

# EFFECTS OF MOISTURE REGIMES AND PLASTIC MULCHING ON TOMATO IN SURFACE AND SUBSURFACE DRIP IRRIGATION METHODS

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## ABSTRACT

Tomato is the most important vegetable crops which generally grows under surface irrigation method. In this method, the major proportion of irrigation water is lost by surface evaporation and deep percolation, resulting in lower irrigation efficiencies. Recently due to worldwide aridity and water shortage, there is tendency of farmers to apply drip irrigation for water saving in agriculture. The objective of this paper is determining the impacts of plastic mulching, drip irrigation methods and different amount of applied water and their interactions on yield, water use efficiency and quality characteristic of tomato. This study was conducted during 2006-2008 in Torogh Agricultural Research Station in Razavi Khorasan Province. The soil texture was silty loam and loam in 0-40 and 40-80 cm, respectively. Experimental design was randomized complete blocks design in split split plot with three replications. Treatments included different amount of applied water (60, 80 & 100% water requirement) in main plot, drip irrigation methods (surface and subsurface) in sub plot and mulching (without mulching & plastic mulch) in sub-sub-plot. Results showed that irrigation moisture regime, irrigation method and mulch treatments had significant effects on yield and WUE ( $P \leq 0.01$ ). Yield in 60, 80 and 100% of water consumption was 31.14, 54.58 and 62.27 ton/ha, respectively. This difference was significant. The highest WUE ( $7.88 \text{ kg/m}^3$ ) was obtained at 80% moisture regimes and followed by 60 and 100% of moisture regimes with  $5.93$  and  $7.23 \text{ kg/m}^3$ , respectively. However, there was a significant difference between yield in surface and subsurface drip irrigation methods ( $43.38$  and  $55.27 \text{ ton/ha}$ , respectively). WUE in subsurface drip irrigation was  $7.93 \text{ kg/m}^3$  and greater than surface drip irrigation ( $6.12 \text{ kg/m}^3$ ). Yield in plastic mulching and without mulching treatments were  $55.64$  and  $42.71 \text{ ton/ha}$ , respectively. Application of mulch increased WUE about 30%. Also, when water saving vegetable growth, yield and economics return were taken into account, then an irrigation level of 80% through subsurface drip irrigation along with plastic mulch will be considered optimal.

Keywords: Tomato, Plastic mulching, Drip irrigation, Subsurface irrigation, Water use efficiency.

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## 1. Introduction

Tomato is the most important vegetable crops which generally grown under surface irrigation. In this irrigation method, the major proportion of irrigation water is lost by surface evaporation and deep percolation, resulting in lower irrigation efficiencies. Recently due to worldwide aridity and water shortage, there is tendency to apply drip irrigation for water saving in agriculture. Under limited water supply conditions the farmer tends to increase the irrigation interval, which creates moisture stress resulting in low yields and poor quality. Drip irrigation, with its ability to provide small and frequent water application directly in the vicinity of the plant root zone has created interest because of decreased water requirement and possible increase in production. Small and frequent applications of water enable the plant to grow well without any ill effect of water stress between consecutive irrigations. High irrigation water application efficiencies can also be achieved by this method, enabling coverage of higher irrigated area per unit of available irrigation water. With the same irrigation water application amount, about 20-60% higher tomato yields were obtained with drip irrigation compare to surface irrigation system. However in drip irrigation, tomato yield was slightly lower or equal to that of conventional method or irrigation along with reduction in irrigation requirement of 30-60%. In arid dry land agriculture, reduction in evaporation losses from the wetted soil surface beneath an emitter can significantly increase water use efficiency. So, subsurface drip irrigation has been introduced to eliminate evaporation from soil surface. However, plastic mulching as an agricultural practice has been used to reduce evaporation from soil surface. But further research is required to determine optimal water requirement and irrigation scheduling under a variety of drip irrigation treatments in combination with plastic mulching for specific agro-climatic condition to establish their feasibility. Very little work has been done to establish the feasibility of different types of drip irrigation, plastic mulching and irrigation moisture regimes on tomato in arid and semi arid lands of Iran.

Different strategies have been initiated for saving in water use, increasing irrigation efficiency and water use efficiency. Micro irrigation is one of these methods. Although micro irrigation reduce water use and increase water use efficiency, since that is still considerable amounts of irrigation water is lost through direct soil surface evaporation and transpiration by weeds. The use of a plastic sheet placed between irrigation rows can preserve soil moisture by reducing evaporation, prevent weed growth and water use is thus reduced. Besides the weed control, thereby also reducing the cost of labor, increase yield by reducing competition with the crops. Tomato with 22000 hectares under cultivation is one of the major crops in Khorasan Province. Due to tomato high water requirements, any research about reducing the this crop water use is essential.

