International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 12, December-2014, pp: (125-132), Impact Factor: 1.252, Available online at: www.erpublications.com

Modeling of Integrated Production Tomato under Multispan Greenhouse in Souss Massa region

Ahmed Wifaya[1], Rachid Bouharroud[2], Elame Fouad[3], Azim Khalid[4], Lahcen Bouirden[5], Lahoucine Gourdo[6], Khalid Lekouch[7], Mohamed EL Jazouli[8], Abdelaziz Taoufik[9]

[1,2,3,4,9]Regional Centre of Agricultural Research, Agadir, Morocco
[1,5,6,7,8]Laboratory of thermodynamic and energetic, Faculty of Science, Ibn Zohr University, Agadir, Morocco

Abstract: The renewal of greenhouse in Souss Massa region is a priority to improve the production of protected vegetable crops. The greenhouse structure is a complex system; it is the place of multiple interacting factors continuously in time and space. Aimed at controlling the integrated production under Multispan greenhouse, we need to consider all factors influencing volume and quality of commercial production. Among these factors, microclimate of structure mainly due to its architecture, its coverage material, its ventilation area and weather outside. In parallel with this study other factors will be studied, management of pests, diseases and management of production cost flow, aims to model the integrated production under greenhouse and to provide a convenient way of greenhouses decision making in protected production. This study was conducted in three separate unichapelle compartments 270m ² each. Inputs of fertilizer and water line were managed and controlled by a fertigation compact programmer. As climate data were collected through two weather stations installed in the greenhouse. The results of the first year showed the significant effect of the Multispan greenhouse microclimate on improving the production volume, the management of pests and diseases and economic inputs in comparison with the Canary greenhouse.

Keywords: Modeling, microclimate, Multispan greenhouse, tomato, integrated production, pests and diseases and production cost flow.

Introduction

In the region of Souss Massa vegetable crops occupy an area of approximately 25000ha including protected crops have a total area of 10000ha. For this, 50% of the protected area is dedicated to tomato. The greenhouse park in the region is relatively old and repent over the needs of producers and requirements of foreign markets. Indeed, Canary greenhouse is the most dominant structure in the park. Other new structures, MULTISPAN were installed by some producers, but the higher cost is the main obstacle to their widespread use **[17]**. Production of tomatoes in Canary greenhouse is exposed to two critical periods during its growth cycle. Summer period which coincides with the installation of plant and characterized by long days (> 12), high intensity (> 1600j/cm ² / day) and favorable temperatures for growth. A winter full, production stage (8th or 9th bouquet), characterized by day length (<12), low intensity (<800j/cm ² / day), a low minimum temperature (<12 ° C) and low moisture. These climatic conditions in Canary greenhouses have a negative impact on the growth and health of the plant. Indeed, we are witnessing the withering plants, lack of fruit set, fruit deformation, root rot, the outbreak of fungal diseases and pest intrusion **[13]**.

Thus, to improve the greenhouse park in the region, we analyze three options: The Canary greenhouse improved by mounting the panel and the opening roof angle inclination. It is a structure microclimate experienced with high temperatures and humidity, poor ventilation, intensive use of inputs and production quality is fairly good. Thus, the additional costs for improving the structure and inefficient use of inputs can be reinvested in the acquisition of a new structure. The second option is improved microclimate MULTISPAN greenhouse. Thanks to the efficient use of natural ventilation, inputs and production quality, you can quickly recoup its investment through its profits. Finally, close greenhouse or heated, characterized by its microclimate controlled by means of forced ventilation, air conditioning and heating. It is a structure that requires intensive use inputs. Its cost remains high despite its production more important. Finally, MULTISPAN greenhouse is an intermediate structure between the conventional and closed greenhouse, it can be the most efficient choice for producers in the region **[20][21]**.

The global objectif of this work is:

- Develop a model of integrated decision support for rational use of inputs and microclimate, pests and diseases management.

The specific objectifs are:

- Characterization and modeling microclimate of MULTISPAN greenhouses;
- Design the best climatic conditions inside the greenhouse for optimum production with minimum damage due to pests and diseases;
- Develop a model for integrated greenhouse microclimate and pest management;
- Develop a model to support decision making for plant protection and inputs flows;

Materials and Methods

Plant material: Pristyla;

Planting Date: September 14, 2011.

Factors studied:

- Microclimate 3 compartments unispan greenhouse, a surface area of 290m ² and a height of Ridge-6m;
- 3 ventilation areas, 50% of unispan3 west, 75% for unispan2 in the center and 100% for the last unispan1;
- Four fertilizations balances will be tested;
- Solarization combined soil amendment with three organic fertilizers types, local compost of sheep manure and two commercial composts.

