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A Research on Applicability of Greenhouse Sheep Barns in Bursa Conditions[1]

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ABSTRACT: In this study, possibilities of using greenhouse sheep barns were investigated under the climatic conditions of Bursa/Turkey. The study was carried out for 2 years in plastic covered greenhouse sheep barns (8 m x 25 m) located in Agricultural Research and Application Center of Uludag University. Round tubing and white colored plastic (PE) covering material were used as greenhouse construction materials. In order to determine if the indoor environment of greenhouse barn is suitable for sheep housing, certain climatic data such as temperature and relative humidity were collected. Monthly average indoor air temperatures for winter and summer were ranged 7.8-13.1 °C and 22.4-27.1 °C, respectively. Indoor relative humidity was varied from 59 % to100 % in December and 50 % to 100 % in July. Monthly average relative humidity for December and July were 81 % and 70 %, respectively. Indoor air temperature variations were similar to outdoor air temperature variations while indoor relative humidity variations independent from outdoor relative humidity variations. Indoor relative humidity variations were related to the effective use of ventilation openings. The results, demonstrated that if appropriate operation and measurements were maintained, it would be possible to use greenhouse sheep barns under Bursa conditions.

Keywords: Sheep, Greenhouse Sheep Barns, Environmental Requirements of Sheep.

Sera Tipi Ağılların Bursa Koşullarında Uygulanma Olanaklarının Araştırılması

ÖZET: Bu çalışmada, sera tipi koyun ağılının Bursa bölgesi iklim koşullarında uygulanma olanakları araştırılmıştır. Çalışma, Uludağ Üniversitesi Tarımsal Araştırma ve Uygulama Merkezi'nde 8x25 m boyutlu plastik örtülü sera tipi ağılda 2 yıl süreyle yürütülmüştür. Sera yapı elemanı olarak boru profil ve beyaz renkli plastik(PE) örtü malzemesi kullanılmıştır. Araştırmada, ağıl içi çevre koşullarının koyun isteklerine uygunluğunu değerlendirebilmek amacıyla çeşitli iklimsel ölçümler yapılmıştır. Araştırma sonucunda; ağıl içi aylık ortalama sıcaklığı, kış aylarında 7.8-13.1 °C ve yaz aylarında 22.4-27.1 °C arasında değişmektedir. Aynı biçimde, ağıl içi bağıl nemi Aralık ayında % 59-100 ve Temmuz ayında % 50-100 arasında değişim göstermiş, aylık ortalamalar sırasıyla % 81 ve % 70 olarak gerçekleşmiştir. Ağıl içi ortam sıcaklığının dış ortam sıcaklığına paralel bir değişim gösterdiği, bağıl nem değerlerinin ise dış ortamdan bağımsız, havalandırma açıklıklarının kullanımıyla ilgili olduğu belirlenmiştir. Sonuç olarak, uygun kullanım ve işletmecilikle birlikte sera tipi koyun ağılının bölge koşullarında uygulanabileceği söylenebilir.

Anahtar Kelimeler: Koyun, Sera Tipi Ağıl, Koyunların Çevre İstekleri.

INTRODUCTION

Sheep production is one of the major livestock production system in Turkey and it depends significantly on pasture grazing. Although sheep production cost is low, sheep barns are usually constructed as closed buildings with high cost. However: such barns are not efficient enough to meet the sheep's environmental requirements and using labour. Whereas, construction of low-cost sheep barns considering the local conditions is possible and those barns can be capable of maintaining profitable production.

Sheep can be grown in very different climatic conditions because of their wool fleece. Thus, sheep can survive in very wide range of environmental conditions. However, sheep should be protected from low temperatures and rainfall in cold, and high temperatures in warm climates. Otherwise, desired production efficiency could not be achieved. In critical periods, indoor air temperature and relative humidity values should be maintained within optimum range (Alkan, 1972).

Although appropriate ambient temperature for sheep varies from 4 ^{o}C to 24 ^{o}C, optimum indoor air temperature is recognised as 10-13 ^{o}C (Ekmekyapar, 1991). Damm (1997) suggested that optimum indoor air temperature for sheep, lambs and fattening sheep must be 6-14 °C, 12-14 °C and 14-16 °C, respectively. Sheep can survive at the temperatures as low as – 40 °C. However the resistance level to the cold depends on length and quality of her wool fleece and air flow rate. For instance, a sheep with 60 mm length wool fleece can maintain vital functions and production efficiency at flow rate of 0.2 ms^{-1} and up to – 7 °C indoor air temperature (Webster, 1976). Upper critical temperature for sheep without causing any loss in efficiency and production can be as high as 32 °C while the relative humidity is below 50 % (Ekmekyapar, 1991).

