INFLUENCE OF DIFFERENT AGRONET COVERS ON VEGETATIVE GROWTH, YIELD AND QUALITY OF AFRICAN NIGHTSHADE (*Solanum scabrum* Mill.) AND SPIDERPLANT (*Cleome gynandra* L.)

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been presented to any University for the award of a degree.

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Recommendation

This thesis has been submitted with our approval as University supervisors.

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DEDICATION

I dedicate this thesis to my mother whose encouragement and prayers have been a source of inspiration and strength in this academic journey.

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ABSTRACT

African indigenous leafy vegetables (AILVs) contribute significantly to improved nutrition and food security. However, the potential to meet the growing demand for AILVs has not been met. This study determined the effect of agronets on growth, yield and nutritive values of African nightshade and spiderplant. The experiment was laid on a RCBD, replicated thrice. Blue, gray, white, yellow agronets and uncovered plants (control) were used as the treatments. Spiderplant was direct seeded and later thinned to a spacing of 30 cm by 30 cm. Nightshade was started in the nursery and transplanted five weeks after sowing. From 7 weeks after planting (WAP), and thereafter at two weeks interval, growth, yield and leaf nutritive value were measured and data analyzed using SAS, version 9.1. Blue net yielded significantly taller plants of nightshade by 25 and 38% than the control by 13 WAP for trial 1 and 2, respectively. Spiderplant were taller under white net by 13% and 88% by 13 WAP than the control for trial 1 and 2, respectively. Compared to control, yellow net improved branching of nightshade by 20% and 14% by 13 WAP in trial 1 and 2, respectively; while number of branches of spiderplant improved by 40% under yellow net and 35% under white net by 13 WAP for trial 1 and 2, respectively. Blue net significantly delayed flowering of nightshade by 13 and 9 days and for spiderplant by 20 and 15 days compared to control in trial 1 and 2, respectively. Yellow net improved leaf yield of nightshade by 27% and 15% and for spiderplant by 26% and 27% compared to control in trial 1 and 2, respectively. Leaf calcium improved under yellow net by 166% and 7% in nightshade and 64% and 17% under white net for spiderplant by 15 WAP than control in trial 1 and 2, respectively. Leaf iron content also improved under yellow net and blue net by 267% and 83% at 15 WAP in trial 1 for nightshade and spiderplant, respectively; and also by 104% and 86% at 15 WAP in trial 2 for nightshade and spiderplant, respectively. Agronet covers reduced vitamin C content with highest reduction registered under the blue net by 70% and 51% in nightshade and 171% and 65% in spiderplant compared to control by 15 WAP in trial 1 and 2, respectively. β-carotene increased by 6% under white net in nightshade by 13 WAP compared to control in trial 1 and 2, respectively. Spiderplant β-carotene was significantly high in the control compared to blue net. Phenolic content was significantly high under white net and open field for both vegetables than the other treatments. Based on the results, agronet covers influence growth, yield and nutritive quality of nightshade and spiderplant. Yellow net is recommended for use in nightshade and spiderplant production since it improved leaf yield and nutritive quality.

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LIST OF ABBREVIATIONS AND ACRONYMS

AILVs	African Indigenous Leafy Vegetables
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
AVRDC	Asian Vegetable Research and Development Centre
DAP	Diammonium Phosphate
FAO	Food and Agriculture Organization
HCDA	Horticultural Crops Development Authority
PAR	Photosynthetically Active Radiation
RCBD	Randomized Complete Block Design

CHAPTER ONE

INTRODUCTION

1.1 Background Information

African indigenous leafy vegetables (AILVs) are crops that are cultivated or plants that grow wild and are harvested or gathered for food within a particular African ecosystem (Alleman *et al.,* 1996; Aphane *et al*., 2003). AILVs including spiderplant (*Cleome gynandra*), African nightshades (*Solanum villosum, Solanum americanum and Solanum scabrum*), Amaranth (*Amaranthus spp*.), Jute mallow (*Corchorus olitorius*), Crotalaria (*Crotalaria ochroleuca* and *Crotalaria brevidens*), Ethiopian kale (*Brassica carinata*) and African eggplant (*Solanum aethiopicum*), significantly contribute to food security and nutrition for smallholder farmers in the east and central African regions (Abukutsa, 2010).

According to the Food and Agriculture Organization (FAO, 2013), around 868 million people (12.5% of the world's population) are undernourished in terms of energy intake while another 2 billion people suffer from one or more micronutrient deficiencies also known as 'hidden hunger'. Flyman and Afolayan (2006) and Oniang'o *et al*. (2004) suggest that the food and nutritional insecurity that most African countries face today could potentially be mitigated and sustainably be reversed if a greater change can be realized through the appreciation and domestication of African indigenous leafy foods. African indigenous leafy vegetables constitute important sources of both macronutrients and non-bio-active phytochemicals that have been linked to protection against cardiovascular and other degenerative diseases (Agbo *et al*., 2014; Andreas, 2014; Akhatar *et al*., 2012; Uusiku *et al*., 2010; Smith and Eyzaguirre, 2007). They are important crops to bring into intensive agriculture and to ensure substantial returns for poor farmers (Ndega, 2013) as AILVs are several times more expensive than the routinely cultivated exotic vegetables especially during the dry seasons; standing a chance to offer better income to growers (Adebooye, 2004). AILVs also provide high yield within short production cycles and are well suited to small plots and limited resources of village families. These vegetables can therefore support rural and urban populations in terms of subsistence and income generation without requiring huge investments. This is especially so for the resource poor farmers with low capital investments (Mwaura *et al*., 2014; Adebooye, 2004).

Whereas AILVs can contribute significantly to livelihood of the people the potential to meet the growing demand for these vegetables in the rural and urban areas still remains limited (Karanja *et al*., 2013). While low yields of AILVs of less than 1.2 tons per hectare are common, yield potential of 20-30 tons per hectare and 15 – 20 tons per hectare have been reported for spiderplant and African nightshade, respectively (Oluoch *et al*., 2009). Lack of suitable and sustainable horticultural practices that lead to improved performance are some of the constraints that limit improved yield and quality of AILVs (Abukutsa, 2010). Developing and promoting appropriate farming or agronomic technologies could therefore ensure sustainable production and consumption of AILVs for the ever increasing population (Abukutsa, 2010).

Numerous studies have reported improved productivity and quality of different crops when grown under nets as opposed to open field cultivation (Ilic *et al*., 2016; Fallik *et al*., 2014; Gogo *et al*., 2014; Muleke *et al*., 2014). Nets have been found to be beneficial for crop growth and development by significantly altering air temperature, light quality and intensity and soil moisture which positively influence plant physiological activities leading to improved crop yield and quality. In addition, nets protect crops from excessive radiation, wind, birds and insect pest damage which also favour optimum crop growth and development (Arthur *et al*., 2013).

Coloured nets have been developed during the past few decades and present a new agro-technological concept which aims at combining the physical protection together with the differential filtration of the solar radiation and concomitantly inducing light scattering. Various net colours exist including white, purple, red, yellow blue, green, black and gray. Coloured nets not only exhibit special optical properties to optimize desirable physiological responses, but also have the advantage of influencing the microclimate to which the plants are exposed (Ilic *et al*., 2014; Costa *et al*., 2010; Shahak *et al*., 2008). Depending on the pigmentation of the plastic threads, these nets provide varying mixtures of natural unmodified light together with spectrally modified scattered light (Ilic *et al*., 2014). Spectral manipulation by coloured nets promots specific photomorphogenetic and physiological responses, while light scattering improves light penetration into the inner canopy. According to Rajapakse and Shahak (2007), crop radiation use efficiency increases when the diffuse component of the incident radiation is enhanced under shade. On the other hand, photosynthetic pigments within plants utilize different wavelengths to accomplish different growth and development responses. The manipulation of spectral light also enables the regulation of flowering time either by elongating or shortening it depending on the light spectrum received and biomass accumulation (Gretchen, 2014; Valverde *et al*., 2004).

1.2 Statement of the Problem

Although AILVs are easy to grow, realization of their full yield potential and quality has been limited by several factors including lack of appropriate low cost technologies to maximize production. Growers have continued to experience low yields per unit area and short harvesting periods and/or life cycles for most of the AILVs. In addition, growers have limited production options to obtain higher yields in order to meet the market demand. In order to address these concerns, there is a need for research on suitable horticultural practices and cheap technologies that will contribute to improved yield and availability of quality AILVs in the Kenyan markets. At the moment, most AILVs are grown in the open field subject to abiotic and biotic stresses affecting their productivity and quality. Although protected cultivation under greenhouse production could overcome some of these stresses, the practical applicability of greenhouses in the production of AILVs may be unrealistic for most smallholder growers because of the high investments costs. Agronets have successfully been used as an affordable form of protected culture to induce physiological changes in vegetables resulting into improved crop productivity and quality in a number of exotic vegetables. The impact of agronet covers on the performance of AILVs is yet to be documented in places where these vegetables are grown. Moreover, the effect of different colours of agronets on the performance of indigenous vegetables also needs to be investigated.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this study was to contribute to enhanced yield and nutritive quality of indigenous vegetables by use of different agronet covers.

1.3.2 Specific Objectives

The specific objectives of the study were to determine effects of;

i. Different agronet covers on crop physiology and vegetative growth of African nightshade and spiderplant.
ii. Different agronet covers on yield of African nightshade and spiderplant.
iii. Different agronet covers on nutritive quality of African nightshade and spiderplant.

1.4 Hypotheses

The hypotheses tested in this study were;

1. Different agronet covers have no effect on growth of African nightshade and spiderplant.
2. Different agronet covers have no effect on yield of African nightshade and spiderplant.
3. Different agronet covers have no effect on nutritive quality of African nightshade and spiderplant.

1.5 Justification of Study

The nutritional inconsistency noticed in sub-Saharan Africa, Kenya included, has its source in the agricultural practices in which only a few food crops are favoured at the expense of others; of which some of the neglected crops such as the AILVs are more nutritious and resilient to the changing climatic conditions. Ensuring adequate production and supply of AILVs which are high in nutrient contents should be an urgent need to address issues related to increasing food insecurity and hidden hunger facing most people living in rural and urban centers of Kenya. Besides nutrition and food security, AILVs can be an important source of income for the resource-poor, especially women and the youth. Refocusing vegetable production in the country to give more emphasis on such crops and development of horticultural technological practices for yield improvement are thus imperative issues that need to be addressed for realization of the full potential of AILVs. After cowpeas, African nightshade and spiderplant are the most produced AILVs in terms of area coverage per hectare in Kenya. In addition, due to their adaptability to a wide range of ecological zones and minimal maintenance requirement, both African nightshade and spiderplant stand to be the most utilized AILVs in many parts of the country. Hence, a research that tends to promote their yield potentials and nutritive quality would be valuable.

As a result of the vast advantages derived from the AILVs, many research organizations such as the Asian Vegetable Research and Development Center (AVRDC) are currently spending millions of dollars on AILVs research especially on breeding and horticultural practices in order to promote the production and consumption of these vegetables. Studies complementary to such efforts therefore stand to benefit the AILVs sector. The use of net covers has been tested in other crops with promising results in addressing the problem of low yield in vegetables. Agronets have been documented to modify crop microclimate to favour better growth, yield and quality of crops besides offering a physical and visual barrier against crop pests. This technology has provided an opportunity to stabilize air temperatures, relative humidity and soil moisture as well as blocking excessive solar radiation within the environment of the growing crop; attributes that tend to favour plant growth and development leading to better crop performance.

Apart from the general effects of nets, coloured nets with the ability to modify the spectral composition of the transmitted and reflected sunlight have been developed with the aim of manipulating plant growth to achieve desired attributes of the crop by taking advantage of their optical properties. The use of different colours of agronet covers therefore possess great potential in addressing the problem of low yields and short vegetative cycles associated with AILVs. Findings of this study stand to contribute to the existing scientific knowledge on manipulating the growing environment of crops in order to increase production and possibly the nutritional value of these vegetables. Coloured agronet exhibit special optical properties to optimize desirable crop physiological responses and also have the advantage of influencing the microclimate to which crops are exposed. Whereas blue and yellow colours are found on the PAR range, the extents to which they influence crop physiological response still remain unclear., Gray colour, on one hand, might be relatively inactive photosynthetically, but have been found to influence important biological functions that need to be exploited further, while white coloured covers on the other hand, have been shown to influence crop growth with varying degree of crop response in different crops. Thus there is potential to elucidate the impact of these agronet covers on AILVs.

CHAPTER TWO

LITERATURE REVIEW

2.1 Background of African Indigenous Vegetables

Africans have traditionally made use of edible leaves of plant species growing wild as weeds whose origin were in Africa. These vegetables were adopted by people and were grown as intercrops with staples in homestead gardens for mainly for subsistence (Abukutsa, 2010). Some of the common AILVs include Jute mallow (*Corchorus olitorius*), Slender leaf (*Crotalaria ochroleuca* and *C. brevidens*), Ethiopian kale (*Brassica carinata*), African eggplant (*Solanum aethiopicum*) and spiderplant (*Cleome gynandra*), African nightshades (*Solanum nigrum* complex) and Amaranth (*Amaranthus spp.*), (Abukutsa, 2010). The demand for AILVs in Africa has increased over the last decade and in Kenya, AILVs account for 30% of all vegetables sold in the market (http;//www.asareca.org). Moreover, AILVs contain higher nutritional value than most of the exotic vegetables (Table1).

Preference for AILVs has been on the increase due to increased awareness of their health and nutritional benefits. During the year 2014, the area under AILVs production increased by 6% whiles the yields and value increased by 6 and 10%, respectively. In this category of vegetables, cowpeas, African nightshade and spiderplant are the most important accounting for 86% of the volume produced (HCD, 2014). The upsurge in demand for indigenous vegetables has been triggered by promotional campaigns done by research organizations like AVRDC, Kenya Agriculture and Livestock Research Institute, Non-governmental Organizations and the Ministry of Agriculture and other stakeholders (Irungu *et al*, 2007; Ngugi *et al*, 2006). National and international research organizations, universities and NGOs have focused on identification of priority indigenous vegetables, collection and characterization of germplasm and development of technical agronomical practices (Abukutsa, 2010).

In many places where AILVs are grown, their production and yield is frequently below their potential despite the agronomic advantages AILVs have over exotic vegetables, such as being adaptive to the local climate and soils and lower pest incidences (Oluoch *et al.*, 2009). Performances of AILVs regarding yield per hectare and income generated have been increasing compared to most important leafy exotic vegetables (Table 2). It has been documented that research geared towards improved techniques of AILVs production would increase yield and thus improve income for producers, improve nutritional status of the society and lower food insecurity.

Table 1: Nutrient Content of 100g Fresh Weight Edible Portion of Selected AILVs Compared to Kale (*Brassica oleracea* var. *acephala*) and Cabbage (*Brassica oleracea* var. *capitata*)

Nutrients	Spiderplant	Amaranthus	African nightshade	Jute Mallow	Kale	Cabbage
Protein (%)	5.4	4	5.8	4.5	-	1.4
Calcium (mg)	262.0	250	442	250	187.0	44
Iron (mg)	19.0	4	4.2	4	32.0	-
Beta-carotene (mg)	8.7	6	11.6	6	7.3	1.2
Vitamin C	144.0	100	158	100	93	33

Source: Maundu *et al*., 1999; Abukutsa, 2003.

Table 2: Performance of Selected African Indigenous Leafy Vegetables Compared With Exotic Vegetables 2012 -2014

Crop	2012			2013			2014		
	Area-ha	Qty (MT)	Values (Million KES)	Area-ha	Qty (MT)	Values (Million KES)	Area-ha	Qty (MT)	Values (Million KES
Cowpeas	25,544	69,940	910	23,195	55,223	764	24,434	65,096	812
Nightshade	2,820	18,945	505	3,018	29,796	561	3,376	25,435	763
Spiderplant	2,273	20,134	454.7	2,239	20,912	529.6	2,435	16,752	640.7
Amaranth	1,035	9,913	208.5	1,187	12,269	227.4	1,586	17,001	195.7
Slender leaf	286	1,984	43.2	370	2,780	58.2	533	5,100	119.1
Jute mallow	1,708	7,919	214.6	2,096	10,269	251.2	1,832	9,290	284.6
Kales	24,000	308	4,153	24,000	353	4,277	24,000	349	4,844
Cabbages	15,000	412	4,517	16,000	451	5,144	15,000	443	4,931

Source: HCD, 2014

2.2. Overview of Protected Agriculture

Protected agriculture is the modification of the natural environment to achieve optimal plant growth. It is viewed by several countries as a viable technology to attain a level of self-sufficiency in vegetable production and as a potential adaptation to address the vagaries of climate change and food supply (Sabir and Singh, 2013). Protected cultivation is the most contemporary approach to produce many horticultural crops qualitatively and quantitatively and has extensively spread the world over in the last few decades (Jansen and Matter, 1995). According to Sylvan and Nicholas (1995), attempts to adapt crop production to the environment with protective devices or practices date back to ancient times, during the early part of the Roman Empire. In the past, protected agriculture consisted of movable beds of cucumbers and perhaps other crops placed outside on favourable days and inside during severe weather. Transparent slate like plates or sheets of mica or alabaster were used as crop covers. Jansen (2002) reported that, it was not until the late 15th to 18th centuries that the precursors of greenhouse appeared primarily in England, Holland, France, Japan and the world over. They were crude square or rectangular bamboo or bamboo frames or structures covered with panes of glass, oiled paper or glass beetles to cover hot beds where a wide variety out of season crops were grown (Jansen, 2002).

Hickman (2011) reported that by adopting protected cultivation technology, growers can look forward to an increased remuneration for higher quality produce. About 115 countries in the world are in greenhouse vegetable production commercially. Protected cultivation of high value vegetable has shown a tremendous potential during the last decade (Sabir and Singh, 2013). With the progress of liberalized economy and the advent of newer technologies in agriculture, protected cultivation opens up avenues in agriculture until now not seen. These technologies not only create avenues at higher level but also to the growers with smaller holdings as the higher productivity levels retain economic relevance to agricultural production.

