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A STUDY ON YIELD, QUALITY AND STORABILITY OF SNAP BEAN GROWN UNDER DIFFERENT NIGHT TEMPERATURE REGIMES

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ABSTRACT

Two experiments were carried out at Kaha protected cultivation site during winter seasons of 1997/1998 and 1998/1999. These experiments aimed to study the effect of different night temperature regimes (heating the greenhouse from 6pm to 6am continuously, from 6pm to 6am one hour on and one hour off, from 6pm to 12pm and from 12pm to 6am) with minimum temperature of 15°C on yield, quality and storability of snap bean cv. serbo which grown under plastic house conditions.

From the results, it could be concluded that plants exposed to 15°C from 6pm to 6am one hour on and one hour off gave the highest production, high pod quality and storability (weight loss, decay percentages decreased and maintained pod quality during storage) as well as reduction of fuel cost.

During storage periods, bean pods weight loss, decay and fiber percentages were increased, total chlorophyll was decreased with the prolongation of storage period, while dry matter % and TSS of bean pods increased till their peaks after 2 and 4 days, respectively, then it turned to decrease gradually till the end of storage period.

Keywords: snap bean, night temperature regime, greenhouse, yield, quality, storability of snap bean, plastic house.

INTRODUCTION

Beans (*Phaseolus vulgaris*, L.) are self-pollinated, vegetable crop but fruit setting and seed development can be affected by climate conditions because the plants produce only small quantities of pollen grains under the plants normal growing temperature and the general improvement which happens in the common bean pollen grain viability is manifested by the care and attention given to the maintenance of night temperature within the optimum range during the flowering phase (Saleh, 1996). Heating treatments also improvement bean pod characters, and this improvement probably due to the fact that the processes of cell division and/or cell elongation are faster at higher than at lower temperature (Saleh, 1996).

In the Mediterranean area a wide day-night temperature difference is a very common phenomenon in winter or early spring. 90% of the supplied energy in heated, greenhouses is consumed during the night by the heating system. Therefore, a specific control of night temperature, allowing energy saving without damaging the plants, is one of the most ambitious targets that growers attempt to achieve. Saving energy can be realized either by consuming less oil, producing higher yield and quality with the same quantity of oil or by reducing the heating period (Franco, 1990 and Mavroglanopoulos, 1990).

Low temperature, affecting sugar metabolism and translocation (Ho and Baker, 1982; Hurewits and Janes, 1983; Kayat and ziesling, 1986 and 1987), decreases the growth rate of immature leaflets and the amount of dry matter accumulated in organs other than leaves, thus reducing total leaf area and plant height. Moreover, since net assimilation rate (N.A.R.) is not reduced by cold night, dry matter accumulation in source leaflets leads to a higher thickness. Finally, the smaller leaf area of plants grown at low temperature leads to lower relative growth rate.

Franco (1990) reported that low Temperature strongly influences plant growth, and its conditioning largely increases the management costs of greenhouse crops. Reducing the night temperature in the greenhouse leads to lower relative growth rate due to a reduced leaf area ratio and specific leaf area without affecting net assimilation rate. This suggests that low night temperature modifies the growth pattern of the leaf by reducing the expansion and increasing the thickness.

Growing plants at low night temperatures increases their ability to avoid chilling-induced water stress and related injury (leaf desiccation and necrosis, membrane damage) Wilson, (1979).

Total yield of French bean, in terms of both quantity and quality, was highly affected by heating treatments and minimum temperature of 15ºC gave the highest total yield and the lowest malformed fruits, in relation to total yield, compared with the other treatments (Abou-Hadid et al.,1995). These results are in harmony with those obtained on beans by Singh and Mack (1965), Van Schoonhoven and Voysest (1991), Dickson and Boettger (1984) and Olympios and Papachristodoulou (1978).

The duration of cold treatment and the diurnal changes in plant sensitivity to chilling influences the response of plants in terms of morphological and physiological modifications. When low temperature is maintained during the whole night period, the dry matter accumulation is strongly reduced, while a split-night, temperature regime, based on a low temperature only in the second part of the night, does not induce an appreciable reduction of relative growth rate (Franco 1990).