Sheep are sensitive to high relative humidity . Indoor relative humidity should not exceed 80 % except obligatory conditions (Damm, 1997). High relative humidity not only decreases the quantity and quality of wood fleece but also negatively affects the animal health (Balaban and Şen, 1988). Relative humidity of 70-80 % is the most appropriate range for sheep (Geigenmüller, 1992).

Indoor air must be fresh, cool and dry. Therefore, high relative humidity must be prevented and adequate air exchange must be provided. In open sheds, there are no heat and humidity accumulation. However, sufficient air exchange is necessary in closed sheds. Air exchange in sheep barns is usually supplied by natural ventilation (Randall and Boon, 1994). In naturally ventilated sheep houses the air inlet should ideally be positioned above the sheep's back to avoid draughts (Slade and Stubbings, 1994). In order to provide efficient natural ventilation, designed ridge openings must be equal to total area of sidewall openings (Bruce, 1982).

Capital investment for sheep housing and equipment is low comparing to that of other livestock barns. In some cases, construction of a building for sheep housing is not necessary (Lindley and Whitaker, 1996). However, sheep house must be planned properly in order to protect sheep from higher and lower temperature, precipitation, theft and wild animals (Maton ve ark., 1985).

Depending on the traditions, sheep houses can be planned as open or closed sheds depending on the cost and local conditions. In 1980's, plastic covered greenhouse form was developed to reduce cost (Robertson and Lunney, 1982). It provides drier and more hygienic environment in greenhouse barn comparing to conventional buildings. This type of structure is portable and could be constructed easily due to its light framework (Anonymous, 2002). Round tubing and steel are used as load-bearing systems of greenhouse barns (Harmon and Xin, 1996). Colourless or white coloured single or double layer polyethylene, fibreglass, duraflex (in 0.225 mm thickness) can be used as covering materials (Gadd, 1993 ; Anonymous, 2002). Polyethylene with 30 % light transmissivity in 0.15 mm thickness is the most common covering material in greenhouses (Kammel et al., 1997).

In this study, it was aimed to investigate if the indoor environment of greenhouse barn (8x25 m) constructed in Agricultural Research and Application Center of Uludag University is suitable for sheep housing under Bursa conditions.

MATERIALS AND METHODS

The study was carried out at Uludag University Research and Application Center between March 1999 and February 2001. Seventy 3-4 years of *Kivircik and Merinos* sheep were housed in the greenhouse sheep barn. Sheep herd was grown in accordance with pasture grazing which is common type of production type in the region. Sheep were kept in the barn only in the evenings and cold-rainy periods.

In this study, plastic covered greenhouse (8x25 m) with arch roof was used to house sheep herd. This greenhouse barn is a model structure developed for plant production. Some arrangement were performed in order to use it in sheep production. Sidewall and ridge height of greenhouse barn were 2.30 m and 4.00 m, respectively. Greenhouse structure material was galvanized tubing and covering material was UV and IR inhibited plastic silage cover. Floor of barn was adapted to sheep production.

Greenhouse barn was oriented in east-west direction considering land topography and ventilation efficiency. Ventilation is performed by manually rolling the plastic material up to 1 m width on both side of the greenhouse. There is no ridge opening or chimney on roof. Opposite gable opening in 1.85 m by 1.70 m, positioned at 3 m height from the floor and opposite sliding doors were also used for ventilation. Sliding doors were especially used when heat and humidity are at high values.

Temperature and humidity data were collected in order to analyze indoor environmental conditions. An automatic datalogger was used to measure temperature and a hygrograph was used to measure relative humidity . Outdoor weather data were collected from weather station located at the Research and Application Center.

Temperature and relative humidity measurement devices were installed on a truss positioned at the center of barn (Fig. 1). Temperature data were collected from 5 different points and recorded weekly in 10 minutes interval. The aim of data collection from 5 different points is to determine the vertical and horizantal temperature variations in the barn. Data recorded on datalogger's memory were transferred to a PC at the office. After the completion of charging battery, datalogger were mounted to previous position. Average indoor air temperature value were calculated as average of data collected from 5 different points.