Crop covering materials have been developed from glass, polythene and more recently net covering technology. Nets have been applied alone or in addition to the glass or polythene covering materials. Shade netting not only decreases light intensity but also alters light quality to a varying extent which may also change other environmental conditions (Shahak *et al.*, 2004). The use of net covers also influences the crop growing environment temperature and relative humidity which directly affect crop growth. Working with eco – friendly nets in the production of cabbage, Muleke *et al.* (2014) reported an increase in temperature and relative humidity under net covers compared to open field. Net colours influence the crop growing environment differently. Maklad *et al*. (2012) reported an increase in temperature under black and white nets; while Oren- Shamir *et al*. (2001) reported that air temperatures recorded inside the plant canopies growing under green, red, blue, gray, black and reflective nets showed no significant differences. Shahak and Gussakovsky (2004) recorded a 30% reduction in total photosynthetic active radiation (PAR) intensity following the use of net covers. On the other hand, Ilic *et al*. (2011) reported greatest decrease in radiation under black net compared with red, white and the blue net. Similarly, Grinberger *et al*. (2000) found a lower radiation under the Aluminet shade net compared with pearl, red and blue nets.

2.3 Effects of Protected Culture on Growth and Yield of Crops

Protected structures alter the plant growing environment and thus influence crop growth and yield. In an ultra violet stabilized plastic film covered greenhouse, Ganesan (1999) found that tomato crops had increased plant height, number of nodes, and internode lengths compared to open field conditions. The yield performance inside the greenhouse was higher than in the open field conditions; which was attributed to increased temperature and relative humidity within the greenhouse.

Growing vegetable under protected environment and structures has been reported to highly increase vegetable yield more than in open fields. Head weight of lettuce was reported to be heavier when plants were grown under polypropylene cover than in open field (Rikika *et al*., 2009). Head weights of lettuce under agro-textile low tunnels were reported to be higher than those from the open fields (Jenni *et al*., 2003). White polypropylene row cover produced positive results in yield and early harvest of lettuce (Reghin *et al*., 2002). Rekowska and Skupien (2007) reported that covering with non-woven polypropylene increased the yield of spring gallic in comparison to open filed cultivation. Higher yield was obtained when dill plants were grown under polypropylene film than in the open field (Slodkowski *et al*., 1999). Broccoli heads grown under polypropylene non-woven fabric agryl were significantly heavier than those from control plants (Kunicki *et al*., 1996). Chinese cabbage heads grown under non-woven fleece were heavier than those from control plants (Moreno *et al*., 2001). Fresh weight of Chinese cabbage was greater under non-woven fleece polypropylene cover compared to control plants (Pulgar *et al*., 2001). Protected culture might extend the growing season of the crops and significantly allow for the growing of off-season crops. Cheema *et al*. (2003) working with tomato under net house reported that production of off- season tomato crop under net house conditions enhanced total yield and extended the period of tomato fruit availability in the market.

Greenhouse crops yield higher than those obtained from outdoor production. Dexit (2007) studied the performance of leafy vegetables including spinach, amaranths, coriander and fenugreeks under protected environment and open field conditions and observed that greenhouse cultivation had superior yields and yield attribute characters as compared to open field conditions due to modified environmental conditions that suited the growth of the crops than in open fields. In a study by Gogo *et al*. (2014), eco-friendly nets resulted into a favourable microclimate modification and hence faster tomato growth, higher yields and improved fruit quality. According to El-Aidy and Sidavos (1996), higher tomato yields may be achieved from protected tomato seedlings than non-protected seedlings; in addition, the use of protected culture improved tomato plant height, number of leaves, branches, and flower buds per plant and total fruit yields. Covering cucumbers with agro-textiles increased early yield and total yield compared to plants in the open field (Cerne, 1994). Covering cucumber plants with non-woven polypropylene increased early yield, whereas total marketable yield increased only in less favourable years (Rumpel, 1994). Higher early yield and total yield of cucumber were recorded in treatments where plants were covered with Agribon cover of polypropylene compared to plants in control (Ibarra-Jimenez *et al*., 2004). Covering plants with a spun bonded non-woven polypropylene fabric increased beet root biomass compared to uncovered plants (Gimenez *et al*., 2002). Biesiada (2008) demonstrated that the application of flat covers as non-woven polypropylene agro-textile provided significantly higher early and marketable yield of kohlrabi in comparison to the non-covered control. By using polypropylene row cover, marketable yield of tomatoes on open land could be significantly higher than in control (Znidarcic *et al*., 2003). Early yield of tomatoes was significantly increased by the use of spunbonded polypropylene cover compared to plants grown in the open field (Reiners and Nitzsche, 1993).

2.4 Effects of Colour of Covers on Crop Growth and Yield

Coloured covers modify the light spectral quality which influences the crop physiological responses, hence affecting growth and yield components of crops. Plants use the various wavelengths to accomplish different growth and development processes (Shahak, 2008). Retamales, *et al*. (2008) observed that black net treatments reduced PAR, and greatly affected vegetative growth by increasing internode length, shoot length and leaf widths compared with open field conditions of high bush blueberry cultivar. In the same study, other coloured nets (gray, red, white) which reduced PAR by 29% to 41% and had no effect on internode and shoot lengths.

Khandaker *et al*. (2010), observed that red amaranth grown under blue polythene had the highest plant height, stem length, leaf numbers as well as fresh weight followed by plants grown under yellow, white, green and black polythene shade in that order. In the same study, plants in the open field produced longest and widest leaves followed by those under blue, white, yellow and finally black polythene covers. High growth and biomass yield obtained from the blue polythene cover has been attributed to species sensitivity and plants being more sensitive to blue light, which influence plant height and plant bioactive compounds (Khandaker *et al*., 2010). On the other hand, Costa *et al*. (2010) investigated the influence of net colours on *Ocimum selloi* plants and observed that plant height was not different between red and blue net cover but the plants from both red and blue net covers were significantly taller than those grown under direct full sunlight. Song *et al*. (2012) observed that red net covering increased plant height, leaf area, and stem diameter of flowering Chinese cabbage more than the control (no net). While red and blue net covering enhanced the above ground fresh weight, silver and black net coverings decreased the above ground fresh weight. In the same study, it was reported that red and blue net coverings enhanced mineral nutrient uptake which was decreased under silver and black net coverings.

Strawberry plants produced under blue fluorescent films were observed to have higher yield, higher number of fruits and a slightly higher mean fruit size than those produced in the open conditions (Hemming *et al*., 2004). On the contrary, Basile *et al*. (2008) observed that fresh weight of winter pruning of Hayward kiwi fruit was lower in blue net than in no-net and red net treatments. A study carried out by Abdrabbo *et al*. (2013) showed that white net improved vegetative growth of crops producing the highest vegetative characteristics of cabbage in terms of number of leaves, total leaf area and fresh yield compared to yellow, red and open field. . This was attributed to the suitable climatic conditions for cabbage plants under the white net cover. Similarly, white nets were found to increase potato tuber yield per plant compared to other net colours. Yellow net came in second followed by open field while black and blue net colours gave the lowest tuber yields (Abdrabbo *et al*., 2013); this was attributed to proper light distribution for potato under white net which created favourable conditions for photosynthate and metabolite translocation. Coloured nets may reduce the light intensity and significantly influence partitioning of assimilates in crops. Costa *et al*. (2010) observed that the root shoot ratio of *Ocimum selloi* plants was higher in plants cultivated in full sunlight compared to plants cultivated under coloured nets. This was an indication that the distribution and accumulation of photosynthetic products in the roots is significantly enhanced by intense sunlight and therefore, shading treatments diminished the storage of photosynthetic products in the roots.

Crop leaf characteristics are significantly influenced by coloured net materials. Ilic *et al*. (2014) observed that red and pearl shade nets significantly increase the total leaf area index (LAI) while black shade nets produced crops with a lower LAI value than other coloured nets. This was attributed to the fact that, plants grown under cover tend to have a larger leaf area because cells expand more under low light intensities in order to receive light for photosynthesis. Plants acclimatize to shade, in part, by increasing the specific leaf area. Similarly, Costa *et al*. (2010) reported that total leaf area decreased in the order from red net shading, full sunlight to blue shading whilst both the specific leaf area and leaf area ratio decreased in the order from blue shading, red shading and least in full sunlight. The leaf weight ratios were similar in both blue and red net shading but the value was significantly higher than that produced by full sunlight. The increased total leaf area exhibited by plants maintained under red shading was due to the expansion of individual leaves, probably influenced by smaller red: blue ratio of the light spectrum. Plants maintained under net cover with high blue: red light ratios, showed reduced leaf expansion indicating that *Ocimum selloi* is not tolerant towards these wavelengths. A reduction in leaf size results in reduced biomass yield due to a reduction in photosynthetic leaf area (Costa *et al*., 2010).

Semida *et al*. (2013) reported that different crops respond differently to specific wavelengths and that this can be explored to manipulate crop growth and development. Two *Capsicum annum* cultivars (Vergasa and Romans) had increased yield when grown under blue, silver, white and black shade nets as compared with no net (Elad *et al*., 2007). Similarly, Shahak (2008) reported that production of three cultivars of bell pepper was increased by 16% to 32% under pearl and red net compared with black nets. However, Costa *et al*. (2010) observed a reduction in yield of *Ocimum selloi* plants grown under red and blue net which might have resulted from a decrease in the rate of CO_2 assimilation since blue cover majorly have high concentration of blue light; blue light decreases the rate of carbon dioxide assimilation as suggested by Oyaert *et al.* (1992). Andhale *et al*. (2014) reported that green capsicum yield was significantly higher with green and white coloured nets than blue and black nets. Stamps (2008) reported that fresh weight of harvested leaves of variegated cast iron plant was higher under black netting than under blue, gray or red; and total number of harvestable leaves was higher in the black than the blue or red net. Bandara *et al*. (2014) on the other hand observed a significant dry weight gain in tomato and cabbage grown under white net and silver net, respectively.

2.5 Effects of Protected Culture on Quality of Crops

Protected cultivation alters crop growing environment and therefore has been shown to have significant influence on crop quality. Greenhouse grown tomato had improved quality in terms of increased lycopene content while cucumber had increased yield (Lorenzo *et al*., 2006). Semida *et al*. (2013) reported that, Ice berg lettuce‘ Dublin’ showed a clear response to lower night temperatures under the non-thermic film ‘clear’ by increasing secondary metabolites. The total phenolic and flavonoid contents of plants grown under clear film were highest compared to those grown under thermic films; luminal and lumitherm. The greater accumulation of phenolic and flavonoid in the presence of wide fluctuations in temperature under clear film suggested that these products may have a protective role against high temperature stress.

Secondary metabolites have been reported to play a major role in the adaptation of plants to changing environment and in overcoming stress constraints (Edreva *et al*., 2008). Guo *et al.* (2008) working with UV treated polythene cover reported high levels of falconoid compound while Tsormpatsidis *et al*. (2010) reported an increased accumulation of phenolic compounds in lettuce under UV treated polythene cover. Krizek *et al*. (2005) suggested that the growth inhibition in lettuce under ambient levels of UV radiation could be due to damage of chloroplast. However, Semida *et al*. (2013) found that photosystem I was unaffected by the type of plastic used suggesting that phenolics and flavonoid had efficiently protected photosystem I. However, these compounds may have a high cost of plant protection such that the plants divert energy produced by photosynthesis to synthesis of phenolics and flavonoids. Light in the ultraviolet range plays an important role in plant defenses (Ballare *et al*., 2012).

2.6 Effects of Colour of Covers on Quality of Crops

Modified light spectral by coloured covers might influence the synthesis of the various crop pigmentations as well as the nutritive components in crops. Ilic *et al*. (2012) observed that, tomato fruits grown in open fields and under red net had significantly more ß-carotene than fruits grown under black or blue nets. On the other hand, Alkalia-Tuvia *et al*. (2014) observed that carotenoid content increased in two red cultivars of bell pepper during storage and shelf life simulation under black and pearl nets. Carotenoid content was significantly higher under commercial black net than pearl net. Carotenoid content in *Capsicum annum* cultivar Vergasa was significantly higher than in *Capsicum annum* cultivar Romans immediately after harvest (35 and 30 mg/100g fresh weight, respectively) and after storage and shelf life simulation (53 and 50 mg/100g fresh weight, respectively) signifying species differences in response to light quality.

Light spectral quality significantly influences lycopene in fruit vegetables. Ilic *et al*, (2012) showed that the highest concentration of lycopene was detected in tomato grown in plastic house integrated with red colour nets while tomato grown in fields covered with pearl nets (neutral colours nets) had the lowest level of lycopene. Similar results were found by Lopez *et al*. (2011) who recorded higher lycopene content in tomato grown under red and lower lycopene content pearl nets. Lycopene content was significantly higher in tomato grown under black nets and lowest in tomato grown under pearl nets which they attributed to air temperatures and light quality as lycopene content in tomato is affected by higher temperatures. Lycopene biosynthesis depends on temperature and tends to take place at different day temperatures of 12-32 ºC with optimal temperature at around 22-26 ºC (Ilic *et al*., 2014). Selahle *et al.* (2014) reported that red and yellow sweet pepper fruits produced under the black net retained higher β-carotene, lower total phenolic contents and showed deep red and orange colours after storage. Pepper fruits produced under the pearl net retained a higher ascorbic acid content, antioxidant scavenging activity, fruit firmness and also reduced weight loss after storage. Higher total polyphenol content was recorded in leaves of red amaranth grown under blue polyethylene shade than under green polyethylene (Khandaker *et al*, 2010). Decreased production of the total polyphenol in leaves grown under black polyethylene cover is probably due to reduced stimulation of phenolic products by light and temperatures (Islam *et al*., 2003).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at the Horticulture Research and Teaching field of Egerton University, Njoro, Kenya. The total monthly rainfall received at the site for trial one was 41.6 mm, 85.7mm, 90.3 mm and 198.8 mm in August, September, October and November 2015, respectively, and for trial two was 82.9 mm, 86.6 mm, 23.4 mm and 24.0 mm in December, January, February and March 2015-2016, respectively giving totals of 416.4 mm in trial one and 216.9 mm in trial two. The mean monthly temperature experienced during trial one were 20.8 ^{o}C, 21.7 ^{o}C, 19.1 ^{o}C and 19.1 ^{o}C in August, September, October and November, respectively and for trial one was 20.2 ^{o}C, 20.6 ^{o}C 22 ^{o}C and 22.1 ^{o}C in December, January, February and March, respectively. Mean temperatures for trial one and trial two were 20.7 ^{o}C and 21.2 ^{o}C, respectively (Table 3) (Egerton University Engineering Meteorological Station, 2015- 2016)

3.2 Experimental Materials

Seeds of spiderplant and African nightshade were used as planting materials in this study. Seeds were obtained from Asian Vegetable Research and Development Centre (AVRDC) Arusha. Agronet covers were obtained from A to Z Company. Ltd (Arusha, Tanzania) and had average pore size of 0.9mm×0.7mm.

3.3 Treatments and Experimental Design

The experiment was laid on a Randomized Complete Block Design (RCBD), with three replications. Treatments applied on African nightshade and spiderplant were; growing the vegetable under white net, gray net, blue net, yellow net and open field (control). Each block consisted of 10 experimental units each measuring 2 × 3 m and separated by 1 m path (Figure 1). Plots with net treatments had four posts placed at each corner to support nets and two posts placed at the centre to prevent net lodging. Each post was 1.2 m tall and was placed in a hole dug at a depth of 20 cm and well firmed. The vegetables were maintained permanently covered except during cultural practices and data collection periods.

Table 3. Rainfall and Temperature During the Study Period

	Aug. 2015	Sept. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Jan. 2016	Feb. 2016	Mar. 2016
Rainfall (mm)	41.6	85.7	90.3	198.8	82.9	86.6	23.4	25
Temperature (^{o}C)	20.8	21.7	19.1	19.1	20.2	20.6	22	22.1

Source: Egerton University Engineering Meteorological Station, 2015- 2016

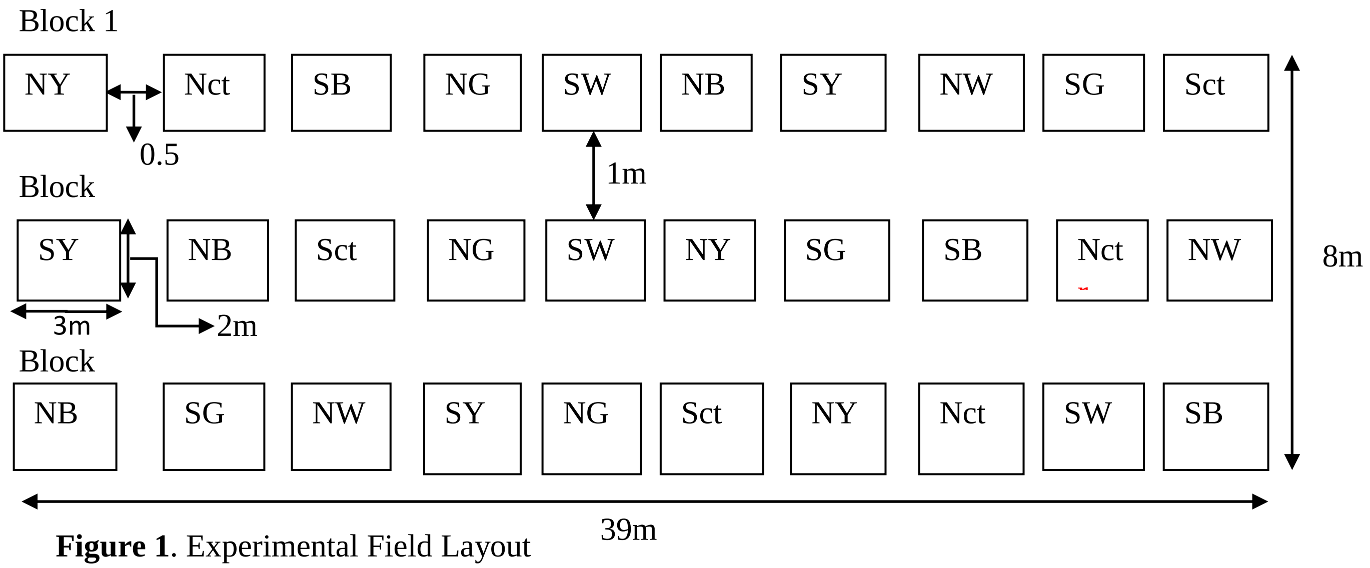

Figure 1. Experimental Field Layout

Where;

Key: NY- Nightshade + yellow net, SY-Spiderplant + yellow net, NB- Nightshade+ blue net, SB- Spiderplant + blue net, NW- Nightshade+white net, SW-Spiderplant+white net, NG- Nightshade+ gray net SG- Spiderplant +gray net, Nct- Nightshade + Control and Sct- Spiderplant + Control

3.4 Land Preparation and Crop Establishment

The field was prepared using hoes and plots of size 2 × 3 meters were demarcated and leveled using a rake to a fine tilth for ease of seedling emergence. In each spiderplant plot, six rows at spacing of 30 cm between the rows were made. Diammonium phosphate (DAP) fertilizer was applied at the rate of 30g per square metre, thoroughly mixed with soil and the plot watered before sowing. Spiderplant seeds were then sown directly in the drills at a depth of about 1cm. Nets were placed immediately after sowing for the net treated plots. General maintenance practices such as watering, manual weeding and pest control were done after seedling emergence and throughout the crop growing period whenever necessary. Thinning was done five weeks after sowing to achieve a spacing of 30 cm between plants. In the case of African nightshade, seeds were established in the nursery; and seedlings transplanted five weeks after sowing when the plants were about 15 cm high. African nightshade seedlings were transplanted in six rows per plot at spacing of 30 cm between rows and 30 cm between plants; and the plots covered with the respective nets assigned. General maintenance practices such as watering, manual weeding and pest control were done from transplanting whenever necessary during the growing period.