Observations:

- Climate inside and outside of greenhouse via weather station (T °, RH, PAR ...);
- weekly observations of growth, development and yield;
- Physiological: Net assimilation rate of leaves (NAR);
- Monitoring of damage on root and aerial part during the cycle;
- The index of galls before planting and at the end of the cycle;
- Diagnostic compost analysis of at the reception.

Pests and diseases monitoring:

- Whiteflies: Installation of 03 enmeshed yellow plates in the middle and on the length of the greenhouse;
- Tuta absoluta: installation of 03 pheromone delta traps in the middle and on the length of the greenhouse;

Other diseases: nematode, mite, leaf miner, aphids, moths and thrips. Selection appropriate control method after diagnosis and identification.

Other observations: inputs flow.

Integrated production of greenhouse tomato MULTISPAN took place in two main steps. The first is the optimization of inputs through the use of bio-compost and solarization in place of chemical nematicides. In addition, water and fertilizers depends on their availability in soil and plant needs by stage. Similarly, the decision is rational chemical treatment according to the climatic threshold and the burden of bio aggressor in greenhouses. The second step is the maximization of outputs via economic inputs, improved production, sustainable management and conservation of the environment and human health. These activities were carried out through a battery of technical equipment and scientific establishment, two weather stations in the greenhouse, two capacitive probes, four dendrometers three debit meters, two leaf wetness a Lysimeter and Conductivi-metre.

Results and Discussion

A. Solarization

Figure1a shows soil temperature at seven depths (0, 10, 20, 30, 40, 60, 80 cm) during the operation of soil solarization. Indeed, we found that the average soil temperature exceeded 30 ° C for all depths with daily maximum temperatures above 60 ° C and especially for the root zone. It is favorable temperatures for the thermal destruction of nematodes and reduce their load in the soil. The same conditions have been described by **[2]** regarding the lethal temperature for the physical treatment of various germs present at the solarization. There are also examples of suppression of disease-causing nematodes in tomato **[5][12][14]**). Analyzes Tomato gall index shows that this factor has being decreased around 88,65% and 49,71% respectively by 2012 and 2014. The combination of solarization and organic supplements were more effective in reducing the population of Meloidogyne spp. in the soil **[10]**. The same technique appears to be just as effective for the control of a different genus of parasitic plants (Orobanche spp.) which attack a number of crop species **[1][9][15]**), including tomato **[11]**.

