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Full Length Research Paper

Effect of three covering materials on vegetative growth of cucurbits in Kenya.

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Different covering materials were compared at Jomo Kenyatta University of Agriculture and Technology, Juja in Kenya (1^{o} 5' S latitude, 37^{o} 1' E longitude and 1520m above sea level) on their effect on vegetative growth of cucurbits. Three structures equivalent of main treatments each having ventilation gaps were covered with 50% shade net (T_1); glass (T_2) and UV stabilized plastic sheet (T_3) materials respectively were used. The sub treatments were cucurbits family; cucumber and butternut respectively. In each structure twelve pots were placed, six of each crop type. The experiment was laid out as a random complete block design and replicated three times, each replication consisting of two pots. Dry bulb temperature was highly significant in all the treatments with plastic house having the highest mean temperature of 33.83^{o}c followed by glass house with 32.5^{o}c and shade house with 30^{o}c respectively while the wet bulb temperature was not significantly different at $p<0.05$. The relative humidity in all the treatments was not significantly different at $p<0.05$ although plastic house had the highest RH of 91.5%, followed by shade house with 90.5% and glass house with 80%. There were significant differences in weeks 3, 6, 7 and 8 for plant height but no significant influence with the type of covering material. However, shade house treatment dominated cumulatively in plant height. Glasshouse treatment yielded most leaves in week 4 for cucumber, weeks 6 and 7 for butternut and week 8 for both butternut and cucumber. Solar rays were more direct to the plant in shade house than in glasshouse or plastic house. There was a positive correlation between light intensity and leaf area (r=0.1) showing that for every unit increase in light intensity, the leaf area increased by 0.1. Considering the temperature and relative humidity variables and the direct effect of solar rays in the shade house coupled with plant height pa rameter, shade house is an appropriate structure for cucurbit production in a tropical climate.

Keywords: Protected cultivation, cucurbitaceae, growth, Kenya

INTRODUCTION

In Kenya, the vegetable sub – sector is important in attaining food security and improving livelihood for smallholder farmers. Smallholders produce 100% of African Leafy Vegetables (ALVs) and up to 70% of the Exotic and Asian vegetables (HCDA, 2013). The production of vegetable crops under structures covered with materials commonly referred to as protected cultivation is gaining popularity in Kenya. Protected cultivation is the production of crops under sheltered structures covered with such materials as glass, plastic films or shade screens (saran cloth) which create a specialized climate inside the structure. Protected cultivation of vegetable crops suitable for domestic and export purposes could be a more efficient alternative for land use and other resources, improve yield, quantity and quality (Sanwal et. al., 2004; Ganesan, 2004). However, the profitability in protected cultivation depends upon the choice of structures, selection of crops/ varieties, production technology and market price.

Changes in the microclimate inside the structures result in modification of plant growth and development and also incidence of fungal diseases (Beckmann *et al*., 2006; Scaranari *et al*., 2008; Chavarria *et al*., 2009). In one study, interactions between protected environments and different cucumber hybrids were evaluated by Costa et al., (2010) and found that the seedling growth and dry biomass was affected by the growing environments. In greenhouse tomato production, Gent (2007) found that the use of the screen with 50% shading increased commercial fruit production by 9% compared to the environment without the screen. Comparisons between aluminized shade screens with 40, 50 and 60% shading and polyethylene plastic film painted with lime on tomato production showed that the screens minimize energy consumption during periods of low temperatures (Fernandez-Rodriguez et al., 2001). In acclimatized environment with evaporative cooling, Costa and Leal (2008) found greater accumulation of leaf biomass and greater leaf area of strawberry plants than in non acclimatized environments, regardless of the season. Shading with 40% shade net was beneficial for lettuce production (Queiroz et al., 2009).

Cucumber and butternut are members of the cucurbitaceae family. The potential for increased production is immense for these cucurbit crops in the on – going rehabilitation and expansion of irrigation schemes in arid and semi – arid counties in Kenya. In the present scenario of perpetual demand for vegetables and drastically shrinking land holdings, protected cultivation is the best alternative for using land and other resources more efficiently. There is an urgent need to assess the suitability of different covering materials for cultivation of vegetables to meet the growing demand. This study investigated the effect of shade net, plastic and glass covering materials on vegetative growth of cucurbits.