Yrisarry et al. (1993) conducted a study that consisted of three irrigation water levels (0.5, 0.9 and 1.3 ETc) for tomato. Results showed the total yield increased when the amount of water was also increased. Candido et al. (2000) carried out the experiment with the aim of evaluating the influence of different irrigation regimes on yield of tomatoes. In this research, five irrigation levels (un-irrigated control and 100%, 66%, 50%, and 33% of ETc) were applied. The highest marketable yields were obtained under conditions of 100% of ETc application. Cetin et al. (2002) conducted an experiment to investigate the irrigation scheduling for drip-irrigated tomatoes using Class A Pan evaporation. Irrigation water was determined as a certain ratio of Class A Pan evaporation ( $k_{pc} = 0.50, 0.75, 1.00, \text{ and } 1.25$ ). The results of the experiment indicated that the maximum marketable fruit yield was obtainable when conditions of  $k_{pc}=1.00$  were applied. Phene et al. (1985) in their research concluded that if a subsurface irrigation system to be used principally and properly, yield of tomato compare to furrow irrigation system can be increased to double. Valenzuela (1994) reported that the use of mulch increased water use efficiency between 75 to 95 percent. Mata et al. (2002) are introduced the advantages of using mulch cases such

as reduce water consumption, increase temperature and soil moisture and increase water use efficiency and nitrogen. Ngoujio (2003) studied the effects of mulch with different colors (black, colorless, brown, gray and green) in tomato cultivation. Radics and Szne Bognar (2004) studied the effect of eight types of mulch on tomato yield in Poland. Their results showed that mulch of plastic, paper and straw have significant effect on yield of tomato.

The objective of this paper is determine the impacts of plastic mulching, drip irrigation methods and different amount of applied water and their interactions on yield, water use efficiency (WUE) and quality characteristic of tomato.

## 2. Material and methods

This study was conducted in Torogh Agricultural Research Station, Razavi Khorasan Province in Iran. The study was done during 2007-2008 years. The soil texture was silty loam and loam in 0-40 and 40-80 cm depth, respectively. Water quality was tested and its results are shown in Table 1. Soil physical characteristics of the experimental site were determined by creating a profile in the soil up to 80 cm depth. The soil conditions in four layers from 0-20, 20-40, 40-60, and 60-80 cm were determined. These results are given in Table 2.

Experimental design was randomized complete blocks design (RCBD) in split-split plot with three replications. Design treatments included different amount of water (60, 80, and 100% water requirement) in main plot, drip irrigation methods (surface and subsurface) in sub plot and mulch (without mulch and with plastic mulch) in sub-sub plot. Mobile cultivar was studied in this research. After transplantation, plastic sheets were installed on each row and their sides were covered with soil. Then with a hole to place the transplant, the transplants were passed of holes in plastic sheets. About 75 cm wide sheets of plastic used and the thickness were about 30 microns. In the surface drip irrigation, one pipeline (tape) was considered for each row which was to widen the distance of rows was 10 cm. In the subsurface irrigation for each row in each plot a lateral line was considered and pipes were installed at a depth of 15 cm of soil in each row. Yield of tomato, water consumption and water use efficiency of each treatment were determined. Data were analyzed statistically using the MSTAT-C software. However, Mean Comparison was performed using Duncan's Multiple Range tests.

