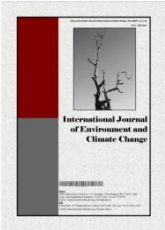

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Effect of aging of Cladding Material on Crop Yield under Greenhouse Cultivation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Agriculture is the basis of our economic activity. For improving agricultural production greenhouse technology was developed to prevent adverse climatic conditions. Even though higher yield and profit were obtained from greenhouse production compared to open field cultivation farmers were not satisfied with this technique due to the drastic reduction of crop yield with the aging of cladding material. To test this, an experiment was conducted in the instructional farm of Kelappaji College of Agricultural Engineering and Technology (KCAET), Tavanur, Kerala during the period from April to June 2021. Amaranthus variety CO1 was planted inside two greenhouses where one is having cleaned cladding material and the other is an old one. Microclimatic parameters and the biometric observations of crop in both conditions were compared. Mean monthly values of temperature and light intensity were higher inside the cleaned greenhouse than the old one while relative humidity was higher inside the old greenhouse. Crop growth parameters were higher inside the cleaned greenhouse than the old one except the internodal length. From this study, it was clear that the aging of cladding material has a significantly higher influence on crop performance under greenhouse.

Keywords: Greenhouse; cladding material; amaranthus variety CO1; crop performance.

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1. INTRODUCTION

Greenhouse technology is the technique of providing suitable environmental conditions to the crop. This is having so many advantages such as off-season production of vegetable and fruit crops, high-quality disease-free organic products but so many constraints also [1]. The property of cladding material and its aging have wide influences on the microclimate inside the greenhouse. Cleaning of cladding material improved the light transmissivity from 36 to 85% [2], and dropwise condensation on cladding surface reduce the solar transmission by 13% [3] Dust accumulation and whitening have a detrimental effect on microclimate and crop yield under greenhouse (Mashonjowa *et al*., 2009) while photo-selective shade netting integrated with greenhouse technology and improved the performance of vegetable crop under greenhouse [4]. In addition to that natural aging of cladding material affects the microclimate inside the greenhouse [5]. Thus, the study aims to evaluate the effect of the aging of cladding material on crop yield.

2. MATERIALS AND METHODS

An experimental research was conducted at KCAET Tavanur, Kerala Agricultural University in 2021 from April to June. The location receives an annual rainfall of 2904 mm and the experimental area lies between 10◦51'18'' N Latitude and 75◦59'11'' E Longitude at an altitude of 8.54 m above mean sea level. Two greenhouses are located in the instructional farm of KCAET identical in all aspects except in case of cladding material. 200 micron UV stabilized polyethylene film is used as cladding material, one having cleaned cladding material and the other having old one. The Amaranthus variety CO1 was planted inside both greenhouses located in the same region at an area of 50 m^2each. Dry and wet bulb thermometers were used to record the air temperature and relative humidity and also the Lux meter was used to record the light intensity inside both greenhouses and outside. These climatic parameters were recorded from planting to harvesting of Amaranthus variety. All the cultural practices were done according to the Package of Practices Recommendations of

Fig. 1. Cleaning of naturally ventilated greenhouse

Fig. 2. Crop stand in cleaned greenhouse

Fig. 3. Crop stand in greenhouse without cleaning

Kerala Agricultural University (KAU). Plant growth parameters and yield parameters such as plant height, number of branches, number of leaves, internodal length, and average yield per plant were recorded for both greenhouses.

3. RESULTS AND DISCUSSION

The mean monthly temperature at 8 am, 12 pm, and 4 pm during April to June were found to be higher inside the cleaned greenhouse than the old greenhouse. The maximum temperature (43°C) was recorded at 12 pm under cleaned greenhouse in May while the minimum temperature (25°C) was recorded at 8 am under the old greenhouse in June. The higher temperature inside the greenhouse is due to the higher transmissivity of solar radiation through the cleaned cladding material. Temperature variation inside cleaned and uncleaned greenhouse is around 2-6°C. Similar studies were done by Job et al*.,* [6] found that temperature variation inside the polyhouse and outside were 2-9°C.