3.5 Data Collection

Eight plants per plot were randomly selected from the inner rows and tagged for data collection. Four out of the eight plants were tagged for data collection on non-destructive variables while the remaining four plants were used for the destructive variables. The non-destructive variables measured were; plant height, number of primary branches and stomatal conductance. Leaf yield, moisture content, total chlorophyll content, β-carotene (vitamin A), ascorbic acid (vitamin C), calcium, iron, crude fiber and phenolics constituted the destructive variables. Data collection began seven weeks after sowing for spiderplant and two weeks after transplanting (7 weeks after sowing) for African nightshade. Data were collected at two weeks intervals. The procedures for data collection were as follows:

3.5.1. Plant height

The plant height (cm) was measured from the ground to the tip of each of the tagged plants by means of a meter tape. Measurements were taken fortnightly until plants achieved 50% flowering.

3.5.2. Number of primary branches

The number of primary branches that emerged were physically counted, recorded and the average number of primary branches per plant later computed. This was taken after every week from 7 weeks after planting up to 13 weeks after planting

3.5.3. Stomatal conductance

Stomatal conductance was determined using a leaf porometer (SC-1, Decagon Devices, Inc. Hopkins Court Pullman, USA) according to Campbell and Norman (1998). Stomatal conductance (mmol m^{-2} sec^{-1}.) readings were taken directly from three recently fully expanded leaves of each of the four tagged plants. The readings were recorded and the average per stomatal conductance was later computed. This was also taken after every two weeks from 7 weeks after planting up to 13 weeks after planting

3.5.4. Number of days taken to first and 50% flowering.

The number of days from sowing of both vegetables to the appearance of the first flower and to when 50% of the plants in each experimental unit had at least one flower was monitored and recorded for each experimental unit. Mean number of days to first and 50% flowering for each experimental unit was computed and recorded.

3.5.5. Total leaf fresh weight (yield)

Harvesting of shoots from four tagged plants was done at two weeks interval beginning from the 7th week after planting and continued up to 15th weeks after planting, thus giving a total of five harvests per trial. After each harvest, weight of fresh shoots was measured in grams using a weighing balance (Advanced Technocracy Inc. Ambala). Total fresh yield per experimental unit was computed after the last harvesting date by adding the weight values from week 7 through week 15. Total fresh yield was then expressed in kilogram per hectare (Kg/ha) as follows;

$$\text{Total yield (Kg/ha)} = \text{Yield/plant (Kg)} \times \text{Plant population/ha}$$

$$\text{Where plant population} = \text{Area (ha)/Spacing } (0.3\text{m} \times 0.3\text{m})$$

3.5.6. Moisture content

Using a weighing balance (Advanced Technocracy Inc. Ambala), a sample of 100 grams of the fresh harvested vegetable was weighed from the harvest of each experimental unit at each harvest and transferred into an aluminium dish. The samples were oven dried at 70 °C for 24 hours to a constant weight; then cooled in a desiccator for 10 minutes. The moisture content was calculated as the difference between the fresh weight and the dry weight. This was obtained done after every harvest. The moisture was converted to percentage (AOAC, 1990) as shown below;

$$\text{Amount of moisture (\%)} = \frac{\text{Fresh weight- dry weight (g)}}{\text{Fresh Weight}} \times 100$$

3.5.7. Beta -Carotene (Pro-Vitamin A)

Beta -Carotene was determined according to the method described by Godwin and Barret (1988). An extractant, acetone- hexane mixture was prepared in the ratio of 4:5. Fresh samples weighing 0.5g each were ground in a mortar and placed in centrifuge tubes. Fifteen mls of extractant were added into the tubes and centrifuged (Kubota HSC-700, Tokyo Japan) for 10 minutes at 4000 revolutions per minute. The supernatant was then transferred using a pipette into 25 mls volumetric flasks and the residues washed with 5 mls acetone –hexane extractant and centrifuged again for 10 minutes at 4000 revolution per minute. The second supernatant was transferred with a pipette into 25 mls volumetric flasks and topped up with acetone –hexane extractant to 25 mls. Extinction of samples was measured in glass cuvettes using a spectrophotometer (U-2000, Hitachi, Tokyo, Japan) at a wavelength of 453 nanometer (nm). Concentrations (μg g^{-1} DW) of beta-carotene were determined using the following equations:

Beta-carotene = $(E_x \times V)/FW$

Where; $_x$ = Extinction (E) = concentration; V= Volume of supernatant (25mls);

FW= Sample fresh weight (0.5g)

3.5.8. Chlorophyll content

Both chlorophyll a and chlorophyll b were determined using the method described by Godwin and Barret (1988). An extractant, acetone- hexane mixture, was prepared in the ratio of 4:5. Fresh leaf samples weighing 0.5g each was in a mortar and placed in centrifuge tubes. Fifteen mls of extractant were added into the tubes and centrifuged (HSC-700, Tokyo Japan) for 10 minutes at 4000 revolutions per minute. The first supernatant was then transferred using a pipette into 25 ml volumetric flasks and the residues washed with 5mls of the acetone-hexane extractant and centrifuged again for 10 minutes at 4000 revolution per minute. The second supernatant was transferred using a pipette into 25 mls volumetric flasks and topped up with acetone –hexane extractant to 25 mls. Extinction of samples was measured in glass cuvettes using a spectrophotometer (U-2000, Hitachi, Tokyo, Japan) at a wavelength of 663 nanometer (nm) and 645nm for chlorophyll a and b respectively. Concentrations (µg g^{-1} DW) of Chlorophyll a and Chlorophyll b were determined using the following equations;

Chlorophyll a = $\{(10.1\times E_{663})-(1.01\times E_{645})\}\times V/FW$

Chlorophyll b = $\{(16.4\times E_{645})-(2.57\times E_{663})\}\times V/FW$

3.5.9. Ascorbic acid (Vitamin C)

Ascorbic acid was determined by titration with 2, 6-dichlorophenolindophenol dye (AOAC, 1990). Fresh leaf sample each weighing 10g were extracted in 30 ml of 5% oxalic acid using a pestle and mortar, and then filtered, Whatman No.1 filter paper. Standard indophenol solution was prepared by dissolving 0.05g of 2, 6- dichlorophenol-indophenol in distilled water then diluted to 100 ml and filtered. Ascorbic acid standard solution was prepared by dissolving 0.05g of pure ascorbic acid in a small volume of 5% oxalic acid solution and then diluted to 250 ml with the same oxalic acid solution. Ten ml of the ascorbic acid standard solution was then titrated with the indophenol solution to a slight pink end point. Ten ml of oxalic acid was titrated as a blank. The amount of ascorbic acid corresponding to 1 ml of indophenol solution was then calculated. Ten ml of the filtered sample extract was pipetted into a 50 ml flask and made to the mark with the 5% oxalic acid solution. The standard indophenol solution was used to titrate 10 ml of the filtrate. The vitamin C content was calculated as mg/100g sample. Using the formula;

Ascorbic acid = $C\times V\times (DF/WT)$

Where C = ascorbic acid (mg); V= Volume of dye used for titration of diluted samples (ml)

DF = dilution factor, WT= sample weight (g)

3.5.10. Calcium (Ca)

Calcium was analyzed using an Atomic Absorption Spectrophotometer (Buck 210 VGP) according to Jones and Case (1990). Dried ground sample weighing 1g was added into 100 ml beaker and ashed for 2 hrs at 550 ºC. The ash was cooled to room temperature and the residue was dissolved in 20 ml of 50% hydrochloric acid. Twenty mls of distilled water was added and the boiling continued until the sample was clear. The content was filtered through Whatman No.1 filter paper into 100 ml volumetric flask. One ml of nitric acid was added to the extracts to prevent phosphorous interference. The filtrate was filled to the mark with distilled water. Standard calcium dilutions of 250 ppm, 500 ppm, 750 ppm and 1000 ppm were prepared. The amounts of calcium were calculated against their standards and calcium expressed in mg/100g dry weight.

3.5.11. Iron (Fe)

Iron content was analyzed using an Atomic Absorption Spectrophotometer (Buck 210 VGP) according to Jones and Case (1990). Dried ground sample weighing 1g was added into 100 ml beaker and ashed for 8 hrs at 550 ºC. The ash was cooled to room temperature and the residue dissolved in 20 ml of 50% hydrochloric acid. Twenty ml of distilled water was added and the boiling continued until the sample was clear. The content was filtered through Whatman No.1 filter paper into100 ml volumetric flask. The filtrate was filled to the mark with distilled deionized water. Standard iron dilutions of 250 ppm, 500 ppm, 750 ppm and 1000 ppm were prepared. The amount of iron was calculated against their standards and iron expressed in mg/100g dry weight.

3.5.12. Crude fiber

Dry ground samples each weighing 5g was added into 25 ml of 2.04 M H_2 SO_4 and contents topped up to 200 ml. The sample was boiled for 30 minutes in a hot plate then washed thoroughly with hot water for 2-3 minutes. The sample was washed again with 200 ml of 1.78 M NaOH. Finally, the sample was washed with 70% ethanol and contents transferred to crucibles. The sample was dried in an oven at 70 ºC for 3 hours and thereafter weighed. The sample was then ashed in a muffle furnace at 550 ºC for 3 hours then cooled to room temperature in a desiccator and weighed. Crude fiber was calculated as the difference between sample weights from furnace and that of from the oven.

Fiber = Residue weight from oven – weight from ashing

3.5.13. Total phenolics

Leaf total phenolic content was determined using the Folin-Ciocalteu method according to Singleton (1999). One gram of dry crushed leaves was soaked in 10 ml of 70% methanol and centrifuged (Kubota HSC-700, Tokyo Japan) at 1000 rpm for 10 min. An aliquot (1 ml) of supernatant was oxidized with 1 ml of Folin–Ciocalteu’s reagent and neutralized by 1 ml of 20% sodium carbonate. The reaction mixture was incubated for 30 minutes at ambient temperature and absorbance was measured at 745 nm using a CE 440 UV/Vis double beam scanning spectrophotometer (V-200-RS, London, United Kingdom). Total phenolic content was obtained using a calibration curve of gallic acid (1 mg/ml) as standard. Total phenolics were expressed in milligrams equivalents of gallic acid per 100g of the sample (mg GAE/100g).

3.6 Statistical Data Analysis

All the data were subjected to analysis of variance (ANOVA) at $P \leq 0.05$ level of significance. Significant means at F-test were separated using Tukey's honestly significant difference (Tukey's HSD) test at $P \leq 0.05$. The general linear model procedure of the statistical analysis system (SAS) program, SAS version 9.1 (SAS institute I.nc, 2006) was used for data analysis.

The basic model fitted for the experiment was:

$Y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$

$i = 1, 2, 3, j = 1, 2, 3, 4, 5,$

Where Y_{ij}= Observation in the i^{th} block due to j^{th} agronets treatments.

μ -is the overall mean

α_i- effect due to the i^{th} block

β_j- effect due to the j^{th} agronet treatment

ε_{ij}- random error component which is assumed to be normally and independently distributed about zero mean with a common variance, σ^2.

The results were analyzed to determine whether agronet colour has significant effect on growth, yield and quality of spiderplant and African nightshade.

CHAPTER FOUR

RESULTS

Results obtained in this study are presented in this chapter following the order: growth variables, physiological variables, crop yield and quality variables.

4.1 Influence of Agronet Covers on Growth of African Nightshade and Spiderplant

Growth variables measured in this study were plant height, number of primary branches and days to first and 50% flowering.

4.1.1 Influence of Different Agronet Covers on Plant Height of African Nightshade and Spiderplant

Growing African nightshade and spiderplant under agronet covers significantly influenced plant height of the two vegetables during both trials of the study (Table 4). In both trials, African nightshade grown under blue net cover had significantly taller plants compared to plants in the open field. Plants grown under white cover however did not differ significantly from those grown in the open field except at 7 WAP during both trials of the study. Yellow and gray net also differed significantly with control at 7 and 11 WAP in both trials of the study. Plant height among net covers (blue, yellow gray and white nets) did not differ significantly from each other.

Growing spiderplant under agronet covers also influenced plant height, although the effect was not consistent in the two trials (Table 5). In both trials, the tallest plants were obtained under the white net cover in all sampling dates except at the final data collection day (13 WAP) when plants under the gray net surpassed those under the white net in height. On the other hand, plants were shortest under the blue net cover throughout trial 1 while in trial 2; the shortest plants were obtained in the open field treatment throughout the trial. Net covers did not significantly influence height of spiderplant in trial 1 except at 9 WAP when blue cover had significantly lower plant height compared to control; while in trial 2 open field had significantly lower plant height compared to the rest of the net covers except at 7 WAP. Spiderplant grown under the yellow and gray net covers tended to be intermediate in height during most sampling dates of the two trials.

Table 4 Plant Height (cm) of African Nightshade as influenced by Agronet Covers

	Weeks After Planting			
Agronet cover	7	9	11	13
		Trial 1		
Control	6.75b*	20.42b	51.17b	74.58b
White	10.1a	21.92b	55.75ab	78.25ab
Yellow	12.58a	26.25b	73.14a	90.74ab
Gray	14.17a	28.00ab	64.17ab	82.33ab
Blue	14.58a	36.25a	74.00a	93.25a
		Trial 2		
Control	16.08b	31.17b	51.83b	71.58b
White	21.75a	37.42ab	64.92ab	83.29ab
Yellow	23.41a	37.42ab	65.92a	83.92ab
Gray	23.00a	43.17ab	72.50a	93.33a
Blue	24.83a	49.33a	79.00a	98.58a

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

Table 5. Plant Height (cm) of Spiderplant as influenced by Agronet Covers

Agronet cover	Weeks After Planting			
	7	9	11	13
		Trial 1		
Control	6.92*	22.17a	51.83	66.25
White	7.63	29.67a	65.83	74.67
Yellow	6.29	18.58ab	63.67	68.67
Gray	6.75	19.33ab	58.75	66.00
Blue	5.2	11.92b	50.17	52.50
		Trial 2		
Control	4.88	8.42b	23.58b	42.67b
White	13.38	31.83a	61.75a	79.33a
Yellow	10.13	24.75a	50.67a	69.08a
Gray	12.46	29.25a	60.67a	84.33a
Blue	10.58	24.25a	53.50a	79.25a

*Means followed by same letter or no letter within a sampling date and trial are not significantly different according to Tukey’s HSD test at p≤0.05.

4.1.2 Influence of Agronet Covers on Number of Primary Branches of African Nightshade and Spiderplant

Agronet covers had no significant effect on number of primary branches of African nightshade during both trials of the study except in trial 1 at 13 WAP where plants under white and yellow net covers had significantly higher number of primary branches compared to plants under blue net (Table 6). Growing nightshade under the yellow net however, cover, however, tended to yield higher number of primary branches in both trials.

Spiderplant grown under white net cover had significantly higher number of primary branches in both trials compared to blue cover and open field (Table 7). Spiderplants under blue cover had significantly the least number of branches compared to the rest of the treatments in both trials of the study. Spiderplants grown under the gray and yellow net cover treatments tended to have higher number of primary branches compared to those in the open field treatment although with no significance difference most sampling dates.

4.1.3 Influence of Agronet Covers on Days to First and 50% Flowering of African Nightshade and Spiderplant

Growing African nightshade under agronet covers significantly influenced days to first and 50% flowering (Table 8). African nightshade grown under blue net cover resulted in a significant increase in the number of days to both first and 50% flowering compared to plants in the open field. The earliest flowering was observed in the open field which also took the shortest time to attain 50% flowering. Plants grown under the gray and yellow net covers took slightly more number of days to first and 50% flowering compared to the control plants. No difference was noted in the number of days to first and 50% flowering by plants grown under the white net cover compared to control plants in both trials.

Similar to African nightshade, the use of blue agronet cover significantly delayed flowering in spiderplant in both trials (Table 9). Flowering of spiderplant was also substantially delayed under the gray and yellow net covers compared to the control plants. In both trials, flowering tended to be advanced under the white net cover compared to control plants. Plants grown under the white net cover produced the first flower in less number of days compared to control plants. Plants under white net also attained 50% flowering much earlier than the control plants in both trials.

Table 6. Number of Primary Branches of African Nightshade as influenced by Agronet Covers.

	Weeks After Planting			
Agronet Cover	7	9	11	13
		Trial 1		
Control	3.82*	8.58	10.97	13.08ab
White	3.84	8.33	10.17	14.42a
Yellow	4.25	9.67	12.9	15.63a
Gray	3.58	8.00	11.9	13.58ab
Blue	3.75	8.58	10.7	12.75b
		Trial 2		
Control	2.0	6.3	11.2	14.3
White	2.0	6.8	10.0	16.2
Yellow	3.0	7.0	12.2	16.3
Gray	2.3	6.9	10.0	14.8
Blue	1.8	6.1	10.1	14.0

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at $p \leq 0.05$.

Table 7. Number of Primary Branches of Spiderplant as influenced by Agronet Covers.