**Table 1.** Test results of irrigation water quality  
Les résultats des tests de qualité de l'eau d'irrigation

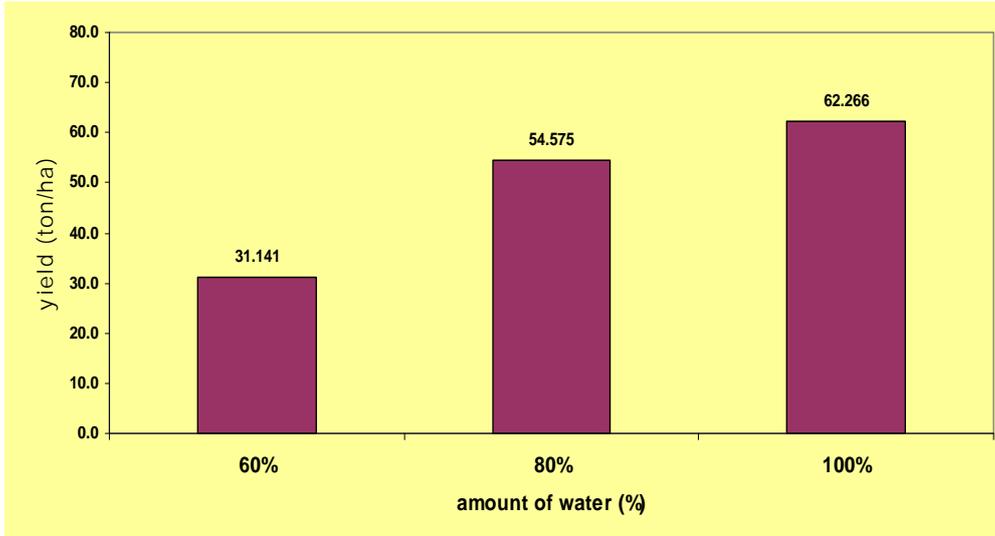
EC (dS/m)	PH	Soluble cations (meq/lit)				Soluble anions (meq/lit)			SAR
		Na <sup>+</sup>	Mg <sup>++</sup>	Ca <sup>++</sup>	K <sup>+</sup>	CL <sup>-</sup>	So <sub>4</sub> <sup>-</sup>	Co <sub>3</sub> <sup>-</sup>	
0.8	7.89	3	2.4	2.4	-	-	1.8	2.35	1.93

**Table 2.** Soil physical properties of the test site  
Propriétés physiques du sol du site d'essai

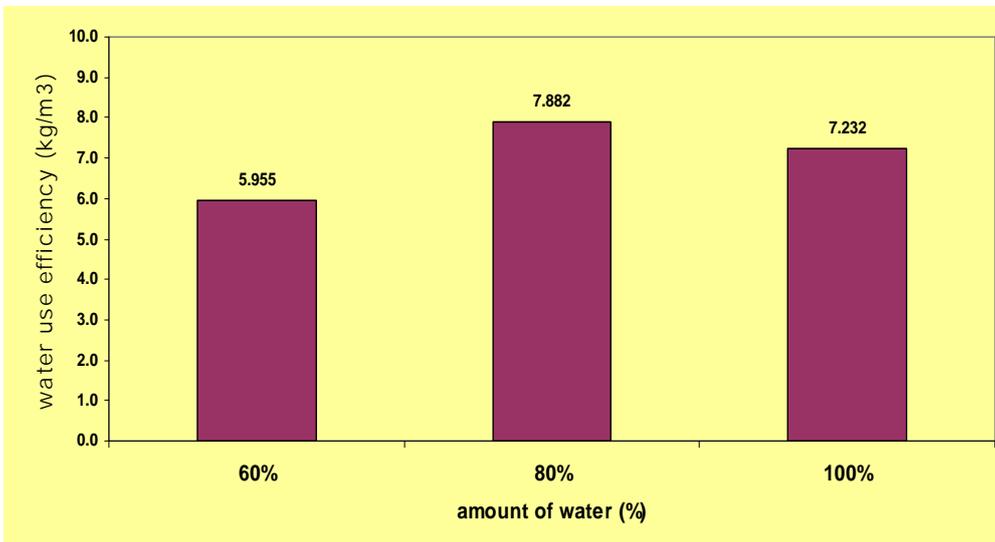
Soil depth (cm)	Particle size Distribution (%)			Texture	Bulk density (g/cm <sup>3</sup> )	Soil Moisture (%)		
	Sand	Silt	Clay			FC	PWP	AW
0-20	28	58	14	SL	1.41	27.99	12.20	15.79
20-40	24	54	22	SL	1.51	29.9	12.70	17.20
40-60	26	50	24	L	1.45	26.92	13.30	13.62
60-40	36	46	18	L	1.42	23.71	9.80	13.91

