Effect of plastic greenhouse structure's design on productivity and quality of cucumber crop

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ABSTRACT

The experiment was carried out during spring seasons of 2012 and 2013 at Protected Center, Faculty of Agriculture, Kafr El-Sheikh University, Egypt, to study the impact of plastic houses design on the changes of microclimate of plastic house and its effect on productivity of cucumber F_1 hybrid "Laurens".

The main results of this study indicated that that normal and modified plastic greenhouses increased minimum and maximum air temperature compared with the open field which had the lowest values, also the normal house had higher maximum air temperature than that of the modified one. The greatest values of minimum and maximum relative humidity recorded by normal house compared to the lowest values obtained by modified house. Normal plastic greenhouse increased the early fruit weight in the second season only, while there were non-significant differences between treatments in the first season. Modified plastic greenhouse type increased the total yield/m^2, marketable fruit yield as weight, number and percentage from total yield compared to the normal plastic greenhouse in both seasons

Keywords: **plastic houses design, cucumber.**

INTRODUCTION

Cucumber is one of the major vegetable crops cultivated in Egypt, under greenhouse conditions. It is a sub-tropical vegetable crop that grown successfully under conditions of high: light, humidity, soil moisture, temperature and fertilizers in green-house (**El-Aidy *et al*., 2007)**. The total number of greenhouses in Egypt was estimated to be 22,000 units of 540 m^2 each, according to 2009 statistics; among them, 10,000 greenhouses were devoted to cucumber cultivated in the spring season. The dominant type is single plastic tunnel, this type of greenhouse faces some problem related to unsuitable design, poor ventilation, small greenhouse volume and the net greenhouse floor area fit for plant cultivation is small comparing with the multiple span as the space left between two tunnels reaches between 2 to 2.5 meters, the plant near the side wall ventilation and gables grow less than those in middle of greenhouse and single type is consuming more covering plastic. With the accumulated experience gained by the researchers at recent years in Egypt, several attempts modification in greenhouse construction was related to the construction of multiple span houses instead of the single house. Multiple span houses with higher roofs are believed to be more suitable for the continental climate than the single houses (**Castilla *et al*., 1990).** One of the attempts made is to improve the climate in single house and the problems related to poor ventilation and high temperature (**Short *et al*., 2001).**

The ventilation system within any greenhouse plays a pivotal role in plant health and crop production. Not only are ventilation systems vital to maintaining environmental conditions but they also directly influence a plant's ability to perform photosynthesis, uptake essential elements, and complete reproductive cycles (pollination). Ventilation systems in greenhouses actually serve four imperative functions: temperature control, humidity control, CO_2/oxygen replacement, and air circulation (**Drich and Parsons, 1982).** So, the objectives of this work are to study the effect of plastic greenhouse design on cucumber plants under North Delta of Egypt.

MATERIALS AND METHODS

The experiment was carried out under plastic-house conditions at the protected cultivation center, Faculty of Agriculture, Kafrelsheikh University at the two successive spring seasons of 2012 and 2013.

Cucumber hybrid F1" Laurens" seeds were sown on 15th of February in both seasons in seedling trays (84 cells) filled with a mixture of peat and vermiculate (1:1) including the recommended seedling's nutrients and fungicides.

Cucumber plants were trained vertically on single stem, where all lateral branches were removed till 40 cm above the soil. After that, the all lateral branches were cut off after two leaves (two fruits) till the end of the growing seasons. Organic and mineral fertilizers were added to the soil during preparation as the recommendations of Ministry of Agriculture and dissolved in water then injected through drip irrigation system to each plastic house per day during the growing season. All cultural practices (pests, diseases control and others) were carried out whenever they were necessary.

The experiment included two design types of unheated plastic houses as follows:

1. Side opening ventilation design (modified plastic greenhouse MPGH):

This greenhouse was modified to be with side ventilation by putting metallic ruler (5 cm width) at 50 cm and another one at 250 cm above ground surface along the length of the sides of the greenhouse. The ventilation opening was 200 cm width x 30 m length, the insect proof net was fixed between two metallic rulers.

2. Top ventilation design (Normal plastic greenhouse NPGH):

The opening of ventilation of this design was only the overlap opening.

Both design types of plastic houses were 9 m width x 30 m length x 3.2 m height at the normal house and 4.5 m at the modified one, covered with polyethylene film (180 µm). Each one was divided into 5 ridges (170 cm width). Planting density was 2.35 plants/m2.

Measurements:

1. Climatic data:

Air temperature and relative humidity were recorded by using weather station connected with the different greenhouses to measure maximum and minimum air temperature as well as relative humidity inside and outside grean-houses (GH) in the two seasons.

