

EFFECT OF PHOTO-SELECTIVE NETTING ON GROWTH DEVELOPMENT OF GREEN AMARANTH (*Amaranthus viridis* L.)

SITINABILAH MOHAMMAD SABRI^{1,2}, SUHAIZAN LOB^{1*}, AND NURUL FAZIHA IBRAHIM¹

¹Faculty of School Fisheries and Food Securities, Universiti Malaysia Terengganu 21030 Kuala Nerus, Terengganu, Malaysia.

²Center for Development of Advanced Science and Technology (CDAST), University Jember, Indonesia.

*Corresponding author: suhaizanlob@umt.edu.my

Abstract: Green amaranth (*Amaranthus viridis* L.) is one of the most popular leafy vegetables cultivated in Malaysia. Photo-selective netting is a revolutionary agricultural-technical idea, allowing traditional nets to be improved to a sophisticated level, which can impact microclimate and solar radiation as well as protect crops from pests. This study aims to investigate the growth performance of green amaranth under different three different treatments of photo-selective nets including black, and yellow shade nets and control. The assessed physiological, pre-harvest and post-harvest parameters were air temperature and relative humidity, measurement of absorption of photosynthetically active radiation (PAR), plant height, number of leaves, and dry weight. This study found that the yellow shade net showed the best performance in plant growth with the average difference in plant height (4.11 cm), average leaves number (7 leaves) and average dry weight (18.58 mg) were the highest compared to black shade net and control (without shading). In conclusion, photo-selective yellow shade net was able to enhance the growth development of green amaranth and could be applied in the large scale production to boost the growth and yield of leafy vegetables.

Keywords: Shade net, solar radiation, light quality, vegetables, plant growth and development, *Amaranthus viridis* L.

Introduction

Leafy vegetables are generally sensitive to high temperature. The problem such as the climatic change that resulted from global warming across the world can cause crop failure, shortage of yields, and reduction in quality and increase in pest and disease problems to vegetable cultivation such as green amaranth (*Amaranthus viridis* L.). This crop is one of the most popular leafy vegetables consumed in Malaysia and has high market demand (Amin *et al.*, 2006). It is also one of the most exported vegetables to Singapore and Brunei (Ali & Shaari, 2015). According to Tafoya (2018), 70% of crops have been lost because of pests. Besides, other problem like increasing concentration of the dioxides of nitrogen and sulfur in the atmosphere can cause degradation of the ozone layer leading to the penetration of harmful UV rays on the earth surface. All these factors causing excessive exposure of leafy vegetables to a high level of UV-B that significantly reduces dry weight and plant height (Khandaker, 2010).

The potential of the new technology of photo-selective has been used to improve the productivity, quality and harvest time of horticultural crops (Tey *et al.*, 2009). The photo-selective shade is a multi-benefit tool to reduce light intensity, incoming radiation, and canopy temperature. The photo-selective shade net also has been reported to reduce the occurrence of fungal spores under the pearl and yellow nets and enhanced the natural resistance from pathogens that affect the plants grown under this nets (Mudagul, 2014).

Thus, shade nets with less energy cost, more advanced and innovative practices are used in planting the green amaranth (*Amaranthus viridis* L.) because of the ability to modify environmental conditions. A study by Shahak (2008) found that the black nets shading did not affect the light quality and reduce the amount of light reaching the underneath plants that can affect higher fresh mass in lettuce. In Malaysia, photo-selective shade net is still not

commercially used by farmers to increase the productivity of green amaranth or other types of vegetables. To investigate the aims of this study about the effect of photo-selective shade net on the growth development of green amaranth and to determine the best colour of photo-selective shade net in producing better yield. Hence, it gives benefit for farmers to improve the productivity and quality of yield.

Materials and Methods

Seedling Establishment

Seeds of green amaranth were immersed in water overnight to fasten the germination. Then, the seeds were sown at 0.5-1 cm depth into germination tray and allow to grow for two weeks. Healthy seedlings with 2-3 true leave stage were transplanted into polybag containing growth media in the early morning. The seedlings were water twice a day until transplanting.

Shading Preparation

There were two types of shade-net with 95% radiation of 1.5×1.5m in size for each replicate (black and yellow) and control without shading used in this study. The shade net was set up 1m above the ground for good air condition around the plants (Zhang *et al.*, 2017). All treatments were set up in four replication with four-unit of plants for each replicate. All the treatments were arranged in a randomized complete block design (CRBD).

Measurement of Plant Growth

Measurement of plant growth was assessed based on plant height, the number of leaves and dry weight. The data of plant height were measure by using a measuring tape from the ground to the topmost part of the plant (Desai, 2015). The number of leaves per plant was counted manually from the whole plant (Mundhe, 2013). After the harvested green amaranth was dried using an oven at 75°C for 72h with the dry weight were measured using

an electronic balance. Plant height, number of leaves and dry weight conducted at every three days interval for five weeks until harvest.