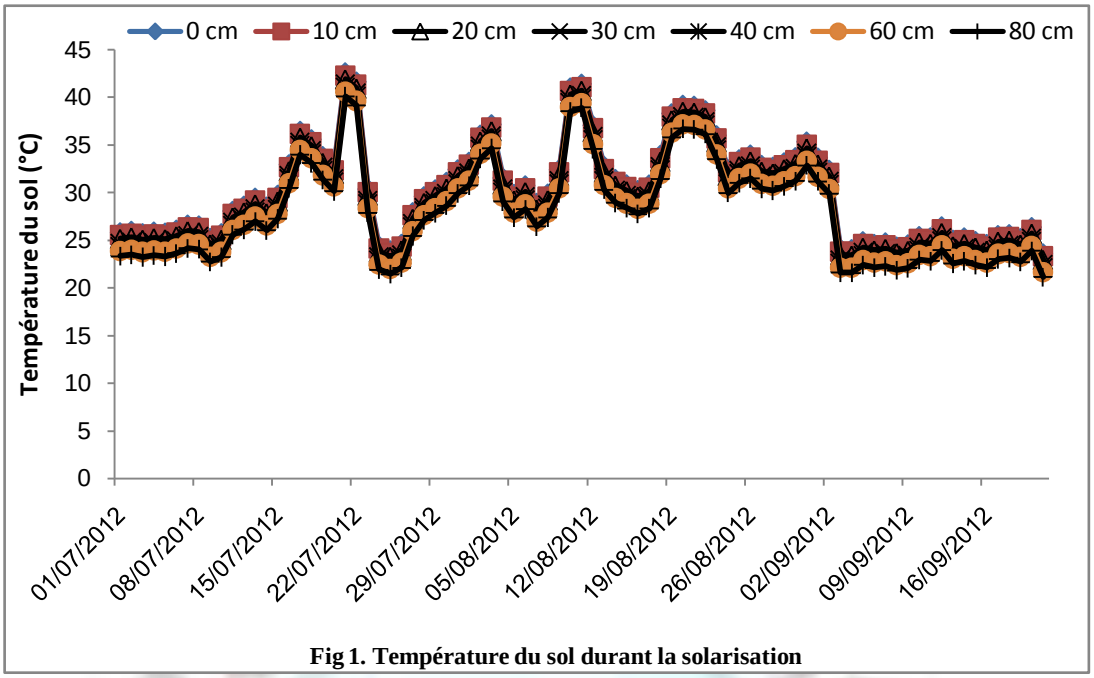

Fig 1. Température du sol durant la solarisation

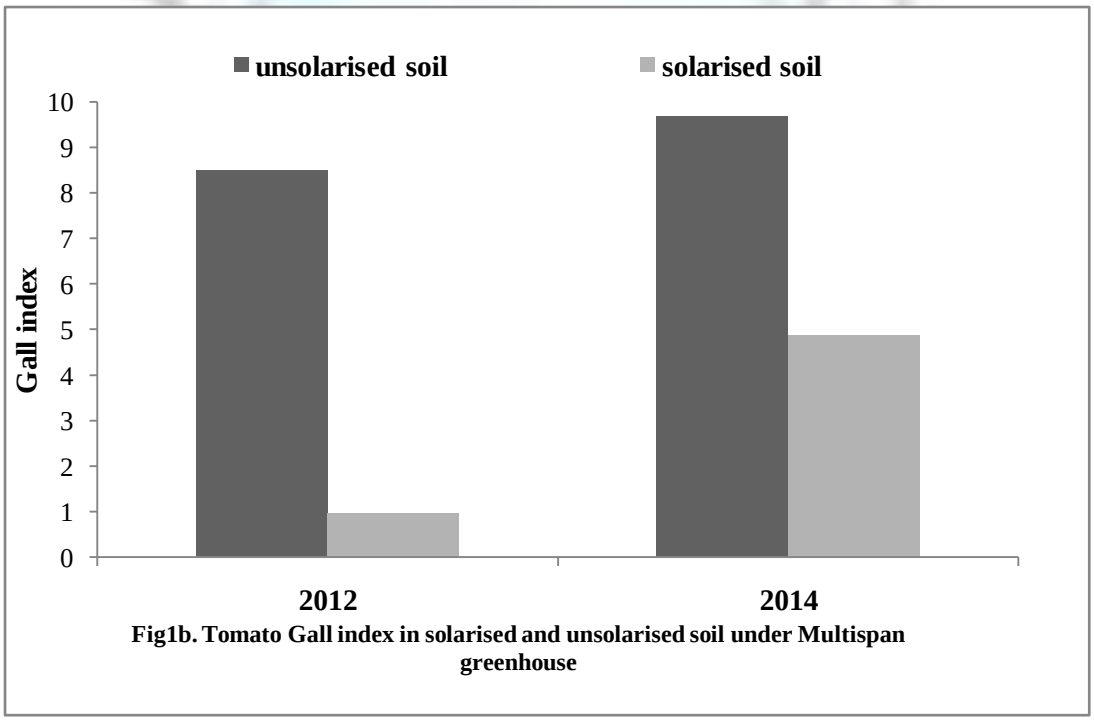

Fig1b. Tomato Gall index in solarised and unsolarised soil under Multispan greenhouse

B. Characterization of MULTISPAN greenhouse microclimate

The analysis of the parameters climate evolution under MULTISPAN greenhouse showed that the campaign is relatively wet and cold. It is characterized by an average maximum temperature of 30°C and at least 10°C, and an average relative humidity of 65%. However, the temperature range of up to 6 Average 9°C, at least 1 to 2°C and a humidity of magnitude 10 to 12% (Figure2). Generally, under MULTISPAN greenhouse conditions were favorable for the growth of tomato in comparison with the external environment **[20]**. In addition, the number of intrusion of whitefly and Tuta absoluta stay away from trigger chemical treatments. Also, the climate demand for MULTISPAN greenhouse remains moderate in comparison with the Canary greenhouse.

