# CHAPTER 1

# INTRODUCTION

Water is a precious natural resource, basic human need and a prime national asset. The extent to which water is plentiful or scare, clean or polluted, beneficial or destructed profoundly influence the extend and quality of human life. It is essential for broad based agricultural and rural development in order to improve food security and poverty. This renewable resource, water is deteriorating in terms of quantity and quality. As per the global water scenario, the water occupies about 70.8 per cent of the earth surface and only 29.2 per cent remains as land. Out of world water scenario; about 97.3 per cent is ocean which is saline and only 2.7 per cent of the global water remaining as fresh water. Out of this fresh water, 75 per cent is in the form of icecaps and glaciers and is not available for mankind. A major part of the remaining (22 per cent) occurs as groundwater and 56 per cent of this volume is located aquifers deeper than 800 m.

Water is one of the critical inputs for sustainable agriculture and about 80 per cent of available water is used in agricultural sector for irrigation. But irrigation efficiency of traditional irrigation methods is only 40 per cent.

Because of the importance and advantages of issues related to use, availability and quality deterioration, water as a source, requires unique consideration. Present water resource scenario in India, in terms of both of quality and quantity, requires judicious usage of water and proper management in the coming years. The way we handled water management in India during past is no more justifiable as the crevice between the demand of water resources and renewability of resources is getting limited.

While the irrigation projects have added to the improvement of water resources, the ordinary techniques for water transport and irrigation being exceedingly wasteful, has not only prompted wastage of water but also have given way to few natural issues like water logging, salinization and soil degradation. It has been perceived that the utilization of advanced irrigation system strategies like micro irrigation system is the main choice for the effective utilization of surface and ground water resources

As far as Indian agricultural is concerned, irrigation plays an important role in various development project of country. The existing method of surface irrigation method is less efficient and we are confronted with many problems regarding soil and water. Expansion of irrigation system is also essential for increasing food production for the alarming Indian population of 1.21 billion at present. With present potential of 114 M ha m of water only 57 M ha (40 per cent) is under irrigation in India against the total cultivated area of 145 M ha. Therefore the effective management of water resources is essential to meet the increasing competition for water between agricultural and non-agricultural sectors. It is also possible to reduce the water use by plant from 90 per cent to 75-80 per cent by introducing plant that requires les water.

Effective irrigation practices can improve yield and quality, with minimum water use. So the adoption of modern irrigation system in terms of water use efficiency and quality of produce decides the environmental advantages. The choices of selection of different irrigation technique are enormous and therefore selection is based on priority of avoiding wastage of water, safety in field use, energy management etc. The usual practice of watering is pot irrigation or hose irrigation, which has its own limitations. Water stress can occur from too much as well as from too little water. Stress caused by too little water reduces yield, with the level of reduction depending on when stress occurs in relation to crop development. Quality can also be affected. Over irrigation may also stress the crop through reduced soil aeration and cause similar consequences.

Research activities in the field of micro irrigation systems are conducted all over the country through ICAR institutes and State Agriculture Universities, AICRP on application of plastics in agriculture, AICRP on water management, DRIPNET project and Adhoc schemes. The ministry of agriculture through NCPAH, which has 17 precision farming development centres (PFDC) located in different agro climatic conditions has also focused attention to develop regionally differentiated technologies on micro irrigation, besides imparting training to large number of farmers and department staff. Now the adoption of micro irrigation systems has started in areas having water scarcity, poor quality water and undulating terrain.

Micro irrigation which includes mainly drip irrigation and micro sprinklers is an effective tool for conserving water resource. It is an irrigation system with high frequency application of water in and around the root zone of the plant system, which consists of a network of pipe along with suitable emitting devices it permits a small uniform flow of water at a constant discharge, which does not change significantly throughout the field. It also permits the irrigation to limit the watering closely to the consumptive use of plants thus it minimize the conventional losses such as deep percolation, runoff and soil evaporation. It also permits the utilization of fertilizer, pesticides and other water soluble chemicals along with irrigation water for better crop response.

It has been found the micro irrigation increase the yield up to 100 per cent with saving of water up to 70 per cent. It also prevents weed growth, saves energy and improves the quality of the produce. Thus the micro irrigation system has to be seen as a holistic approach to address poverty alleviation, horticulture-led diversification of agriculture, enhanced productivity, environmental protection and ecological security, promotion of equality and reduced biotic and abiotic stresses. Now micro irrigation is a means of precision farming too. In spite of these advantages that, the micro irrigation has certain limitations also, like clogging, salt accumulation, high initial cost, and high skilled labours are required.

With the objective of solving these problems, a user-friendly irrigation method 'wick irrigation' was developed by Centre for Water Resources Development and Management (CWRDM) during the past many years. This method is cheap and at the same time water efficient. The scientific principle behind this irrigation method is capillary action. Generally the material used for making wick is glass wool and the limitation behind this material is that the health hazards of this material and the availability. Due to these reasons many farmers are made wicks with different material but there is no scientific study regarding the performance of thesewick used in wick irrigation system and hence the present study is proposed to evaluate the performance of different materials used for making wick in wick irrigation system.

**Objectives of the study**

- To evaluate the performance of wick irrigation system developed by CRWDM, Kunnamagalam, Kozhikode.
- To evaluate the effect of wick irrigation on the growth and yield parameters of vegetable (tomato)
- To compare the performance of different wick material based on water uptake rate.

# CHAPTER 2
# REVIEW OF LITERATURE

Water is a precious natural resource and irrigation plays an important role in agriculture. Development of surface as well as ground water for increasing the agricultural production to meet the growing requirement of the country is very important. Crop yield can be increased through irrigation at suitable time intervals in correct proportions. However, high labour cost has given way for the prominence of automated irrigation systems.