Data Analysis

The collected data were analysed using ANOVA (one way anova) in SPSS version 22 with one black factor, and yellow shade nets and control Standard deviation and significant value were subjected based on Tukey test at ($p \leq 0.05$).

Results and Discussion

Photosynthetically Active Radiation (PAR)

Figure 1 shows the effect of different shading on photosynthetically active radiation (PAR). Results show that there was a significant effect ($p \leq 0.05$) of the different shading on PAR. From the graph, the black shade net (17.11) shows the best performance compared to control (338.98) and yellow shade net (113.25). However, the PAR from any type of shading showed no significant difference.

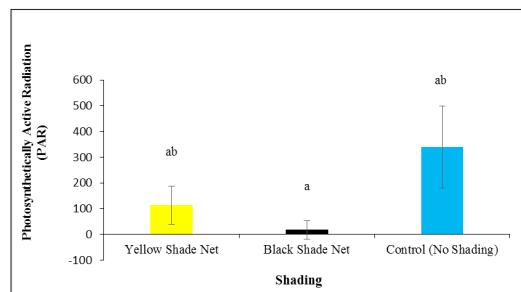


Figure 1: Effect of different shading on photosynthetically active radiation (PAR)

Solar radiation is the major mode of energy exchange between plant and environment which played an important role in photosynthesis and transpiration (Gaurav *et al.*, 2016). Besides, the black shade net gives less reflection in all colour spectra and thereby reduced PAR rate (Tafoya *et al.*, 2018). The open field highest absorbed PAR compared to the shading effect of different shade net colour because light intensity increases PAR value (Ntsoane *et al.*, 2016).

Microenvironment Analysis

Table 1 showed the air temperature (AT) and relative humidity (RH) recorded during the experimental period. The air temperature of green amaranth is negatively correlated with the relative humidity. When the temperature increases, the relative humidity decrease ($r = -0.987, p < 0.05$).

Table 1: The air temperature (°C) and relative humidity (%) recorded during the experimental period

Collect Times	1	2	3	4	5	6
Temperature (°C)	48	28	48	44	44	36
Relative Humidity (%)	35	99	32	38	37	57

In the present study, AT and RH are the factors to reduce radiation under shade net (Gaurav *et al.*, 2016). According to Diaz (2014), shading help to reduced plant transpiration and increased soil moisture by reducing radiation and air temperature. Mudau *et al.* (2017) reported that shade nets are mainly deployed over crops to lessen heat stress but by using photosensitive nets are regarded as nets which prevent excess radiation and improve the soil moisture levels that promote proper plant growth. The reduction of radiation and AT is responsible for a great deal in regulating the photosynthetic capacity of leaves and, consequently, a reduced light-saturated photosynthetic rate unlike in the open field.

Plant Height

Figure 1 shows that there was a significant effect ($p \leq 0.05$) of the different shading on the average of plant height. The yellow shade net (4.11 cm) and black shade net (3.90 cm) showed significantly better performance compared to control (2.93 cm).

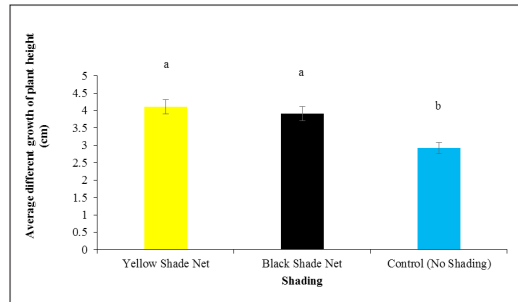


Figure 1: Effect of different shading on average different growth of plant height during five weeks of the growing period

The height of the plant is the prime factor directly related to the growth of the plant in every plant species. Numerous study found that plant height of okra (Gadage, 2015), garlic, fenugreek and coriander (Desai, 2015) and cabbage (Mundhe, 2013) was influenced significantly due to different colours of the shade net. This might be associated with higher accumulation of heat units resulting in higher growth rate during active vegetative growth phases consequently resulting in taller plants with the advancement of crop age (Mudagul, 2014).

The previous study showed that plants grown in low PAR values were found to be more apical dominant than those grown in high PAR values, resulting the plants under shade have a great competition for the light which forcing the plants to grow taller (Vinod, 2015). With lower PAR, this can increase stomata conductance which can lead to higher assimilation of photosynthesis in plants. In the present study, the green amaranth had higher plant height because of higher photosynthesis through lower PAR. Thus, this function might have supported to increase plant height under yellow and black shade net condition.

