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Drip irrigation with fertigation in soil-less media for tomato under controlled cultivation

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Abstract

A field experiment was conducted at Department of Soil and Water Conservation Engineering, Tamil Nadu Agricultural University, Coimbatore, during 2009 to 2010 to study the effect of drip irrigation with fertigation in soil-less culture under controlled cultivation for Tomato. The highest yield per plant (2.16 kg/plant) and yield per hectare (112 t/ha) was registered in Peat:Vermicompost (T_4F_2) and the lowest yield per plant was recorded in Coir pith :Vermicompost (T_2F_1) (1.07 kg and 55.48 t/ha) under polyhouse condition. The highest water use efficiency (1972.87 kg/ha cm) was obtained in T_4F_2 and the lowest was obtained in T_2F_2 (977.30 kg/ha cm) in poly house. The highest N fertilizer use efficiency (700 kg/ ha.kg of N) was recorded in T_4F_2 at 80 % of fertigation and the least efficiency was noted in T_2F_1 (277 kg/ ha kg of N). The highest K fertilizer use efficiency (560 kg/ ha.kg of K) was recorded in T_4F_2 at 80 % of fertigation and the least efficiency (222 kg /ha.kg of K) was noted in T_2F_1. The highest benefit cost ratio 2.33 was recorded in T_4F_2. The results of the study indicated that the controlled cultivation of tomato in soil-less media has more benefits, in terms of yield, water and fertilizer use efficiency, and benefit cost ratio.

Key words: Drip irrigation, fertigation, micro irrigation, soil-less media, tomato

Introduction

In India, with the growing population, per capita availability of soil and water resources are diminishing day by day and their increasing scarcity for crop production in the country highlights the importance of optimizing its use. In 1960, with 3 billion population over the world, per capita land was 0.5 ha but presently, with 6 billion people it is only 0.25 ha and by 2050, it is proejcted to reach at 0.16 ha and in future and it will be impossible to feed the entire population using open field system of agricultural production only (Mamta and Shraddha, 2013). Though, soil is most available growing medium for successful crop production, it has some serious limitations *viz.,* presence of disease causing organisms and nematodes, unsuitable soil reaction, unfavourable soil compaction, poor drainage, degradation due to erosion, etc. which results in poor soil fertility, poor yield and quality (Sengupta and Banerjee, 2012). Soil-less culture is a system of growing plants in soilless media which helps to reduce the soil related problems experienced in conventional crop cultivation (Murumkar *et al.,* 2012). Pest and disease accumulation in soil and water availability have always been a problem in protected cultivation and the use of soilless culture can be one of the alternatives to overcome soil problems and to increase water use efficiency (Majid *et al.,* 2010).

In soilless culture, drip irrigation is used to supply the water to crops and amount of irrigation applied and its timing throughout the crop cycle influence both yield and fruit quality (Metin *et al.,* 2006). Soiless culture offers a valuable alternative compared to crop production in soil and has been widely adapted by specialist producers of green house crops in the world, particularly for vegetables such as tomato and cucumber (Winsor and Baudoin, 1992). Fertigation with drip irrigation in soilless culture ensures a good yield with higher fertilizer use efficiency and avoids nutrient wastage which may decrease production costs and reduce the risk of water pollution in surrounding environment (Dufour and Guérin, 2005).

India is the second largest country to grow tomato under 865000 ha with productivity of 19.5 mt/ha in 2011 and it is one of the most important vegetable accounting for about 8.23 per cent of the total vegetable production in the country (NHB, 2011). Very limited information is available in India on cultivation of tomato in soil-less media with drip irrigation under controlled cultivation. Therefore, an attempt has been made in present study to find out suitable soil-less media and drip irrigation with fertigation schedule in soil-less culture.

Materials and methods

Experimental layout: The experiment was carried out in a naturally ventilated poly house made of 200 micron UV stabilized LDPE sheet. The length, width and height of the poly house were 17, 4 and 4 m, respectively.

Frame work: Inside the poly house, troughs with a size of 300 x 30 x 45 cm were used and the inner sides were firmly attached with 750 micron HDPE black poly film. The poly film was attached with the frame by bolts and screws and it could be adjusted to alter the depth of the media. With this set up it was possible to have a media depth 17 to 20 cm at the center of the trough. Thirty numbers of such troughs were fabricated, painted with rust resistant paint and installed inside the poly house. The different combination of media under the scheduled treatments used are presented in Table 1. Two levels of fertigation, *viz.,* 100 % (F_1) and 80 % (F_2) of recommended dose (200:250:250 kg/ha N, P and K respectively) were adopted.