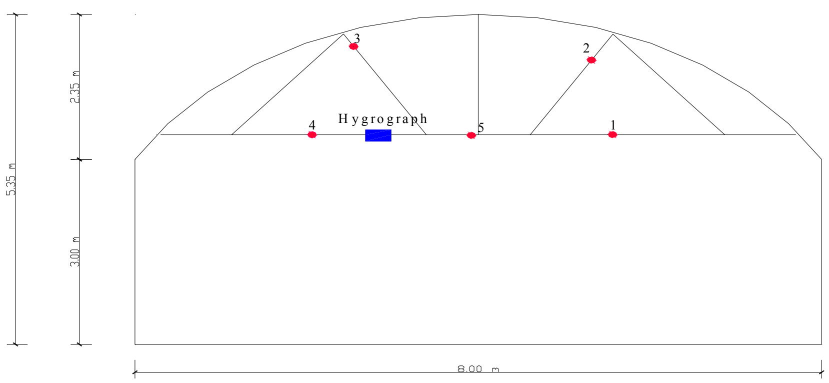


Figure 1. Position of Temperature and Relative Humidity Measurement Devices.

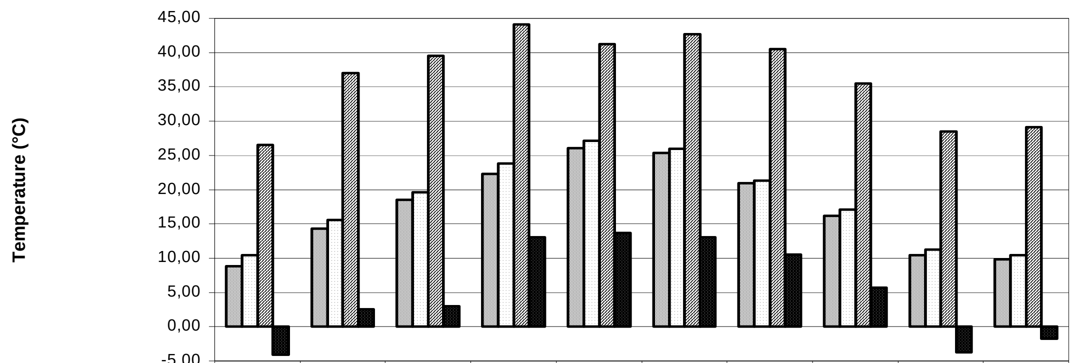
Hygrograph used in relative humidity measurements was installed closed to datalogger. Relative humidity data were recorded on a graphic chart as weekly basis and transferred to a PC, then required calculations were performed.
Outdoor temperature and relative humidity data were collected by digital measurement devices placed in weather station with 10 minutes time intervals. Data recorded on devices' memory were transferred to a PC once in every 15 day and analyzed later. Microsoft Excel software was used in analysis of indoor and outdoor weather data.

RESULTS AND DISCUSSION

Temperature and humidity were measured between March 1999 and February 2001. Plastic covering material was damaged due to severe regional wind occurred in January 2000. So that, measurements could not be taken during the period of January-May 2000 due to delay in supplying new covering material.

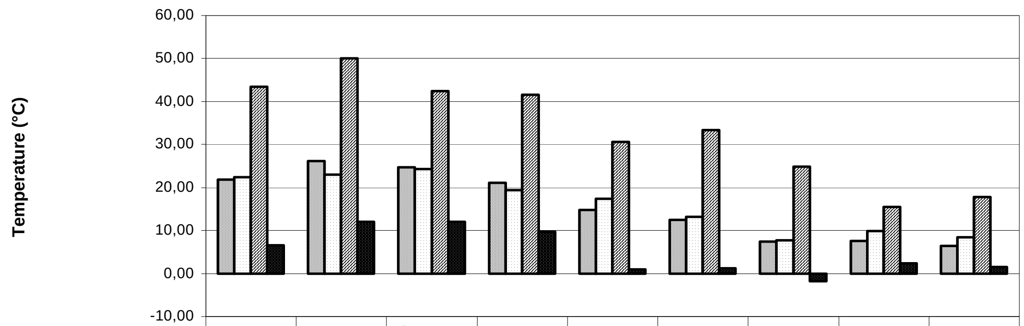
The data were evaluated to see if the indoor environmental conditions are suitable for sheep housing. It was found that averages of indoor air temperature was 1-2 °C higher than outdoor average temperature for winter and intermediate seasons in monthly basis (Figure 2 and 3). Due to low transmissivity of covering material, indoor average temperature were 0.5-3 °C lower than outdoor average temperature in July, August and September in which average temperature was relatively high.

