Horizontal spacialization of evaporation in protected environment in Botucatu - SP

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Abstract

The management of irrigation water in a culture is important because it allows the rational use of this factor of production aimed at obtaining the maximum output per unit of water applied. Allied to this technology, the cultivation in protected environment enables continuous production at times of the year in which conditions are usually unfavorable to the field, allowing the supply of the domestic market in all seasons. The study was conducted in the experimental area of Department of Rural Engineering of the Paulista State University - UNESP, *campus* of Botucatu, to evaluate the spatial protected environment through the distribution of minievaporimeters to check the distribution of energy in three heights, 40, 80 and 120 cm from the ground and the horizontal specialization. The study was conducted in plastic greenhouse, with guidance Northwest-Southwest. The climatological variables, and the weekly evaporation of minievaporimeters were evaluated for 8 months. The results indicated that the spatial distribution of minievaporimeters showed that during the study period from 07th May to 16th July ocurred greater evaporation in the environment to 40 cm of soil, ie, during the coldest months. The period from July 30th to September 16th the highest evaporation occurred at 80 cm soil. The minievaporimeters installed to 120 cm of soil showed values less than or equal, in other times, regardless of the evaluation period. The west side of the environment had higher evaporation for the entire study period. There was more evaporation in the protected environment during the coldest months of the year for minievaporimeters which were near the ground.

Key words: energy balance, agricultural climatology, evaporation.

Introduction

More and more there is a need to increase the world food production. With the use of technologies that verticalize the production, the individuals can achieve high rates of productivity in almost all sectors of agriculture, because the expansion of agricultural areas is restricted and it is a privilege of a few countries. The use of agricultural areas has to be rational and to ensure the maintenance of the life of man on the planet. Many of these areas, with intensive use and inadequate management are being compromised and causing loss and damage, not only economic, to the producer, but also damage to the environment, making impossible the use of them.

Manage a culture means changing the natural functioning of the plants that compose it, to better adjust their behavior in accordance with the desired agronomic goals. For the management, it is necessary to know the relations governing the operation of the plant, and then understand the way in which these relations are linked between them to result in final yield (ANDRIOLO, 1999).

The protected crops have become a production system widespread in agriculture because of the need to provide products *in nature* and in good quality throughout the year.

In recent decades the growth in greenhouse showed significant growth in Brazil, mainly for production of vegetables and flowers. Considering the importance of food crops, its production cost and its high economic value, especially in off-season, it has been necessary to search in order to provide technology to increase productivity and reduce risks.

Among the benefits of cultivation in protected environment, it can be cited the increasing diversity of agricultural products and the stability of annual production, with optimization of land use. In places where the land is more valued, or more scarce, cultivation in greenhouses is a valuable strategy to increase productivity and absorb the increased agricultural production (SOUZA, 2003).

Despite the advantages offered by cultivation in protected environment, some difficulties found by producers result in abandon of this activity, and the main reasons are the difficulties of marketing and lack of knowledge about the rational management of climate parameters and irrigation.

The protected environment makes possible the exploration of cultures at times uncommon in cultivation and therefore, can be achieved better economic return due to product quality, and to production that occurs off- season.

Inside the greenhouse the evapotranspiration is generally lower than that seen externally, which is attributed mainly to the partial opacity of the plastic cover on solar radiation and reduce the action of winds, which are the main factors of water evaporative demand of the atmosphere while the air temperature and relative humidity in some moments, can be respectively higher or lower in the greenhouse than in the open area, which would reflect in the evapotranspiration. The difference between the internal and external evapotranspiration varies according to weather conditions, generally the inside evapotranspiration is around 60-80% than the one observed outside (FARIAS et al. 1993).

The meteorological variables inside the greenhouses present spatial variability, influencing the development of crops through effects on transpiration and photosynthesis. The control and monitoring of meteorological variables, especially humidity and air temperature are important factors in controlling diseases of plants grown inside the greenhouses.

Thus this work aimed to evaluate the spatial distribution of water evaporation in the greenhouse at three different heights of collection.