Agronet Cover	Weeks After Planting			
	7	9	11	13
Trial 1				
Control	2.42b	7.05b	9.92b	10.71bc
White	5.25a	10.25a	14.58a	15.01a
Yellow	3.67ab	9.58ab	13.58a	14.58a
Gray	2.5b	7.50b	10.25ab	11.17b
Blue	0.33b	4.83c	6.67c	7.17c
Trial 2				
Control	0	1.3b	8.8ab	10.7ab
White	0	6.5a	12.0a	14.4a
Yellow	1.5	3.3ab	10.3a	12.8ab
Gray	0	4.5ab	9.8a	12.0ab
Blue	0	2.3b	6.9b	9.0b

*Means followed by same letter or no letter within a sampling date and trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

Table 8. Days to First and 50% Flowering of African Nightshade as influenced by Agronet Covers

Agronet Cover	Days to First Flowering	Days to 50% Flowering
	Trial 1	
Control	84.33c*	85.67c
White	84.33c	87.33c
Yellow	88.67b	93.33b
Gray	90.33b	92.67b
Blue	96.67a	98.33a
	Trial 2	
Control	87.3b	92.3a
White	89.0b	97.3a
Yellow	91.0b	96.3a
Gray	91.0b	94.5a
Blue	95.7a	97.9a

*Means followed by same letter within a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

Table 9. Days to First and 50% Flowering of Spiderplant as influenced by Agronet Covers

Agronet Cover	Days to First Flowering	Days to 50% Flowering
	Trial 1	
Control	34.67c*	38.67cd
White	33.33c	36.00d
Yellow	48.33b	52.33b
Gray	38.67c	43.00c
Blue	54.67a	55.00a
	Trial 2	
Control	44.0bc	48.7b
White	40.0c	46.3b
Yellow	46.3ab	49.0b
Gray	44.3bc	48.7b
Blue	49.0a	54.7a

*Means followed by same letter within a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

4.2 Influence of Agronet Covers on Physiology of African Nightshade and Spiderplant

Physiological variables measured in this study were leaf stomatal conductance and leaf chlorophyll a and b concentrations.

4.2.1 Influence of Agronet Covers on Leaf Stomatal Conductance of African Nightshade and Spiderplant.

Growing African nightshade under agronet covers increased leaf stomatal conductance throughout the two trials although with no significant difference compared to control plants in most sampling dates (Table 10). Growing African nightshade under yellow net cover resulted in plants with the highest leaf stomatal conductance while the least leaf stomatal conductance was obtained in plants grown in the open field in both trials. Blue, gray and white net covers also yielded plants with relatively higher leaf stomatal conductance compared with control plants although the difference was not significant in most sampling dates. A significant difference in plant leaf stomatal conductance was observed in trial 2 where plants grown under yellow net cover had significantly higher leaf stomatal conductance compared to control plants by 11 weeks after planting.

Similar to African nightshade, spiderplant grown under agronet covers tended to exhibit higher stomatal conductance compared to those grown under open field conditions (Table 11). Unlike African nightshade, the highest leaf stomatal conductance in spiderplant was recorded in plants grown under the white net cover while the lowest was in plants grown under the blue net cover in both trials. Compared to control, gray and yellow net covers also resulted into plants with relatively higher leaf stomatal conductance although the difference was not significant in most sampling dates. Blue cover had significantly lower leaf stomatal conductance compared to white cover at 7 and 9 WAP in trial 1 and significantly lower than both white and open field at 11 WAP in trial 2. Leaf stomatal conductance was also lower in spiderplants grown in the open compared to those under white net at 13 WAP in trial 2.

Table 10. Leaf Stomatal Conductance (mmolm^{-2}sec^{-1}) of African Nightshade as influenced by Agronet Covers

	Weeks After Planting			
Agronet Cover	7	9	11	13
			Trial 1	
Control	82.7*	105.1	88.7	88.6
White	86.8	97.5	89.6	89.3
Yellow	86.6	119.8	94.0	96.7
Gray	95.1	114.7	91.9	90.6
Blue	99.8	112.1	93.94	96.6
			Trial 2	
Control	104.5	99.5	89.2b	88.1b
White	93.4	105.5	104.4ab	98.2ab
Yellow	93.8	197.85	123.6a	106.1a
Gray	122.9	108.2	114.6a	101.3a
Blue	88.5	108.7	97.3ab	105.1a

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at p≤0.05.

Table 11. Leaf Stomatal Conductance (mmolm^{-2}sec^{-1}) of Spiderplant as influenced by Agronet Covers

	Weeks After Planting			
Agronet Cover	7	9	11	13
		Trial 1		
Control	76.7ab*	100.4a	78.5	74.9
White	98.5a	111.0a	99.1	90.8
Yellow	79.1ab	107.5a	86.6	90.6
Gray	88.0ab	111.9a	86.8	84.2
Blue	64.3b	76.0b	91.6	83.0
		Trial 2		
Control	78.2	66.8	74.4a	61.9b
White	102.8	77.4	85.0a	73.0a
Yellow	81.3	89.0	76.6ab	71.0ab
Gray	79.7	73.6	66.7ab	70.9ab
Blue	68.6	74.2	56.5b	70.8ab

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

4.2.2. Influence of Agronet Covers on Leaf Chlorophyll Content of African Nightshade and Spiderplant

Growing African nightshade under agronet covers increased leaf chlorophyll ***a*** content although the difference with the control was not significant in most sampling dates of both trials (Table 12). African nightshade plants grown under the yellow net cover had significantly higher chlorophyll ***a*** content, followed by those grown under the blue and gray net covers in that order in most sampling dates of the two trials. The least chlorophyll ***a*** content was obtained in plants grown in the open field. While white net cover tended to produce plants with relatively higher chlorophyll ***a*** content compared to the control, the values were not significantly different in most sampling dates.

Similar to African nightshade, use of yellow agronet cover also resulted into plants with the highest chlorophyll ***a*** content with the least chlorophyll ***a*** content obtained in the open field grown spiderplant during most sampling dates of the two trials (Table 13). Compared to the control plants, growing spiderplant under blue, gray and white net covers resulted into plants with higher chlorophyll ***a*** content although the difference not significant during most sampling dates of the two trials.

Contrary to chlorophyll ***a*** content, the highest chlorophyll ***b*** content was recorded in African nightshade plants grown under blue net cover while the least chlorophyll ***b*** content was obtained in plants grown in the open field during most sampling dates of both trials (Table 14). Compared to chlorophyll ***b*** content of plants grown in the open field, plants grown under the yellow, gray and white net covers had significantly higher chlorophyll ***b*** content in most sampling dates of both trials. Chlorophyll ***b*** content in these treatments was in descending order from yellow, to gray to white in most sampling dates.

Chlorophyll ***b*** content of leaves of spiderplant exhibited a trend similar to that of chlorophyll ***a*** content with plants grown under the yellow cover recording the highest chlorophyll ***b*** content (Table 15). The least chlorophyll ***b*** content was obtained in plants grown in the open field. Plants grown under the blue, gray and white net covers had significantly higher chlorophyll ***b*** content compared to control plants in both trials.

Table 12. African Nightshade Leaf Chlorophyll *a* (μgg^{-1}DW) Content as influenced by Agronet Covers

Agronet Cover	Weeks After Planting			
	7	9	11	13
		Trial 1		
Control	6783.7b*	10961.8bc	8764.0	8900.1b
White	6812.4b	10417.8c	9062.5	9100.2a
Yellow	12282.0a	14442.1a	12501.9	12342.1a
Gray	12328.5a	11187.5b	11071.6	11671.7a
Blue	9630.2ab	14371.0a	12288.4	12101.3a
		Trial 2		
Control	11296.2	10332.8b	11111.3	11109.9
White	8411.5	12828.9a	11372.1	11521.0
Yellow	11623.33	13751.7a	13579.7	13257.2
Gray	11980.7	12461.3a	13044.6	12968.3
Blue	137251.6	13162.7a	12964.5	13012.7

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at p≤0.05.

Table 13. Spiderplant Leaf Chlorophyll a ($\mu g g^{-1}$FW) Content as influenced by Agronet Covers

	Weeks After Planting			
Agronet Cover	7	9	11	13
		Trial 1		
Control	7830.0b*	8818.6ab	6996.4b	8177.9
White	9174.6b	8129.5b	7792.5ab	9326.1
Yellow	10777.0ab	10611.6a	11096.9a	11193.1
Gray	13114.5a	9570.7ab	10309.1ab	9453.8
Blue	10352.5ab	9913.8ab	9261.5ab	9878.3
		Trial 2		
Control	8013.3b	9872.6	8124.8b	9012.3
White	10603.0ab	11532.5	11485.6a	11758.5
Yellow	15251.3a	11569.9	12846.6a	12761.6
Gray	11605.8ab	11516.4	11502.3a	11567.0
Blue	13179.4ab	12111.9	12076.9a	12719.9

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

Table 14. African Nightshade Leaf Chlorophyll b (μgg^{-1} FW) Content as influenced by Agronet Covers

	Weeks After Planting			
Agronet Cover	7	9	11	13
		Trial 1		
Control	3393.2b*	4058.8c	4183.5b	4965.9c
White	6317.8a	5163.2b	7961.6a	6189.3b
Yellow	8287.4a	7492.7a	11238.7a	10034.7a
Gray	3955.9a	5176.1b	9895.0a	8132.8a
Blue	8491.7a	7927.1a	11464.0a	11871.1a
		Trial 2		
Control	3145.0b	3191.7b	4889.5	6203.2
White	4311.8b	3893.5b	4261.2	6227.6
Yellow	4343.1b	6676.7a	7961.0	7691.7
Gray	5786.1ab	6834.9a	8093.6	7123.7
Blue	9011.2a	7281.7a	8484.6	8629.2

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

Table 15. Spiderplant Leaf Chlorophyll b ($\mu g g^{-1}$FW) Content as influenced by Agronet Covers

	Weeks After Planting			
Agronet Cover	7	9	11	13
		Trial 1		
Control	5460.6ab*	4655.5c	2648.6b	2467.9b
White	4738.6b	5582.6bc	3927.8b	40129.0a
Yellow	13486.8a	9211.9a	7001.6a	6851.7a
Gray	10076.7ab	9836.1a	5119.3ab	5718.5a
Blue	7200.6ab	6554.0b	4774.4ab	4685.1a
		Trial 2		
Control	5928.1b	5090.0b	4991.5c	4132.6c
White	5738.8b	8072.5ab	7680.4b	6609.9b
Yellow	7998.1a	10563.5ab	9915.8a	9215.9a
Gray	7768.6a	13618.6a	9012.8a	9007.4a
Blue	7188.1ab	9985.9a	8984.3a	7685.9ab

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at p≤0.05.

4.3. Influence of Agronet Covers on Fresh Leaf Yield of African Nightshade and Spiderplant

Fresh leaf yield in this study was influenced by the use of agronet covers. Production of nightshade under yellow net cover had significantly higher total leaf yield compared to blue cover in trial 2 with no significance difference in fresh leaf yield among treatments noted in trial1 (Table 16). In both trials, higher leaf yield was generally obtained in plants grown under yellow net cover

Similar to African nightshade, spiderplant grown under yellow net cover had highest total leaf yield in both trials. Yellow and gray cover had significantly higher total leaf yield compared to blue and control in both trials while use of white net cover resulted in yields that were not significantly different from those of open field production. The use of the blue cover on the other hand significantly reduced yield compared to all other treatments (white, yellow gray and open field). There was no significant difference in yields obtained under yellow and gray net covers in both trials.

4.4 Influence of Agronet Covers on Leaf Moisture Content of African Nightshade and Spiderplant

Leaf moisture content of African nightshade was significantly ($p \leq 0.05$) influenced by the different agronet covers (Table 17). The highest leaf moisture content was obtained in plants grown under the blue net while the lowest leaf moisture content obtained in plants grown in the open field. Leaf moisture content in plants grown under white net cover was also significantly lower compared to that of leaves of plants grown under yellow, gray and blue net covers. Compared to control plants, plants grown under white net had significantly higher leaf moisture content in most of the sampling dates. Leaf moisture increased in the order; white, gray, yellow and blue net covers during both trials.

Leaf moisture content of spiderplant was also highest under blue net and lowest in plants grown in the open field (Table 18). Plants grown under the white net cover had significantly lower leaf moisture content compared to those grown under gray, yellow and blue net covers but significantly higher than those of the control treatment. Plants grown under gray and yellow nets were not significantly different in their leaf moisture content but had significantly lower moisture content than those grown under blue net in most sampling dates.

Table 16. Total Yield (Kg/ha) of African Nightshade and Spiderplant as affected by Agronet Covers

Agronet covers	Total Yield	
	African nightshade	Spiderplant
	Trial 1	
Control	8946*	7737bc
White	10425	8167ab
Yellow	11394	9721a
Gray	10735	9531a
Blue	8872	6001c
	Trial 2	
Control	18712a	7912b
White	19102a	10064a
Yellow	21594a	10490a
Gray	21264a	10200a
Blue	14782b	7512.8b

*Means followed by same letter or no letter within a trial and a vegetable are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

Table 17. Influence of Agronet Covers on Leaf Moisture (%) Content of African Nightshade

	Weeks After Planting				
Agronet cover	7	9	11	13	15
			Trial 1		
Control	85.7d*	89.4c	85.4e	87.0c	85.4e
White	87.5c	89.6bc	88.0d	89.0b	88.0d
Yellow	89.7b	89.4c	88.4c	89.2b	88.4c
Gray	89.1bc	90.5b	88.9b	88.6c	88.9b
Blue	90.4a	91.8a	89.6a	90.0a	89.6a
			Trial 2		
Control	88.3d	88.9e	88.1e	88.1e	84.2e
White	87.9e	89.2d	89.0d	88.5d	85.2d
Yellow	89.5b	90.0b	89.5c	89.7b	87.6ab
Gray	88.8c	90.1c	90.7a	89.3c	86.9c
Blue	89.6a	90.2a	89.9b	90.4a	88.1a

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

Table 18 . Influence of Agronet Covers on Leaf Moisture (%) Content of Spiderplant

	Weeks After Planting				
Agronet cover	7	9	11	13	15
			Trial 1		
Control	86.4e*	84.7e	84.8e	82.7e	84.8e
White	87.2c	85.1d	85.4d	83.9d	85.4d
Yellow	86.5d	88.1b	88.1b	84.8b	88.1b
Gray	88.1b	87.4c	87.8c	84.6c	87.9c
Blue	89.8a	88.3a	90.6a	85.7a	90.6a
			Trial 2		
Control	82.4e	84.7e	83.7e	85.6e	82.0e
White	85.3d	86. 4d	87.3b	88.1c	83.5d
Yellow	85.9b	87.8a	87.8c	88.3d	85.1b
Gray	85.8c	87.6c	87.6d	88.2b	85.0c
Blue	86.0a	87.7b	88.5e	89.4e	86.4a

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at p≤0.05.

4.5. Influence of Agronet Covers on Nutritive Quality of African Nightshade and Spiderplant

Nutritive quality variables measured were β-carotene vitamin C, leaf calcium and iron content, crude fiber content and total phenolic content.

4.5.1. Influence of Agronet Covers on β-carotene Content of African Nightshade and Spiderplant

Production of African nightshade under white net yielded plants with significantly higher leaf β-carotene content compared to the other treatments at 9 WAP (Table 19).Plants under white net had significantly higher leaf β-carotene than plants under yellow net throughout trial 1 except at 7 WAP Similar trend was observed in trial 2 with white net cover yielding plants with significantly higher leaf β-carotene content at 9 WAP compared to other treatments though not significantly different from that of control plants. African nightshade grown under blue net also had significantly lower β-carotene content compared to those grown under white net and control plants at 13 WAP. Compared to control plants, African nightshade grown under gray, yellow and blue net covers tended to contain lower leaf β-carotene although with no significant difference in most sampling dates. Leaf β-carotene of African nightshade grown under grey and blue net covers was not significantly different from plants grown under yellow net cover except at 9 WAP during trial 1.

Spiderplant on the other hand exhibited significantly higher leaf β-carotene in plants grown in the open field compared to those under yellow, gray and blue nets in trial 1 except at 11 WAP. During this trial, leaf β-carotene recorded in plants grown under the white net cover was not significantly different from spiderplant that of open field grown plants (Table 20). Plants grown under the blue cover had significantly lower leaf β-carotene than those produced in the white net cover and open field at 7 and 13 WAP in trial 2. Plants grown under yellow and gray net were not significantly different from blue net except at 9 WAP in trial 1when both plants under yellow and grey net were significantly higher than those spiderplant under blue net. Generally, spiderplant grown in the open field had higher leaf β-carotene content followed by plants grown under white net cover for both trials.

Table 19. Influence of Agronet Covers on β-carotene (μg g^{-1} FW) of African Nightshade

Agronet Cover	Weeks After Planting			
	7	9	11	13
		Trial 1		
Control	11931.4*	11025.9b	12618.4ab	12237.0ab
White	11568.2	14527.0a	13756.6a	12972.7a
Yellow	9470.7	7690.8c	6358.4b	7643.2b
Gray	10101.6	11838.1b	11725.2ab	12012.3ab
Blue	8018.1	10642.2b	8950.8ab	9017.2ab
		Trial 2		
Control	13064.9	14106.6ab	14072.1	15171.3a
White	13486.9	1510.3.3a	15242.6	16137.1a
Yellow	12823.1	13003.7b	13093.2	14125.2ab
Gray	15099.6	13358.0b	14299.2	14159.7ab
Blue	10419.1	11586.1b	13506.6	13813.8b

*Means followed by same letter or no letter within a trial and sampling date are not significantly different according to Tukey’s HSD test at p≤0.05.

Table 20. Influence of Agronet Covers on β-carotene (μg g^{-1} FW) of Spiderplant

Agronet Cover	Weeks After Planting			
	7	9	11	13
		Trial 1		
Control	12544.9a	10596.6a	11023.3	10239.2a
White	10250.0ab	9888.9ab	10700.1	11971.7a
Yellow	9095.0b	9134.6b	8558.5	8780.1b
Gray	9291.6b	9484.7b	9703.1	9536.8b
Blue	8060.3b	8080.8c	7267.5	8214.3b
		Trial 2		
Control	12627.7ab	12471.6	13447.8	11231.0a
White	14453.0a	11937.9	10856.4	10872.1a
Yellow	12618.9ab	11209.0	9177.5	9872.7ab
Gray	10503.9bc	11581.9	10831.4	10959.3a
Blue	8560.0c	10387.5	9261.7	8767.9b

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

4.5.2. Influence of Agronet Covers on Leaf Vitamin C Content of African Nightshade and Spiderplant

Production of African nightshade under agronet covers influenced leaf vitamin C content, although with no significant difference amongst the different treatments in most sampling dates (Table 21). Leaf vitamin C content in African nightshade tended to be higher under open field conditions followed by under white net, yellow net and gray net in that order. A significantly lower vitamin C was obtained in plants grown under blue and gray net cover at 9 and 15 WAP. Generally, the amount of leaf vitamin C content was lowest in plants grown under the blue net cover.

