 2020

Average light intensity under each greenhouse net colour and open field treatment during the two studied seasons is shown in Figure 3. The highest light intensity during the cultivation seasons was found during summer months (June, July and August) under the open field treatment followed by white and yellow net (Figure 3). At the same period, light intensity under black net was lower than under the white net, yellow net, red net and blue net. The obtained results are in agreement with those of who reported that cover greenhouse with screen net led to reduce radiation reaching crops underneath (Stamps, 2008). On the other hand, Aboul-Soud et al. (2014) reported that the higher shade factor led to reduction of light intensity inside the greenhouse.

Average relative humidity increased by the use of all coloured shade nets by 3-7% compared to open field during the two seasons (Figure 4). The highest relative humidity was obtained under the black net followed by blue net. White and yellow net had the lowest relative humidity compared to the other shade net treatments. These results were in line with those reported found that using shade nets caused rise in relative humidity by 2 to 6%. Moreover, reduction in evaporation and a considerable drop in wind speed as a result of using nets (Elad et al., 2007). The ventilation

effect was discussed by (Campen and Bot, 2003). One of the driving factors for natural ventilation is the pressure gradient over the scent net openings, which might be caused by the wind outside of the greenhouse or by the temperature differential over the net cover. At lesser wind speed as was the case therefore in case, the buoyancy effect is mainly responsible for greenhouse natural ventilation (Medany et al., 2009).

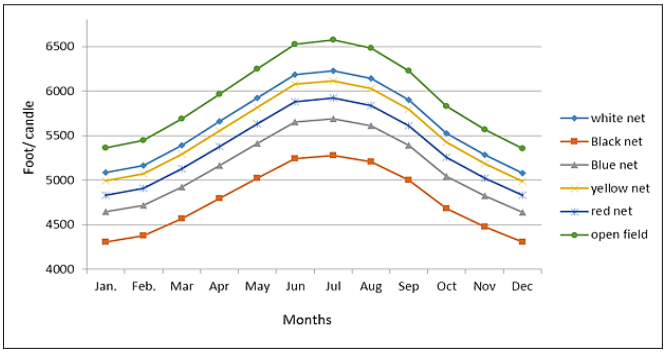

Figure 3: Average monthly light intensity under different shade net covers compared to open field during 2019 and 2020

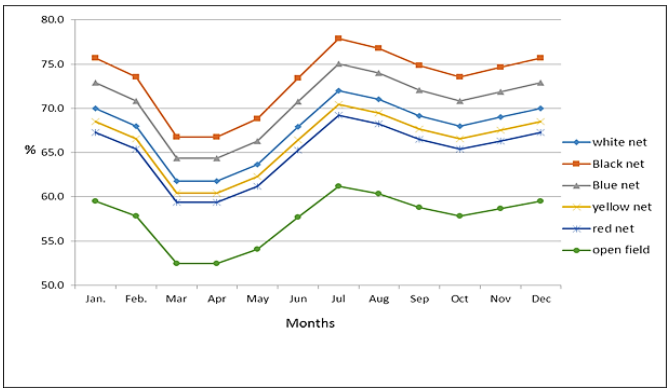

Figure 4: Average monthly mean relative humidity under different shade net covers compared to open field during 2019 and 2020

3.2 Yield

Table 1 confirmed that the coloured shade net has significantly affected the production mango trees. The white net treatment produced the highest mango yield in terms of number of fruits per plant, average yield per plant and total yield of the cultivated area. The yellow net cover came in the second order followed by red net, while black net produced the lowest yield. Increasing vegetative characteristics under white net could be attributed to the suitable climatic conditions for mango which is considered one of the tropical fruit trees. The study provides the ability of using net house especially white and yellow in producing mango fruit. The cover net "especially light color" led to diffuse light and then increase light use efficiency in addition to yields which led to increase the plant photosynthesis processes and then increase productivity (Medany et al., 2009). Cover greenhouse with shade net led to scatter solar radiation (Wong, 1994). Shade netting enhance plant growth and yield due to increase the photosynthesis process via avoiding abiotic stress from severe high temperature during summer and decrease the wind speed which allow better microclimate for plant growth (Guenter et al., 2008). On the other hand, black and blue net reduce radiation reaching crops underneath. Obviously, the higher the shade factor in dark net colour, the more radiation will be blocked. Reductions in radiation resulting from netting will affect the plant growth especially in the winter season because of low natural radiation (Abul-Soud, et al., 2014).