Material and methods

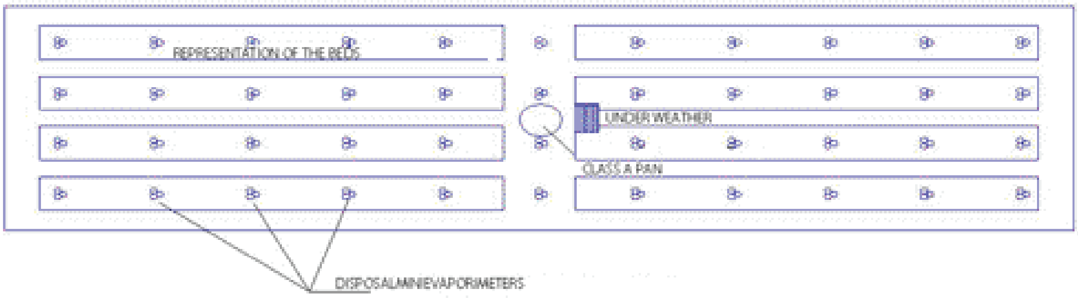
The study was conducted at the experimental area of Department of Rural Engineering, Faculty of Agricultural Sciences, belonging to the Universidade Estadual Paulista, Campus of Botucatu - SP, whose geographical coordinates are 22° 51’03”south latitude and 48º25’37” west longitude with average altitude of 786 meters.

The climate is defined in the Temperate Climate (mesothermic) by Köppen. The region is wet, with rainfall of about 1,516.8 mm and average annual evapotranspiration of 692 mm. The average annual temperature is 20.6 º C with average maximum and minimum temperatures of 23.5 and 17.4 º C, respectively.

The study was conducted in a plastic greenhouse geographically oriented in the northeast-southwest direction. The plastic greenhouse was a kind of tunnel with coverage in the form of an arc, with the following dimensions: width of 7 meters, 20 meters of length, height of the right foot of 1.85 meters and center of 3.35 meters, covered along with polyethylene plastic films, 100 microns of thickness. In the sides and in the funds were placed sunlight 40% .

In the figure 1 are presented the minievaporimeters, Class A tank and thermohygrograph. The 132 minievaporimeters were installed distant from each other at 2.0 m to 2.10 m in the longitudinal and transverse direction of the greenhouse, and three levels of height 0.40, 0.80 and 1.20 m. The minievaporimeters consisted of a plastic container of volume 1.0 L. For determination of the evaporated blade in minievaporimeters they were filled with 500 ml of water each, and once a week the resulting water in each minievaporimeters was measured and again filled with 500 ml of water. By the difference of water offered every week was determined the weekly evaporation in the greenhouse.

Figure 1. Schematic representation of the location and arrangement of equipment in the plastic greenhouse.



The data of temperature and air humidity were recorded in the oven, using a thermohygrograph, Dickson model, with accuracy of at least 95%, installed under appropriate weather and positioned near the center of the oven, at a height of 1.5 m. The analysis of space were done using the software Surfer 7.0. (Golden Software). The method of interpolation used was Krigagem.

Results and discussion

The monthly average relative humidity during the May-June term, was approximately 62.5%, 50% for July-August, 54% for September-October and 61% for February to April. The monthly average temperatures were 15.5, 18.2, 20.3 and 21.8º C for the above marking periods.

Pezzopane et al (1996) reported that the average minimum temperature of the air inside the greenhouse covered with low-density polyethylene tends to be equal or slightly higher when compared to the external environment.The average temperature for May-June, July-August, September-October, February-April in the greenhouse were 17 C, 19 C, 20 º and 20.5 º C respectively.

The relative humidity of the air was inversely proportional to air temperature. This showed that the daily average values of relative humidity inside the greenhouse were related to the values of air temperature, in agreement with Santos (2001) and Prados (1996). Thus, in the greenhouse, the raise of the air temperature during the day on which the balance of energy is positive reduces the values of relative humidity, making them inferior than that observed in the field, in the hottest hours of the day. In figure 2 there are the changes inside and outside the protected environment, and the average temperature for the first cycle, when different potentials were applied to culture.