Low temperature during the first part of the night reduces dry matter accumulation; on the contrary, treating the plant with low temperature from midnight to dawn only slightly affects R.G.R., even if some modifications of the plant habite (higher specific leaf area shorter stem, smaller leaf area) occurred (Franco 1990).

The seedlings grown at low temperature in the first or in the second part of the night show the same degree of resistance to subsequent chilling stress, this indicating that the hardening effect of a cold night temperature regime does not depend on the starting period of cold treatment and can be achieved also without negative consequences on growth rate. Growing young plant at low night temperature may improve plant morphology and stress resistance or even stimulate the productivity (Franco 1990).

Some studies were conducted to find out the effect of varying night temperature on total and marketable yields of some vegetable crops for instance. Singh and Mack (1965) stated that increasing soil temperature from 60 to 75 ºF increased snap bean yield. In another experiment, cucumber plants exposed to 16 ºC for 4 hours, remaining 8 hours at 10ºC at night increased total yield by 12% and decreased fuel oil cost by 15% as compared with those of 13ºC constant (Toki et. al. 1979) with regard to the effect of heating treatment on some physical and chemical properties during storage EL-Sheikh et al., (1998) on green bean, found that heating plants at 15ºC as a minimum temperature caused an increase on weight loss and reduction in T.S.S. dry matter chlorophyll and fiber and content than the plants exposed to lower temperature during storage.

MATERIALS AND METHODS

The experiments were performed during the two successive seasons of 1997/1998 and 1998/1999 at Kaha experimental station, Agricultural Research Center, Egypt. Seeds of green bean (*phaseolus vulgaris* L.) cv. serbo were sown on September 5th in a plastic house of 50 meters long, 7.5 meters wide, and 4.2 meters high. The greenhouse has four raised beds for cultivation, each was 100cm wide, 20cm high and 50cm apart. Double rows have been planted on each bed at a distance of 60cm between rows and 50cm between hills, each hill seeded with four seeds. At two true leaf stage, the plants were thinned and three plants per hill were left. Plants were trained and directed along three-polyethylene thread to the crop support. Cultural operations other than the experimental treatments were carried out normally according to the recommendations of Ministry of Agriculture, Egypt. The effect of different air heating periods during the night on the growth and yield of green bean was studied.

The experiment included the following treatments:

1- Continuous heating of night temperature to 15 ºC from 6pm to 6am (T1).
2- Intermittent heating of night temperature to 15 ºC from 6pm to 6am on the bases of the heater works one hour on and one hour off (T2).
3- Continuous heating of night temperature to 15 ºC from 6pm to 12pm (T3).
4- Continuous heating of night temperature to 15 ºC from 12pm to 6am (T4).

The treatments were arranged using a complete block experimental design with 4 replicates.

Warm air heater was used for those treatments, the heater had a capacity of 80 thousand kilo calories per hour. The fuel used for energy was kerosene and electricity for the fan to force the warm air around the heater into the perforated tube, which distributed the air in the greenhouse.

For post harvest analysis, snap bean pods were picked at the proper stage of marketing and transported immediately to the laboratory at Giza, where sound and healthy pods were chosen for storage experiment.

A split plot design was adopted having the heating treatments in the main plots and shelf life period (five periods) in the sub plots. The sound pods were divided into fifteen replicates for each treatment weighted approximately 800 gram. Pods of each replicate were placed in carton box (30X20X10 cm). All treatments were stored at room temperature (18$\pm$2°C and 65-70% RH).

Three replicates from each treatment were taken and examined at 2 days interval during storage.

Measurements:

The following data were recorded

1- Total yield kg per m^2. (yield/tunnel)

2- Marketable yield (kg/m^2)

3- a random sample of 30 pods from each treatment were taken at the day of harvest and examined for the following characters:

a) Pod length and diameter (in cm). Using vernier

b) Total soluble solids, dry matter and fiber in percentage

c) Total chlorophyll as mg/100g fresh weight.