Relative humidity was varying at different growing conditions. Higher humidity (93%) was recorded inside uncleaned greenhouse in June while lower humidity (43%)was recorded inside cleaned greenhouse. This higher humidity is due to the aging of cladding material which results in changes in microclimate.

Light intensity was maximum recorded in outside condition(83500 lux) in May at 12 pm but minimum light intensity(2000 lux) was recorded in June at 8 am. Maximum light intensity was always recorded at outside conditions because of the direct solar radiation followed by cleaned greenhouse and uncleaned greenhouse. Lowest light intensity under the uncleaned greenhouse is due to the aging of cladding material.

In addition to that plant growth parameters and yield parameters such as plant height, number of branches, number of leaves, average yield per plant were higher inside cleaned greenhouse rather than uncleaned greenhouse while the internodal length was higher inside the uncleaned greenhouse. Likewise Roy et al. [7] found that product obtained from polyhouse having higher fruit length, higher yield and maximum number of fruits per plant compared to open field in case of Chili cultivation. This is because of the aging of cladding material in uncleaned greenhouse which results in positive phototropism of plants in the shaded region. Hence plants in the uncleaned greenhouse was growing towards the sunlight direction, due to the lack of uniform light intensity inside the greenhouse, intermodal length of plants was increasing comparatively more than cleaned greenhouse which results in reduction of yield.

Fig. 4. Harvested Amaranthus from cleaned greenhouse

Fig. 5. Harvested Amaranthus from greenhouse without cleaning

Table 1. Average monthly air temperature (°C) variation in cleaned greenhouse, uncleaned greenhouse and outside condition at 8 am, 12 pm and 4 pm

Month	Cleaned greenhouse			Uncleaned greenhouse			Outside		
	8am	12pm	4pm	8am	12pm	4pm	8am	12pm	4pm
April	29.25	36.75	35.25	27.75	33.5	29.5	27.5	32.5	30.75
May	30.5	37.5	36	28.5	31.75	31	28	34	31.75
June	28.5	32.5	30.25	27.5	30.5	29	26.5	29.5	29

Table 2. Average monthly relative humidity(%)variation in cleaned greenhouse, uncleaned greenhouse and outside condition at 8 am, 12 pm and 4 pm

Month	Cleaned greenhouse			Uncleaned greenhouse			Outside		
	8am	12pm	4am	8am	12pm	4am	8am	12pm	4am
April	80.5	54	61	84.5	65	66	84	54.5	65
May	78	51.5	59	82.5	59	64.5	83	52.5	63
June	84	57.5	68.5	86	61.5	71.5	86.5	59	69.5

Table 3. Average monthly light intensity(Lux) variation in cleaned greenhouse, uncleaned greenhouse and outside condition at 8 am, 12 pm and 4 pm

Month	Cleaned greenhouse			Uncleaned greenhouse			Outside		
	8am	12pm	4am	8am	12pm	4am	8am	12pm	4am
April	14000	31500	16640	4800	17900	8050	17800	49250	27700
May	15500	37000	17800	7100	19700	9600	19050	59500	32650
June	9250	23850	14750	4250	16600	7600	15000	46650	25500

Table 4. Plant growth parameters under cleaned and uncleaned greenhouses

Growth parameters	2nd weeks after transplanting		4th weeks after transplanting		6th weeks after transplanting	
	Cleaned greenhouse	Uncleaned greenhouse	Cleaned greenhouse	Uncleaned greenhouse	Cleaned greenhouse	Uncleaned greenhouse
Plant height(cm)	20	19	45	40	78	72
No. of branches	4	3	9	5	12	8
No. of leaves	18	14	37	21	53	28
Inter nodal length(cm)	3.5	5.2	6.5	7	8	9