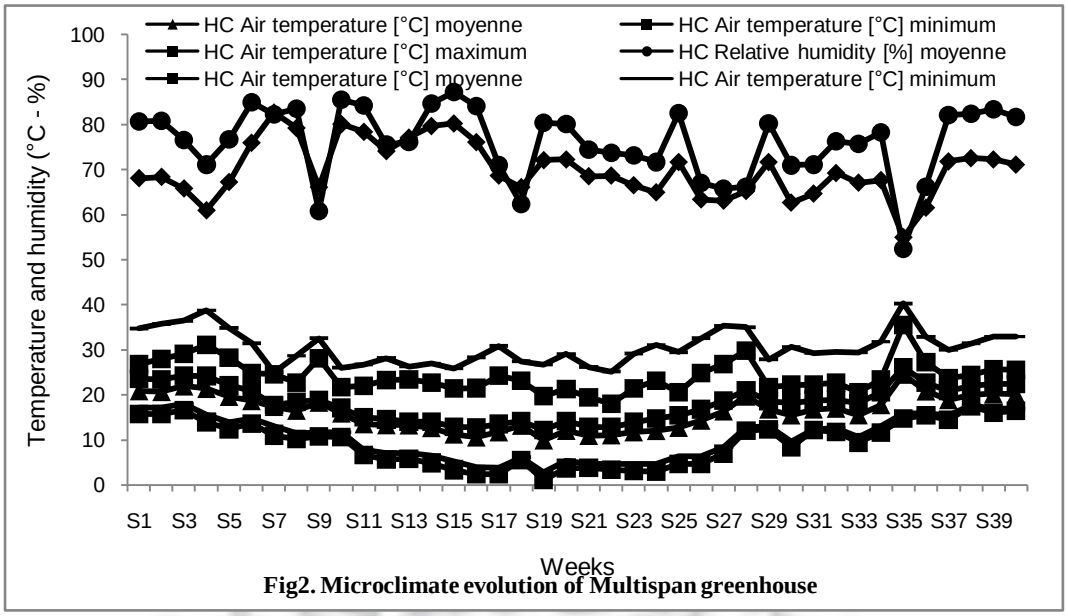

Fig2. Microclimate evolution of Multispan greenhouse

C. Efficiency of active radiation transmission

The figure3 shows the evolution of total external radiation, photosynthetically active radiation under greenhouse and efficiency of active radiation transmission (EART). Generally, this efficiency is between 20 and 45% throughout the campaign. However, during the production active cycle of the plant EART has exceeded 30% due to the architecture of the chapel emissions **[16]**, which contributes significantly to improving the productivity of tomato. For cons, the transmission efficiency is very low in the structure because of uniform roof architecture for greenhouse Canary. Thus, improving greenhouse Canary architecture is a promising research for an intermediate structure with better technical and economic efficiency.

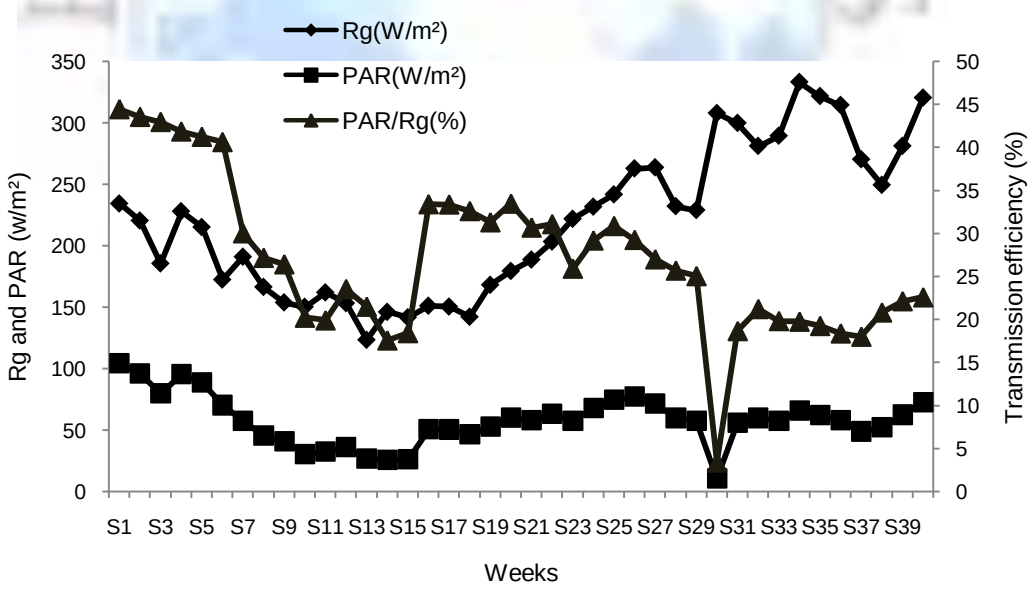

Fig 3. Efficiency of active radiation transmisssion

D. Satisfaction rate of water supply

The analysis of the figure4 shows that the satisfaction rate of water supply for tomatoes in MULTISPAN greenhouse tends to reference values (ideal). In other words, the water needs of tomato are close to the real ones with the regulation of transpiration in this microclimate. The structure offers efficient natural ventilation which reduces water loss through transpiration and thus reduces the demand for additional water **[3][4]**. Consequently, this structure can ensure water saving of 36% compared to conventional greenhouse.