Sustainability of food production depends on efficient use of water including development and management of new irrigation methods, livestock water supply and inland fisheries. Achieving food security is a high priority in many countries. Agriculture should provide food for the rising population and safe water for other uses. It is essential to develop and apply water-saving technology and management methods. Through capacity building, communities should be able to adopt new approaches, for both rain-fed and irrigated agriculture.

This chapter reviews the importance of irrigation and some literature available on different types of modern irrigation methods, its advantages, disadvantages and wick irrigation system.

## 2.1. MICRO-IRRIGATION

The term "micro-irrigation" describes a family of irrigation systems that supply water through small devices. These devices deliver water on to the soil surface very near to the plant or below the soil surfaced directly on to the soil very accurately at the plant root zone. Growers, producers and land scarpers have adopted micro-irrigation systems are immensely popular not only in arid regions and urban settings but also in sub-humid and humid zones where water supplies are limited or water is expensive. In irrigated agriculture, micro-irrigation is used extensively for raw crops, mulched crops, orchards, gardens, greenhouse and nurseries. In urban landscapes, micro-irrigation is widely used for ornamental plants

Sivnappan*et al.* (1975) conducted an experiment with vegetables and cash crops at TNAU and observed that water used in drip method was only 1/2 to 1/5 of the controlled surface method and at the same time yield was increased to 10-40 per cent for some crop

Sivanappan*et al*. (1977) conducted experiments to compare drip irrigation and showed that farmers save up to 80 per cent water, reduce weed growth, improve germination and give the same or some times more yield.

Sheela*et al*. (1988) noticed that average conveyance loss of water in the basin method while irrigating one ha of land was 27.7 per cent where as these losses were found to be considerably less under trickle irrigation system.

Anitha*et al. (*1990) conducted a study to design and develop an automatic drip irrigation system. The study showed that labour cost and operational costs could be reduced by this system thereby achieving a highly economic and efficient irrigation application.

Malania*et al*. (2001) found that the sprinkler method of irrigation was superior to surface method of irrigation in a field experiment at Junagadh. They observed a higher pod yield of ground nut by 24.3per cent in summer season.

Narayanamoorthy (2001) illustrated the benefits of micro-irrigation in terms of water saving and productivity gains were substantial in comparison to the same crops cultivated under flood method of irrigation. Apart from being beneficial to the farmers, irrigation development also helps to increase the employmentopportunitiesand wage rate of the agricultural landless labourers, both being are essential to reduce the poverty among the landless labour households.

Sarma*et al* (2005) found that micro irrigation system save irrigation water by 40percent and fertilizers by 25 per cent enhance yield up to 50 per cent, improves water use efficiency by 2 to 4 times with benefit - cost ratio of 2.77. Through the good management of micro-irrigation systems, the root zone water content can be maintained near field capacity throughout the season providing a level of water and air balance close to optimum for plant growth. In addition nutrient levels that are applied with water through the system (fertigation) can be controlled precisely.

Sing *et al*. (2005) conducted a study at PAU Ludhiana, to study the response of cauliflower and hybrid chilli to drip irrigation with its economic feasibility. The results revealed that in hybrid chilli crop, drip irrigation at lowest level of irrigation gave highest yield with highest water use efficiency and proved to be significantly better than all levels of drip irrigation and check basin method of irrigation.

**2.1.1. Drip irrigation**

Drip irrigation is the most efficient method to provide water at the required rate near the root zone of the crop. Drip irrigation is one such hi-tech system, receiving acceptance and adoption, especially in areas of water scarcity.

Drip irrigation is a form of irrigation that saves water and fertilizer by allowing water to drip slowly to the roots of many different plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. It is done through narrow tubes that deliver water directly to the base of the plant. It is chosen instead of surface irrigation for various reasons, often including concern about minimizing evaporation.

Hayne (1985) described that the drip or daily flow irrigation has been developed sufficiently for condition of intensive irrigated agricultural production and it has gained wide acceptance because of, it not only conserves water but also allows more effective management of water or fertiliser application than do other irrigation techniques.

Nakayama and Bucks (1991) found that high soil metric potential in the root zone is maintained with the help of high frequency water management by drip irrigation. It provides daily requirements of water to a portion of the rhizhosphere of each plant and reduces plant water stress.

#### 2.1.1.1 Impact of drip irrigation on growth and yield of crop

Singh *et al.* (2000) made an attempt to study the effect of drip irrigation compared to conventional irrigation on growth and yield of Apricot to work out its irrigation requirement. Drip irrigation at 80 per cent evapotranspiration of water gave significantly higher growth and fruit yield of 8.6 tonnes per hectare compared to the surface irrigation. Plastic mulch plus drip irrigation further raised the fruit yield to 10.9 tonnes per hectare. Drip irrigation besides saving 98 per cent irrigation resulted in 3.3 metric tonnes per hectare higher fruit yield.

Ashokaraja and Kumar (2001) conducted studies on Micro irrigation, which proved that drip irrigation is an effective tool for conserving water resources. The studies revealed that 40 to 70 per cent water saving was achieved by drip irrigation compared to surface irrigation and in some crops in specific location yield increased as high as 100 per cent.

The response of potato under drip irrigation and plastic mulching was studied by Jain *et al.* (2001). The highest water use efficiency was found to be 3.24 t/ha- cm for the treatment irrigated with drip system at 80 per cent level with mulch as compared to 2.17 t/ha-cm control treatment.

The water requirement, yield and economics of drip irrigation in litchi were studied by Singh *et al*. (2001) at farmer's field in Uttar Pradesh. It was found that good quality marketable yield of litchi varied from 12.5 to 16 metric tonnes per hectare for drip system. The total volume of water applied was 282 mm for drip irrigation during four months of system operation. The benefit cost ratio of drip irrigated litchi was found to be 3.91 and for surface irrigated litchi it was 3.05.