Similarly, spiderplant grown in the open field tended to have higher leaf vitamin C content than those of leaves from the other treatments (Table 22). Leaf vitamin C content for plants grown under white, gray and yellow net covers was not significantly different from that of open field grown gray. Leaves of plant grown under blue net cover had the lowest vitamin C content during all sampling dates of both seasons.

4.5.3. Influence of Agronet Covers on Leaf Calcium (Ca) Content of African Nightshade and Spiderplant

Leaf calcium content was significantly influenced by agronet covers in African nightshade in the two trials of the study (Table 23). African nightshade grown under yellow net cover resulted in significantly higher leaf calcium concentrations than those grown under the control, blue net cover and white net cover treatments during most sampling dates except at 11 and 15 WAP. The least calcium concentration was obtained in plants grown under the blue cover which tended to yield relatively lower leaf calcium concentration than even the control plants, although with no significant difference in most sampling dates of the two trials.

On the other hand, spiderplant grown under the white net had significantly higher leaf calcium content than the rest of the treatments except at 13 and 15 WAP in trial 2 when leaf calcium content of plant under the white net cover differed only with that of plants grown under the blue cover. Blue net cover yielded plants with the least leaf calcium concentration in both trials of the study (Table 24). Gray and yellow net cover tended to yield plants with higher leaf calcium concentration than control plants although with no significant difference.

Table 21. Influence of Agronet Cover on Leaf Vitamin C Content (mg/100g) of African Nightshade

	Weeks After Planting				
Agronet Cover	7	9	11	13	15
			Trial 1		
Control	226.5*	229.3a	193.8	215.4	285.9a
White	273.8	206.7ab	179.0	215.5	239.3a
Yellow	228.8	185.5ab	191.3	192.5	221.4a
Gray	246.7	165.7b	162.8	184.0	177.1b
Blue	224.6	155.1b	162.7	186.5	165.5b
			Trial 2		
Control	200.8a	168.5	273.2	241.3	260.4a
White	188.2a	165.1	267.9	224.6	217.7a
Yellow	175.4a	157.8	257.4	237.4	256.1a
Gray	204.6a	138.8	231.2	212.0	205.2b
Blue	143.0b	116.9	225.5	200.3	172.8b

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at p≤0.05.

Table 22 . Influence of Agronet Cover on Leaf Vitamin C Content (mg/100g) of Spiderplant

	Weeks After Planting				
Agronet Cover	7	9	11	13	15
			Trial 1		
Control	253.9	197.8	201.4	205.5ab	356.3a
White	256.3	162.2	169.1	220.8a	283.4ab
Yellow	222.0	145.8	150.7	184.8a	281.1ab
Gray	252.0	163.9	154.9	176.5ab	243.7ab
Blue	191.3	144.7	130.3	161.8b	198.7b
			Trial 2		
Control	146.3a	163.8a	211.8	236.5a	254.5a
White	159.0a	152.2a	201.6	250.2a	230.0a
Yellow	178.4a	116.5a	185.7	193.6ab	206.8ab
Gray	122.7b	122.4a	202.8	197.8ab	223.1a
Blue	121.7b	111.8b	181.1	172.0b	154.4b

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at p≤0.05.

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Table 23. Influence of Agronet Covers on Leaf Calcium (Ca) mg/100g of African Nightshade

	Weeks After Planting				
Agronet Cover	7	9	11	13	15
			Trial 1		
Control	11.5b*	22.9ab	9.7b	10.4c	8.6c
White	21.5a	25.0ab	10.6b	21.2b	10.8bc
Yellow	23.1a	27.0a	23.1a	28.2a	22.9a
Gray	20.7a	26.1ab	19.4a	22.2b	18.9ab
Blue	16.9b	18.6b	8.1b	15.0c	8.2c
			Trial 2		
Control	18.9b	13.4b	13.6b	17.2	16.1
White	18.3b	14.3b	14.5b	17.5	17.0
Yellow	25.8a	20.7a	20.9a	18.4	17.2
Gray	19.7b	14.5b	14.7b	16.4	18.2
Blue	14.2b	12.0b	12.2b	16.1	15.9

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

Table 24. Influence of Agronet Covers on Leaf Calcium (Ca) (mg/100g) Content of Spiderplant

	Weeks After Planting				
Agronet Cover	7	9	11	13	15
			Trial 1		
Control	16.1bc*	23.4b	26.0b	22.1b	20.5b
White	27.6a	39.0a	35.4a	28.6a	33.6a
Yellow	19.5b	24.1b	27.2b	23.0b	23.2b
Gray	25.6a	27.8ab	33.8ab	23.7b	25.9b
Blue	13.7c	12.9c	10.5c	7.2c	12.2c
			Trial 2		
Control	15.3c	18.0b	17.3b	19.1a	17.0a
White	25.3a	30.3a	32.5a	20.5a	19.9a
Yellow	18.6b	18.4b	18.0b	19.8a	19.4a
Gray	18.3b	18.1b	18.9b	20.1a	16.8a
Blue	20.0b	11.5c	11.0c	12.7b	13.3b

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at p≤0.05.

4.5.4. Influence of Agronet Covers on Leaf Iron (Fe) Content of African Nightshade and Spiderplant

Leaf iron content was significantly influenced by the different agronet covers in African nightshade (Table 25). Nightshade grown under yellow and blue covers had significantly higher leaf iron content compared open field in both trials of the study. Compared to control, growing nightshade under white net did not result in any significant effect on leaf iron content in both trials of the study. Gray net also tended to give nightshade with higher leaf iron content compared to control plants although with no significant difference in most sampling dates of both trials.

Spiderplant grown under yellow and blue net covers also had significantly higher leaf iron content compared to those grown under white net cover and open field in both trials of the study (Table 26). There was no significant difference in leaf iron content of plants grown under white net cover and those grown in the open field. Gray net tended to give plants with higher leaf iron content which was not significantly different from that of plants grown under white net cover and open field but was significantly lower than that of plants grown under yellow and blue net cover. Plants grown under yellow net cover generally had high leaf iron content.

4.5.5. Influence of Agronet Covers on Crude Fiber Content in African Nightshade and Spiderplant

Leaf crude fiber content of African nightshade was significantly reduced when grown under the different agronet covers (Table 27). Plants in the open field had significantly higher leaf fiber content compared to that of plants grown under yellow, gray and blue net covers in both trials. Compared to control plants, plants grown under white net tended to produce lower crude fiber content although with no significant difference. Plants grown under blue cover had the lowest leaf fiber content compared to those from other treatments Crude fiber content of plants grown under gray cover was also not significantly different from that of plants grown under white cover

Similarly, spiderplant grown in the open field had significantly higher leaf fiber content compared to plants grown under the blue cover (Table 28). Crude fiber content of control plants was not significantly different from that of spiderplant grown under white net cover but significantly higher than that of plants grown under the yellow net cover except at 13 and 15 WAP in trial1. Plants under blue net cover had significantly lower fiber content in both trials compared to those from other treatments except for plants grown under yellow cover

Table 25. Influence of Agronet Covers on Iron (Fe) (mg/100g) Content in African Nightshade

	Weeks After Planting				
Agronet Cover	7	9	11	13	15
			Trial 1		
Control	26.0b*	25.5b	8.6c	16.1b	9.6c
White	35.9b	28.1b	15.0bc	19.6ab	16.0bc
Yellow	107.2a	34.2b	34.2a	30.3a	35.2a
Gray	45.6b	31.3b	15.2bc	22.9ab	16.3bc
Blue	87.0a	139.2a	27.2ab	23.7ab	28.2ab
			Trial 2		
Control	15.8c	47.2c	37.0b	37.1b	33.3b
White	17.1c	34.3c	61.7a	45.7ab	34.6b
Yellow	35.8b	132.4a	70.6a	70.3a	53.3a
Gray	25.7c	99.1ab	60.7a	35.8b	43.2ab
Blue	50.3a	73.4b	66.7a	55.8ab	67.8a

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$.

Table 26 . Influence of Agronet Covers on Leaf iron (Fe) (mg/100g) Content of Spiderplant

	Weeks After Planting				
Agronet Cover	7	9	11	13	15
			Trial 1		
Control	32.6c*	25.5c	7.1c	8.0c	16.3b
White	40.9bc	35.9bc	15.3bc	13.3c	8.1c
Yellow	54.2b	73.1a	28.9a	71.2a	27.4a
Gray	41.1b	29.2bc	16.1bc	16.4c	17.1b
Blue	80.1a	46.0b	26.4ab	43.8b	29.9a
			Trial 2		
Control	16.2b	16.8b	10.4b	40.3b	38.8b
White	20.3b	27.7b	51.7ab	36.2b	34.7b
Yellow	27.8b	103.1a	65.8a	73.6a	72.1a
Gray	53.6a	80.9a	53.6ab	43.8b	39.9b
Blue	23.9b	95.9a	56.4ab	47.8b	52.3ab

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at $p \leq 0.05$.

Table 27. Influence of Agronet Covers on Crude Fiber (mg/100g) Content of African Nightshade

	Weeks After Planting				
Agronet Cover	7	9	11	13	15
			Trial 1		
Control	3.2a*	3.2a	3.6a	3.6a	4.0a
White	2.7ab	2.8b	3.0b	3.5a	3.5ab
Yellow	2.2c	2.3c	2.5bc	2.8b	2.9c
Gray	2.6bc	2.6b	2.9b	3.1b	3.3bc
Blue	1.7d	1.9d	2.1c	2.7b	3.0c
			Trial 2		
Control	2.7a	3.1a	3.7a	3.5a	3.7a
White	2.5ab	2.6b	2.9b	3.0b	3.4ab
Yellow	2.0c	2.4b	2.4bc	2.7b	3.0bc
Gray	2.3bc	2.4b	2.7b	3.0b	3.2bc
Blue	1.5d	1.6c	1.9c	2.9b	2.9c

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at $p \leq 0.05$.

Table 28. Influence of Agronet Covers on Crude Fiber (mg/100g) Content of Spiderplant

	Weeks After Planting				
Agronet Cover	7	9	11	13	15
			Trial 1		
Control	3.5a	3.6a	3.8a	3.9a	4.6a
White	3.2ab	3.5a	3.7ab	3.8a	3.9ab
Yellow	2.7bc	2.9bc	3.1bc	3.5a	3.8ab
Gray	3.0bc	3.1ab	3.4ab	3.6a	4.1ab
Blue	2.5c	2.5c	2.7c	2.8b	3.4b
			Trial 2		
Control	3.2a	3.5a	3.9a	3.8a	4.2a
White	2.9ab	3.3a	3.6ab	3.9a	4.0a
Yellow	2.4bc	2.6bc	2.9b	3.0b	3.7ab
Gray	2.7bc	3.0a	3.3ab	3.5a	3.9ab
Blue	2.2c	2.3c	3.0b	2.9b	3.3b

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at $p \leq 0.05$.

4.5.6. Influence of Agronet Covers on Total Leaf Phenolics of African Nightshade and Spiderplant

African nightshade grown under white net cover and open field had significantly higher total phenolics compared to plants grown under yellow and blue net covers in trial 1; and significantly higher than blue net cover in trial 2 in all sampling dates (Table 29). White net cover tended to yield plants with higher phenolics contents but was not significantly different from control plants and gray net covered plants in both trials in most sampling dates. Yellow net also tended to give plants with higher total phenolic content compared to plants under blue net but with no significant difference in most sampling dates.

Similarly, spiderplant grown under white cover and open field had significantly higher total phenolics content compared to plants grown under yellow and blue net cover (Table 30). Leaf phenolics of plants under white and gray net covers were not significantly different from control plants. Plants under yellow net had significantly higher total phenolics than those under blue net in trial 1 with no significance difference in trial 2. Plants grown under gray and yellow net covers were not significantly different in total phenolics except at 9 and 11WAP in trial 2.

4.6. Correlation between Measured Variables in African Nightshade and Spiderplant

The average total yield in African nightshade was positively correlated to the average leaf stomatal conductance, average number of primary branches and chlorophyll ***a*** and ***b***. (Table 31). Average leaf calcium in African nightshade was positively correlated to average leaf moisture and leaf stomatal conductance. Leaf iron content of African nightshade was positively correlated to the average leaf stomatal and chlorophyll ***a*** and ***b*** and average leaf moisture. Average leaf fiber was positively correlated to the average leaf stomatal conductance, but negatively correlated with leaf moisture and days to flowering. Average total leaf phenolics was positively correlated to average leaf stomatal conductance but negatively correlated to leaf moisture

Average total yield in spiderplant was positively correlated to average leaf chlorophyll ***a*** and ***b***, average leaf stomatal conductance and number of branches but negatively correlated to days to flowering (Table 32). Average leaf calcium and iron content were positively correlated to chlorophyll ***a*** and ***b***, average leaf stomatal conductance and average leaf moisture content. Just like in African nightshade, total phenolic content was positively correlated to the average leaf stomatal conductance.

Table 29. Influence of Agronet Covers on Total Phenolics (mg GAE100g^{-1}DW) of African Nightshade

	Weeks After Planting			
Agronet Cover	7	9	11	13
	Trial 1			
Control	60.17a*	61.70ab	66.26abc	63.13a
White	60.37a	64.13ab	68.10ab	63.66a
Yellow	53.67c	53.33c	57.00c	59.33a
Gray	55.33bc	58.33b	62.33bc	64.00a
Blue	51.00c	52.66c	56.33c	58.67a
	Trial 2			
Control	48.20b	51.60b	58.26a	58.26ab
White	54.67ab	57.90a	60.67a	58.90ab
Yellow	52.33ab	53.67b	55.67ab	63.00a
Gray	52.33ab	54.00ab	58.00a	61.67a
Blue	45.67b	47.67c	51.00b	56.00b

*Means followed by same letter within a sampling date and a trial are not significantly different according to Tukey’s HSD test at $p \leq 0.05$. GAE-Gallic Acid Equivalent.

Table 30. Influence of Agronet Covers on Total Phenolics (mg GAE100g^{-1}DW) of Spiderplant

Agronet Cover	Weeks After Planting			
	7	9	11	13
		Trial 1		
Control	74.00a*	74.67ab	76.67a	77.33a
White	75.00a	78.00a	78.00a	77.00a
Yellow	62.00bc	64.67bc	66.00b	67.67ab
Gray	66.00 b	68.00b	70.67ab	64.00b
Blue	55.33d	56.67c	59.33c	55.67c
		Trial 2		
Control	62.00a	66.67a	67.67a	69.33a
White	63.33a	66.33a	70.00a	72.00a
Yellow	58.67ab	55.33b	56.33b	63.00a
Gray	62.00ab	65.33a	67.67a	71.67a
Blue	55.00b	52.67b	50.67bc	56.33c

*Means followed by same letter or no letter within a sampling date and a trial are not significantly different according to Tukey's HSD test at $p \leq 0.05$. GAE-Gallic Acid Equivalent.

Table 31. Correlation between Measured Variables in African Nightshade

Variables	ChA	ChB	Stcnd	Pheight	Branches	Dflowering	VitA
ChA	1.00						
ChB	0.7801	1.00					
Stcnd	-0.823	-0.753	1.00				
Pheight	0.117	0.532	-0.576	1.00			
Branches	0.136	-0.299	-0.371	-0.0535	1.00		
Dflowering	-0.180	0.449	-0.160	0.837	-0.480	1.00	
VitA	0.862	0.469	-0.483	-0.276	0.0449	-0.523	1.00
VitC	0.0768	0.443	-0.381	0.8599	-0.311	0.7257	-0.0923
Calcium	-0.445	-0.564	0.017	0.229	0.758	-0.0366	-0.5426
Iron	-0.209	-0.48	0.174	-0.082	0.1865	-0.332	0.1276
Moisture	0.154	0.5187	-0.638	0.9901	0.0755	0.7811	-0.267
Yield	0.796	0.97*	0.688	-0.455	0.395	-0.370	-0.5879
Leaf fiber	-0.127	-0.585	0.5619	-0.909	0.0259	-0.84925	0.3677
Tphenolics	0.301	-0.336	0.0131	-0.6786	0.447	-0.946*	0.661

Variables	VitC	Calcium	Iron	Moisture	Yield	Leaf fiber	Tphenolic
VitC	1.00						
Calcium	0.0304	1.00					
Iron	0.2926	0.3535	1.00				
Moisture	0.7956	0.309	-0.111	1.00			
Yield	-0.490	0.661	0.314	-0.4198	1.00		
Leaf fiber	-0.594	-0.173	0.4715	-0.924*	0.429	1.00	
Tphenolics	-0.465	0.01819	0.545	-0.6385	0.2089	0.8149	1.00

Pearson Correlation Coefficients, Prob > |r| under H0: Rho=0

*Significant value at P≤0.05. ChA = Chlorophyll a, ChB = Chlorophyll b, pheight = plant height, Stcnd = Stomatal conductance, Dflowering = days to flowering, VitA = vitamin A, VitC = vitamin C, Tphenolics = total phenolics

Table 32. Correlation between Measured Variables in Spiderplant

Variables	ChA	ChB	Stcnd	Pheight	Branches	Dflowering	VitA
ChA	1.00						
ChB	-0.0486	1.00					
Stcnd	-0.1009	0.6065	1.00				
Pheight	-0.3335	0.836	0.8266	1.00			
Branches	0.6897	0.2327	0.5920	0.1653	1.00		
Dflowering	-0.7260	0.0124	-0.446	0.0508	-0.9693*	1.00	
VitA	0.9642*	-0.3053	-0.256	-0.520	0.580	-0.6769	1.00
VitC	-0.1929	-0.877*	-0.821	-0.7675	-0.6505	0.447	0.054
Calcium	0.609	0.650	0.522	0.346	0.819	-0.6845	0.3904
Iron	0.6964	0.664	0.3749	0.30944	0.7229	-0.5819	0.4812
Moisture	0.777	0.4939	0.4674	0.2369	0.8988*	-0.8032	0.60025
Yield	0.6470	0.5686	0.3298	0.1668	0.74029	-0.6285	0.44132
Leaf fiber	0.8952*	0.0641	0.2352	-0.12083	0.8534	-0.8906	0.8740
Tphenolics	0.5285	-0.1593	0.2738	0.0864	0.5031	-0.5425	0.5801

Variables	VitC	Calcium	Iron	Moisture	Yield	Leaf fiber	Tphenolic
VitC	1.00						
Calcium	-0.8612	1.00					
Iron	-0.7921	0.9618*	1.00				
Moisture	-0.7606	0.9592*	0.951*	1.00			
Yield	-0.7484	0.9724*	0.946*	0.9178*	1.00		
Leaf fiber	-0.2994	0.5820	0.6019	0.7839	0.5260	1.00	
Tphenolics	-0.0775	0.1176	0.1839	0.3683	-0.0262	0.7788	1.00

Pearson Correlation Coefficients, Prob > |r| under H0: Rho=0

*Significant value at P≤0.05. ChA = Chlorophyll a, ChB = Chlorophyll b, pheight = plant height, Stcnd = Stomatal conductance, Dflowering = days to flowering, VitA = vitamin A, VitC = vitamin C, Tphenolics = total phenolics

CHAPTER FIVE

DISCUSSION

This chapter presents a discussion of the results. Layout of this chapter follows sequentially the order in which the results were presented in chapter four of this document.