MATERIALS AND METHODS

Different covering materials were compared for their effect on vegetative growth of cucurbits at Juja, Kenya during the periods between 26th June 2013 and 14th May 2014. The farm is located at 1^{o} 5' S latitude, 37^{o} 1' E longitude and 1520m above sea level. Three structures each having ventilation gaps were covered with 50% shade net; glass film and UV stabilized plastic sheet materials respectively. The soil media used was a cocktail of garden soil, manure and sand mixed in the ratio of 3:2:1 and put into poly tubes measuring 19cm in diameter and 21cm height. Five (5) gms of Diammonium phosphate (DAP) was placed in the soil media per pot, thoroughly mixed then watered. Seeds of butternut pumpkin (Curcubita *moschata*) variety 'squash' and cucumber (Cucumis *sativus*) variety 'Ashley' were sown in thirty six pots; eighteen pots of each crop. The poly tubes were then left in the open field for the seeds to germinate which took approximately seven days before being transferred to the protective structures. Each structure contained six pots of butternut and six of cucumber giving a total of twelve pots. The treatments were thus;

T_1 – Shade house which was fully covered with 50% shade net with the door kept open for ventilation during day time

T_2- The glasshouse consisted of the entire roof and four sides covered with glass but the sides alternated with glass and wire mesh.

T_3 – The plastic house was made up of the four sides and the roof covered with polyethylene film with side ventilation

In each structure, the experiment was laid out as a randomized complete block design and replicated three times. Each replication consisted of two pots. Standard cultural practices for cucurbit production were followed.

Data taking and Analysis

Data for solar radiation was taken using a luximeter while humidity and temperature data were taken using a wet and dry thermometer (Figure 1 and 2). The side for measuring temperature was kept wet everyday by adding water in the container with the wick. Plant height was taken using a ruler and physical counting of leaves was done to determine the number of leaves per plant. Leaf size was determined by measuring the leaf lamina horizontally and vertically thus the leaf area was obtained by multiplying the horizontal and then vertical measurements of the leaf lamina. Horizontal measurements entailed measuring the widest parts of the leaf lamina and vertical measurements were obtained by measuring from the tip of the leaf to where the leaf stalk joined the lamina. Data collected was entered into Microsoft spreadsheets and subjected to computer statistical analysis using Genstat VSN International version 14.

RESULTS

Temperature

Dry bulb temperature was highly significant in all the treatments with plastic house having the highest mean temperature of 33.83^{o}c followed by glass house with 32.5^{o}c and Shade house with 30^{o}c respectively at $p<0.05$(Table 1). Similarly, the wet bulb temperature was significantly different for all the treatments. Nevertheless, plastic house still had the highest mean temperature of 32.5^{o}c followed

Figure 1. Luximeter

Figure 2. Wet and dry bulb thermometer

Table 1. Means of the Wet and dry bulb temperature (°c), Luxmeter (Lux) and relative humidity (RH) for the three treatments

Treatment	Wet°c	Dry°c	RH(%)	Lux
Shade house	26c	30b	90.5a	440a
Glass house	29.33b	32.5c	80a	306b
Plastic house	32.5a	33.83a	91.5a	251c
Grand mean	29.28	32.11	87.2	333
CV%	11.5	3.6	15.2	19.4
L.S.D	4.13	1.4	16.32	79.2

Means with the same letters are not significant at $p< 0.05$

by glass house with 29.33°c and Shade house with 26°c, respectively.

Light intensity

The luxmeter readings in all the treatments was significantly different at $p<0.05$ with the highest light intensity being in shade house (440 lux) and the lowest was in plastic house (251 lux) (Table 1).

Relative humidity

The relative humidity in all the treatments was not significantly different at $p<0.05$ although plastic house had the highest relative humidity of 91.5%, followed by shade house with 90.5% and glass house with 80% (Table 1). In the glasshouse treatment there were cases of blights on leaves and the fruit that formed aborted due to fungal infection (Figure. 3).