### 3. Results and discussion

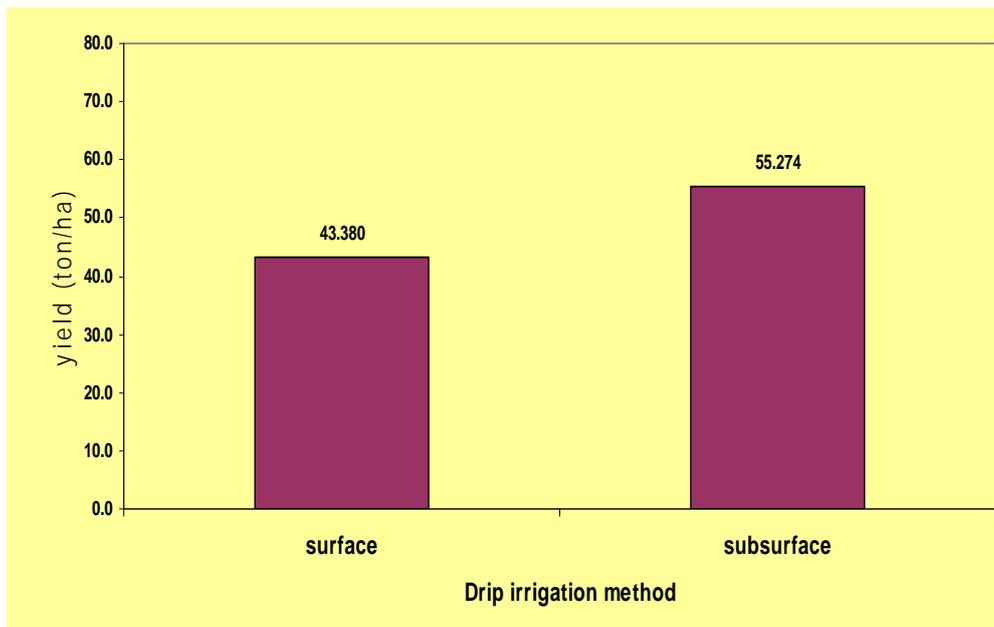
The combined statistical analysis showed that irrigation water amount, irrigation method and mulch treatments had significant effect on yield and water use efficiency ( $P \leq 0.01$ ). Yield in 60, 80 and 100% water requirement treatments was 31.141, 54.575, and 62.265 ton/ha, respectively, which showed significant difference between them (Figure1). Also, the highest WUE ( $7.881 \text{ kg/m}^3$ ) was in 80% irrigation treatment, followed by 60 and 100% (with  $5.925$  and  $7.232 \text{ kg/m}^3$ ), respectively (Figure2).



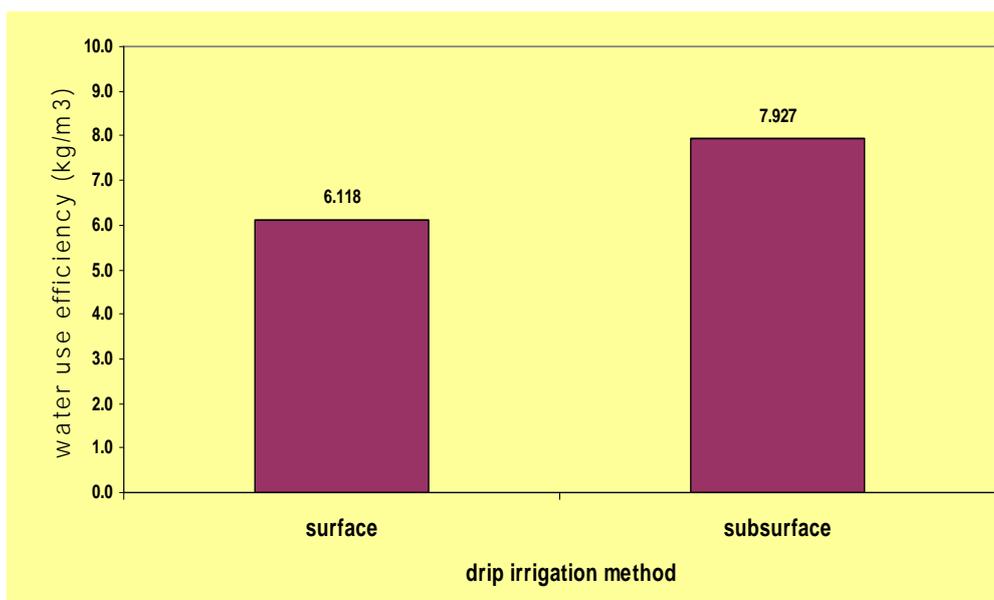
**Figure 1.** Effect of water amounts on yield of tomato.  
Effet de quantités d'eau sur le rendement de la tomate.