2. Yield and its components:

Data included early and total fruit yield. Early fruit yield was determined as weight and number of fruits/plant and per m2 of the first 10 pickings, also the total fruits yield was determined as weight and number/plant and per m2 for all pickings. Earliness was expressed as number of days from transplanting to the first picking of fruits (**Van de Vooren et al., 1978**).

3. Fruit quality:

It included marketable fruit yield as weight, number of fruits/plant and as % from total yield, average fruit weight, length and diameter and total soluble solids percentage (TSS%) in juice of fresh cucumber fruits was estimated by a hand refractometer according to **A.O.A.C. (1980)**. The characters of fruits were estimated of the 1st picking.

Data were tested by analysis of variance according to **Little and Hills (1975)**. Duncan's multiple range test was used for comparison among treatments (**Duncan, 1955**).

RESULTS AND DISCUSSION

Air temperature (Minimum & Maximum):

Data in Table (1) Show that NPGH and MPGH increased minimum air temperature compared with the open field (OF) which had the lowest values during the two seasons. The NPGH had higher minimum air temperature than the MPGH.

The increase in minimum air temperature inside the NPGH were ranged from 2.2-1.2 to 0.8-3.5 oC and from 1-0.9 to 0.5-1.5oC inside the MPGH above the OF in both seasons, respectively.

Regarding maximum air temperature, data in Table (1) Indicated that NPGH and MPGH increased average monthly maximum temperature compared with the open field which had the lowest values in both seasons. The NPGH had higher maximum air temperature than that of the MPGH. The differences in maximum air temperature between the NPGH and OF were ranged from 17.5-14.7oC to 18.4-16.5oC and the difference in max. air temperature between MPGH and OF were ranged from 15.0-14.3 to 16-17.4 in both seasons.

Table (1): Effect of plastic houses structure design on monthly average air temperature (^{o}C) during the spring seasons of 2012 and 2013.

Date	Plastic house design														
	NPGH			MPGH			OF (control)			Increase above control					
										NPGH		MPGH		Av.	
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Min.	Max.	Min.	Max.
2012															
March	11.2	41.3	26.25	10.0	39.2	24.6	9.0	23.8	16.40	2.2	17.5	1.0	15.4	1.60	16.45

April	13.8	39.1	26.45	11.8	37.2	19.5	10.7	24.0	17.35	3.1	15.1	1.1	13.2	2.10	14.15
May	16.0	41.5	28.75	14.5	39.5	27.00	12.5	28.2	20.35	3.5	13.3	2.0	11.3	2.75	12.30
June	18.2	43.2	30.70	17.2	40.8	29.00	16.5	28.9	22.70	1.7	14.3	0.7	11.9	1.20	13.10
July	19.1	44.0	31.55	18.8	42.3	30.55	17.9	29.3	23.60	1.2	14.7	0.9	13.0	2.10	13.85
2013															
March	11.4	42.4	26.9	11.1	40.5	25.8	10.6	24.0	17.30	0.8	18.4	0.5	16.5	0.65	17.45
April	14.0	40.2	27.1	12.0	39.8	25.9	11.6	24.3	17.65	2.4	15.9	0.4	15.5	1.40	15.70
May	16.9	42.3	29.6	13.8	41.6	27.7	13.4	29.8	21.60	3.5	12.5	0.4	11.8	1.95	12.15
June	19.0	45.3	32.15	17.0	44.3	30.65	16.2	30.4	23.30	2.8	14.9	0.8	13.9	1.80	14.40
July	19.8	46.5	33.15	17.8	44.7	31.25	16.3	30.0	23.15	3.5	16.5	1.5	14.7	2.50	15.60

It could be concluded that the NPGH and MPGH increased both max. and min. air temperature compared with those of the outside. Such increase in air temperature were the highest in the NPGH than MPGH. This could be attributed to the low level of ventilation of the NPGH compared with MPGH. These results are in agreement with those reported by **El-Aidy (1979), Boodley (1998), Barroso *et al*. (1999), and El-Sawy (2003).**

b. Relative humidity:

Data in Table (2) demonstrated that the NPGH had the highest minimum and maximum relative humidity compared to the lowest values obtained by MPGH. The observed high values of the maximum and minimum relative humidity in NPGH compared to MPGH could be attributed to the reduction of ventilation in this type. These findings are in agreement with those of **Verheye and Verlodt (1990), Boodley (1998), Abreu *et al.* (2001), Wadid** *et al*. **(2000), El-Sawy (2003).**

Table (2): Effect of plastic house structure's design on monthly average relative humidity % during the spring seasons of 2012 and 2013.

Date	Plastic house design								
	NPGH			MPGH			OF (control)		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.