The response to urea fertilizer with drip irrigation and compared with conventional furrow irrigation for two years. Application of nitrogen through the drip irrigation in ten equal splits at eight days interval saved 20- 40 perentage nitrogen compared to the furrow irrigation when it was applied in two equal split. Similarly, higher fruit yield of 3.7 to 12.5 per cent was obtained with 31 to 37 per cent saving of water by the drip system. Water use efficiency in drip irrigation, nitrogen level was 68 and 77 per centon an average higher over surface irrigation in 1995 and 1996, respectively. At a nitrogen application rate of 120 kg/ha, maximum tomato fruit yield of 27.4 and 35.2 tonnes per hectare in two years was recorded (Singhandhube*et al.*, 2003).

Bozkurt and Mansuroglu (2009) conducted studies to investigate the effects of drip irrigation methods and different irrigation levels onquality, yield and water use characteristics of lettuce cultivated in solar green house. The result obtained revealed that the highest yield was obtained from subsurface drip irrigation at 10cm drip line depth and 100 per cent of Class A Pan Evaporation rate treatment. The water use efficiency and irrigation use efficiency increased as with reduction in the irrigation.

Singh(2009) conducted studies on drip irrigation resulted in significant increase in production and water use efficiency of potato. At Udaipur it was reported that besides saving in water, the yield of potato tubers was high and weed growth was least in drip irrigation compared to surface irrigation

#### 2.1.1.2 Advantages of drip irrigation

Major advantages of drip irrigation include the slow delivery of water on immediately above or below the surface of the soil which helps in minimizing water loss due to runoff, evaporation and wind and moreover it reduces the weed growth.This higher water use efficiency of drip irrigation system improves the quality of crop yield and uniformity coefficient of water distribution. Tis uniformity minimizes the damage to the soil structure. This drip irrigation system helps to irrigate cultivated area with undulation and less permeability. Themould spots, staining and deterioration experienced with overspray from sprinkler irrigation can be eliminated with the use of drip. It also reduces the foliar disease incidence compared to overhead irrigation methods (Hochmuth and Smajestrla, 2003).

The low volume requirements of drip irrigation favours water application in water scarce areas. An AC (Alternating Current) or battery powered controller is enough to manage a drip system. Above all, it requires less labour and energy.

#### 2.1.1.3 Disadvantages of drip irrigation

In spite of the fact that, the drip irrigation has so many potential benefits; it has certain limitations also. They are as follows:

- Sensitivity to clogging.
- Salt accumulation.
- High cost compared to other conventional irrigation methods.
- High skill is required for designing, installation and operation**.**

(Wilson and Bauer, 2005).

### 2.2. WICKIRRIGATION-*A smart and user friendly method for grow bag cultivation of vegetables and ornamental plants.*

At a time when organic farming is gaining popularity in Kerala, there are more options for farmers. ‘Wick irrigation’ is an oldtechnique, which used in many countries,but it has its own limitations for commercial cultivation.Kamalam Joseph, a scientist from Centre for Water Resource Development and Management (CWRDM) kunnamagalam in Kozhikode, modified the wick irrigation system and developed a system with an aim to facilitating vegetable cultivation in grow bags especially in terrace cultivation in urban areas.

‘Wick Irrigation’ (termed Thiri-Nana in Malayalam) reduces the water consumption for agriculture to a great extent. It is specifically designed for terrace cultivation, of mostly vegetables, in grow bags. A specially designed wick is used sucks up the water supplying bottle at an amount necessary for the plant.

The usual practice of watering is pot irrigation or hose irrigation, which has its own limitations. Water stress can occur due to over irrigation or under irrigation. Stress caused by too little water reduces yield, with the level of reduction depending on stress occurs in relation to crop development. Quality of produce can also be affected by under irrigation. Over irrigation may also stress the crop through reduced soil aeration, whichcauses similar consequences. A major effect of excess water is the reduction of nitrogen levels within the root zone to less than favourable levels. Further, there is lack of adequate knowledge on actual water requirement of crops at varying growth phases.  With the objective of solving these problems, experiments were carried out in the Centre for Water Resources development and Management during the past many years. As a result, a user-friendly irrigation method ‘wick irrigation’ was developed which is cheap and at the same time water efficient. The scientific principle behind this irrigation method is capillary action.

### 2.2.1 A comparison of the wick technology with other commonly used irrigation methods

Wick irrigation is a low cost/ no cost technology when compared to the material and installation cost of drip and sprinkler systems and the high labour cost of surface irrigation. There is no electricity cost involved in wick irrigation.

In wick irrigation, the wetting will be mostly in the lower part of the growing medium (root zone) and the surface will always remain dry. The surface soil acts as mulch and hence the evaporation loss is almost nil in this case. But, in the other methods, water travels from the top down, and hence the top soil will always be wet which enhances the unproductive evaporation loss which will vary depending on the temperature, humidity and wind velocity. It was earlier reported that sub-irrigation systems which supply water from below the root zone are more efficient watering techniques (Elliot 1992, Dole *et al.* 1994, Morvant*et al*. 2001).

In surface irrigation method, as water flows down during irrigation, a part of the dissolved nutrients also will flow down with the leachate. The runoff of water, fertilizer, and pesticides resulting from these irrigation methods are a potential risk to the quality of the environment in proximity to a greenhouse operation. In wick irrigation, such loss will be nil. Instead, nutrients if added to the irrigation water in the bottle in the dissolved form will be carried to the root zone of the plants for the plants to absorb. Pipe sub irrigation systems were reported to be more efficient in terms of nutrient use (Kent and Reed 1996).