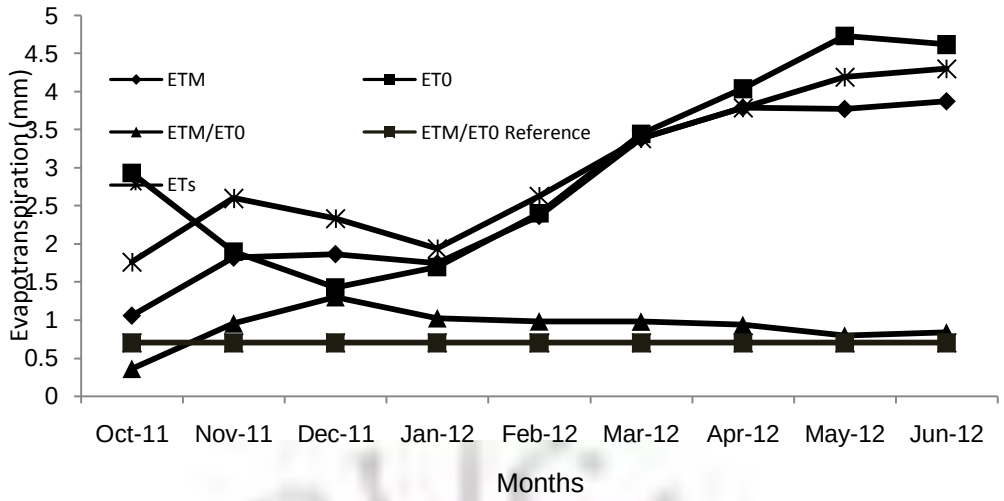

Fig 4. Satisfaction rate of water supply

E. Water consumption and yield

The microclimate of the MULTISPAN greenhouse significantly influenced the yield of tomato. Indeed, the yield of tomato under this structure has exceeded its performance in the Canary greenhouse 40% (280t/ha). This increase in production is a direct response to improving the microclimate of this structure. The span architecture provides better efficiency lighting and ventilation. Similarly, the height of 6m and these three roof, two Ridge, one side increases the rate of air exchange, the release of moist air in the morning and conservation of heat in the evening **[6][7]**.
In the same way, these conditions have allowed the plant to balance its water needs in a moderate climatic demand. Thus, the water consumption of tomato is reduced by 36% (5000m3) in this structure compared with the Canary greenhouse (figure5). It is a good tool for improving water productivity and particularly for intensive farming and water-intensive horticulture in an area with low water availability **[18]**.

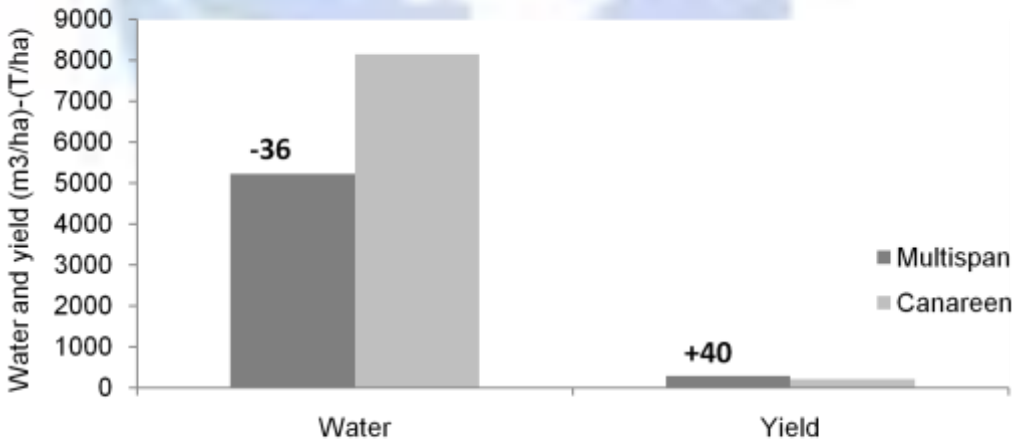

Fig5. Water consumption and yield under Multispanand canary greenhouse

F. Area ventilation and tomato yield

Statistical analysis showed a significant effect of area ventilation on greenhouse tomato yield. In contrast, the second greenhouse that has an area ventilation of 75% recorded highest yield about 25.5 kg/m², followed by the third greenhouse with 24.3 kg/m² (50%) and finally, the first greenhouse with only 23kg/m² and an area of 100%. As a result, knowledge of the optimal area ventilation is an important factor for the optimization of production (figure6). In conclusion, we can say that for this type of greenhouse 75% of area ventilation is recommended for better ventilation efficiency and also to have a greater level of production **[19]**.

Regarding the use of fertilizers, statistical analysis revealed no significant differences in performance for the four fertilizers balance. Thus, it can be balanced using less fertilizer as a baseline for fertilizing tomatoes in this structure **[21]**.