**Figure 2.** Effect of water amounts on water use efficiency in tomato plantation.  
Effet de quantités d'eau sur l'efficacité d'utilisation de l'eau dans une plantation de tomates.  
According to Figure 3, There was significant difference between yield in surface and subsurface drip irrigation methods which was 43.380 and 55.274 ton/ha, respectively. However, water use efficiency in subsurface drip irrigation was  $7.927 \text{ kg/m}^3$  that were greater than WUE in surface drip irrigation (Figure 4).

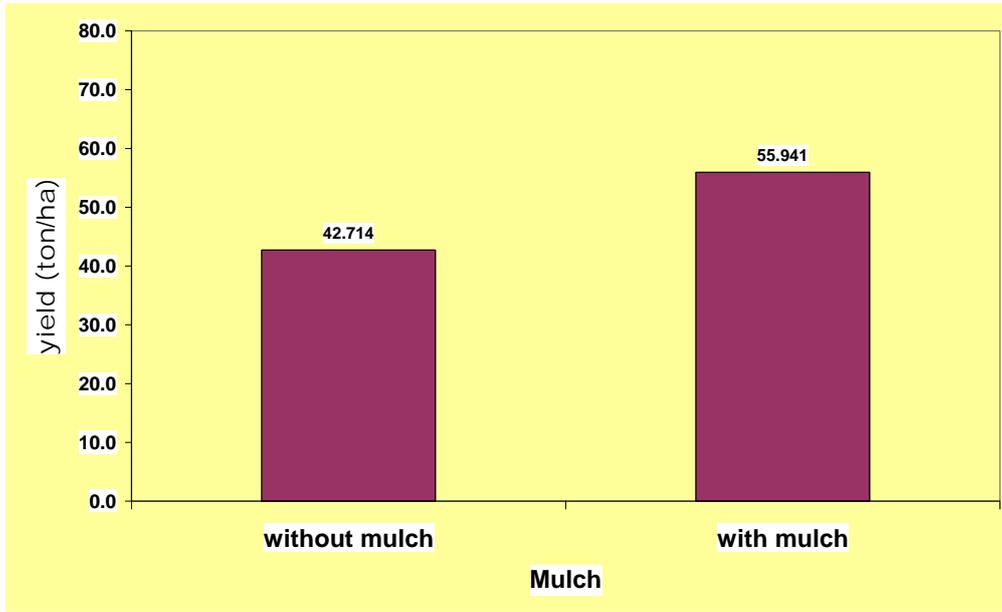


**Figure 3.** Effect of irrigation method on yield of tomato.  
Effet de la méthode d'irrigation sur le rendement de la tomate.

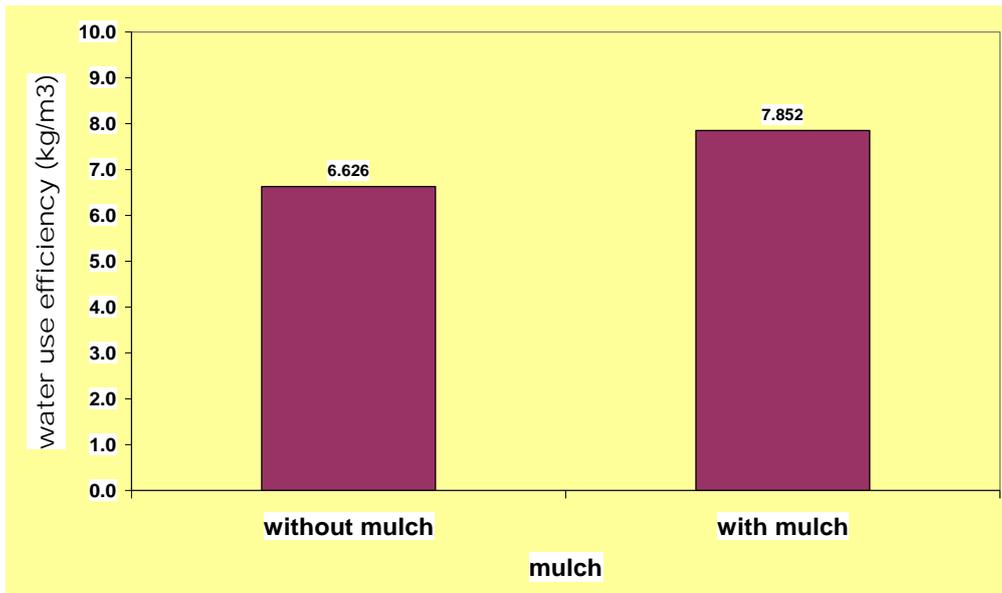


**Figure 4.** Effect of irrigation method on water use efficiency in tomato plantation.  
Effet de la méthode d'irrigation sur l'efficacité d'utilisation de l'eau dans une plantation de tomates.