By adopting wick irrigation, an environment most conducive for water absorption is developed through adequate aeration of the root zone, which is not the case in surface (alternate wetting and drying created) or drip methods (wetting zone is wetted) of irrigation. This method can be adopted by the rich and the poor, young and old and so many innovations can be brought out in future. Thus gender equity, social equity, age equity and financial equity can be ensured. In the long run, it will keep the building cool and protect it from direct sun, which will add to the life of the roof. If done scientifically, the urban roof top farming will revolutionise the vegetable production in the urban areas. Maintaining greenery on the roof will help to increase amount of oxygen in the air and at the same time reduce the indoor temperature by 6-8 degree. Roof top gardening will help to relieve stress and strain especially with the easy irrigation technique and hence good for physical and mental health

### 2.2.2. Wick system - Principle

John M Wesonga*et al* (2014) studied that in the wick irrigationsystem; the matrix potential of the soil provides the driving force (capillary force) behind the flow of water through the irrigation system. If the flux of water through the soil could be eliminated by developing a wick that coupled directly to the root zone, the large negative potentials at root surface could provide a greater suction than that possible in the soil. This coupling would also minimize water losses due to downward water flux and surface evaporation by providing the water directly into the plant. Any implementation of this design, however, would need to look at the limit as to the amount of water a single root could absorb. In this system water was delivered to all directly to plant roots. However, In this system there would be a large discrepancy between the wick directly coupled to the line receiving water, and those in the soil. It would be critical to investigate the limitation on a wick providing water to the whole plant.

Wick irrigation system hold the potential to substantially reduce the necessary pumping power required for irrigation, potentially even serving as a source of power generation. While a system that relies on both the negative water potential of soil as well as that of plants could provide reduction in irrigation power, creating a direct connection between the wick and the water in the container and the plant root would enable the use of large negative water potential at the root zone. Such system would provide the greatest power benefits, while minimizing water loss through soil evaporation and downward flux in to the water

**2.2.3. *Wick***

The main component of the irrigation system is the wick, which carries water from the water container to the rooting medium as per the requirement to keep it wet. Different materials used for making the wick are glass wool, cotton and silk wool.

According to Andriolo *et al.* (2004) studied that wick irrigation needs less man power and it is independent of electricity for operation, as the management is simplified compared with other irrigation system, it is cost effective in operation.

Son *et al.* (2006) reported that wick irrigation system operates in a closed cycle, without runoff, permitting appropriate plant nutrition and creating alternatives to improve production uniformity i.e.; this irrigation system is water and nutrient use efficient.

Laviola *et al* (2007) studied the temperature control of root system and he suggested that the wick irrigation can be used for ornamental plants and

Oh and Son (2008) studied that the wick irrigation will reduce the evaporation loss as the surface is covered with substrate and he also suggested that wick irrigation can be used as an efficient irrigation method for the production of vegetables and aromatic plants.

Kang *et al* (2009) studies revealed the optimum wick width, wick length and suitable water depth for wick contact for effective working of the wick in the system and he also found that that the wick length in wick irrigation improves the rate of distribution.

John M Wesonga *et al* (2014) identification of the best wick material for use in the capillary wick irrigation system was determined through laboratory experiments.

Five wick materials were evaluated. Parameters measured included water holding capacity (WHC), water absorption pattern (WAP) and maximum capillary height (MCH). The experiments were carried out in a completely randomized design and the treatments were replicated three times. The dimensions of the wick material were 4 cm wide by 45 cm long.  Five wick materials were compared for water absorption pattern (capillarity action), maximum capillary height (MCH) and water holding capacity (WHC). The wick materials were significantly different in water absorption (P <0.01) over the entire time course. The cloth material (CL, 100% polyester) had the highest water absorption pattern with 10.9 cm at 180 minutes while lowest capillarity action was recorded in cotton woven material (CW) with 4.4 cm at 180 minutes .Capillarity action was in the order CL > IWM > CNW > BM > CW over the entire time course. This cloth material commonly used as a shoulder shawl and composed of 100% polyester performed even better than the control (IWM) used for wick irrigation in Japan which had a water rise of 8.1 cm at 180 minutes. Significant differences also existed (P <0.01) in MCH and WHC. MCH was measured at 48 hrs. when there was no further water rise. The MCH followed the order CL>IWM>CNW>BM>CW with 19.4 cm, 14.4 cm, 10.9 cm, 6.4 cm and 5.2 cm respectively. CW, CNW and IWM were not significantly different in WHC with 86.9%, 86.7% and 86.3% respectively. The cloth material however had a significantly lower water holding capacity of 79.7%.

Cornelius Wainaina *et al* (2014) studied about the selection of suitable media for wick irrigation. The media types were significantly different in water absorption pattern and water holding capacity. Water absorption rate was high in SSM with 132.7 ml at 30 minutes and lowest in CMP with 61.3 ml at 30 minutes. The water absorption rate followed the order SSM>SCMP>SCMS>CMP with 132.7 ml, 114 ml, 84.7 ml and 61.3 ml respectively. The bulk densities of the media were: SSM (1.07 g/cm3), SCMP (0.35 g/cm3), SCMS (0.42 g/cm3) and CMP (0.32 g/cm3). Water holding capacity was high in SCMP with 72% while SSM had the lowest water holding capacity of 38%. Significant differences were also observed in moisture release characteristics (MRC) of the media types . Of importance are two characteristic points; pF 2.48 (equivalent to field capacity) and pF 4.2 (equivalent to permanent wilting point) of which the difference in soil water content between these two points is the available water (AW). SSM had significantly higher amount of available water (7.4%) compared to 5.3%, 4.9% and 3.2% under SCMP, SCMS and CMP respectively

| Media type | Description |
|---|---|
| SSM | 3 parts forest soil, 2 parts sand and 1 part manure |
| SCMS | 2 parts forest soil, 4 parts cocopeat, 1 part manure and 1 part sand |
| SCMP | 2 parts forest soil, 4 parts cocopeat, 1 part manure and 1 part pumice |
| CMP | 4 parts cocopeat, 1 part manure and 2 parts pumice |

**2.2.4. Advantages of wick irrigation**

- ❖ Low cost irrigation technique
- ❖ In wick irrigation, the wetting will be mostly in the lower part of the growing medium (root zone) and the surface will always remain dry. Hence evaporation loss is less.
- ❖ In surface irrigation method, as water flows down during each irrigation, apart of the dissolved nutrients also will flow down; it decreases the efficiency of fertiliser application, but in wick irrigation such loss is nil.
- ❖ By adopting wick irrigation, an environment most conducive for water

absorption is developed through adequate aeration of the root zone.