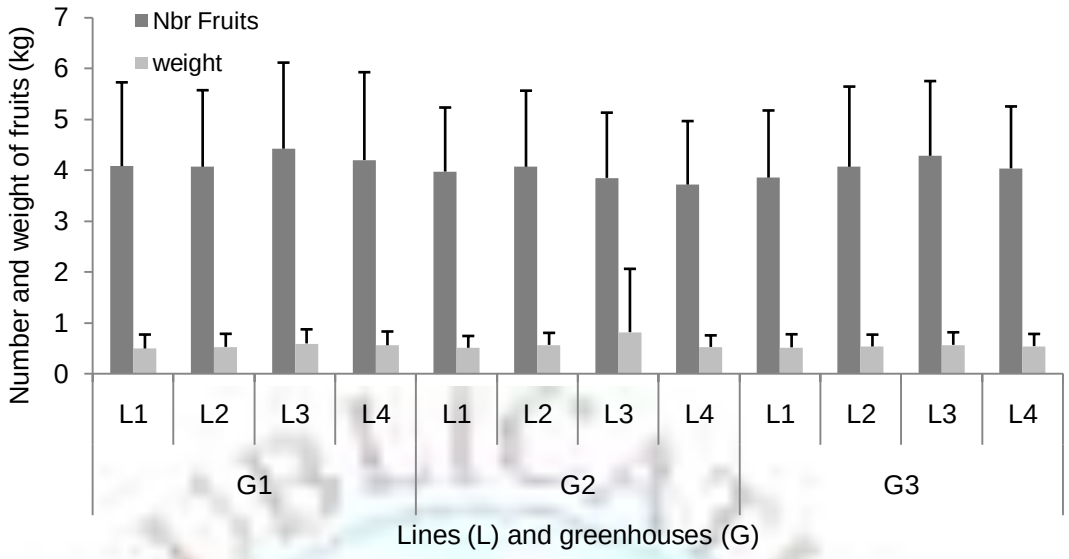

Fig 6. Number and weight of fruits par line and greenhouse

G. Fertilizers and chemicals costs

The figure7 shows one hand, the positive effect of the MULTISPAN greenhouse microclimate on the chemicals and fertilizers economy and consequently costs fertilizers which were lowered by 65% compared to the Canary greenhouse. On the other hand, good climatic conditions inside the MULTISPAN were among the tomato relatively free from diseases and pests ensure companion. In fact, costs of pesticides were reduced by 52% in this structure compared to the Canary **[8]**. This shows the economic benefit of this structure for the use of inputs and human, production and environment health **[21]**. Finally, additional benefits can be identified reinvest for the depreciation cost of the structure.

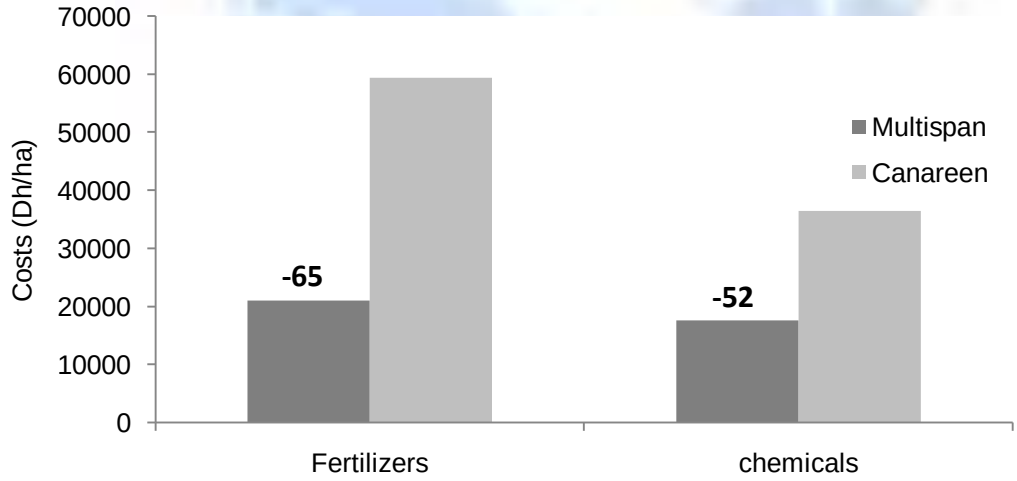

Fig 7. Fertilizers and chemicals costs under Multispan and Canareen greenhouse

H. Intrusion of pests

The estimated number of generations of T. absoluta and B. tabaci MULTISPAN greenhouse using climatic data and particularly the degree day, we were able to detect the presence of 8 generations. In other words, we need eight interventions by the chemical treatment. However, monitoring weekly catch adults of pests showed that the intrusion remains relatively low and below the economic threshold for treatment initiation. End of the cycle, we observed a slight shift of the burden of two pests due to an tear plastic cover accident under violent winds occurred during this period with excess speeds 100km/h. This intrusion has no effect on production because this period coincided with the end of tomato cycle (figure8 and 9).