During the study period, minimum and maximum indoor air temperatures were measured as –4.1 °C in March 1999 and 50.1 °C in July 2000, respectively. While indoor average temperature varied from 7.8 to 13.1 °C for winter, the same values for summer were realized as 22.4-27.1 °C. Average temperature values for winter months were compatible with recommended optimum range (6-14 °C) for sheep (Damm, 1997). Optimum temperature range was exceeded during summer months due to high indoor air temperature based on outdoor air temperature increase. For instance in July 2000, outdoor air temperature was recorded as above 50 °C and consequently maximum indoor air temperature was reached to 50 °C. However, indoor air temperature was below the upper limit (32 °C) (Ekmekyapar, 1991) when monthly average temperature variations were considered.
Daily variations of temperature values obtained from 5 different measurement points in January 23, 2001 is given in Figure 4. As can be seen from the figure, temperature variations were almost similar for each measurement points. Maximum temperature differences among 5 different measurement points were observed as 1-1.5 °C during the night and mid-day. Temperatures measured on south surface were slightly high in comparing to north surface. Temperature values measured at two different points in ridge were similar.



	March 99	April 99	May.99	June 99	July 99	August 99	Sept. 99	Oct. 99	Nov. 99	Dec. 99
Aver. Outdoor	8,85	14,33	18,49	22,30	26,03	25,37	20,95	16,22	10,42	9,80
Aver. Indoor	10,44	15,56	19,60	23,81	27,14	26,01	21,30	17,04	11,25	10,42
Max. Indoor	26,50	37,00	39,50	44,10	41,20	42,70	40,50	35,50	28,50	29,10
Min. Indoor	-4,10	2,50	3,00	13,00	13,70	13,00	10,50	5,70	-3,70	-1,80

Figure 2. Average, Maximum, and Minimum Indoor and Outdoor Temperatures for various months of 1999 in Sheep Barn



	June 00	July 00	August 00	Sept. 00	Oct. 00	Nov. 00	Dec. 00	Jan. 01	Feb. 01
Aver. Outdoor	21,79	26,15	24,77	21,18	14,78	12,51	7,39	7,61	6,36
Aver. Indoor	22,40	22,94	24,30	19,45	17,32	13,14	7,75	9,88	8,39
Max. Indoor	43,50	50,10	42,50	41,50	30,60	33,30	24,90	15,46	17,83
Min. Indoor	6,50	12,00	12,00	9,80	1,00	1,20	-1,80	2,34	1,50

Figure 3. Average, Maximum, and Minimum Indoor and Outdoor Temperatures for various months of 2000 in Sheep Barn

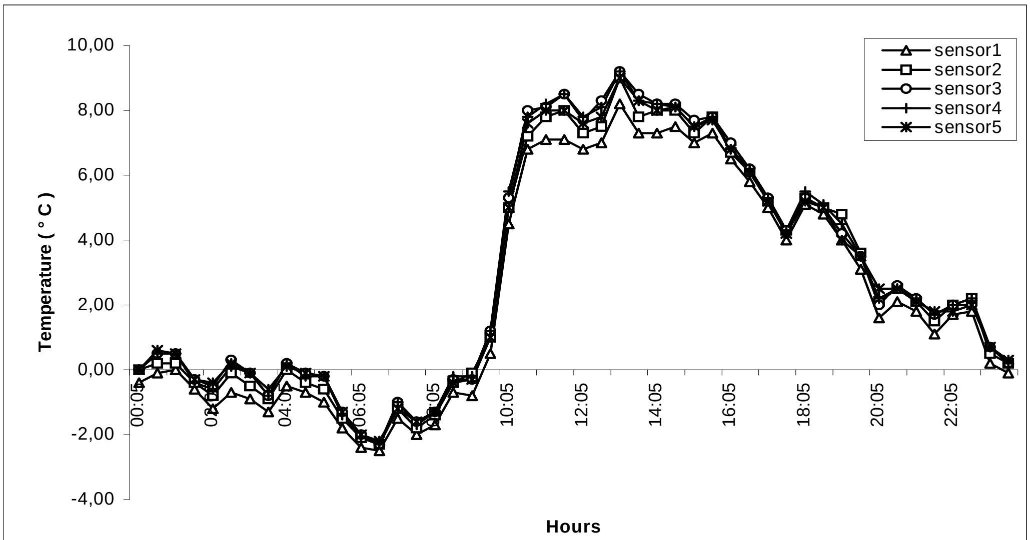


Figure 4. Daily Temperature Variations for 5 different measurement points on 23th January 2001 in greenhouse barn.