The results presented in figure 3 show that the average values of evaporation from Class A tank had a behavior similar to the observed values of air temperature. During the months with values of higher air temperatures and low relative humidity, there was a tendency to increase evaporation, as well as in the days of values of lower air temperature and relative humidity high, there were reductions.

There was a gradual increase in evaporation period of transition from winter to spring, mainly because of the influence of higher temperatures during this season. The daily average evaporation in the tank Class A, in the term of development was 1.93 mm day-1; for the second term of 3.28 mm day-1 and 3.59 mm day-1 in the term. Santos (2001) found values of evaporation in Class A tank lower inside protected environments

Figure 2. Temperature and relative humidity, internal and external to the environment protected, for the first cycle of cultivation, May-July.

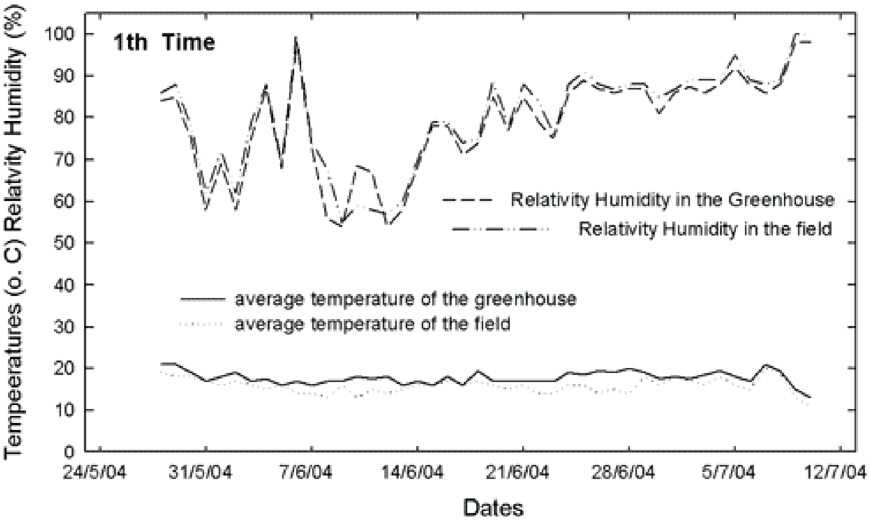
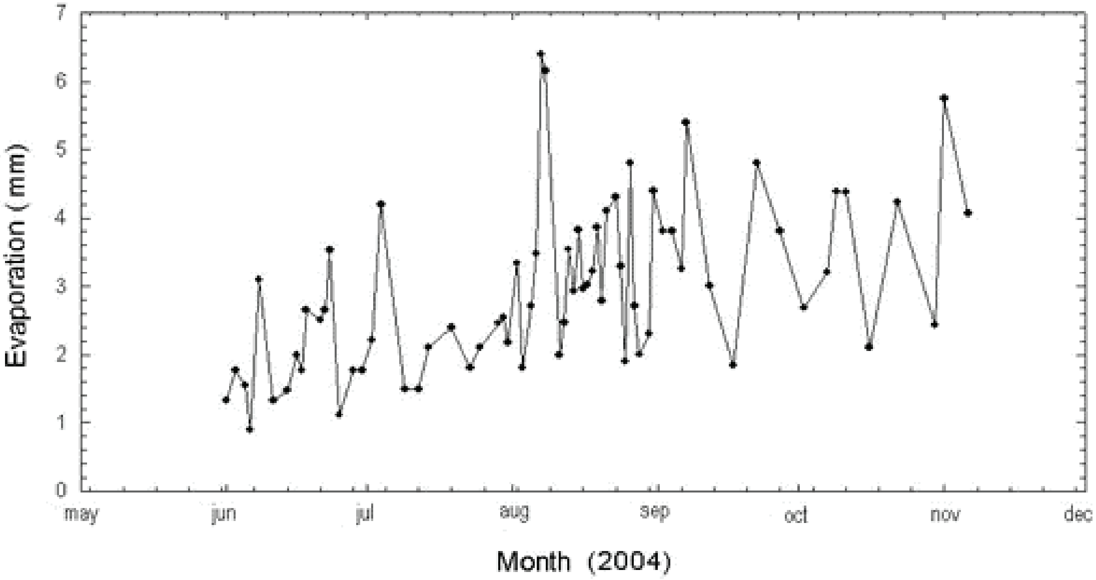


Figure 3. Evaporation of the Class A tank for the assessment period.



for similar periods of the year, possibly because of changes in air temperature but for different periods of precipitation.