Plant height

There were significant differences within varieties in weeks 3, 6, 7 and 8 but there were no significant differences with the type of covering material. Interaction between Variety and treatment was not significant in all the weeks (Figure. 4). Butternut dominated in height in shade house treatment in week 3 and glasshouse in weeks 6, 7 and 8. Cucumber was the tallest in week 4 only although shade house

Figure 3. Butternut leaf affected with blight

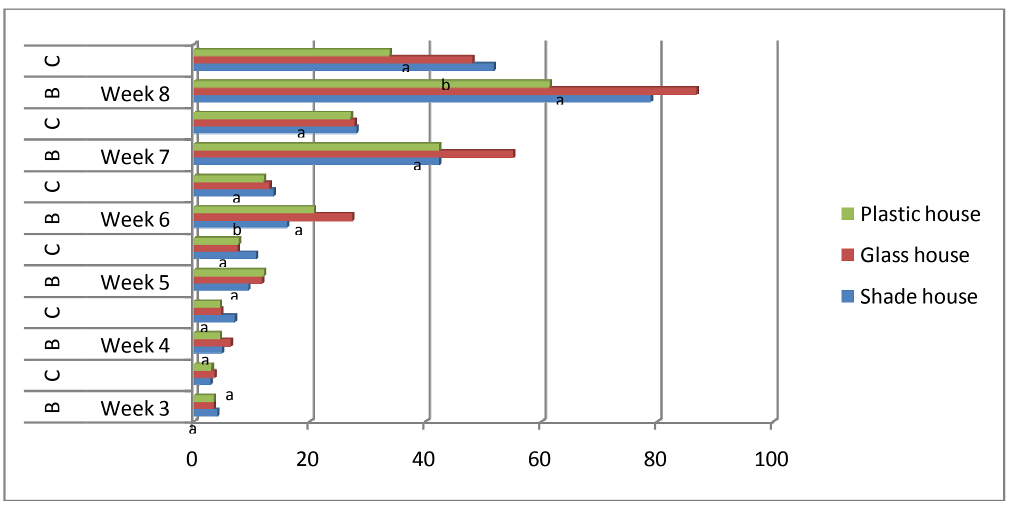

Figure 4. The influence of covering material on plant height increase from week3 to week 8
Means with the same letters are not significantly different at p<0.05

treatment dominated in all the weeks with 2.83, 7, 10.67, 13.7, 28 and 51cm, respectively.

Number of leaves

There were significant differences within the varieties of cucurbits in all the treatments as the number of weeks increased at P<0.05(Figure 5). But there were no significant differences within the treatments at week level. Butternut had the highest number of leaves from week 3 to week 7 in all the treatments while cucumber had the highest number of leaves in all the treatments in week 8. Glasshouse treatment yielded most leaves in week 4 for cucumber; weeks 6 and 7 for butternut and week 8 for both butternut and cucumber (Figure 5).

Leaf area

There was a positive correlation between light intensity and leaf area (r=0.1) showing that for every unit increase in light intensity, the leaf area increased by 0.1(Figure 6). Increase in leaf area directly affected plant growth and hence plant height.