5.1 Influence of Agronet Covers on Growth of African Nightshade and Spiderplant

Use of different agronet covers influenced the growth variables: plant height, number of primary branches and days to first and 50% flowering measured in this study.

5.1.1 Influence of Agronet Covers on Plant Height of African Nightshade and Spiderplant

According to Stamps (2009), net covers not only decrease light quantity but also alter light quality to a varying extent and might also change other environmental conditions. The spectral manipulation of light by net covers alters crop physiological and morphological responses (Shahak, 2016) and light colour may influence shoot elongation (Schroeter-Zakrzewska and Kleiber, 2014). These arguments support the findings of the current study. In this study, use of blue net cover significantly enhanced plant growth yielding taller African nightshade plants and shorter stem lengths in spiderplants compared to those grown in the open field. The response of African nightshade to blue net cover observed in this study supports that by Farnanda *et al.* (2014) who reported highest growth measured in terms of plant height in *Piper aduncum* cultivated under blue nets throughout the experiment compared to under red nets and open field. Similar results were observed for *Ocimum selloi, Mikania glomerata* and *Mikania laevigata,* (Costa *et al.*, 2010; Souza *et al.*, 2007)*, Ocimum gratissimum* (Martin *et al.*, 2008*) and Melissa officinalis* (Oleivera *et al.*, 2016), who also recorded taller plants under blue net compared to under other net covers.

In nature, equilibrium between red and far red exists, but the ratio of red to far red decreases under shade conditions. In many species the decrease in the red to far red causes stem elongation and increased apical dominance (Franlin and Whitelam, 2005); phenomenon referred to as shade avoidance syndrome. In the current study, higher stem elongation observed in African nightshade grown under blue cover could be attributed to a greater reduction in red to far red ratio which occurs under blue net cover compared to yellow, gray and white net covers.

While blue net resulted in taller plants in African nightshade, it was observed that it generally caused dwarfing in spiderplant signifying that responsiveness of plants to different light wavelengths varies amongst species (Rajapakse and Shahak 2007; Oren-Shamir *et al.*, 2003). Similarly, Oren-Shamir *et al.* (2001) reported that blue net caused dwarfing on *Pittosporum variagatum* compared to control plants. The effect of the blue net might be attributed to either enriching or reducing the blue verses red and far red spectral bands in the filtered light and might further be related to similar effect reported for photoselective films and artificial illuminations (Rajapakse and Shahak, 2007). In addition, blue light (430nm-450nm) enables cryptochromes and phototropins to mediate plant responses such as inhibition of stem elongation which could provide an explanation for the shorter spiderplants observed under the blue net cover in the present study. Decreased stem elongation due to blue light effects have also been reported in tomato grown under different light quality regimes (Javanmardi and Emami, 2013; Nanya *et al.* 2012; Menard *et al.* 2006). Similarly, Appelgren (1991) reported inhibited hypocotyl elongation by blue light irradiation and increased intensity of blue light in sprouts of different lettuce vegetable as well as stem elongation in *Pelargonium* plantlets.

Oren-Shamir *et al.* (2001) reported that blue nets do not transmit light between 580 and 750 nm, thus keeping the red/far red ratio similar to that of natural sunlight. The lack of far red (700-750 nm) may be a major inducer of dwarfing and other inhibition effects under blue nets. In addition, under blue net cover where blue light dominates, cryptochrome1 (cry1) is transported to the cytosol, where it regulates the cytosolic and plasma membrane proteins (Lin and Shalitin, 2003). Cryptochromes affect the anion channel activity of plant plasma membranes causing depolarization of the membranes (Spalding and Smith, 2000) which has been documented to affect cell elongation, leading to inhibited cell expansion and inhibition of stem elongation.

In the current study, use of white net cover resulted in increased plant height of spiderplant more than the other net covers used and the open field. Similar results have been reported by Abul-Soud *et al*. (2014) who documented higher stem elongation under white net treatments than under yellow, blue, red and black net covers while open field gave the least plant height. The aforementioned authors suggest that increased plant height under white net cover could be attributed to the suitable climatic conditions for cabbage plants under the white net cover. Contrary to these findings, white net cover recorded lower plant height compared to blue, yellow, red and black net in *Solanum tuberosum* (Abdrabbo *et al.*, 2013) which supports the observation made in African nightshade in the present study. It is possible that since both nightshade and potato belong to the same family (Solanaceae), they react in a similar manner to a given light treatment. Higher spiderplant height recorded under white net in the present study could also be attributed to the fact that being a C_4 plant (AVRDC, 2009), spiderplant growth is maximized under higher solar radiation and temperature, conditions that could have prevailed under the white net cover.

5.1.2 Influence of Agronet Covers on Primary Branches of African Nightshade and Spiderplant

Any net cover can scatter radiation, especially ultraviolet because nets are usually made using ultraviolet-resistant materials (Wong, 1994). According to Nissim-Levi *et al.* (2008), a net cover that increases light scattering but does not affect the light spectrum increase branching, plant compactness, and the number of leaves per plant. Coloured net covers can also increase light scattering by 50% or more and this alone may influence plant development and growth (Abdrabbo, 2013).

In the present study, use of yellow net cover enhanced primary branching of African nightshade followed by white, gray net and control plants while the least branching was exhibited by plants under blue net cover. On the other hand, use of white net cover significantly enhanced primary branching of spiderplant, with plants grown under the gray and yellow net cover treatments also tending to have higher number of primary branches compared to those in the open field treatment. However, in both vegetables, use of blue net cover substantially reduced branching. Findings of this study in part support those of Oren-Shamir *et al.* (2001), Shahak (2008) and Shahak *et al.* (2004) who also observed that yellow nets specifically stimulated vegetative growth rate and vigour, while the gray net specifically enhanced branching and bushiness in Pittosporum while blue net inhibited branching. As previously discussed, the effects of blue and yellow nets result from their enriching or reducing the relative content of blue and yellow spectral bands of the transmitted light, and might be related to similar effects reported for photoselective films and artificial illumination (Rajapakse and Shahak, 2007). The effects of the gray net might relate to its distinct absorption in the infra- red (IR) range.

Primary branching of both African nightshade and spiderplant was inhibited in plants grown under blue net cover. Blue net covers have been speculated to maintain a high blue: red light ratio which inhibits branching (Shahak, 2016). The inhibitory effect of blue net cover on the vegetative growth of plants has also been reported by Abul-Soud *et al.* (2014) who also suggested that blue net reduced radiation reaching crops underneath. Stamps (2008) argued that reductions in radiation resulting from netting will affect the climatic conditions under the net cover and reduce plant growth.

Increased number of branches of spiderplant observed in the current study under white net might relate wholly to similar reasons discussed above under plant height and partly because white net cover absorb spectral bands shorter or longer than the visible range which might have favoured growth and branching of this crop. In addition, white net increases light scattering but does not alter light spectrum. Increased light scattering increases radiation use efficiency thus improving crop growth (Rajapaske and Shahak, 2007).

5.1.3. Influence of Agronet Covers on Days to First Flowering and Days to Fifty Percent Flowering of African Nightshade and Spiderplant

Floral induction is one of the most drastic and abrupt changes that occurs during both spiderplant and African nightshade life cycles. The ability to control flowering time in vegetables grown for fresh shoot or leaf harvesting has the advantage of extending the vegetative phase hence prolonging the harvest season. The transition from vegetative growth to floral development is strongly influenced by light (Mouradov *et al.*, 2002; Guo *et al.*, 1998). According to Shahak (2008), different wavebands of light exhibit distinct roles in the regulation of floral initiation. The current study agrees with this affirmation since spectral modification using coloured net covers influenced crop flowering time. Use of blue net cover in this study significantly delayed flowering time in both African nightshade and spiderplant compared to the other net colours and open field conditions. Yellow and gray net cover also delayed flowering in both vegetables compared to the control while the effect of white net was not significantly different from control plants but slightly accelerated under white net than in the control, especially for spiderplant. The number of days to attainment of 50% flowering also followed a similar pattern. Similar to findings of the current study, Shahak (2008) and Ovadia *et al.* (2009) reported that *Ornithogalum dubium*, under red net advanced flowering while the yellow net delayed flowering relative to their equivalent black shading control.

Plants absorbs red but transmit far-red light so that light under a canopy or reflected from nearby stems has more of the far-red light or has a low red to far-red (red/far-red) light ratio. This induces early flowering of plants to outgrow competitors and to complete their life cycle (Arboretum, 2010) which are part of the characteristic responses of the shade-avoidance syndrome (Cerdan and Chory, 2003). Kadman-Zahavi *et al.* (1976) also observed that tomato seedlings grown under filters with far-red transmitting characteristics flowered early while those under blue light delayed in flowering. Similar results were also observed in a study by Mortensen and Stromme (1987) with chrysanthemum, tomato and lettuce seedlings. In this study, since net colours correspond to specific wavelengths, then it is worth noting that flowering is hastened as wavelengths approach red and far red range but delayed in the reverse order. This assumption is made because flowering was delayed in crops under blue net cover (430 nm-500 nm), and progressively facilitated towards yellow (500-590 nm) and gray (700-800 nm/far red). This argument is further supported by Ovadia *et al.* (2009) who reported that the most significant effect was a shortening of the time to flowering of Ornithogalum under the red net compared to the blue net. The aforementioned authors further emphasized that *Zantedeschia aethiopica* (calla lily) showed similar results, with the greatest promotion of flowering under red net followed by yellow nets compared to blue nets. Similarly, Shahak (2016) observed delayed flowering under yellow net cover than in red net. This means that cryptochrome 2 receptor pigment triggered by blue light delays flowering of plants. Altering the spectrum of sunlight may serve to control the time to flower of plants. In this study, it is evident that use of blue net cover can be used to delay flowering of African nightshade and spiderplant in order to mitigate early flowering which is a common occurrence in these vegetables.

Although flowering is under genetic control, it is as well affected by aspects of the weather such as solar radiation and air temperature (Kobayasi *et al.*, 2010; Nakagawa and Nagata, 2007) rather than light quality alone. There is a positive correlation between high solar radiation and early flowering of crops under both open field and controlled environments (Kobayasi *et al.*, 2012). High solar radiation and high temperature induces stress factor on plants which consequently induces early flowering. Abul-Soud *et al.* (2014) noted air temperature and solar radiation were higher in the open field followed by under red and white nets while such variables were low under black and blue net covers. Even though high air temperature induce early flowering of nightshade and spiderplant, the prevailing air temperature during the study period were not high to induce early flowering in crops in the open field and under white net cover. Thus the observed early flowering in crops in the open field and under white net might have been due to other factors such as moisture deficit. Uncovered plots and white net experience more soil water loss through evapotranspiration. Rapid water loss or limitation triggers plants to complete their life-cycle and early flowering is the fast morphological change observed in response to water deficit (Shavrukov *et al.*, 2017).

5.2 Influence of Agronet Covers on African Nightshade and Spiderplant Physiology

Agronet covers influenced African nightshade and spiderplant leaf stomatal conductance and chlorophyll ***a*** and ***b***.

5.2.1. Influence of Agronet Covers on Leaf Stomatal Conductance of African Nightshade and Spiderplant

Plant leaf stomatal conductance was enhanced when both African nightshade and spiderplant were grown under agronet covers. These finding are consistent with those of Muleke *et al.* (2014) who reported enhanced cabbage leaf stomatal conductance under net covers compared to the open field. Similarly Smith (2007) reported increased stomatal conductance in blushed apple cultivars under net cover. In addition to a generally increased stomatal conductance following the use of agronet covers, different net colours in the current study differentially influenced stomatal conductance. Plants grown under yellow and gray nets exhibited higher stomatal conductance than those in the open field, although with no significant difference. Similarly, Oliveira *et al.* (2016) observed non-significant difference in stomatal conductance in lemon balm plants grown under coloured nets in relation to those grown in the open field.

Several studies have revealed higher stomatal conductance under blue net covers (Wang *et al*., 2015; Bastias *et al.*, 2012; Zeiger *et al.*, 2002). Blue light stimulates hydrogen ion release from guard cells through electrogenic pumping by hydrogen ion and adenosine triphosphatases (ATPases) leading to transient membrane hyperpolarization. ATPases, activated by blue light, pump hydrogen ion resulting to an electrochemical potential gradient, which drives the movement of potassium (K^+) and chlorine ions (Cl^-) into the guard cells through ion channels (Tallman, 1992), causing the guard cell osmotic potential to increase and water to flow into the guard cells.

Higher stomatal conductance of African nightshade under yellow net observed in the present study might be attributed to the advantages possessed by yellow net in which it transmit highly scattered light which is enriched in the green, red and far-red spectral range relative to the ultra violet and blue range thus combine suitable characteristics of an array of wave bands as suggested by Shahak (2016). White net cover on the other hand induced higher stomatal conductance in spiderplant. Similar finding has been reported by Silva *et al.* (2014) in banana plantlets where plantlets grown under white net cover had higher stomatal conductance compared to blue, red and yellow nets. A study by Schroeter-Zakrzewska *et al.* (2016) using light emitting diodes also revealed higher stomatal conductance under white light compared to blue, red and green light. High stomatal conductance under white net cover might also be attributed to elevated temperatures.

Besides light quality, stomatal conductance is known to be affected by other factors such as carbon dioxide concentration, humidity and temperature. According to Bunce (1999), plants are known to react to low relative humidity by closing their stomata with a consequent reduction in carbon dioxide uptake and water loss. Stomatal response to atmospheric humidity is further intensified by the effect of high wind speed, which reduces the leaf water potential by depleting the moist boundary layer close to the leaf surface. The low stomatal conductance observed in African nightshade and spiderplant produced in the open field in this study could therefore have been a response of the plants to low relative humidity. Soil moisture reduction leads to a decline in gaseous exchange and leaf water potential as reported by Gitlin *et al.* (2006). Findings of the current study corroborates those of an earlier study by Muleke *et al*. (2014) who reported low stomatal conductance under low soil moisture and low relative humidity in open field cabbage production compared to under net covers.

5.2.2. Influence of Agronet Covers on Leaf Chlorophyll Content of African Nightshade and Spiderplant

Chlorophyll which allows plants to absorb energy from light is vital for photosynthesis. Chlorophyll a is essential for most photosynthetic organisms to convert chemical energy though it is not the only pigment that is used for photosynthesis. All oxygenic photosynthetic organisms use chlorophyll ***a*** but differ in accessory pigments like chlorophyll ***b*** (Wang *et al.*, 2015). Higher values of chlorophyll content (chlorophyll ***a*** and chlorophyll ***b***) were observed in African nightshade and spiderplant grown under agronet covers compared to those grown in the open field in the current study. Similarly, Ilic *et al*. (2016) and Zervoudakis *et al.* (2012) observed higher chlorophyll ***a*** and ***b*** under net covers than under open fields.

Although chlorophyll estimates were higher under agronet covers than open field, yellow net cover induced the highest chlorophyll ***a*** content in both vegetables followed by blue, gray and white net covers. Conversely, Chlorophyll ***b*** content was maximized under blue net covers. Partly in line with findings of this study, Casierra-Posada and Pena-Olmos (2012) found that different light quality influenced chlorophyll content of strawberry plants upon exposure to different coloured covers. They also found that chlorophyll ***a*** concentration was highest in leaves growing under green and red covers, followed by leaves in the blue, transparent, and yellow treatments.

The current study indicates that African nightshade and spiderplant have maximum concentration of chlorophyll ***b*** under blue light wavebands (400-500nm) while chlorophyll ***a*** is best maximized under yellow light wavelengths (500- 600 nm). In relation to this supposition, Wang *et al.* (2009) emphasized that plant pigments have specific wavelength absorption patterns known as absorption spectra. Silva *et al*. (2015) further affirms that the absorption peaks of chlorophyll ***a*** are at 660 nm and 430 nm, and those of chlorophyll ***b*** at 640 and 450 nm, covering the red, yellow and blue waveband fractions of the PAR spectrum. According to Wang *et al.* (2015), chloroplast is a light-induced organelle and normally synthesized in large numbers under blue and yellow light; which might further explain the higher chlorophyll contents under blue and yellow net covers in the present study. Similar to findings of the current study, Ilic *et al.* (2016) reported significantly higher total chlorophyll content in tomato plants grown under black and blue nets than in leaves of plants grown in the open field (control) or grown under pearl net. Souza *et al.* (2011) also reported significantly higher total chlorophyll content in *Mikania laevigata* plants grown under blue net. These observations are in line with those of Oliveira *et al.* (2016) who also observed high chlorophyll in plants under blue nets. According to Poudel *et al.* (2008), blue light exerts a positive and coordinated influence during development of chloroplasts and synthesis of chlorophyll in plant cells, which may explain the chlorophyll increase under this net colour. It should be noted that maximum absorption ranges for chlorophyll occur in the blue-violet range (400-500 nm) and the orange-red range (600-700 nm) of the visible spectrum (Mc Donald, 2003), which explains the behavior of chlorophyll in plants grown under yellow and blue net covers.