- ❖ Since used plastic bottles are used for filling water, there is great scope for re-use of the waste plastic.
- ❖ This will help to quantify the water requirement of different plants at different growth stages, hence it can helps to reduce the loss of water in different stages of plant
- ❖ No energy consumption is needed.
- ❖ Less labour requirement

# CHAPTER 3

# MATERIALS AND METHODS

A study was conducted to evaluate and compare the performance of different wick materials used in wick irrigation method. The experiment was conducted in two seasons. The first season was from May to August and the second set of experiment was performed from September to December of the 2017. The field experiment was carried out to evaluate the performance of wick with respect to growth and yield parameters of vegetable crop. Materials used for the study and the methodology adopted for achieving the objectives are discussed in this chapter.

## 3.1. LOCATION

The experiment was conducted at KCAET, Tavanur situated at $10^0$ 53’33” N latitude and $75^0$59`14``E longitudes. Agro climatically, the area falls within the border line of northern zone, central zone and kole land of Kerala .The area receives rainfall mainly from the south-west monsoon and to certain extends from the North-East monsoon. The climatological data of the experimental area is shown below:

- Latitude - 10 °59`5``N
- Longitude - 75° 59`14``E
- Mean maximum temperature - 32.5°c
- Mean minimum temperature - 22 c
- Average relative humidity - 83%
- Average rainfall - 3000mm
- Mean evaporation - 6mm/day
- Mean solar radiation - 85 w/m/day

## 3.2. PERFORMANCE EVALUATION OF WIK IRRIGATION SYSTEM

### 3.2.1. Nursery preparation

Tomato variety ANAGHA was selected for the study. Seeds were sown and covered with soil in the greenhouse and watering was done regularly by using rose can during morning and evening. The seedlings were ready for transplantation in 22 to 25 days (Plate 1).

### 3.2.2. Grow bag preparation

For the grow bag filling, potting mixture of sand, soil, and cow dung in the ratio of 1:1:1 is mixed thoroughly after sprinkling water. Then a hole of 25 mm size to insert a wick is made at the bottom of bag. Grow bag is filled up to one third volume and made in to round shape by inserting the corners inside. Wick is then inserted into the bag through the bottom of hole in such a way that one-third of length of wick is projected outside the bag. There after the bag is filled up to desired depth (Plate 2).

### 3.2.3. Installation of wick irrigation system

Two litre bottle water bottles are used for the installation of wick irrigation system as water container. Two holes of 25mm size are made on the bottle as shown in Plate (3.1). One hole is at 3-3.5above the bottom for inserting the wick and other near to the neck of the bottle for filling water as shown in Plate (3.2). Bottle cap should be made tight and the bottle is placed in between two bricks in such a way that the holes are facing up as shown in Plate (3.2). The filled grow bag, containing wick is placed above bottle supported by two bricks and the wick is inserted in to the hole on the bottom of the bottle as shown in Plate (3.3).

### 3.2.4. Transplanting

One day after the installation of wick irrigation system, the seedling prepared in the nursery are transplanted in to the grow bag. It is shown in Plate 4.

### 3.2.5. Fertiliser application

Recommended dose of N-P-K and Pseudomonas enriched coir pith compost are needed to be applied at regular interval for improving the productivity of the vegetable plant. 200 gm of Pseudomonas enriched coir pith compost isapplied to each plant in one week interval after transplanting. Foliar spray of 13 N:0 P:45 K is also given fortnightly with 0.5 per cent concentration (Plate 6).

Manual fertiliser applicationshould be given as;

| | |
|---|---|
| Basal application | :- 0.5 N: 1P: .5K |
| 30days after transplanting | :- 0.25N: 0.0P: .25K |
| 60 days after transplanting | :- 0.25N; 0.0P: .25K |

### 3.2.6. Weeding

Weeds interfere with the growth of crop by absorbing water & nutrients. Therefore periodical removal of weeds was carried to maintain an optimum growth rate for the crop. The manual weeding was done at 20 days interval.

## 3.3. EXPERIMENTAL LAYOUT

The statistical design selected for the study was complete block design (CBD) with four treatments and six replications..The design was done in such a way that each row contains six replicates of one treatment.

**$T_1$**- wick made up of cotton material

**$T_2$**- wick made up of silk wool

**$T_3$**-wick made up of glass wool

**$T_4$**-control (manual irrigation with manual fertilizer application)

The experimental layout is shown in (Fig.1) and field level setup is shown in (Plate 6)

| | | | | | |
|---|---|---|---|---|---|
| **T1$R_1$** | **$T_1R_2$** | **$T_1R_3$** | **$T_1R_4$** | **$T_1R_5$** | **$T_1R_6$** |
| **$T_2R_1$** | **$T_2R_2$** | **$T_2R_3$** | **$T_2R_4$** | **$T_2R_5$** | **$T_2R_6$** |
| **$T_3R_1$** | **$T_3R_2$** | **$T_3R_3$** | **$T_3R_4$** | **$T_3R_5$** | **$T_3R_6$** |
| **$T_4R_1$** | **$T_4R_2$** | **$T_4R_3$** | **$T_4R_4$** | **$T_4R_5$** | **$T_4R_6$** |

**Fig. 1. Experimental layout**

**Plate 1. Tomato seedlings ready for transplanting**

**Plate 2. Preparation of grow bag**


**Plate 3. Installation of wick irrigation system**

**Plate 4. Transplanting**

### 3.4. PARAMETERS RECORDED

The performance of the wick irrigation system and the different wick materials are evaluated under the following subhead;

- ❖ Water uptake by different wick material (volume per day)
- ❖ Moisture distribution by different wick material.
- ❖ Biometric observation
  - Height of the plant
  - Stem girth
  - Number of branches
  - Root length
  - Root lateral distribution
  - Root wet weight
  - Root dry weight
- ❖ Yield parameters
  - Total Yield
  - Number of fruits
  - Diameter of fruit

#### 3.4.1 Water uptake by different wick material

The water uptake volume by all plants of all treatments was taken dailyand the average water uptake volume of each treatment was computed in millimetre per day for every week to evaluate the performance.