According to Gaurav *et al.* (2016), plants that grow under coloured shade net were taller due to the increase in internode length but not due to the increase in the number of nodes (leaves). Ovadia *et al.* (2009) stated that the coloured shade-nets can affect the height of stems and increased branch length compared with the stems that use plant growth regulators which causes thinning of the stems and no increase in weight. These similar results were also reported on a different type of plants such as blackberry (Clark, 2004), cucumber (Semida *et al.*, 2017), bell pepper (Diaz, 2014), fruit trees (Shahak *et al.*, 2016), okra (Gadage, 2015), garlic, fenugreek and coriander (Desai, 2015) and cabbage (Mundhe, 2013).

Number of Leaves

Figure 2 shows that there was a significant effect ($p \leq 0.05$) of different shading on the average number of leaves. The yellow shade net (7 leaves) showed the best performance compared to control (5 leaves) and black shade net (6 leaves). However, there was no significant difference in the leaf number assessed between black shade net and control.

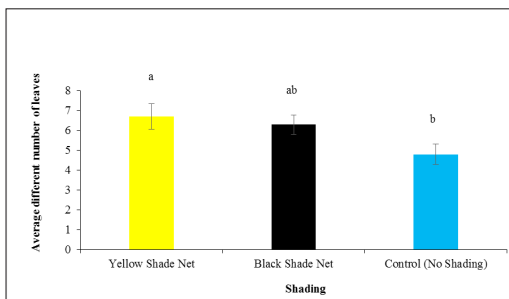


Figure 2: Effect of different shading on the average number of leaves during five weeks of the growing period

A previous study found that a number of leaves of the plant such as garlic, fenugreek and coriander (Desai, 2015), cabbage varieties (Mundle, 2013; Mudagul, 2014) were influenced significantly by different shade net colours.

In the present study, the yellow shade net and black shade net showed a significant effect on

the average different number of leaves. Ovadia *et al.* (2009) stated that to reduce the intensity, shade-nets are often used for plants grown in open fields in regions where the intensity of sunlight is extremely high. Filtering of sunlight through photo-selective filters may serve as a useful and environmentally-friendly way to control the growth, development, and flowering of plants. Coloured nets may have an additional horticultural advantage that influenced several species and cultivars, in the same way, may enable a better choice of colour shade net to improve the growth characteristics of plants. Gaurav *et al.* (2016) stated that all plant grown under shade nets can improve the production of leaves rather than a plant that is grown under control with harsh weather. According to Desai (2015), the favourable condition like the reduction of PAR, higher humidity and air temperature can maintain turgidity through the reduction in evapotranspiration rate, higher stomatal thereby higher photosynthesis. This can help to induce a higher number of leaves. On contrary, control was the lowest number of leaves as compared to of different colour shade nets, was also reported by Elad *et al.* (2007) due to unfavourable climatic condition such as direct sunlight that can produce more heat to the plant.

Dry Weight

Figure 3 shows that there was a significant effect ($p \leq 0.05$) of different shading on the dry weight. The yellow shade net (18.58 mg) produced significantly higher dry weight compared to control (16.04 mg) but not with black shade net (17.65 mg). Stamps (2009) has reported that bell peppers present leaf and stem morphological and physiological adaptations in response to shade. This might due to dry weight show the solid matter present in leaf reported by Gaurav *et al.* (2016). This similar result with this Shahak *et al.* (2016) described that the Yellow net and black shade-net were significantly enhanced stem length, stem weight and inflorescence size. According to Diaz-Perez (2013), dry leaf weight increase for the plant that grown under shade net compared to control (no shading).

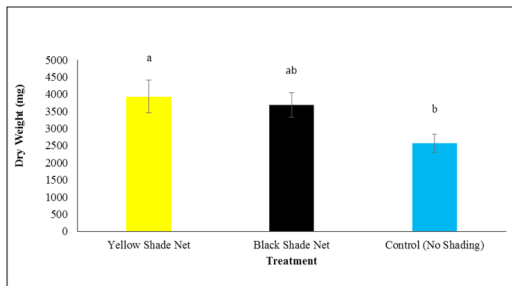


Figure 3: Effect of different shading on dry weight (mg) obtained after harvest

According to Costa *et al.* (2002), plant under shade net responds depended on the complex interaction between quality and quantity of the incident light. This can influence development and morphogenesis by alterations in light composition while growth and production are influenced by light intensity. Thus, vegetative growth of plants maintained under low light intensity is optimized to increase light interception and to facilitate photosynthetic processes which eventually affecting the dry weight of the plants.

Conclusion

In conclusion, photo-selective shade net for example yellow shade net and black shade net were able to enhance the growth development of green amaranth based on plant height, the number of leaves, and dry weight. In this study, yellow shade net and black shade net effect the growth performance of green amaranth with the yellow shade net exhibited the highest growth performance compared to the other treatments. Further study should be conducted to increase more different photo-selective colour with the same shading intensity to determine the effectiveness of different colour on the green amaranth. The result from this study has provided useful information for farmers in helping them to boost the growth performance and yield of their vegetable crops.

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