Layout of drip system: Irrigation water was pumped from 7.5

Table 1. Treatment details

Treatments	Growing media (v/v)
T_1	Sawdust : Vermicompost (1:1)
T_2	Coir pith: Vermicompost (1:1)
T_3	Vermiculite: Vermicompost (1:1)
T_4	Peat: Vermicompost (1:1)
T_5	Clay loam soil

HP bore well pump and conveyed through the PVC main line of 63 mm dia. pipes after filtering through screen filter. From the main pipe, sub main of 50 mm diameter, PVC pipes were drawn. From the sub main, laterals of 12 mm diameter LLDPE pipes were installed. Each lateral was provided with individual tap control for imposing irrigation. Along the laterals, online drippers were fixed at a spacing of 45 cm. During the irrigation period an average uniformity coefficient of 90 to 95 % was observed.

Design data

Length of each lateral from sub main (12 mm dia. LLDPE)	: 15 m
Number of laterals from sub main	: 6 nos
Number of emitters per lateral	: 30
Emitter type	: Online dripper (Pressure compensating)
Emitter discharge rate	: 2 lit h^{-1}

With the above mentioned design, irrigation through drip was given immediately after sowing and subsequent irrigations were scheduled once in three days. Total water requirement and fertigation for tomato (109.5 L per plant) was calculated by using the standard data table (National Committee on Plasticulture Applications in Horticulture) and water use efficiency and fertilizer use efficiency calculated based on the formula below.

Water use efficiency (WUE): It was calculated for each treatment, which is the ratio of yield of the crop per kg and total water used in mm.

$$WUE = \frac{Y}{WA} \text{ (kg /ha cm)} \quad (1)$$

Where,

WUE = Water Use Efficiency, kg / ha cm of water used

Y = Yield of the crop (kg/mm)

WA = Total water utilized, cm

Fertilizer use efficiency (FUE): It was calculated for each treatment, which is the ratio of yield of the crop in kg/ha and total nitrogen, potassium and phosphorus applied in kg/ha.

$$FUE = \frac{Y}{FA} \quad (2)$$

Where,

FUE = Fertilizer Use Efficiency (kg /ha kg of fertilizer)

Y = Yield of the crop, (kg/ha)

FA = Total fertilizer applied

Cost economics: Economics of tomato production under poly house was worked out in terms of total expenditure. The total return was based on realized yield and Benefit Cost Ratio was calculated.

$$\text{Benefit Cost Ratio} = \frac{\text{Gross income ha}^{-1}}{\text{Total cost of cultivation ha}^{-1}}$$

Results and discussion

Effect of growing media and fertigation on fruit yield: The higher yield (2.16 kg/plant) and (112 t/ha) was recorded in T_4F_2 followed by T_3F_2 (2.08 kg/plant) and (107.85 t/ha) and lowest yield was recorded in T_2F_1 (1.07 kg/plant) and (55.48 t/ha) in poly house (Table 2). The highest organic content was found in peat, which may be reason of improved yield in this treatment. Murumkar *et al.* (2012) reported that the best performance of beet root in terms of growth, yield and quality was observed in treatment with peat : vermicompost and peat mixture attributes better root-zone water environment. In all the stages, pH 6.20 was noticed in T_4F_2. Plants require different pH ranges in growing medium, but many horticultural plants grow well in a substrate close to 6.5 (Agaoglu *et al.*, 1995; Maynard and Hochmuth, 1997). This is the range in which macronutrients are most readily available for uptake by the plant.

Water use efficiency of growing media: The effect of differential amount of fertilizer added through drip irrigation system showed significant improvement on irrigation water use efficiency and fertilizer use efficiency. The highest water use efficiency (1972.87 kg/ha cm) was obtained in T_4F_2 and the lowest was obtained in T_2F_1 (977.30 kg/ha cm) in poly house (Table 2).

The water holding capacity of soil-less media was more and due to this the number of irrigation had been reduced hence higher water use efficiency could be achieved in closed system. The main advantages of the closed systems are the reduction in water and nutrient loss to the environment resulting in better water use efficiency. Tomato grown in closed container could elevate the water productivity up to 45.7% (Uttam *et al.*, 2005). The soil-less culture needs 10 times less water than traditional cultivation for the same yield (Melgarejo and Martinez, 2007). In soilless culture use of drip irrigation also facilitates frequent fertilizer application via injection in the irrigation system, which allows growers to improve the synchronization between nutrient application and crop nutrient uptake which leads higher water and fertilizer use efficiencies (Metin *et al.*, 2010).