#### 3.4.2 Moisture distribution

Soil moisture content of all replication of each treatment was taken by oven drying methodto evaluate the moisture distribution by wick materials. In oven dry method the samples were weighed (W1) and placed in an oven at a temperature

105°C for 24 hrs. Then the sample is taken out and weighed again (W2) for the measurement of moisture content

$$\text{Moisture content \% (db)} = \frac{(W1-W2)\ 100}{W2}$$

### 3.4.3 Biometric observation

Biometric observations were taken 14,28,42,56 days after transplanting. Observations on height, girth and number of branches of all plants from each treatment were recorded.

#### 3.4.3.1 Height of the plant

Average height of all plants from each treatment wastaken. The measurements were taken from the bottom of the plant to the shoot tip for all plants at 14 days interval.

#### 3.4.3.2 Girth of the plant

Girth of the plant was measured at 2.5 cm above the ground. The measurements were taken at 14 days interval.

#### 3.4.3.3 Number of branches

Number of branches of the all plants of each treatment wascounted.

#### 3.4.3.4 Root length

Average root length of the all plants of each treatment wastaken immediately after the harvest in both seasons.

#### 3.4.3.5 Lateral root distribution

Average lateral root distribution of the all plants of each treatment wastaken immediately after the harvest in both seasons.

#### 3.4.3.6 Root wet weight

Average root wet weight of the all plants of each treatment wastaken immediately after the harvest in both seasons.

#### 3.4.3.7 Root dry weight

Average root dry weight of the all plants of each treatment wastaken after sun drying of the roots for 3 to 4 days after harvest.

### 3.4.4 Yield parameters

First harvest was done in the middle of July 2017 for the first season and middle of October 2017 for the second season. Afterwards harvesting was done on alternate days**.** Total weight was recorded separately for each treatment. These yield data were evaluated to know the performance evaluation of different wick material in wick irrigation.

#### 3.4.4.1 Weight of fruit

Average fruit weight of each treatment was observed.

#### 3.4.4.2 Number of fruits

Total number of fruits was counted for all treatments.

#### 3.4.4.3 Fruit diameter

Average fruit diameter of each treatment were observed

**Plate 5. Foliar spray of fertilizer**

**Plate 6. Field level set up of the study**

**Plate 7.Stem height measurement Plate 8.  Stem girth measurement**

# CHAPTER 4
# RESULTS AND DISCUSSION

A field study is conducted to determine the performance of wick irrigation system and to compare the performance of different materials used for making wick. The experiment was conducted in two seasons. The first season was from May to August and the second season was from September to December, 2017. The results obtained during this period is analysed and discussed in this chapter.

## 4.1. Water uptake rate

The water uptake rate of each wick material was recorded daily. The average volume uptake rate (ml/day) in second week, fourth week, sixth week, eighth week and tenth week after transplanting were calculated and presented below.

### 4.1.1. Water uptake rate (ml/day) in second weeks after transplanting

Average of water uptake rate of different treatments is given in Table 1 and a plot of water uptake rate with time is shown in Fig .2.

**Table 1. Water uptake rate**

| **Treatments** | **Water uptake rate (ml/day)** | |
|---|---|---|
| | **Season 1** | **Season 2** |
| T1 | 222.97 | 315.55 |
| T2 | 150.56 | 225.00 |
| T3 | 280.50 | 375.15 |
| T4 | 300.00 | 300.00 |

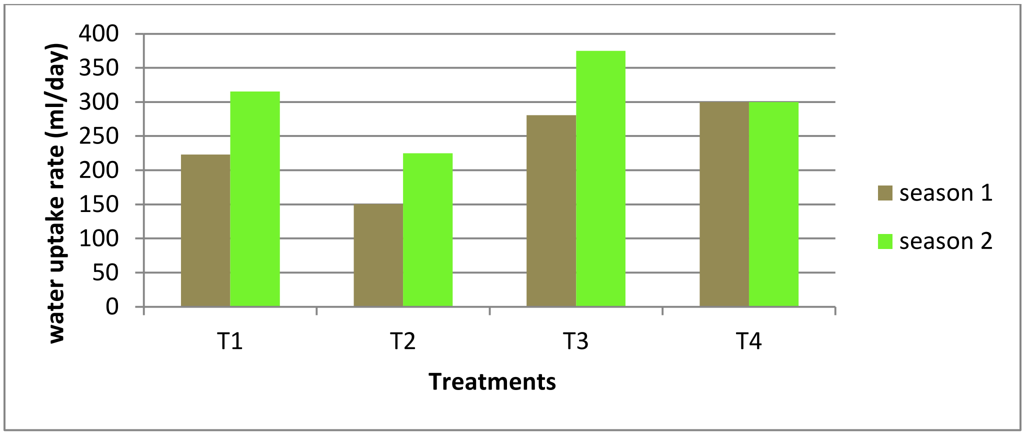


**Fig.2 Graphical representation of water uptake rate in second week**

From Table 1, it is found that the water uptake rate was maximum in T3(glass wool) that is 280.55 ml per day, in season 1and 375.15 ml per day in season 2.The minimum water uptake rate was observed in T2 (silk wool) in both seasons that is 150.56 ml and 225.00 ml per day respectively.