4- Post harvest properties:

a) Weight loss, decay, dry matter and fiber (%) were determined using the methods of A.O.A.C. (1980).

b) Total soluble solids (TSS) percentage was determined using an Abbe refractometer (A.O.A.C. 1980)

c) Total chlorophyll was measured as mg/100g fresh weight according to A.O.A.C. (1970).

Data were subjected to statistical analysis of variance (Snedicor and cochran 1980).

RESULTS AND DISCUSSION

Results of total and marketable yield of green pods are presented in Table (1) and Fig (1). The data revealed that heated plants at 15°C from 6pm to 6am and 15°C from 6pm to 6am one hour on and one hour off treatments had significantly higher total and marketable snap bean yield compared with those exposed to 15°Cfrom 6pm to 12pm and 15°C from 12pm to 6am treatments in the two seasons. In the mean time there was no significant difference between the former two treatments. It can be stated here that fuel consumption (which is one of the main factors of snap bean production in the greenhouses) could be saved to 50% by applying the treatment of heating one hour on and one hour off without any significant losses in total or marketable yields. Moreover, continuos or partial heating from 6 pm to 6 am gave an increase of total yield reached 126.05, 125.1, 125.5, 124.6% and 123.3, 120.9, 122.6, 120.3% and marketable yield reached 179.7, 174.6, 175.2, 170.2% and 164.4, 164.0, 163.0, 160.1, 159.1% in 1996/1997 and 1997/1998 respectively compared with heating for 6 hours from 6 pm to midnight or from midnight to 6am. This may be due to the effect of temperature on pollen grain production, viability or both. These results agree with Dickson and Boettger (1984) who found that a night temperature of 15ºC resulted in a significant higher percentage of pollen germination than low night temperature (8 and 12ºC) on snap bean, and they found that low night temperature after pollination delayed pollen growth. Many investigators found that higher night temperature increased pollen grain viability (Van Schoonhover and Voysest, 1991 on snap bean and Loots, 1991 on tomato).

Table (1): Effect of varying night temperature on physical pod characteristics, total and marketable yield of snap bean pods in 1996-1997 and 1997-1998 seasons.

Treatments	1996-1997				
	Total yield Kg/m^2	Marketable yield Kg/m^2	Pod Length (cm)	Pod diameter(cm)	Pod weight(g)
15°C from 6pm to 6am	4.976	4.037	12.24	1.14	9.23
15°C from 6pm to 6am	4.955	3.935	11.98	1.13	9.08
(one hour on and one hour off)					
15°C from 6pm to 12pm	3.948	2.246	11.24	1.08	7.35
15°C from 12pm to 6am	3.978	2.313	11.42	1.09	8.06
L.S.D (5%)	0.112	0.135	0.34	0.03	0.23
	1997-1998				
15°C from 6pm to 6am	4.723	3.922	11.23	1.13	9.44
15°C from 6pm to 6am	4.697	3.828	10.96	1.12	9.23
(one hour on and one hour off)					
15°C from 6pm to 12pm	3.831	2.391	9.73	1.06	7.76
15°C from 12pm to 6am	3.906	2.407	9.96	1.08	7.93
L.S.D (5%)	0.271	0.233	0.28	0.03	0.26

Thus it can be concluded that the best treatment was to apply heating from 6pm to 6 am with one hour on and one hour off as fuel cost is the main obstacle in greenhouse bean production.

Effect of various night temperatures on bean pod characters (length, diameter and average pod weight) was shown in Table (1). Pod characters were affected by heating treatments. Heated treatments of 15°C from 6pm to 6am and 15°C from 6pm to 6am one hour on and one hour off significantly improved all previous characters as compared with the two other treatments. This may be due to the fact that the processes of cell division, cell elongation and photosynthesis are faster at higher temperature. Heating with 15°C from 6pm to 12pm and 15°C from 12pm to 6am gave pods with smaller values of length, diameter and pod weight as compared with the other heating treatments. These results are true in the two seasons. These results are in agreement with those obtained by Van De Vooren (1980) on cucumber and El-Sheikh et. al., (1998) on snap beans.