Low chlorophyll contents obtained under open field compared to those under net covers was not surprising. Extremely strong irradiance in the open field often decrease chlorophyll content of crops owing to inhibition of chloroplast synthesis as suggested by Wang *et al*. (2015). According to Ilic *et al*. (2015), crops grown under cover trap lower levels of light, and thus contain more chlorophyll or produce additional chlorophyll to capture diffuse radiation to produce the carbohydrates needed for a plant to grow than plant leaves exposed to direct sun. Since the nets consist of holes in addition to the translucent photo-selective plastic threads, shade nets actually create mixtures of natural unmodified light which passes through the holes together with the diffused, spectrally modified light and altered proportions of red/far-red waveband (R/FR) ratio. The increase in chlorophyll ***a*** and ***b*** or ***a/b*** ratio observed under net covers in the current study could also be associated with the protection of the photosynthetic system under stress conditions, due to a lesser radiation absorption at shorter wavelength.

5.3. Influence of Agronet Covers on Fresh Leaf Yield of African Nightshade and Spiderplant

Use of different net covers has been shown to increase yield of crops. Elad *et al.* (2007) observed increased yields of *Solanum annum* with usage of white, black, blue, blue-silver and silver net covers compared to control plants. Shahak (2008) reported increased yields of *Solanum annum* under pearl and red net compared with black. Fallik *et al.* (2009) reported significantly higher yield of sweet pepper with the use of red and yellow nets compared with black net and open field. Abul-Soud *et al.* (2014) also reported higher mango yield under net covers than under open field control. The current study supports these findings with fresh leaf yield being enhanced under agronet covers. Yellow net cover recorded the highest fresh leaf yield followed by white, gray and control treatments; while blue net cover gave the least yield. Similarly, Ambrozy *et al.* (2015) recorded the highest yield of sweet pepper in yellow nets than that of control (open field); and attributed this to higher blue: red ratio under yellow net. Blue light reduces photosynthetic capacity of plants (Fallik *et al*., 2009).

Considering that leaf chlorophyll, especially chlorophyll ***a*** molecule that makes photosynthesis possible (Calatayud and Barreno, 2004) and stomatal conductance were maximized under yellow net cover, it is likely that the increased yield exhibited by the two vegetables grown under yellow net cover in the present study was due to increased photosynthetic efficiency that led to increased branching of crops under this net cover and consequently more shoot harvesting points. A positive correlation between total yield and chlorophyll ***a*** and ***b***, leaf stomatal conductance and number of primary branches in this study also explains the higher yields recorded for this treatment. Similar finding was reported by Ilic (2015) who observed that an increase in biomass yield (vegetative and reproductive) coincided with increase in chlorophyll content. According to Li *et al.* (2000), reduction in primary branches results in a reduction in photosynthetic area and consequently in a reduction of fresh and dry biomass yield. This affirmation is wholly applicable for African nightshade and partially for spiderplant in the current study. This is because, although both branching and leaf stomatal conductance was maximized under white net cover in the case of spiderplant in the current study, yellow net cover outperformed the white net in the long run with regards to total yield. The slight disparity observed might be attributed to the fact that spiderplant grown under white net cover attained early senescence as depicted by the earlier flowering observed under this net cover in this study; hence reduction in harvestable shoots compared to under the yellow net. Shahak (2016) argued that the superiority of yellow net over other net colours arise from the fact that yellow net operates as cut-off filters, absorbing the shorter and longer wavelength bands and light below a specific wavelength range, while transmitting light thereafter. It transmits light from 515nm and above, thus allowing the blue, green and yellow light to pass through this net, in addition to the red and far red light. Such properties make yellow net to be more beneficial to crops and this might further explain higher yield obtained under yellow net in this study.

Use of blue net cover, on the other hand, resulted in lower total yield compared to the control treatment in both vegetables in the present study. Similar finding has been reported by Costa *et al.* (2010) who reported striking reduction in plant biomass under blue net cover. Reduction in total fresh yield observed in the present study may have resulted from a decrease in the rate of carbon dioxide assimilation under blue net as suggested by Oyaert *et al.* (1992). In addition, Kim *et al.* (2004) reported that there is a reduction in the net photosynthetic rate of plants subjected to blue and blue-far red light treatments. Consistent with these findings, Oleiveira *et al.* (2016) further reported that plants under blue and red nets showed lower photosynthetic capacity as well as lower rates of dark respiration, suggesting that both assimilation process and carbon dioxide consumption were affected by such treatments.

Several other studies have shown that under blue light, plants have higher stomatal conductance (Fraszczak *et al.*, 2016; Wang *et al*., 2015) but is not always correlated with an increase in photosynthetic efficiency and productivity (Wang *et al.*, 2009). The present study confirms the above findings since both stomatal conductance and chlorophyll content were high under the blue net compared to control, but branching and yields were lower under this net cover which could be indicative of low photosynthetic efficiency and productivity. According to Shahak (2014) even though net covers reduce the total amount of light underneath, the photoselective, light-dispersive nettings can actually increase light availability in the inner canopies and stimulate photosynthesis and productivity. Such assertion might explain the higher yield under most net covers compared to open field in this study.

5.4. Influence of Agronet Covers on Leaf Moisture Content of African Nightshade and Spiderplant

The highest leaf moisture content was obtained in plants grown under the blue net cover while plants grown in the open field had the least leaf moisture content. According to Diaz-Perez and Juan (2013), shading of crops as provided by net covers results in reduced leaf temperature and leaf transpiration without reducing net photosynthesis. Reduced leaf transpiration is attributed to reduced evaporative demand and probably explains the higher leaf water content under net covers than under open field in the present study. Abul-Soud *et al*. (2014) reported increased average relative humidity by 4-8% with the use of all net colours compared to under open field. Similarly, Elad *et al*. (2007) reported a 2-6% increase in relative 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. It is worth noting that the level of leaf moisture content varies with relative humidity under net cover. Since blue net is associated with higher relative humidity as previously mentioned, it could possibly offer an explanation for the higher leaf moisture content recorded for leaves produced under this net cover compared to the other covers.

5.5. Influence of Agronet Covers on Quality of African Nightshade and Spiderplant

Use of different agronet covers differentially influenced quality variables measured in this study. The quality variables measured were; beta-carotene, vitamin C, calcium, iron, crude fiber and total phenolic contents.

5.5.1. Influence of Agronet Covers on Beta-carotene Content of African Nightshade and Spiderplant

Higher levels of blue light favours beta-carotene biosynthesis, as well as activation of cryptochrome (photoreceptor) which is involved in carotenoid gene activation (Johkan *et al*., 2010). However, species specific response to beta-carotene biosynthesis was noted under the agronets in this study; with nightshade showing higher beta-carotene in plants grown under the white net cover while spiderplant grown in the open field had the highest beta -carotene. Similar to nightshade in the present study, Lucia *et al*. (2016) reported higher beta-carotene content in lettuce produced under white net compared to open field. Consistent with the present study, Ilic *et al*. (2014) also reported higher beta-carotene of tomato fruits grown in the open field and under white net covers compared to those grown under blue net covers.

It is well known that shading decreases carotenoids and according to Lucia *et al*. (2016). Beta- carotene is one of the most important carotenoids with pro-vitamin A activity. It is also an accessory (or antenna) pigment which assists in absorbing light for photosynthesis in regions of the spectrum where chlorophyll does poorly. Since white net cover and open field showed low chlorophyll content compared to blue, yellow and gray nets, then the accessory role would probably have been more important in this study where additional light absorption to support photosynthetic activity would have been necessary which could explain the higher beta-carotene in open field and white net cover in this study. In addition, high beta-carotene concentrations is induced by higher UV-A irradiation as stated by Zoratti *et al*. (2014) to inhibit leaf photo damage, conditions that would have been favoured under the white net cover and open field conditions in this study.

5.5.2. Influence of Agronet Covers on Vitamin C Content of African Nightshade and Spiderplant

Use of agronet covers in the present study generally reduced leaf vitamin C content relative to open field production in both vegetables. In line with the present study, Neerja *et al*. (2014) reported high ascorbic acid in tomato fruits grown in the open field than those grown under protected covers. Milenkovic *et al*. (2012) on the other hand found the highest concentration of vitamin C in peppers grown under red nets while Hamner *et al*. (1945) reported lower vitamin C content in tomato fruits produced under shade compared to fruits produced under open field conditions.

Light quality is a key factor in regulating the biosynthesis and accumulation of Vitamin C in plants. Cheng *et al*. (2007) found higher vitamin C concentration in lettuce grown under blue light and a mixture of red and blue light. Ohashi-Kaneko *et al*. (2010) also obtained significantly increased levels of vitamin C in *Lactuca sativa* and *Brassica rapa* under illumination with higher-wavelength of blue spectra which was partly attributed to the fact that illumination containing higher blue spectra can increase plant photosynthesis capacity and increase the synthesis and accumulation of hexose and D-glucose. Hexose and D-glucose are vitamin C precursors and can stimulate vitamin C synthesis via several metabolic pathways in higher plants. According to Milenkovic *et al*. (2012), despite light intensity not being essential for ascorbic acid synthesis, it may affect its synthesis and accumulation during the growth of the plant. Ascorbic acid is synthesized from photosynthesis-produced sugars (Lee and Kader, 2000) and sugar production is a function of the plant's photosynthetic rate, which, in turn, is a function of light intensity. Bergquist *et al*. (2007) added that biosynthesis of a higher concentration of ascorbic acid under higher light intensities can be linked to the participation of ascorbic acid in preventing damage of leaf cells as a result of high radiations.

Similar to findings of the present study, Li and Kubota (2009) did not observe significant influence of diversified spectral composition of light on the content of vitamin C in lettuce leaves.

5.5.3. Influence of Agronet Covers on Leaf Calcium Content of African Nightshade and Spiderplant

Net colour has a strong effect on the leaf calcium nutrient uptake through modifying the macro-climate and light spectrum under net cover (Abul- Soud, *et al*., 2014). Findings of the current study support this statement since African nightshade grown under yellow net cover exhibited significantly higher leaf calcium concentrations. Spiderplant, on the other hand, exhibited significantly high leaf calcium content under the white net while the least calcium concentration was obtained under blue net cover. Consistent with the findings of the present study, Abul- Soud, *et al*. (2014) reported higher cabbage leaf calcium contents under white net cover followed by yellow net cover, with the lowest content recorded under black net cover. According to Al-Helal and Abdel-Ghany (2010), increased uptake of calcium by white and yellow net may be due to increase in soil temperature around roots of plants, which leads to increased plant growth, and hence increasing calcium absorption and uptake. This could explain the higher calcium contents recorded in African nightshade and spiderplant under white and yellow net cover in this study.

It has been established that spectral quality may exert an influence on plant leaf mineral nutrition through related physiological processes such as stomatal control, transpiration and carbohydrate translocation in protected cultivation (Tremblay *et al*., 1988). Since calcium uptake is related to the transpiration flux (Banuelos *et al*., 1985), it would be expected that control plants in this study would show high leaf calcium concentration because the xylem flow is mainly directed to the highly transpiring leaves, and that high transpirational rate resulting from low relative humidity improves uptake and translocation of minerals in plant as suggested by Torre *et al*. (2001). However this was not the case in the present study. Since plant leaf stomatal conductance was maximized under white net and yellow net covers in spiderplant and African nightshade, respectively, it could therefore mean that high leaf calcium content in the respective net covers was due to increased leaf stomatal conductance enhanced by light spectrum depending on vegetable species. A correlation analysis in this study also reveals that leaf calcium concentration is positively correlated with leaf stomatal conductance. According to White (2012), increased stomatal conductance increases the rate of xylem volume flow and therefore increases calcium translocation. As previously mentioned, the high leaf moisture content of plants under blue net cover might have created high relative humidity within the crop growing environment in this study. It is, therefore possible that the low leaf calcium concentration of plants grown under blue net cover might be attributed to the reduced transpiration due to increased relative humidity (Gislerod *et al.*,1987) that diminishes the rate of xylem volume flow and hence calcium nutrient translocation (Roriz *et al*., 2014; White, 2012).

5.5.4. Influence of Agronet Covers on Leaf Iron Content of African Nightshade and Spiderplant

Different spectral bands can influence mineral uptake and translocation in plant tissues (Tremblay *et al.,* 1988). Schakrroeter-Zakrzewska and Kleiber (2014) reported high leaf iron content on plants subjected to blue light signifying influential role of light spectrum to plant leaf iron concentration. In the present study, the highest leaf iron content in both vegetable species was obtained from plants grown under yellow net followed by blue net cover with the least content obtained from plants in the open field.

From a physiological perspective, light stimulates iron transport to chloroplasts (Bughio *et al*., 1990) since iron is essential for the photosynthetic processes and chlorophyll production. Zheng, 2010). Roriz *et al*. (2014) also reported that soy bean plants with high iron leaf concentration concomitantly had high chlorophyll concentrations. In line with findings of the above studies, net covers in the present study that exhibited high leaf chlorophyll contents, that is yellow and blue nets, correspondingly yielded high leaf iron content. It is worth noting that light spectrum that promotes chlorophyll synthesis would concurrently promote leaf iron accumulation. A correlation analysis in this study shows that leaf iron concentration is positively correlated with chlorophyll content. Just like any other mineral, the uptake and translocation of iron is also affected by transpiration pull which is also a function of stomatal conductance. Matsui *et al*. (1981) showed that transpiration is affected by light quality in the visible range and that blue light is more effective in stimulating stomatal opening. Based on the aforementioned finding and also considering that stomatal conductance was maximized under yellow and blue net covers compared to open field in the current study, it is likely that stomatal conductance might have facilitated influx of water and concomitantly resulted into iron accumulation on the leaves.

5.5.5. Influence of Agronet Covers on Leaf Crude Fiber Content of African Nightshade and Spiderplant

Fiber is composed mainly of cellulose, hemicellulose and lignin which are the primary components of the cell wall (Van Soest, l994). Use of agronet covers irrespective of the net colour reduced leaf crude fiber content of African nightshade and spiderplant in this study. Control plants yielded the highest leaf crude fiber content while the least crude fiber content obtained in plants grown under the blue cover. In line with this study, Islam *et al*. (2009) also reported low crude fiber content of *Eryngium foetidum* L. grown under covers than in the open field. According to Santiago *et al*. (2013), plants exposed to high irradiance develop more leaf fiber as a protective mechanism to prevent damage of tissues due to high temperature and high intensity. Since use of net covers reduces light intensity compared to open field, then it would be worth noting that light intensity induced higher fiber content of the vegetable grown in the open field than those under agronet covers. Fiber content increased with time in this study, indicating that as plants mature they becomes more fibrous (Oduntan and Olaleye, 2012).

Considering that blue net cover retained more leaf moisture content in this study compared to the rest of the net covers and open field, the low fiber content recorded for leaves of vegetables grown under this net cover might have resulted from the softening of the leaf tissues.

5.5.6. Influence of Agronet Covers on Leaf Total Phenolic Content of African Nightshade and Spiderplant

Phenolic compounds constitute one of the most important groups of the bioactive compounds in food plants because they possess antioxidant properties (Zoratti *et al*, 2014). Although numerous studies have investigated the effect of light quality on phytochemical accumulation in plants, the results vary depending on plant species (Dou *et al*., 2017; Changhoo *et al*., 2015; Dong *et al*., 2013). Li and Kubota (2009) reported that the total phenolic content in leaf lettuce increased with red light and supposes that the increase in cytokinins levels generated by red light stimulated the synthesis of phenolic compounds. Johkan *et al*. (2010) found that high total phenolic content was induced by blue light in red leaf lettuce seedlings. However the total phenolic content in buckwheat sprouts did not significantly differ under red and blue light conditions (Lee *et al*. 2014).

According to Kadomura-Ishikawa *et al*. (2013) biosynthesis of phenolics is enhanced by supplementation with blue, UV-A, or UV-B light via activation of cytochrome-mediated responses. Moreover, blue light causes the induction of genes that regulate the expression of phenylalanine ammonialyase (PAL) (Meng *et al*., 2004). PAL is a key enzyme in the secondary metabolic pathway of phenolics, and the high contents of total phenolics can be related to the hight activity of this enzyme (Ghasemzadeh, 2011). Based on this, blue agronet cover used in the current study should have yielded higher total phenolics but it significantly reduced total phenolic content compared to open and white net cover. Consistent with the current study, Fernandez *et al*. (2016) also reported higher phenolic content of *Physalis peruviana* grown under white cover compared to blue, red, black and open field conditions. Similarly, Mashabela *et al*., (2015) also reported higher content of phenolic contents in pepper fruits grown under white net compared to open field and red nets. The synthesis of phenolics in plants is also triggered when plants are under stress factors such as high temperature and water deficit (Xie, 2002). Since blue net cover increased the leaf moisture content, probably plants faced least moisture deficit which could not induce excessive phenolic production compared to white net and open field conditions. UV light is more effective in optimizing the concentration of phenolic compounds than other types of light, partly because phenolic compounds have a strong capacity for UV radiation absorption and increasing their concentration can protect plants from photo-damage (Schreiner, 2012). Thines *et al*. (2007) and Izaguirre *et al*. (2007) also reported that increased UV-A increased total phenolics in sagebrush and nicotiana species. According to Zoratti *et al*, (2015) and Shahak, (2008), use of white net cover increases the ultra violet A (UV-A) component of the radiation compared to open field conditions, while blue, black and red nets tend to screen the UV-A radiation from reaching the crops. Such affirmation might help explain the reason for higher phenolic content recorded in the vegetables grown under white net and open field in the present study.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

Based on the findings, it can be concluded that;

1. Use of different agronet covers influences physiology and growth of both African nightshade and spiderplant. Use of blue net delays flowering time while yellow covers promotes vegetative branching, leaf chlorophyll content and stomatal conductance of the vegetables.
2. Use of different agronet covers influences yield of both African nightshade and spiderplant. Use of yellow net cover produces highest total leaf yield while blue cover reduces total leaf yield.
3. Use of agronet covers influences leaf nutritive quality of both African nightshade and spiderplant. Use of yellow net improves leaf calcium and iron content. Use of white net cover improves leaf beta carotene and vitamin C content in both vegetables. Use of blue net reduces leaf vitamin C, calcium, fiber and total phenolic content compared to open field conditions and other net colours.