### 4.1.2 Water uptake rate (ml/day) at fourth weeks after transplanting

Average uptake rate of different treatments is given Table 2 and a plot of water uptake rate with time is shown in Fig .3.

**Table 2. Water uptake rate**

| **Treatments** | **Water uptake rate (ml/day)** | |
|---|---|---|
| | **Season 1** | **Season 2** |
| T1 | 268.75 | 266.90 |
| T2 | 175.25 | 269.30 |
| T3 | 299.35 | 422.96 |
| T4 | 300.00 | 300.00 |

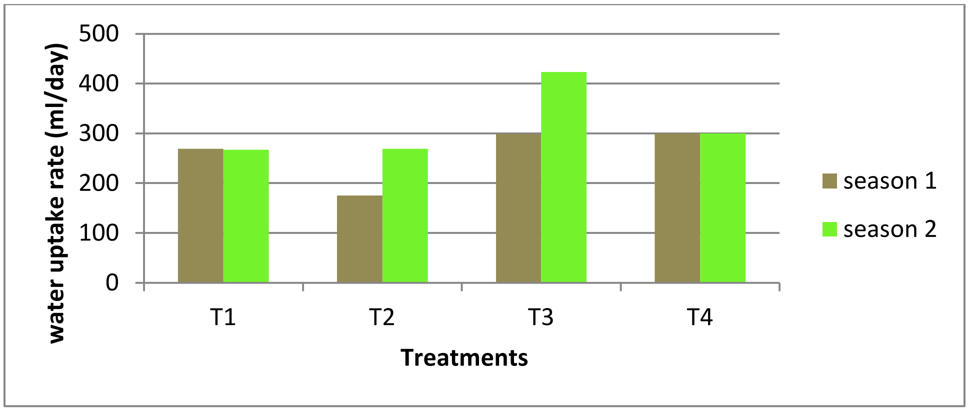


**Fig.3 Graphical representation of water uptake rate in fourth week**

From Table 2, it is found that the water uptake rate is maximum in T3 (glass wool) that is 299.35 ml per day in season1and 422.96 ml per day in season 2. The minimum water uptake rate is observed in T2 (silk wool) in both seasons that is 175.25 ml and 269.30 ml per day respectively.

### 4.1.3 Water uptake rate (ml/day) in sixth weeks after transplanting

Average water uptake rate of different treatments are given Table 3 and a plot of water uptake rate with time is shown in Fig .4.

**Table 3. Water uptake rate**

| Treatments | Water uptake rate (ml/day) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 285.54 | 275.09 |
| T2 | 185.63 | 389.03 |
| T3 | 315.25 | 441.21 |
| T4 | 300.00 | 300.00 |

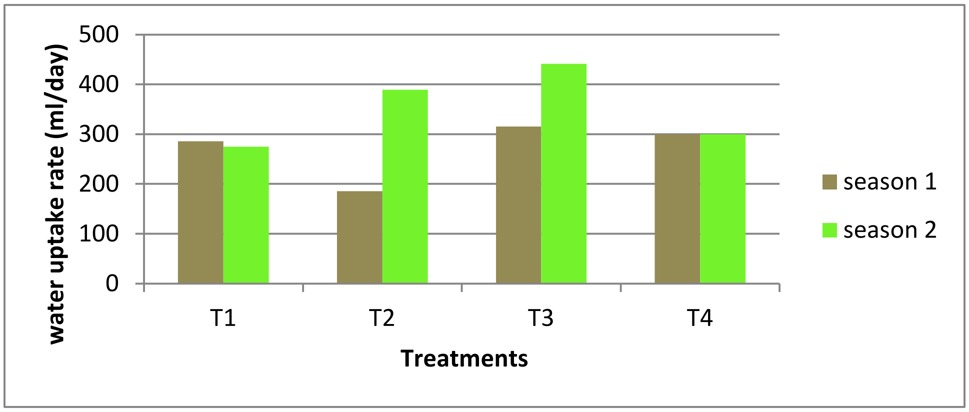


**Fig.4.Graphical representation of water uptake rate in sixth week**

From Table 3, it is found that the water uptake rate was maximum in T3 (glass wool) that is 315.25 ml per day in season1 and 441.21 ml per day in season 2. The minimum water uptake rate of 185.63 ml/day was observed in T2 (silk wool)in season 1 that is 185.63 ml and 279.09 ml per day from T1(cotton) in season 2.

**4.3.4 Water uptake rate (ml/day) in eighth weeks after transplanting.**

Average water uptake rate of different treatments are given Table 4 and a plot of water uptake rate with time is shown in Fig .5.

**Table 4. Water uptake rate**

| Treatments | Water uptake rate (ml/day) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 305.85 | 241.42 |
| T2 | 210.25 | 383.22 |
| T3 | 318.24 | 448.67 |
| T4 | 300.00 | 300.00 |