Studying the effect of various heating treatments on snap bean pods dry matter, TSS, total chlorophyll and fiber content was presented in Table (2). Data indicated clearly that there were significant differences among the treatments on these physical and chemical properties of bean pods. Exposing bean plants to 15°Cfrom 6pm to 6am reduced all these constituents as compared with the other treatments. Increasing air temperature with kerosene increases the losses in these components. These results might owe much to the utilization of some of these components in respiration i.e. dry matter and TSS. Also, this reduction in these components in pods may be due to better water absorption with higher temperature, which resulted in high water content of pods. These results agree with the results obtained by El-Sheikh *et.al*., (1998). The reduction in pod chlorophyll contents may be due to the bigger vegetative growth under higher temperature, which reduced the penetrated solar radiation to the pods. These results are in the same line with Smittle (1986) and El-Sheikh *et. al*., (1998) on bean.

Increasing exposing time to higher temperature decreased fiber content in bean pods (Table 2), these reduction may be due to the faster cell division and cell elongation and better water absorption with these treatments. Also, these results may be attributed to that higher temperature reduced sugar contents, which is considered as a building units of fibers.

Table(2): Effect of varying night temperature on physical and chemical properties of snap bean pods at harvest in 1996-1997 and 1997-1998 seasons.

Treatments	1996-1997			
	Dry matter Content (%)	**TSS (%)**	**Total Chlorophyll Cont Content Mg/100g FW**	**Fiber (%)**
15°C from 6pm to 6am	4.17	4.93	86.90	1.74
15°C from 6pm to 6am	4.50	5.40	93.23	1.76
(one hour on and one hour off)				
15°C from 6pm to 12pm	4.36	5.27	92.20	1.91
15°C from 12pm to 6am	4.30	5.30	89.33	1.89
L.S.D (5%)	0.18	0.25	0.86	0.10
	1997-1998			
15°C from 6pm to 6am	4.17	5.00	88.27	1.60
15°C from 6pm to 6am	4.87	5.50	94.47	1.66
(one hour on and one hour off)				
15°C from 6pm to 12pm	4.65	5.17	93.40	1.96
15°C from 12pm to 6am	4.43	5.11	90.40	1.87
L.S.D (5%)	0.12	0.23	0.88	0.12

It was found from the data that heating bean plants at 15°C from 6pm to 6am one hour on and one hour off treatment was superior in dry matter, TSS and total chlorophyll content followed by heating treatment at 15°C from 6pm to 12pm.

The results reported in Table (3) showed that the percentage of the fresh weight loss of bean pods increased with increasing the heating duration. Growing bean plants at 15°C from 6pm to 6am gave the highest pods weight loss compared to other treatments. Data indicated that growing bean at 15°C one hour on and one hour off appeared to be the best treatment in reducing the weight loss. These results agreed with those reported by Medany et. al. (1990) on sweet pepper. The increase in weight loss of pods resulted from increasing exposing heating period might owe much to the increase in water content and the metabolic activity which can be resulted in water loss and higher respiration rate, similar results were obtained by El-Sheikh et. al. (1998).

Regarding decay percentage, data reported in Table (3) show that heating bean plants to 15°C from 6pm to 6am one hour on and one hour off treatment was the most effective treatment in minimizing the decay percentage during storage followed by continuos heating at 15°C from 6 pm to 6 am. On the contrary, the highest percentages of decay were obtained from the treatment with 6pm to 12pm followed by heating to 15°C from 12pm to 6am. These results were similar to those obtained by El-Sheikh *et al.,* (1998) on bean pods.