Table 2. Yield, water use efficiency and fertilizer use efficiency of different treatments

Treatments		Yield (kg/plant)	Yield (t/ha)	Water Use Efficiency (kg/ha cm)
T_1F_1		1.48	76.74	1351.78
T_1F_2		1.37	71.03	1251.31
T_2F_1		1.07	55.48	977.30
T_2F_2		1.93	100.07	1762.79
T_3F_1		1.87	96.96	1707.99
T_3F_2		2.08	107.85	1899.80
T_4F_1		1.89	98.00	1726.26
T_4F_2		2.16	112.00	1972.87
T_5F_1		1.35	70.00	1233.04
T_5F_2		1.22	63.25	1114.30
Mean		1.64	85.13	1499.74
T	SEd	0.03	1.57	27.71
	LSD(0.05)	0.06	3.30	58.21
F	SEd	0.02	0.99	17.52
	CD(0.05)	0.04	2.09	36.82
T × F	SEd	0.04	2.22	39.18
	CD(0.05)	0.09	4.67	82.32

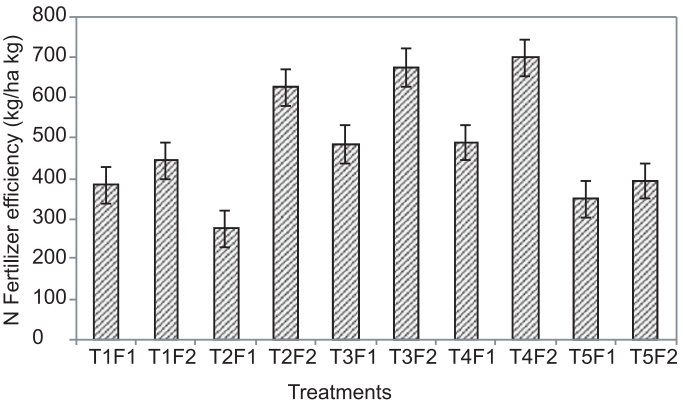

Fig. 1. N-Fertilizer use efficiency of different treatments

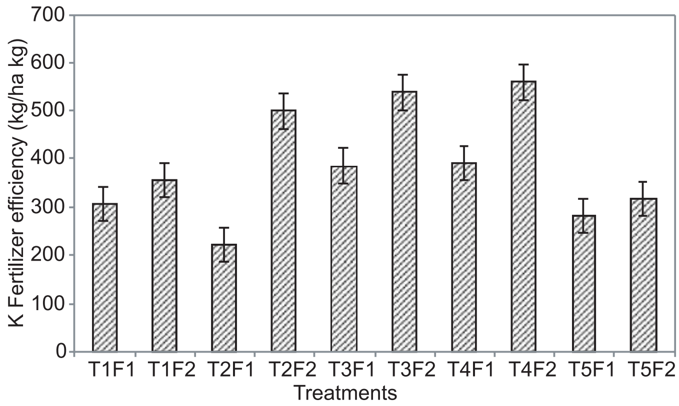

Fig. 2. K-Fertilizer use efficiency of different treatments

Fertilizer use efficiency of growing media: The influence of irrigation and fertilizer levels on N and K fertilizer use efficiency is furnished in Fig. 1 and 2, respectively. Increased fertilizer use efficiency with the decreased level of fertilizer dose through drip was observed. The highest N fertilizer use efficiency of 700 kg/ ha kg of N was recorded in T_4F_2 at 80 % of fertigation followed by T_3F_2 (674 kg /ha kg of N) and the least efficiency was noted in T_2F_1 (277 kg/ ha kg of N). The highest K fertilizer use efficiency of (560 kg/ ha .kg of K) was recorded in T_4F_2 at 80 % of fertigation and the least efficiency (222 kg /ha kg of K) was noted in T_2F_1. Fertilizer use efficiency of both N & K was highest in treatment T_4F_2 (peat: vermicompost) with 80% fertigation. It may be due to the fact that peat is rich in nutrient availability and adding of vermicompost to peat increased the yield in both cases. Janapriya *et al.* (2010) reported that media containing peat: vermicompost : sand with 80% fertigation gave highest fertilizer use efficiency of 880 kg/ha kg of N and 1319 kg/ha kg of K. In soilless culture, fertilizers are fed directly to the roots, as a result plants grow faster with smaller roots, plants may also be grown closer, and only 1/5th of overall space and 1/20th of total water is needed to grow plants under soil-less culture in comparison to soil-based culture (Silberbush and Asher J. 2001).

Cost economics of tomato cultivation under polyhouse: In order to study the feasibility of cultivation of tomato under poly house with soilless media, cost of structure, cost of cultivation and revenue were estimated. The highest benefit cost ratio (2.33) was recorded in T_4F_2 and least (0.90) was in T_2F_2. These results are in agreement with the findings of Metin (2006). The results have indicated that the poly house cultivation of tomato using soil-less media has more benefits, in terms of yield, water use efficiency, and benefit cost ratio. Hence, it is concluded that growing tomato under naturally ventilated polyhouse in a growing medium consisting of peat: vermicompost can be highly profitable and can be undertaken round the year.

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