Relative humidity is another environmental factor that should be considered in any animal housing as well as sheep barns. Relative humidity varies mostly with temperature. Thus, it is better to analyze temperature and humidity values together.

Seasonal variations in indoor relative humidity were separately examined for winter and summer. Temperature and relative humidity variations for indoor and outdoor in December 1999 are shown in Figure 5. Outdoor relative humidity was higher than indoor relative humidity only for 3 days in December 1999. Indoor relative humidity was recorded as 10-35 % higher than outdoor relative humidity in the rest of this month. Average indoor relative humidity values were observed as 80 % and more for 16 days. Air temperatures were observed as low as 10 C or less when the relative humidity was high. It was observed that condensation occurred on the inner surface of plastic covering material in cold days. Similarity observed in between outdoor and indoor air temperature variations was not observed in between outdoor and indoor relative humidity variations. Abrupt changes occured in outdoor relative humidity occasionally was not similarly realised in indoor relative humidity**.** The main reasons of discrepancy are low outdoor air temperature, closing of sidewall ventilation openings completely at evening due to unconscious tendency of protecting the sheep from low temperature, and unsuitability of used greenhouse model for ridge ventilation due to its structure. Additionally, vapor added to indoor environment with respiration, moisture in urine and moisture resulted from waterworks are the factors affecting increase of indoor relative humidity.

According to the observed data, it is found out that recommended maximum relative humidity value(Damm, 1997) (80 %) for winter was exceeded in certain days. In order to analyze relative humidity variations for summer conditions, temperature and relative humidity data for July 2000 were used (Figure 6).

While the temperature values for indoor and outdoor were similar, difference between indoor and outdoor relative humidity values were observed as high as 20 %. Indoor relative humidity was observed as 80 % or more for 6 days in July 2000. However, outdoor relative humidity values were also high in those days. In this month temperature values are higher than seasonal averages. Daily average indoor relative humidity was recorded as about 70 % while the minimum value of daily average relative humidity for this month is 50 %. This situation has justified that possible decrease of relative humidity with high temperature had not been noticed in indoor environment. In rainy days of the same month, average outdoor relative humidity was found as 90 %. To retain rainwater out of building, all ventilation openings were closed; therefore indoor relative humidity reached up to 100 %.

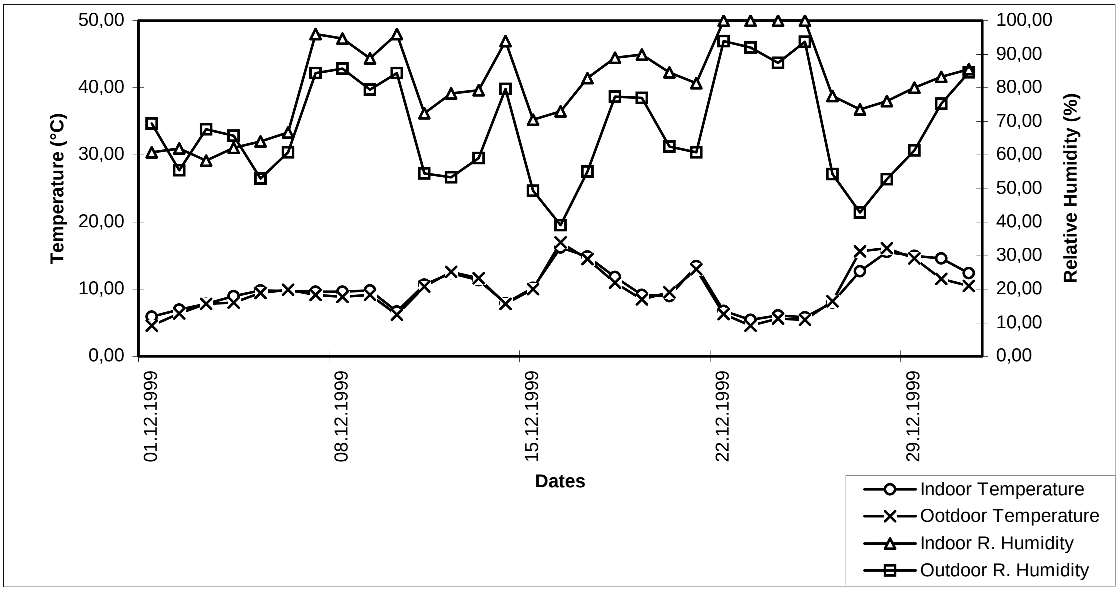


Figure 5. Temperature and relative humidity variations for December 1999.