Table (3) Effect of varying night temperature on physical and chemical properties of snap bean pods during storage in 1996-1997 and 1997-1998 seasons

Treatments	Weight loss (%)	Decay (%)	Dry Matter Content (%)	TSS (%)	Total Chlorophyll Content (mg/100g FW)	Fiber (%)
1996-1997						
15°C from 6pm to 6am	9.00	8.00	4.05	4.90	76.84	1.84
15°C from 6pm to 6am **(one hour on and one hour off)**	8.29	5.93	4.59	5.58	84.09	1.88
15°C from 6pm to 12pm	8.58	9.65	4.46	5.44	83.59	2.14
15°C from 12pm to 6am	8.70	9.86	4.17	5.22	80.98	1.96
L.S.D (5%)	0.13	-	0.10	0.11	0.56	0.07
1997-1998						
15°C from 6pm to 6am	9.28	7.43	4.18	5.07	78.44	1.69
15°C from 6pm to 6am **(one hour on and one hour off)**	8.68	6.58	4.74	5.44	83.81	1.73
15°C from 6pm to 12pm	8.83	10.91	4.64	5.34	82.87	2.05
15°C from 12pm to 6am	8.95	10.04	4.52	5.31	81.84	1.95
L.S.D (5%)	0.14	-	0.09	0.09	0.59	0.07

These results suggested that heated snap bean plants with 15°C from 6pm to 6am one hour on and one hour off delayed the deterioration and decay incidence of the produced pods during storage periods.

Concerning dry matter and total soluble solids percentages of bean pods, data in Table (3) show that heating bean plants to 15°C from 6pm to 6am lost greater dry matter and TSS during storage than the other used treatments. On the contrary, the lowest losses of the above mentioned characters of snap bean pods were obtained from plants heated with 15°C one hour on and one hour off followed by heating to 15°C from 6pm to 12pm. these results agree with Medany et. al. (1990) on sweet pepper and El-Sheikh et. al. (1998) on snap bean.

The values of dry matter and TSS percentages were lower in pods produced by bean plants heated to 15°C from 6pm to 6am. This may be due to the rapid rate of loss of water and dry matter through respiration as compared with pods exposed to shorter periods of heating which led a lower temperature in part of the night.

Results reported in Table (3) indicated that there were significant differences between heating treatment used in this work regarding total chlorophyll in bean pods. In this concern, the highest values of these contents were recorded during storage of pods grown at 15°C from 6pm to 6am one hour on and one hour off followed by those of pods grown at 6 pm to 12 pm without significant differences between them. The lowest values of this character was obtained during storage of pods produced by plants exposed to heating treatment of 15°C from 6pm to 6am. These results are in agreement with results obtained by El-Sheikh et al., (1998). This may be due to the increase in respiration and transpiration rates with the increase of exposing heating period.

With respect of fiber content, data in Table (3) clearly show that the lower fiber contents of pods were obtained from heating bean plants up to 15°C from 6pm to 6am followed by heating treatment 15°C from 6pm to 6am one hour on and one hour off. On the contrary, the highest fiber contents were found in pods produced by plants exposed to 15°C from 6pm to 12pm. These results are true in the two seasons. These results are in agreement with those obtained by Abd-El-Salam (1990) and El-Sheikh et. al., (1998) on green bean.

From the previous results, it can be concluded that plants exposed to 15 from 6pm to 6am one hour on and one hour off as pre-harvest treatment play an important role in keeping quality of snap bean pods during storage.

The presented data in Table (4) show that the loss in pod weight was increased as the storage period elapsed in the two seasons. This decrease in fresh weight might be attributed to the loss in moisture content through transpiration and loss in dry matter content through respiration. Dessouky et. al., (1995) and El-Sheikh et al. (1998) came to similar conclusion on bean pods.

Table (4): Effect of storage period at room temperature on physical and chemical properties of snap bean pods in 1996-1997 and 1997-1998 seasons.

Storage Period in days	Weight Loss (%)	Decay (%)	Dry Matter Content (%)	TSS (%)	Total Chlorophyll Content (mg/100g FW)	Fiber (%)
1996-1997						
Zero	-	-	4.33	5.23	90.42	1.83
2	4.92	0.00	4.75	5.43	85.33	1.87
4	7.40	0.00	4.42	5.65	81.36	1.97
6	10.33	13.94	4.16	5.17	77.18	2.02
8	11.92	19.5	3.93	4.95	72.60	2.09
L.S.D (5%)	0.14	-	0.12	0.15	0.51	0.03
1997-1998						
Zero	-	-	4.53	5.20	91.63	1.77
2	5.28	0.00	4.87	5.43	86.48	1.81
4	7.32	0.00	4.63	5.64	81.81	1.85
6	10.73	15.24	4.38	5.28	76.46	1.90
8	12.42	19.71	4.18	4.90	72.21	1.95
L.S.D (5%)	0.17	-	0.10	0.18	0.54	0.03