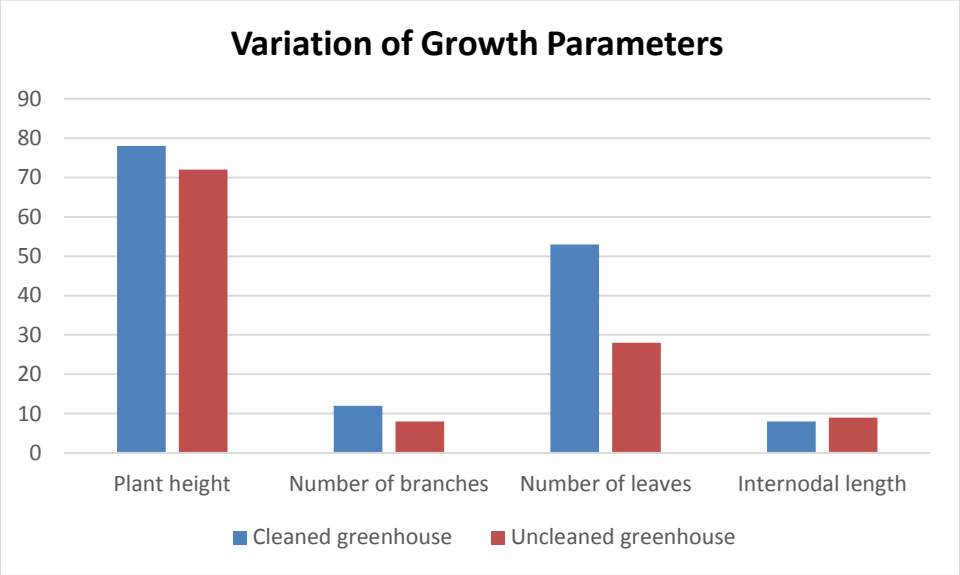

Fig. 6. Graphical analysis of growth parameters in cleaned and uncleaned greenhouses

Table 5. Yield parameters under cleaned and uncleaned greenhouses

Treatment	Yield per plant(Kg)				
	7th Week	8th Week	9th Week	10thWeek	11thWeek
Cleaned greenhouse	0.218	0.223	0.325	0.255	0.2
Greenhouse without cleaning	0.076	0.066	0.086	0.124	0.083

Table 6. Statistical analysis of yield data

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.050721	1	0.050721	17.14323	0.006076	5.987378
Within Groups	0.017752	6	0.002959			
Total	0.068473	7				

From the above graph, it is clear that growth parameters vary in cleaned and uncleaned greenhouses. Hence aging of cladding material has wide influences on plant growth parameters.

From the experimental study, it was clear that higher crop yield was recorded in cleaned greenhouse than uncleaned greenhouse. Statistical analysis of crop yield indicates that there is a significant difference between aging of cladding material and crop yield.

4. CONCLUSION

This experiment depicts that the aging of cladding material has a significant influence on

microclimate and crop yield under greenhouses. There exists a temperature variation of around 2-6°C between cleaned and uncleaned greenhouses similarly for light intensity around 10000 – 13000 lux variation among two greenhouses. And for relative humidity, it varies around 4-9% between two greenhouses. It is because of aging of cladding material reduced the transparency of sheet thereby reduction in the entry of solar radiation into the greenhouse. Which adversely affect the microclimate inside greenhouse. In addition to that plant growth parameters and yield parameters such as plant height, number of branches, number of leaves, internodal length and average yield per plant have wide influences on the aging of cladding material. Which indicates that entry of solar radiation or microclimate inside the polyhouse is the major limiting factor for crop growth. From this experiment, it was clear that higher crop yield and crop quality were obtained from the cleaned greenhouse than an uncleaned greenhouse. Hence aging of cladding material has direct influences on plant microclimate and indirect influences on crop yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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