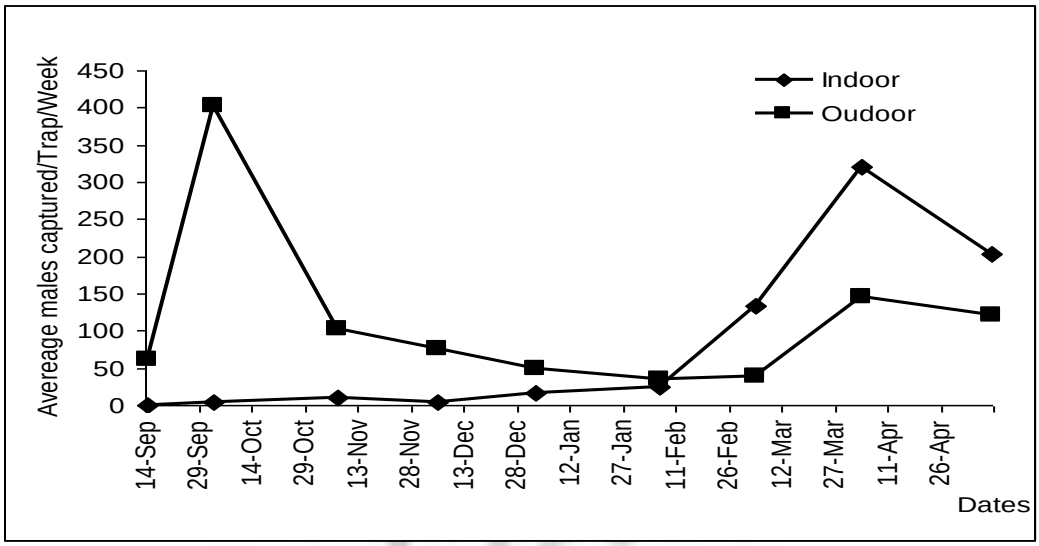

Fig 8. Evolution of captured males of *T. absoluta* indoor and outdoor multispan greenhouses

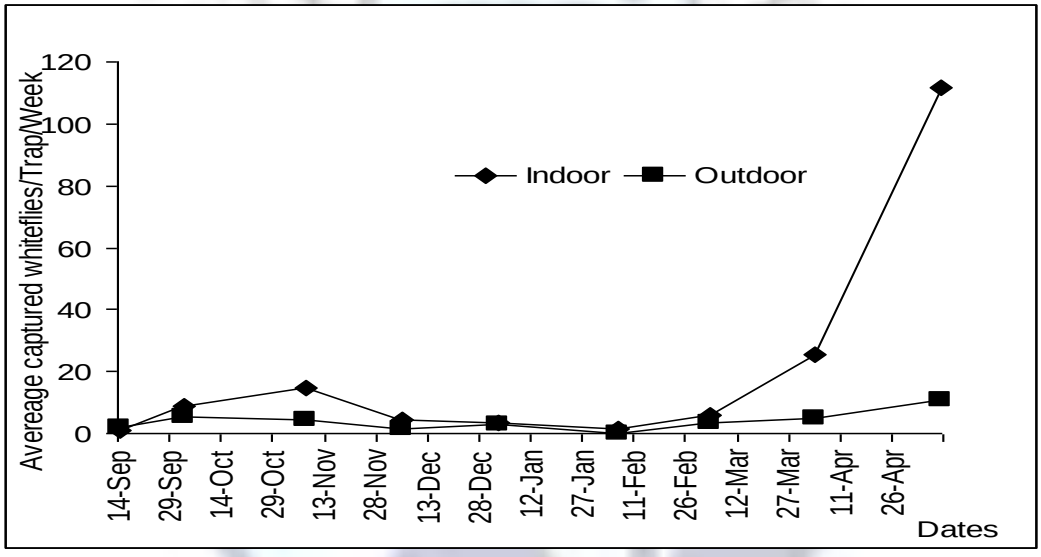

Fig 9. Evolution of captured whiteflies B. Tabaci indoor and outdoor multispan greenhouses

Conclusion

MULTISPAN structure was more efficient in comparison with the Canarian in terms of microclimate management, input use and production of tomato. Indeed, the additional revenue identified in tomato production and economic inputs can be reinvested to reduce MULTISPAN greenhouse investment, the main obstacle to access to this technology for horticultural producers. Currently, new grants applied for equipment acquisition of this structure remains a factor in the renewal of greenhouse in Souss Massa region. In the end, the work of microclimate MULTISPAN characterization is a step towards a model of integrated production of tomato with the integration of two sub-models, first on the protection of tomato and the second on optimizing of inputs flow.