Data in Table (4) show that the decay percentage of bean pods increased with prolongation the storage period. Decay was occurred 6 days from storage in the two seasons. It is clear from the data that the decay was not noticeable until day 4 of storage period then it was markedly obvious on day 6 where it reached 15% and in two days later it reached about 20%. This may be due to changes occurred in pod chemical constituents and water content, which in turn negatively affect pod firmness, during storage. (Dessouky et. al (1995) and El-Sheikh et al., (1998) on snap bean pods.

Data in Table (4) indicated that the value of dry matter and TSS significantly increased till 2 and 4 days respectively in the two seasons. After that it decreased gradually and reached its lowest value at the end of storage period. This is due to the rate of moisture loss through transpiration and the rate of dry matter loss through respiration. These results are similar to those obtained by El-Sheikh et al., (1998) on snap bean pods.

The influence of storage period on the content of total chlorophyll in green bean pods is shown in Table (4). Total chlorophyll content was decreased gradually with the prolongation of storage period in the two seasons. This decrement in chlorophyll content could be attributed to the gradual destruction by chlorophyllase activity and transformation of chlorophlasts to chromoplasts. These results agree with those obtained by El-Sheik et al., (1998) on bean pods.

Data presented in Table (4) indicate that fiber content of the pods increased with prolongation of storage period, and reached its maximum peak at the end of storage, this may be due to the moisture loss during storage.

The interaction between heating treatments and storage periods had remarkable effect on physical and chemical characters of snap bean pods. In Table (5 & 6) it is clear that growing bean plants at 15ºC from 6 pm to 6 am one hour on and one hour off treatment were the most effective ones in minimizing the weight loss and decay percentage during the whole storage periods for snap bean pods. Generally, there was a continuous increase in weight loss and decay percentages with prolongation of storage period in all heating treatments.

Table (5): Effect of interaction of varying night temperature and storage periods on physical and chemical properties of snap bean pods in 1996-1997 season.

Treatments	Storage Period in days	weight loss (%)	Decay (%)	Dry Matter Content (%)	TSS (%)	Total Chlorophyll Content (mg/100g FW)	Fiber (%)
	0	-	-	4.17	4.93	86.90	1.74
	2	5.20	0.00	4.47	5.13	81.33	1.79
15°C from 6pm to 6am	4	7.70	0.00	4.17	5.33 76.77	76.77	1.84
	6	10.73	13.71	3.87	4.70	72.27	1.89
	8	12.40	18.29	3.57	4.43	66.93	1.94
	0	-	-	4.50	5.40	93.23	1.76
	2	4.47	0.00	4.90	5.60	88.10	1.81
15°C from 6pm to 6am	4	7.00	0.00	4.70	5.90	84.03	1.86
(one hour on and one hour off)	6	10.07	9.37	4.50	5.60	80.10	1.93
	8	11.63	14.34	4.37	5.40	75.00	2.01
	0	-	-	4.36	5.27	92.20	1.91
	2	5.00	0.00	4.82	5.57	87.20	1.95
15°C from 6pm to 12pm	4	7.45	0.00	4.50	5.77	83.63	2.22
	6	10.13	16.54	4.40	5.40	79.53	2.27
	8	11.75	22.06	4.20	5.17	75.40	2.34
	0	-	-	4.30	5.30	89.33	1.89
	2	5.00	0.00	4.83	5.40	84.67	1.92
15°C from 12pm to 6am	4	7.47	0.00	4.30	5.60	81.0	1.95
	6	10.40	16.12	3.87	5.00	76.83	1.99
	8	11.91	23.31	3.57	4.80	73.07	2.06
L.S.D (5%)		0.20	-	0.17	0.20	0.95	0.08

As regard to the effect of heating treatments and storage periods interaction on dry matter at T.S.S. percentages, the results in Table (5 & 6) indicate that there were significant differences in the mentioned contents in the two seasons.