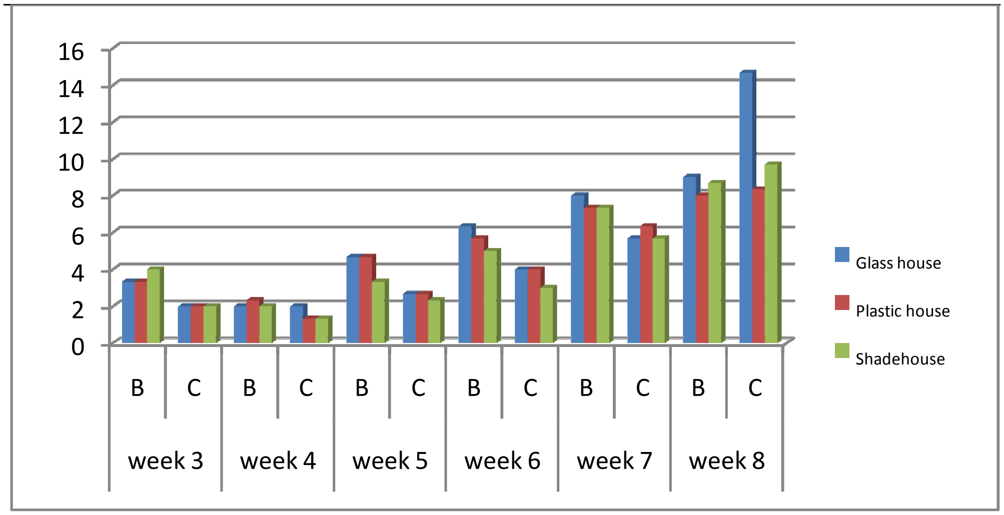

Figure 5. The number of leaves per treatment from week 3 to week 8

Key: B- Butternut
C-Cucumber

DISCUSSION

Among environmental factors, light intensity, temperature and relative humidity influence crop growth and development in protected cultivation (Rajasekar et. al. 2013). The influence of environmental variables; temperature, relative humidity and light intensity under different covering materials were studied. The temperature in the plastic house was the highest probably due to the thermal transmissivity characteristics of plastic film. Despite plastic house treatment having significant temperatures above shade house and glasshouse respectively, dry matter accumulation that could have resulted into significant plant height was not achieved. This could be explained probably due to the fact that high temperatures which could have slowed down the cell metabolic activities thus lowering the growth rate. Similar studies with radish (*Raphanus sativus* L.) showed that higher temperatures had more adverse influence on net photosynthesis than lower temperatures leading to decreased production of photosynthates (Reddy et. al. 1999). Solar rays were more direct to the plants in shade house than in glass house or plastic house. In plastic house the light was more diffused and opaque as compared to the other two treatments. Despite the Shade house obtaining on average higher light intensity than other treatments (glasshouse and plastic house), the growth rate determined by plant height in this case was not significant.

A high relative humidity on the one hand encourages fungal diseases (Figure 3), because under fluctuating temperatures and sharply increasing evaporation during the first morning hours, condensation can easily occur on the crop creating the ideal conditions for fungal spores to germinate rapidly. A high relative humidity can also cause a crop to weaken and become more susceptible to changes in the weather. High relative humidity could have contributed to slower growth rate because the air was almost at the saturation point and thus the respiration rate was slowed down. If the respiration rate is slowed down, there's accumulation of photosynthates within the tissues thus this also leads to lower photosynthetic rate and hence slower growth rate. This explains the reason why there were lower number of leaves in this treatment as compared with glasshouse and shade house (Figure 5) and also lower leaf area despite the high light intensity (Figure 6). Cucumber did not exhibit significant differences in the treatments applied. Shade house treatment dominated cumulatively in plant height because of its optimal temperature of 26^{o}c, high relative humidity of 90.5% and high light intensity that supported growth and development. This observation supports the findings of Marcelis and Baan Hofman – Eijer (1993) which indicated that cucumber require more light intensity and high temperatures for better growth and development. A larger leaf area signified a larger proportion for light interception and since light is the critical energy for photosynthesis, the more the light translates to more photosynthates. These results agree with Papadopoulos and Omrod (1991) that higher leaf area increases leaf physiology and number of stomata and thus photosynthesis. This therefore leads to faster and higher growth rate as is the case in glasshouse (Figure 3). The higher the photosynthetic rate, the faster the phenological events taking place in a plant thus also the better the quality of the plant. Therefore this also could have caused the glasshouse treatment which had a lux of 306 (Table 1) to have the highest number of leaves (Figure 5).

Ultimately, this study revealed that the prospect of cucurbits cultivation under shade house is promising. Other structures could also be used but only with sufficient ventilation to regulate the temperature and the humidity. In conclusion, the best protective covering for production of cucurbits and generally vegetables in areas of high temperatures and light intensity could be the Shade net. However, varietal interaction with the type of cover used needs investigation.

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