References

[1]. Abu-Irmaileh, B.E., 1991. Soil solarization controls broomrapes (Orobanche spp.) in host vegetable crops in the Jordan valley. Weed Technol. 5, 57-581.
[2]. Borrero, C., Trillas, M.I., Ordovas, J., Tello, J.C., Aviles, M., 2004. Predictive factors for the suppression of Fusarium wilt of tomato in plant growth media. Phytopathology 94, 1094–1101.
[3]. Boulard, T., Baille, A., (1995a). Modelling of air exchange rate in a greenhouse equipped with continuous roof vents. Journal of Agricultural Engineering Reserch, 61(1), 37–48.
[4]. Boulard, T., Draoui, B., (1995b). Natural ventilation of a greenhouse with continuous roof vents: measurements and data analysis. Journal of Agricultural Engineering Research, 61(1), 27–36.

[5]. Everts, K.L., 2006. Root-knot and root-lesion nematode suppression by cover crops, poultry litter, and poultry litter compost. Plant Dis 90, 487–492.
[6]. Fatnassi, H., Boulard, T., Demrati, H., Bouirden, L., Sappe, G., (2002). Ventilation performance of a large Canarian-type greenhouse equipped with insect proof nets. Biosystems Engineering, 82(1), 97–105.
[7]. Fatnassi, H., Boulard, T., Lagier, J., (2004). Simple indirect estimation of ventilation and crop transpiration rates in a greenhouse. Biosystems Engineering, 88(4), 467–478.
[8]. Gary, C., Montbroussous B., Tchamitchian M., 2000. Tommy : simulateur d'un peuplement de tomate sous serre : développement et physiologie des organes en interaction avec l'environnement interne et externe. Version1.0, bibliothèque DIESE, INRA.
[9]. Jacobsohn, R., Greenberger, A., Katan, J., Levi, M., Alon, H., 1980. Control of Egyptian broomrape (Orobanche aegyptiaca) and other weeds by means of solar heating of the soil by polyethylene mulching. Weed Sci. 28, 312-316.
[10]. Lombardo S., Longo A.M.G., Lo Monaco A. and Mauromicale G. (2012). The effect of soil solarization and fumigation on pests and yields in greenhouse tomatoes. Crop Protection, 37, 59-64.
[11]. Mauromicale, G., Lo Monaco, A., Longo, A.M.G., Restuccia, A., 2005. Soil solarization, a non-chemical method to control branched broomrape (Orobanche ramosa) and improve the yield of greenhouse tomato. Weed Sci. 53, 877-883.
[12]. Oka, Y., Yermiyahu, U., 2002. Suppressive effects of composts against the root- knot nematode Meloidogyne javanica on tomato. Nematology 4, 891–898.
[13]. Producers and exporters Association of fruits and vegetables. Technical report, 2010.
[14]. Raviv, M., Oka, Y., Katan, J., Hadar, Y., Yogev, A., Medina, S., Krassnovsky, A., Ziadna, H., 2005. High-nitrogen compost as a medium for organic containergrown crops. Bioresource Technol 96, 419–427.
[15]. Saueborn, J., Linke, K.-H., Saxena, M.C., Koch, W., 1989. Solarization; a physical control method for weeds and parasitic plants (Orobanche spp.) in Mediterranean agriculture. Weed Res. 29, 391-397.
[16]. Soriano, T., Montero, J. I., Sa´nchez-Guerrero, M. C., Medrano, E., Anto´ n, A., Herna´ndez, J., et al. (2004). A study of direct solar radiation transmission in asymmetrical multi-span greenhouses using scale models and simulation models. Biosystems Engineering, 88(2), 243e253.
[17]. Souss Massa Regional Office of Agricultural Development. Statistics report, 2012.
[18]. Vanthoor, B. H. E., De Visser, P. H. B., Stanghellini, C., & Van Henten, E. J. (2011b). A methodology for model-based greenhouse design: part 2, description and validation of a tomato yield model. Biosystems Engineering, 110, 378-395.
[19]. Vanthoor, B. H. E., Stanghellini, C., Van Henten, E. J., & De Visser, P. H. B. (2011a). A methodology for model-based greenhouse design: part 1, a greenhouse climate model for a broad range of designs and climates. Biosystems Engineering, 110, 363-377.
[20]. Vanthoor, B. H. E., Stigter, J. D., Van Henten, E. J., Stanghellini, C., De Visser, P. H. B., & Hemming, S. (2012b). A methodology for model based greenhouse design: Part 5, greenhouse design optimisation for southern-Spanish and Dutch conditions. Biosystems Engineering, 111(4), 350-368.
[21]. Vanthoor, B. H. E., Stigter, J. D., Van Henten, E. J., Stanghellini, C., De Visser, P. H. B., & Hemming, S. (2012a). A methodology for model based greenhouse design: Part 4, economic evaluation of different greenhouse designs: A Spanish case. Biosystems Engineering, 111(4), 336-349.