The increase in air temperature significantly influences the intensity of evaporation due to the greater amount of water vapor present in the same volume of air, so the higher the humidity of the air, the lower the intensity of evaporation.

The tests were made weekly and the data presented below are those from a few intermediate weeks for a subdivision term corresponding to the average periods of cycles of deployment of the short period for vegetable cultivation in this type of structure. For minievaporimeters installed at 40, 80 and 120 cm from soil, it was observed a weekly variation of 20.35, 20.50 and 18.66 mm respectively for the week of May 7th to 15th, presenting significant higher evaporation by Tukey test, for the first two heights. The spatialization of evaporation to this week can be observed in Figure 4. The evaporation for the week of May 28th to June 4th presented the following values 12.05, 11.73 10.38 mm for the heights 40, 80 and 120 cm from soil, respectively, presenting significant higher evaporation by Tukey test for the first two heights, similar to the behavior studied in May, but lower values of evaporation, caused mainly by low temperatures recorded in the period. The spatialization of evaporation for this week can be observed in Figure 5.

The evaporation for weeks June 18th to 25th, July 9th to 16th and July 30th to August 6th, (Figure 6 and 7) presented similar values, slightly higher in the first week referred, with around 15 mm per week, at different heights.

For the week August 20th to 27th, the values of increased evaporation, near the spring, and were 26.01 mm for the height of 80 cm, 25.04 mm to 40 cm, equal significantly by Tukey test, and 24.63 to 120 mm, differing in height 80 cm and similar at 40 cm (Figure 8).

In the week September 9th to 16th, with low temperatures, the evaporation of 80 cm height in was significantly higher by Tukey test, with weekly average of 16.72 mm and 15.72 mm and 19.93 for the heights 40 and 120 cm respectively, these two averages do not differ by the same test. The spatialization of evaporation can be observed in figure 9. The protected environment (plastic tunnel) was positioned in Northest-southwest approximately perpendicular to the apparent movement of the sun. It was observed that for almost every week observed the average evaporation was higher in the face toward the southwest.

Figure 4. Spatialization through isolines of weekly evaporation (May 7th to 15th) of minievaporimeters installed at 40, 80 and 120cm from soil.

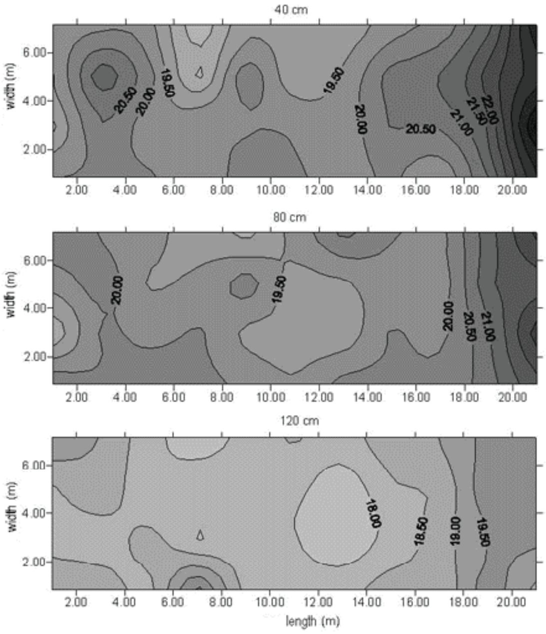


Figure 5. Spatialization through isolines of weekly evaporation (May 28th to June 4th) of minievaporimeters installed at 40, 80 and 120cm from soil.