The interaction between heating treatments and storage periods was significant on chlorophyll and fiber contents in bean pods in both seasons. Generally, there was a gradual reduction in chlorophyll and increase in fiber contents with the prolongation of storage period in all heating treatments.

From the previous results, it could be stated that plants exposed to heating of 15°C from 6pm to 6am one hour on and one hour off had the highest production, high pod quality and storability compared with other used treatments. Besides fuel cost was also reduced.

Table (6): Effect of interaction of varying night temperature and storage periods on physical and chemical properties of snap bean pods in 1997-1998 season.

Treatments	Storage Period in days	weight loss	Decay	Dry matter Content	TSS	Total Chlorophyll Content	Fiber
		(%)	(%)	(%)	(%)	(mg/100g FW)	(%)
	0	-	-	4.17	5.00	88.27	1.61
	2	5.60	0.00	4.59	5.20	83.88	1.65
15°C from 6pm to 6am	4	7.70	0.00	4.32	5.40	78.53	1.68
	6	11.00	12.56	4.00	5.07	73.47	1.72
	8	12.80	17.16	3.81	4.67	68.03	1.78
	0	-	-	4.87	5.50	94.47	1.66
	2	5.00	0.00	5.30	5.58	88.23	1.67
15°C from 6pm to 6am	4	7.10	0.00	4.90	5.77	83.63	1.70
(one hour on and one hour off)	6	10.40	11.03	4.50	5.37	78.37	1.77
	8	12.20	15.28	4.17	5.00	74.33	1.83
	0	-	-	4.65	5.17	93.40	1.96
	2	5.30	0.00	4.77	5.47	87.40	2.00
15°C from 6pm to 12pm	4	7.06	0.00	4.68	5.67	82.66	2.08
	6	10.80	19.46	4.60	5.37	77.65	2.10
	8	12.17	24.17	4.50	5.07	73.26	2.14
	0	-	-	4.43	5.11	90.40	1.87
	2	5.20	0.00	4.83	5.47	86.42	1.91
15°C from 12pm to 6am	4	7.40	0.00	4.63	5.70	82.40	1.96
	6	10.70	17.91	4.44	5.32	76.33	2.00
	8	12.50	22.24	4.25	4.94	73.63	2.04
L.S.D (5%)		0.25	-	0.16	0.21	0.98	0.08

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دراسة على المحصول والجودة والقدرة التخزينية لمحصول الفاصوليا الخضراء المنزرع تحت فترات مختلفة من حرارة الليل

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أجريت هذه التجارب بمزرعة قها للزراعة المحمية خلال موسمى الشتاء ١٩٩٧ - ١٩٩٨ و ١٩٩٨ - ١٩٩٩ لدراسة تأثير تغيير درجة حرارة الليل (تدفئة على درجة ١٥°م من ٦ صباحاً إلى ٦ صباحاً مستمره، من ٦ مساء حتى ٦ صباحاً تشغيل ساعة وإيقاف ساعة ومن ٦ مساء إلى ١٢ مساء ومن ١٢مساء حتى ٦ صباحاً) على المحصول والجودة والقدرة التخزينية لمحصول الفاصوليا الخضراء صنف سربو والمنزرع تحت ظروف الزراعة المحمية داخل الصوب.

أوضحت النتائج أن النباتات التى تعرضت إلى ١٥°م من ٦ مساء إلى ٦ صباحاً تشغيل ساعة وإيقاف ساعة قد أعطت أعلى إنتاجية وجودة للقرون وأكثر قدرة تخزينية (أعطت أقل نسبة فقد وزن وتالف مع إحتفاظ القرون بجودتها خلال التخزين) كما أدت إلى تقليل نفقات التدفئة .

لوحظ أن هناك زيادة فى نسبة فقد الوزن والتالف والألياف ونقص فى كمية الكلوروفيل فى القرون بزيادة مدة التخزين كما زادت نسبة المواد الصلبة الذائبة لفترة ثم بدأت فى النقص بزيادة مدة التخزين .