Yield in plastic mulch and without mulch treatment was 55.641 and 42.714 ton/ha, respectively (Figure 5). However, according to Figure 6, application of mulch increased water use efficiency from 6.63 kg/m<sup>3</sup> to 7.85 kg/m<sup>3</sup> (about 30 percent). In general, it seems to be subsurface drip irrigation with 80% water requirement and using of plastic mulch was the best treatment and so it is recommended.



**Figure 5.** Effect of mulch on yield of tomato.  
Effet du paillis sur le rendement de la tomate.



**Figure 6.** Effect of mulch on water use efficiency in tomato plantation.  
Effet du paillis sur l'efficacité d'utilisation de l'eau dans une plantation de tomates.

#### 4. Conclusion and Recommendations

The impact of irrigation water amount, irrigation methods and mulch on yield of tomato was significant. The yield of tomato in the three treatments, 60, 80 and 100 percent of water requirement was obtained 31.141, 54.575 and 62.265 ton/ ha, respectively. Yield of tomato in both surface and subsurface drip irrigation methods were 43.380 and 55.274 ton/ha, respectively which also had significant difference. Yield of tomato in subsurface drip irrigation method was more about 12 ton/ha compare to surface drip irrigation method and in the two treatments with and without

mulch (42.714 and 55.941 ton/ha, respectively) was significant difference. The effect of treatments on WUE was significant. Lowest WUE (5.96 kg/m<sup>3</sup>) was obtained from treatment with water use of 60% water requirement and the most WUE (7.88 kg/m<sup>3</sup>) was obtained from treatment with water use of 80% water requirement. WUE in surface and subsurface drip irrigation were 6.12 and 7.93 kg/m<sup>3</sup>, respectively. The effect of mulch on WUE was significant. WUE in treatment with mulch increased about 30 percent. The main advantage of plastic mulch is increase the air and temperature of soil under the mulch that case more and faster plant growth. Plastic mulch reduces evaporation from the soil surface and soil moisture maintain with greater uniformity. Due to the lack of light under the black plastic mulch, photosynthesis could not be done and weeds can not grow. Therefore, the plant will have greater access to water and nutrients. In other words, if the mulch be used, less water is consumed and the yield can be expected higher.

## 5. References

6. C, etin, Ö., Uygan, D., Boyacı, H., Yıldırım, O., 2002. Effects of different irrigation treatments on yield and quality of drip-irrigated tomatoes under Eskisehir conditions. In: IV Vegetable Agriculture Symposium, 17–20 September, Bursa, Turkey (in Turkish).
7. Candido, V., Miccolis, V., Perniola, M., 2000. Effects of irrigation regime on yield and quality of processing tomato (*Lycopersicon esculentum* Mill.) cultivars. III International Symposium on Irrigation of Horticultural Crops. Acta Horticulturae (ISHS) 537, 779–788.
8. Mata V. H., Nunez R. E., and Sanches P. 2002. Soil temperature and soil moisture in Serrano pepper (*Capsicum annuum* L.) with fertigation and mulching. Proceeding of the 16th International Pepper Conference Tampico, Tamaulipas, Mexico, November 10-12.
9. Ngoujio M. 2003. Colored plastic mulch and tomato production. A288 Plant and Soil Science Building Michigan State University, East Lansing, MI 48824-1325 USA.
10. Phene C. J., McCormick R. L., Miyamoto J. M., Meek D. W., and Davis K. R. 1985. Evapotranspiration and crop coefficient of trickle irrigated tomatoes. In Proceedings of the 3rd International Drip/Trickle Irrigation Congress, Fresno, CA. November, ASAE Publication, No.10-85 (2): 823-831.
11. Radics L., and . Szne Bognar E. 2004. Comparison of different mulching methods for weed control in organic bean and tomato. ISHS Acta Horticulture 638: 189-196.
12. Valenzuela H. 1994. Drip irrigation. Univ. Hawaii Vegetable Crops Uptade Newsletter, Vol. 4, No. 2, March.
13. Yrisarry, B.J.J., Losada, P.M.H., Podriguez, A.R., 1993. Response of processing tomato to three different levels of water and nitrogen applications. In: International Symposium on irrigation of Horticultural Crops, 1 April 1993, Available from: <[http://www.actahort.org/books/335/335\\_16.htm](http://www.actahort.org/books/335/335_16.htm)>.