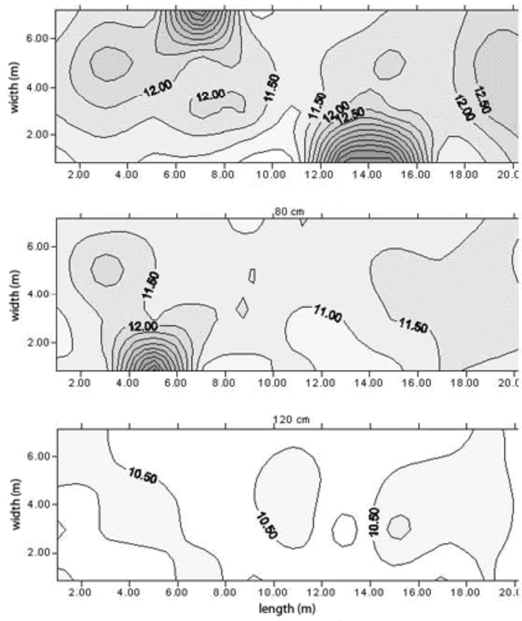


Figure 6. Spatialization, through isolines, of weekly evaporation (June 18th to 25th) of minievaporimeters installed at 40, 80 and 120cm from soil.

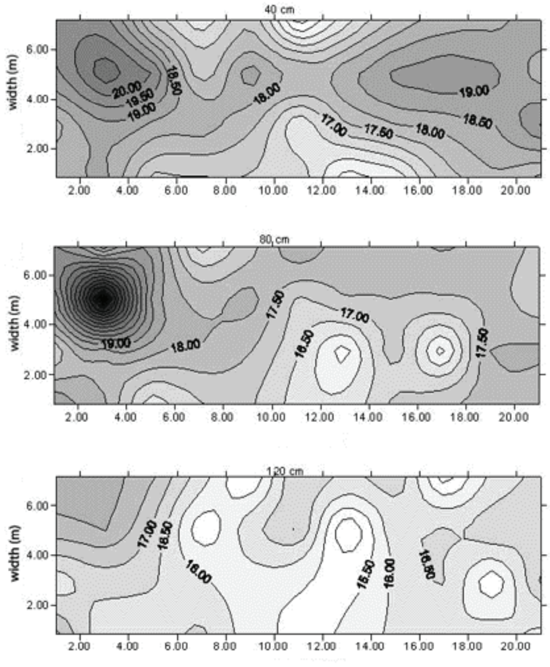


Figure 7. Spatialization through isolines of weekly evaporation (July 9th to 16th) of minievaporimeters installed at 40, 80 and 120cm from soil.

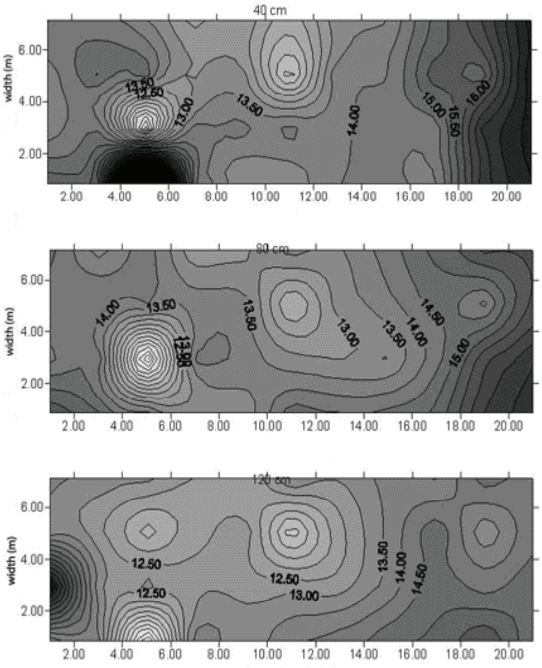


Figure 8. Spatialization through isolines of weekly evaporation (August 20th to 27th) of minievaporimeters installed at 40, 80 and 120cm from soil.