Table 1: Number of fruit and total production of the Keitt mango under different treatments during 2019 and 2020

Treatments	Number of trees	Number of fruit/tree	Yield/ tree (Kg)	Total production (Kg)
2019				
White	333	20 a	10.6 a	3529.8 a
Yellow		17 b	8.8 b	2930.4 b
Red		16 b	8.1 bc	2697.3 c
Blue		15bc	7.6 c	2530.8 d
Black		13 c	6.1 d	2031.3 e
Control		12 c	6.3 d	2097.9 e
2020				
White	333	22a	11.2 a	3729.6 a
Yellow		19 b	9.4 b	3130.2 b
Red		17 c	8.8 c	2930.4 c
Blue		16 c	8.1 c	2697.3 d
Black		12 d	6.3 d	2097.9 f
Control		13 d	6.5 d	2164.5 e

3.3 Economic Analysis

The results of Table 2 indicated that the total production costs were higher in the coloured shade net treatments compared to the open field; the total production costs in the coloured shade net treatments were LE 17765 and LE 18296 in 2019 and 2020 compared to LE 13950 and LE 14400 for the open field per 2000 m^2. Net returns per 2000 m^2 were analysed for each treatment using the above yield data, farm gate prices and grove production costs. The net return for white net in 2019 reached LE 15777 per 2000 m^2 which was more than double those in the open field (LE 5980 per 2000 m^2). In 2020, the net return for white net was the highest with LE 15270; followed by yellow net and red net with LE 9874 and LE 8078, respectively. However, ratio of total revenue to costs was found higher in white net in both season which were 1.9 and 1.8 respectively. Likewise, ratio of total revenue to costs reached only 1.1 and 1.0 respectively in black net

Table 2: Economic indicators of the Keitt mango under different coloured net compared to open field during 2019 and 2020

Treatments	Yield (kg/2000 m^2)	Production Costs LE/ (2000 m^2)	Cost per unit LE/ kg	Total Revenue LE / (2000 m^2)	Net Return LE/ (2000 m^2)	Revenue to cost ratio
2019						
White net	3529.8	17756	5.0	33533	15777	1.9
Yellow net	2930.4	17756	6.1	27835	10079	1.6
Red net	2697.3	17756	6.5	25624	7868	1.4
Blue net	2530.8	17756	7.0	24043	6287	1.4
Black net	2031.3	17756	8.7	19297	1541	1.1
Control	2097.9	13950	6.6	19930	5980	1.4
2020						
White net	3729.6	18296	4.9	33566	15270	1.8
Yellow net	3130.2	18296	5.8	28170	9874	1.5
Red net	2930.4	18296	6.2	26374	8078	1.4
Blue net	2697.3	18296	6.8	24276	5980	1.3
Black net	2097.9	18296	8.7	18881	585	1.0
Control	2164.5	14400	6.7	19481	5081	1.4

4. Conclusions

Egypt is the tenth biggest producer of mango with 1.2 million tonnes. The export value of Egyptian mango was $44.98 million; it represented about 1.2 percent of global market. Present study was an attempt to find a tool to increase the mango yield.

The obtained results provided a comprehensive account to recommend using white and yellow shade coloured net for keitt mango growth, yield and fruit quality.

Finally, it may be concluded that growing mango under white net results in increased yields, total revenue for the mango growers. On the other hand, mangoes production under blue and black coloured net is not economically profitable.

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