6.2. Recommendations

Based on the results of this study, the following recommendations can be made;

1. Production of both African nightshade and spiderplant can be enhanced by the use of yellow net especially in agro-ecological zones similar to the current study area since it promoted total leaf yield and also enhanced nutritive quality such as leaf calcium and iron contents which play integral part in the health of humans.
2. Since blue net delays flowering and subsequently prolong vegetative phase while yellow net promotes production of more numbers of branches which contribute to higher leaf yield, then studies combining use of blue and yellow net covers at predetermined growth stages would be useful.
3. Although, use of yellow net resulted into higher yield, a cost benefit analysis study should be done to assess whether the additional yield and nutritive benefits obtained from the use of yellow net would be economically viable.

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APPENDICES

Appendix A: Samples of ANOVA Tables

i). Effect of Agronet Covers on Plant Height of African Nightshade ANOVA at 13 WAP.

Source	df	Type III SS	MSE	F Value	P>F
		Trial 1			
Total	14	1657.67			
Block	2	467.84	233.92	6.40	0.0219
Cover	4	897.33	224.33	6.14	0.0147
Error	8	292.50	36.56		
Coefficient of variation = 7.31					
		Trial 2			
Total	14	1786.84			
Block	2	82.91	41.45	0.85	0.4629
Cover	4	1313.54	328.39	6.73	0.0113
Error	8	390.39	48.80		
Coefficient of variation = 7.96					

ii). Effect of Agronet Covers on Plant Height of Spiderplant ANOVA at 13 WAP.

Source	df	Type III SS	MSE	F Value	P>F
		Trial 1			
Total	14	3592.15			
Block	2	2473.73	1236.86	18.39	0.0010
Cover	4	580.23	145.058	2.16	0.1649
Error	8	538.19	67.27		
Coefficient of variation = 14.13					
		Trial 2			
Total	14	5557.933333			
Block	2	664.008333	332.004	1.74	0.2363
Cover	4	3365.141667	841.285	4.40	0.0357
Error	8	1528.783333	191.09797		
Coefficient of variation = 19.49					

iii). Effect of Agronet Covers on Number of Primary Branches of African Nightshade ANOVA at 13 WAP.

Source	df	Type III SS	MSE	F Value	P>F
		Trial 1			
Total	14	97.15			
Block	2	57.42	28.71	10.20	0.0063
Cover	4	17.20	4.30	1.53	0.2825
Error	8	22.53	2.82		
Coeffeicient of variation = 12.36					
		Trial 2			
Total	14	30.308			
Block	2	5.01	2.501	1.30	0.3244
Cover	4	9.89	2.47	1.28	0.3527
Error	8	15.41	1.93		
Coefficient of variation = 12.89					

iv). Effect of Agronet Covers on Number of Primary Branches of Spiderplant ANOVA at 13 WAP

Source	df	Type III SS	MSE	F Value	P>F
				Trial 1	
Total	14	162.98			
Block	2	40.76	20.38	6.11	0.0245
Cover	4	95.52	23.88	7.16	0.0094
Error	8	26.70	3.34		
Coefficient of variation = 16.79					
				Trial 2	
Total	14	48.61			
Block	2	7.66	3.83	2.61	0.1337
Cover	4	29.33	7.31	4.99	0.0258
Error	8	11.72	1.46		
Coefficient of variation =	10.63				

v). Effect of Agronet Covers on Days to First Flowering of African Nightshade ANOVA

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	300.93			
Block	2	1.733	0.87	0.54	0.6047
Cover	4	286.27	71.57	44.27	<.0001
Error	8	12.93	1.62		
Coefficient of variation = 1.42					
			Trial 2		
Total	14	163.33			
Block	2	17.73	8.87	0.63	0.5580
Cover	4	32.67	8.17	0.58	0.68
Error	8	112.93	14.117		
Coefficient of variation = 4.19					

vi). Effect of Agronet Covers on Days to First Flowering of Spiderplant ANOVA

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	1052.93			
Block	2	1.73	0.866	0.23	0.7964
Cover	4	1021.60	255.4	69.03	<.0001
Error	8				
Coefficient of variation = 4.59					
			Trial 2		
Total	14	172.00			
Block	2	17.20	8.60	2.93	0.1109
Cover	4	131.33	32.83	11.19	0.0023
Error	8	23.47	2.93		
Coefficient of variation = 3.81					

vii). Effect of Agronet Covers on Stomatal Conductance of African Nightshade ANOVA at 13 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	439.13			
Block	2	1.30	0.651	0.02	0.979
Cover	4	188.14	47.036	1.51	0.288
Error	8	249.69	31.21		
Coefficient of variation = 6.05					
			Trial 2		
Total	14	3242.42			
Block	2	173.33	86.66	0.81	0.477
Cover	4	2215.86	553.96	5.19	0.023
Error	8	853.24	106.65		
Coefficient of variation = 9.77					

viii). Effect of Agronet Covers on Stomatal Conductance of Spiderplant ANOVA at 13 WAP.

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	3250.14			
Block	2	783.41	391.71	2.36	0.1568
Cover	4	1136.84	284.21	1.71	0.2402
Error	8	1329.89	166.24		
Coefficient of variation = 14.86					
			Trial 2		
Total	14	404.66			
Block	2	79.36	39.68	3.38	0.0864
Cover	4	231.32	57.83	4.92	0.0268
Error	8	93.97	11.74		
Coefficient of variation = 4.92					

ix). Effect of Agronet Covers on Chlorophyll a of African Nightshade ANOVA at 13 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	75846058.20			
Block	2	2111687.31	1055843.65	0.39	0.69
Cover	4	52119301.94	13029825.49	4.82	0.02
Error	8	21615068.95	2701883.62		
Coefficient of variation = 17.09					
			Trial 2		
Total	14	25897266.35			
Block	2	645427.67	322713.84	0.27	0.769
Cover	4	15765518.59	3941379.65	3.32	0.069
Error	8	9486320.09	1185790.01		
Coefficient of variation = 12.36					

x). Effect of Agronet Covers on Chlorophyll a of Spiderplant ANOVA at 13 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	6229570698			
Block	2	825170727	412585364	0.96	0.4214
Cover	4	1983131017	495782754	1.16	0.3963
Error	8	342126953	427658619		
Coefficient of variation = 14.6					
			Trial 2		
Total	14	53668934.37			
Block	2	4051438.08	2025719.04	0.86	0.4594
Cover	4	30740629	7685157.29	3.29	0.0729
Error	8	18876866.93	2359608.37		
Coefficient of variation = 14.10					

xi). Effect of Agronet Covers on Chlorophyll b of African Nightshade ANOVA at 13 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	177503504.1			
Block	2	2998944.0	1499472.0	0.18	0835
Cover	4	109297418.3	27324354.6	3.35	0.006
Error	8	65207141.8	8150892.7		
Coefficient of variation = 23.049					
			Trial 2		
Total	14	64925498.87			
Block	2	6867975.99	3433988.00	1.31	0.322
Cover	4	37099528.91	9274882.23	3.54	0.060
Error	8	20957993.97	2619749.25		
Coefficient of variation = 26.43					

xii). Effect of Agronet Covers on Chlorophyll b of Spiderplant ANOVA at 13 WAP.

Source	Df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	34318543.59			
Block	2	358878.61	179439.31	0.29	0.7593
Cover	4	2892748.17	7231187.04	11.49	0.0021
Error	8	5034916.81	629364.60		
Coefficient of variation = 17.298					
			Trial 2		
Total	14	98236039.77			
Block	2	709146.15	354573.07	0.41	0.6770
Cover	4	90602756.00	22650689.00	26.17	0.0001
Error	8	6924137.62	865517.20		
Coefficient of variation = 14.45					

xiii). Effect of Agronet Covers on Yield of African Nightshade ANOVA

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	36793413.69			
Block	2	9195591.376	4597795.69	1.91	0.209
Cover	4	8381911.158	2095477.79	0.87	0.521
Error	8	19215911.16	2401988.89		
Coefficient of variation = 16.31					
			Trial 2		
Total	14	167852276.2			
Block	2	23356668.37	11678334.18	1.69	0.245
Cover	4	89095607.88	22273901.97	3.22	0.008
Error	8	55399999.9	6925000.0		
Coefficient of variation = 13.78					

xiv). Effect of Agronet Covers on Yield of Spiderplant ANOVA

Source	Df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	254819597.1			
Block	2	126850424.8	63425212.4	4.94	0.040
Cover	4	25359749.9	6339937.5	0.49	0.00741
Error	8	102609422.5	12826177.8		
Coefficient of variation = 25.37					
			Trial 2		
Total	14	66859844.39			
Block	2	14938829.08	7469414.54	2.12	0.1825
Cover	4	23733364.41	5933341.10	1.68	0.02457
Error	8	28187650.89	3523456.36		
Coefficient of variation = 20.32					

xv). Effect of Agronet Covers on Leaf Moisture Content of African Nightshade ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	70.62			
Block	2	10.75	5.38	2.47	0.1464
Cover	4	42.43	10.61	4.87	0.0276
Error	8	17.43	2.18		
Coefficient of variation = 1.70					
			Trial 2		
Total	14	50.50			
Block	2	2.28	1.14	0.67	0.5364
Cover	4	34.70	8.68	5.14	0.0239
Error	8	13.52	1.69		
Coefficient of variation = 1.48					

xvi). Effect of Agronet Covers on Leaf Moisture Content of Spiderplant ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	174.94			
Block	2	3.36	1.68	0.32	0.7350
Cover	4	129.55	32.39	6.17	0.0145
Error	8	42.03	5.25		
Coefficient of variation = 2.68					
			Trial 2		
Total	14	145.82			
Block	2	7.92	3.96	4.31	0.0536
Cover	4	130.55	32.64	35.53	<.0001
Error	8	7.35	0.92		
Coefficient of variation = 1.13					

xvii). Effect of Agronet Covers on Beta-carotene of African Nightshade ANOVA at 13 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	709681.86			
Block	2	3788.5311	1894.2656	0.52	0.6155
Cover	4	676528.46	169132.11	46.08	<.0001
Error	8	29364.87	3670.61		
Coefficient of variation = 5.43					
			Trial 2		
Total	14	610892.87			
Block	2	94903.2554	47451.63	2.76	0.1224
Cover	4	378577.96	94644.49	5.51	0.0198
Error	8	137411.66	17176.46		
Coefficient of variation = 16.74					

xviii). Effect of Agronet Covers on Beta-carotene of Spiderplant ANOVA at 13 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	354956.35			
Block	2	1304.67	652.34	0.17	0.8461
Cover	4	323080.26	80770.06	21.14	0.0003
Error	8	30571.40	3821.43		
Coefficient of variation = 6.27					
			Trial 2		
Total	14	696257.49			
Block	2	132227.11	66113.55	15.99	0.0016
Cover	4	5309454.70	132738.68	32.11	<.0001
Error	8	33075.67	4134.46		
Coefficient of variation = 5.51					

xix). Effect of Agronet Covers on Vitamin C of African Nightshade ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	23756.89			
Block	2	2238.71	1119.36	0.89	0.4460
Cover	4	11508.96	2877.24	2.30	0.147
Error	8	10009.21	1251.15		
Coefficient of variation = 15.28					
			Trial 2		
Total	14	40180.00			
Block	2	1699.15	849.58	0.58	0.0324
Cover	4	26774.49	6693.62	4.57	0.0324
Error	8	11706.37	1463.30		
Coefficient of variation = 24.17					

xx). Effect of Agronet Covers on Vitamin C on Spiderplant ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	22834.14			
Block	2	2696.26	1348.13	0.86	0.4603
Cover	4	7541.58	1885.39	1.20	0.382
Error	8	12596.30	1574.54		
Coefficient of variation = 17.58					
			Trial 2		
Total	14	19926.91			
Block	2	580.79	290.40	0.71	0.5187
Cover	4	15830.40	3957.60	9.72	0.0037
Error	8	3256.43	407.05		
Coefficient of variation = 9.42					

xxi). Effect of Agronet Covers on Leaf Calcium Content of African Nightshade ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	607.74			
Block	2	4.99	2.50	0.27	0.7727
Cover	4	527.73	131.93	14.07	0.0011
Error	8	75.01			
Coefficient of variation = 22.09					
			Trial 2		
Total	14	27.02			
Block	2	5.83	2.92	2.18	0.1750
Cover	4	10.51	2.63	1.97	0.1925
Error	8	10.68	1.34		
Coefficient of variation = 16.80					

xxii). Effect of Agronet Covers on Leaf Calcium Content of Spiderplant ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	2020.71			
Block	2	64.32	32.16	5.47	0.0318
Cover	4	1909.37	477.34	81.21	<.0001
Error	8	47.02	5.88		
Coefficient of variation = 22.09					
			Trial 2		
Total	14	104.14			
Block	2	0.263	0.132	0.14	0.868
Cover	4	96.53	24.13	26.28	0.0001
Error	8	7.35	0.918		
Coefficient of variation = 17.65					

xxiii). Effect of Agronet Covers on Leaf Iron Content of African Nightshade ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	1479.81			
Block	2	35.93	17.963	0.93	0.4330
Cover	4	1289.54	322.38	16.71	0.0006
Error	8	154.35	19.29		
Coefficient of variation = 20.86					
			Trial 2		
Total	14	3250.00			
Block	2	362.88	181.44	2.92	0.1118
Cover	4	2389.54	597.39	9.60	0.0038
Error	8	497.58	62.20		
Coefficient of variation = 18.13					

xxiv). Effect of Agronet Covers on Leaf Iron Content of Spiderplant ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	1127.73			
Block	2	32.24	16.12	0.86	0.4601
Cover	4	944.96	236.24	12.55	0.0016
Error	8	150.53	18.82		
Coefficient of variation = 21.95					
			Trial 2		
Total	14	4050.38			
Block	2	180.40	90.201	0.57	0.5851
Cover	4	2611.79	652.947	4.15	0.0413
Error	8	1258.19	157.27		
Coefficient of variation = 27.35					

xxv). Effect of Agronet Covers on Leaf Fiber Content of African Nightshade ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	1.860			
Block	2	0.100	0.050	2.14	0.1789
Cover	4	1.573	0.393	16.86	0.0006
Error	8	0.1867	0.0233		
Coefficient of variation = 4.63					
			Trial 2		
Total	14	1.76			
Block	2	0.15	0.075	3.21	0.1798
Cover	4	1.600	0.400	17.01	0.0007
Error	8	0.870	0.0233		
Coefficient of variation = 4.793					

xxvi). Effect of Agronet Covers on Leaf Fiber Content of Spiderplant ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	2.049			
Block	2	0.201	0.1007	1.26	0.3342
Cover	4	1.2093	0.3023	3.79	0.0516
Error	8	0.6387	0.0798		
Coefficient of variation = 7.23					
			Trial 2		
Total	14	3.04			
Block	2	0.401	0.2007	2.294	0.3342
Cover	4	1.6104	0.4026	4.60	0.0501
Error	8	0.7	0.0875		
Coefficient of variation = 7.448					

xxv). Effect of Agronet Covers on Leaf Phenolic Content of African Nightshade ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	267.71			
Block	2	0.833	0.4167	0.02	0.9765
Cover	4	127.16	31.79	1.82	0.02183
Error	8	139.72	17.465		
Coefficient of variation = 7.259					
			Trial 2		
Total	14	206.78			
Block	2	1.26	0.63	0.03529	0.9765
Cover	4	135.7	33.925	1.9006	0.0227
Error	8	142.8	17.85		
Coefficient of variation = 9.24					

xxvi). Effect of Agronet Covers on Leaf Phenolic Content of Spiderplant ANOVA at 15 WAP

Source	df	Type III SS	MSE	F Value	P>F
			Trial 1		
Total	14	579.73			
Block	2	2.533	1.266	0.29	0.7588
Cover	4	541.73	135.43	30.55	<.0001
Error	8	35.47	4.43		
Coefficient of variation = 3.168					
			Trial 2		
Total	14	614.2			
Block	2	3.56	1.78	0.34479	0.767
Cover	4	586.98	146.745	28.42	<.0001
Error	8	41.3	5.1625		
Coefficient of variation = 3.73					

Appendix B. Published Article

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Different Agronet Covers Influence Physiological Traits, Growth and Yield of African Nightshade (*Solanum scabrum* Mill.) and Spiderplant (*Cleome gynandra* L.)

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ABSTRACT

African indigenous leafy vegetables (AILVs) contribute significantly to improved nutrition, food security and income. However, the potential to meet the growing demand for AILVs in Kenya has not been satisfied. This study was conducted between August, 2015 and April, 2016 to evaluate the effect of different agronet colours on growth and yield of African nightshade and spiderplants. The experiment was a 2x5 factorial laid on a randomized complete block design (RCBD), with three replications. Factors under study were vegetable types (African nightshade and spiderplant) and net covers (white, gray, blue, yellow net and open field). Spiderplant seeds were direct seeded and later thinned to a spacing of 30 cm by 30 cm. African nightshade seeds were started in the nursery and later transplanted five weeks after sowing. From the 7th weeks after planting (WAP) and at two weeks interval, plant height, primary branches, stomatal conductance, chlorophyll and leaf fresh yield were determined. Use of blue net significantly yielded taller plants of African nightshade (29.6%) compared to those in the open field by 13 WAP. Spiderplant were taller under white net (20.7%) and shorter under blue net (20.95%) compared to open field by 13 WAP. Yellow and white net enhanced primary branching of African nightshade and spiderplant, respectively while blue net exhibited the least for both vegetables. Days to first and 50% flowering was delayed under blue net by 13 and 6 days compared to control for spiderplant and African nightshade, respectively. Yellow and white net improved stomatal conductance for African nightshade and spiderplant, respectively. Regarding chlorophyll content, yellow and blue net had the highest concentration of chlorophyll a and b for both vegetables. Use of yellow net improved total fresh leaf yield by 15.82% and 12.42% compared to open field for African nightshade and spiderplant, respectively. Blue net significantly reduced total yield compared to open field for both vegetables. This study shows blue net cover has the potential to prolong the vegetative phase of these crops hence longer harvesting time of these crops and that yellow net has a greater potential to be used for production of African nightshade and spiderplant. However, a cost benefit analysis study should be done to assess the beneficial effect of yellow net over open field.

Keywords*: African leafy vegetables; protected cultivation; light quality; phytochrome; cryptochromes; chlorophyll.*

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