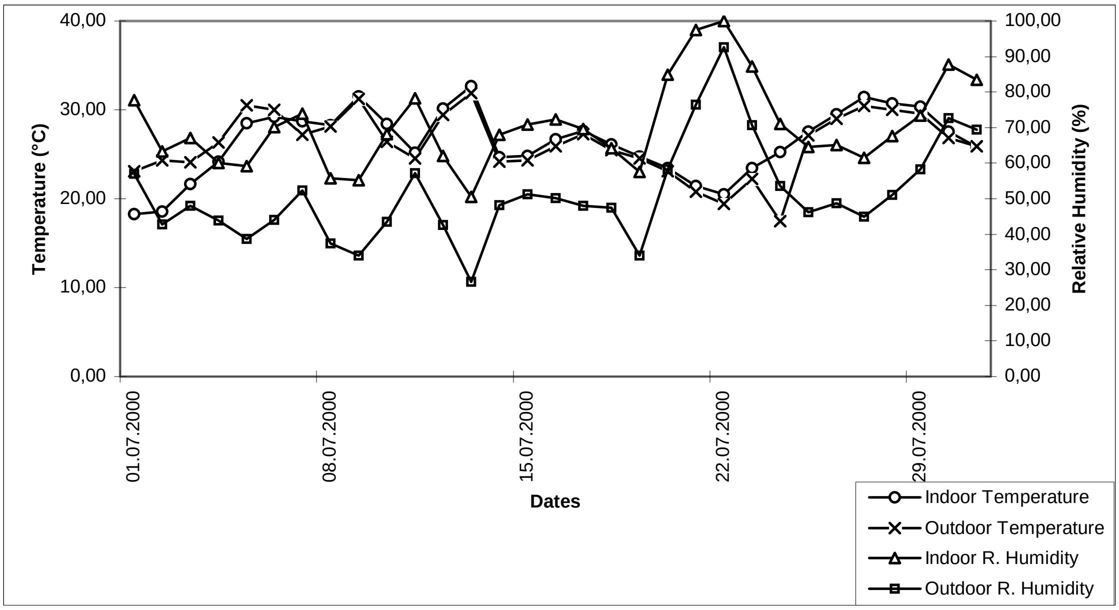


Figure 6. Temperature and relative humidity variations for July 2000

According to obtained results; it was found that greenhouse barn was able to meet sheep's environmental demands throughout the year. Sheep were only housed in the period when they were not in pasture. One of the doors was always kept open in summer and intermediate seasons in order to provide full access to openyard. Sheep are able to walk and rest freely in those periods of time. Amount of manure accumulated in barn was low since sheep spent most of their time in openyard. Well drained barn floor and litter usage has contributed the cleanliness of sheep and arrangement performed in first stage has made manure removal easier. It was observed that there were no negative effects on sheep's health and productivity.

CONCLUSIONS

Greenhouse barns have evolved quickly in the past several years to adequately address the different environment livestock require versus greenhouses' original plant occupants (Wheeler, 2001). However, some problems have been encountered in application. Some recommendations for solution of those problems as follows:

- The design of greenhouse barn is one of the most important stage to be considered. In site selection, land topography should be considered and rainwater must be kept out of the barn (Kammel et al., 1997). In order to increase ventilation efficiency air inlets must be located considering prevailing wind. However, orientation must be done very carefully because harsh wind may be very harmful to structure components. Trees can be used as windbreaks. It will also provide shading for the sheep in hot days.
- Sufficient sidewall openings and continuous ridge openings should be designed since the existing high flock density may cause heated, humid and contaminated air accumulation.
- UV and IR inhibited white colored plastic covering with low light transmissivity, high reflection can be used as covering material.
- Trembling of covering material in windy conditions can be uncomfortable for sheep while it is not a problem in greenhouses for plant production. For that reason, covering material should be located such a way to prevent trembling and movement of covering material must be avoided using strip in certain spaces.

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