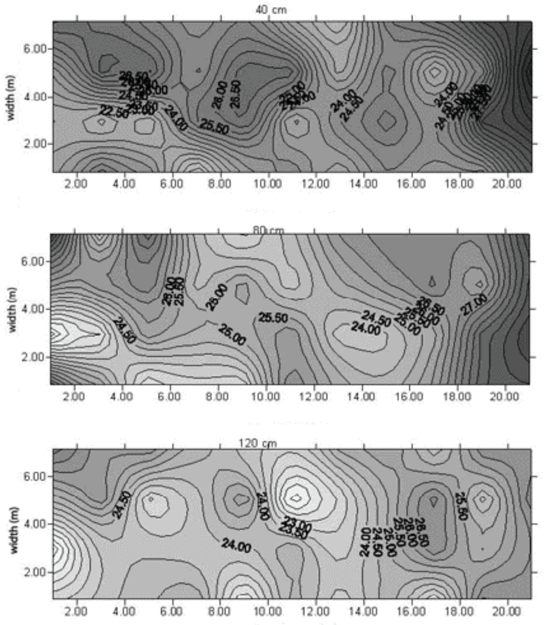
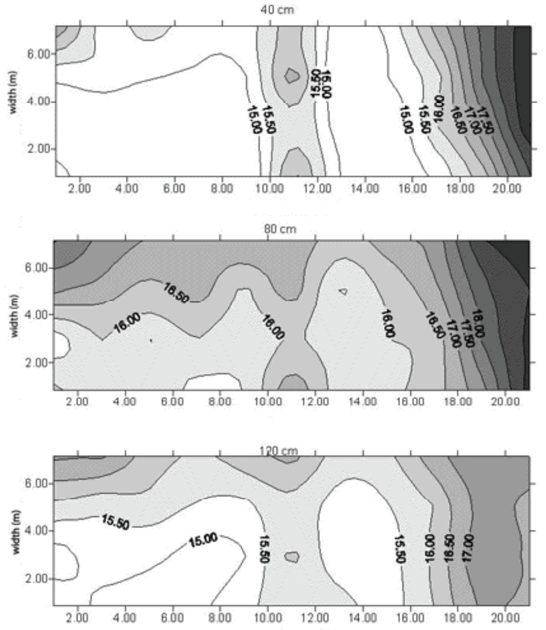


Figure 9. Spatialization through isolines of weekly evaporation (September 9th to 16th) of minievaporimeters installed at 40, 80 and 120cm from soil.



Conclusion

Based on conditions found during the study, it can be concluded that the west side of the environment for the entire study period had higher evaporation in minievaporimeters. There was more evaporation in the greenhouse during the coldest months of the year for minievaporimeters which were near the ground.

Referências

ANDRIOLO, J. L. **Fisiologia das culturas protegidas**. Santa Maria: Ed. da UFSM, 1999, 142p.

FARIAS, J. R. B. et al. Efeito da cobertura plástica de estufa sobre a radiação solar. **Revista Brasileira de Agrometeorologia**, Santa Maria, v.1, n.1, p. 1-36, 1993.

PEZZOPANE, J.E.M.; CUNHA, G.M.; ARNSHOLZ, E.; COSTALONGA, M. Temperatura do solo em função da cobertura morta por palha de café. **Revista Brasileira de Agrometeorologia**, Santa Maria, v.4, n.2, p.7-10, 1996.

PRADOS, N. C. **Contribuitión al estúdio de los cultivos enarenados em almeria: necessidades hídricas y extración de nutrientes del cultivo de tomate de crescimento indeterminado en abrigo de polietileno**. Almeria, 1986, 195p. Tese (Doutorado em Fitotecnia), Caja Rural Provincial, Almeria.

SANTOS, R. F. **Híbridos de pimentão cultivados em ambiente protegido e convencional, fertirrigado com doses de N + K, e avaliação da distribuição da evaporação.** 2001. 162p. Tese (Doutorado em Agronomia – Irrigação e Drenagem) Universidade Estadual Paulista. Botucatu.

SOUZA, C. M. P. de, **Alterações em elementos agrometeorológicos relacionados com a orientação geográfica de estufa de polietileno**. 2003, 84 f. Tese (Doutorado em Agronomia – Irrigação e Drenagem) Faculdade de Ciências Agronômicas, Universidade Estadual Paulista, Botucatu, 2003.