2012									
Time of readings	1 pm	8 am	-	1 pm	8 am	-	1 pm	8 am	-
March	29.8	48.4	39.10	25.0	45.0	35.0	34.0	90.0	62.0
April	35.4	51.0	43.20	30.4	48.3	39.35	26.0	85.2	55.6
May	36.1	60.2	48.15	30.5	52.8	41.65	32.0	92.3	65.15
June	35.3	58.5	47.05	30.5	52.9	41.7	35.4	92.5	63.95
July	34.4	58.0	46.20	31.2	51.4	41.3	36.3	90.0	63.15
2013									
March	30.1	51.3	40.7	26.8	49.2	38.0	33.0	85.0	59.0
April	33.0	52.4	42.7	27.6	50.4	39.0	30.0	77.0	53.5
May	33.0	65.8	49.4	28.0	60.7	44.35	32.8	83.5	58.15
June	34.8	62.3	48.55	28.0	60.2	44.1	38.0	82.2	60.1
July	35.2	64.0	49.6	27.3	58.9	43.1	40.0	83.4	61.7

b. Early and total fruit yield/m2:

Data in in Table (3) show that NPGH treatment increased the early fruit weight in the second season only compared to MPGH, while there were non-significant differences between treatments in the first season. It was noticed that MPGH treatments increased the total yield/m2 compared to NPGH in both seasons. These findings are coincided with those of **Holder and Cockshull (1990), Wadid *et al*. (2000), Farag (2001) and El-Sawy (2003)**. Generally, it could be coincided from the present study that MPGH was the most favorable for enhancing yield/m2 of cucumber plants through the modification of maximum and minimum air temperature as well as relative humidity and increasing the absorption of nutrients compared with NPGH. These agree with those of **El-Aidy (1979), Abou-Khaled and El-Aidy (1986), Salman (1990); Wadid *et al*. (2000), and Short *et al*. (2001).**

Table (3): Effect of plastic greenhouse structure's design on early and total yield of cucumber plant during spring seasons of 2012 and 2013.

Traits	Early fruit yield/m^2		Total fruit yield/m^2	
House type	Wt. of fruits (kg)	No. of fruits	Wt. of fruits (kg)	No. of fruits
	2012			
MPGH	2.14 b	25.83 b	16.80 a	159.58 a
NPGH	2.52 a	28.33 a	14.29 b	143.25 b
F. test	*	*	*	**
	2013			
MPGH	2.44	26.41 b	17.26 a	162.33 a
NPGH	2.49	28.33 a	14.84 b	145.33 b
F. test	NS	*	**	**

b. Marketable fruit yield:

Data in Table (4) show that MPGH increased marketable fruit yield as weight, number and percentage from total yield significantly compared to NPGH in both seasons. The favorable effect of MPGH on marketable fruit yield of cucumber might be a resultant of the increase in total yield. Many investigations had similar results. **Holder and Cockshill (1990), El-Doweny *et al*. (1992) and El-Sawy (2003)** found that the highest fruit quality produced with cucumber plants grown under plastic greenhouse with side ventilation compared to top ventilation.

c. Non-marketable fruit yield (%):

Data in Table (4) show that the highest unmarketable fruits (12.56 and 13.16%) obtained by NPGH compared with the lowest percentage of unmarketable (6.42 and 8.03%) obtained by MPGH in both seasons, respectively.

d. Average fruit weight and length:

Data in Table (4) show that average fruit weight of cucumber plants was increased with using MPGH in the first season. While in the second one, the differences between treatments were not significant. As for, fruit length data indicated that application of MPGH caused a significant increase in average fruit length compared to the NPGH in both seasons.

e. TSS%:

Data in Table (4) declare that NPGH tended to increase TSS% in fruits compared to MPGH. The improvement of most cucumber fruit characteristics (average fruit weight, length and TSS) under modified house might be due to offering better micro-climate and natural ventilation which led to improve vegetative growth, in turn increase photosynthesis subsequently excessive the carbohydrate. In this concern, **Farag (2001), El-Sawy (2003), and El-Dolify (2005)** on cucumber plants.

Table (4): Effect of plastic greenhouse structure design on fruits quality of cucumber fruit during 2012 and 2013 seasons.

Parameters	Fruit quality						
	Marketable fruits yield/m^2			Non marketable yield %	Av. fruit weight (g)	Fruit length (cm)	T.S.S.%
House type	Wt. of fruits (kg)	No. of fruits	% from total yield				
	2012 season						
MPGH	14.82 a	143.08 a	93.57	6.42 b	81.10 a	16.15 a	3.86 b
NPGH	13.38 b	130.83 b	88.67	12.56 a	78.67 b	15.48 b	4.08 a
F. test	**	**	NS	*	**	**	*

	2013 season						
MPGH	144.41 a	144.40 a	92.37 a	8.03 b	84.63	16.44 a	3.88
NPGH	132.41 b	132.41 b	86.83 b	13.16 a	81.73	15.70 b	3.90
F. test	**	**	*	*	NS	*	NS

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