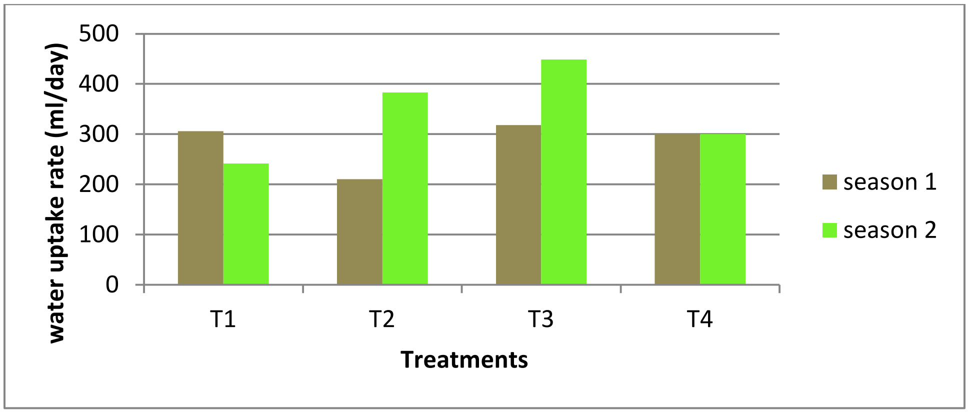


**Fig.5 Graphical representation of water uptake rate in eight week**

From Table 4, it is found that the water uptake rate is maximumin T3 (glass wool) that is 318.24 ml per day in season 1 and 448.67 ml per day in season 2. The minimum water uptake rate of 210.25 ml/day was observed in T2(silk wool) in season 1and 241.42 ml per day in season 2.

### 4.1.5 Water uptake rate (ml/day) in tenth weeks after transplanting.

Average water uptake rate of different treatments are given Table 5 and a plot of water uptake rate with time are shown in Fig. 6.

**Table 5. Water uptake rate**

| Treatments | Water uptake rate (ml/day) | |
|---|---|---|
| | **Season 1** | **Season 2** |
| T1 | 325.55 | 217.50 |
| T2 | 210.00 | 392.85 |
| T3 | 350.65 | 543.68 |
| T4 | 300.00 | 300.00 |

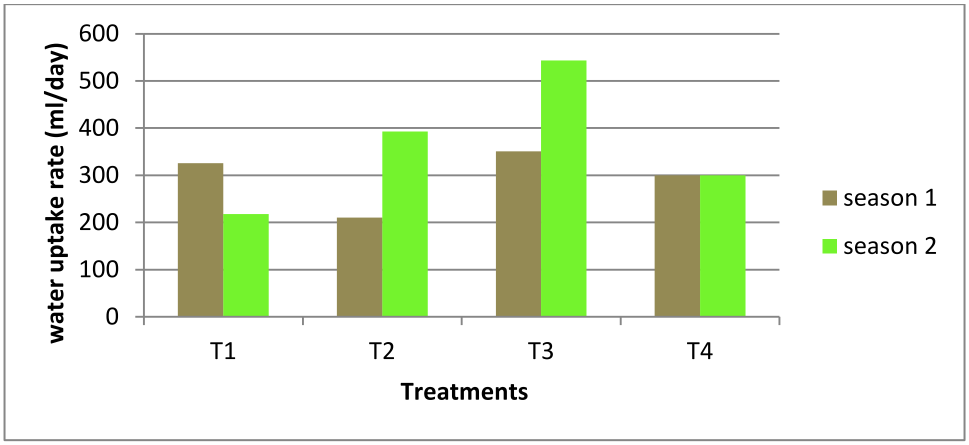


**Fig.6 Graphical representation of water uptake rate in tenth week**

From Table 5, it is found that the water uptake rate is maximum in T3 (glass wool) that is 350.65 ml per day in season 1 and 543.68 ml per day in season 2. The minimum water uptake rate of 210 ml/day was observed from T2 (silk wool) in season 1 that is 210.00 ml per day and 217.50 ml per day from T1 (cotton) in season 2.

Fig.7. shows that the comparison of water uptake rate of different material in season 1, it could be seen that the water uptake rate was maximum in T3 (glass wool) which is on par with T1(cotton) and minimum water uptake rate by T2 (silk wool).

Fig.8. shows that the comparison of water uptake rate of different material in season 2, it could be seen that the water uptake rate is maximum in T3 that is the wick made up of glass wool and minimum water uptake rate by T1 that is the wick made up of cotton.

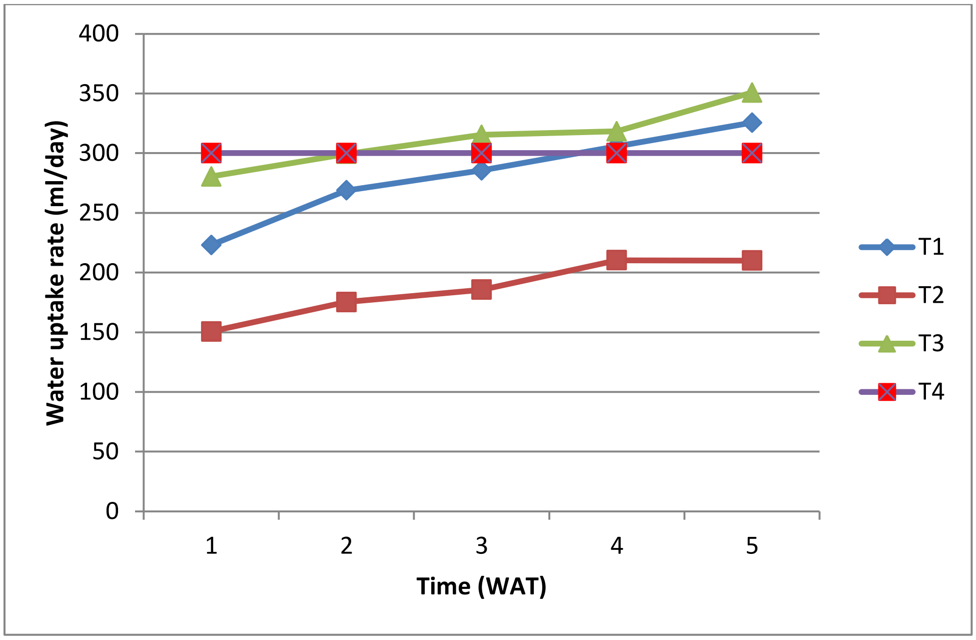


**Fig.7 Graphical representation of water uptake rate in season 1**

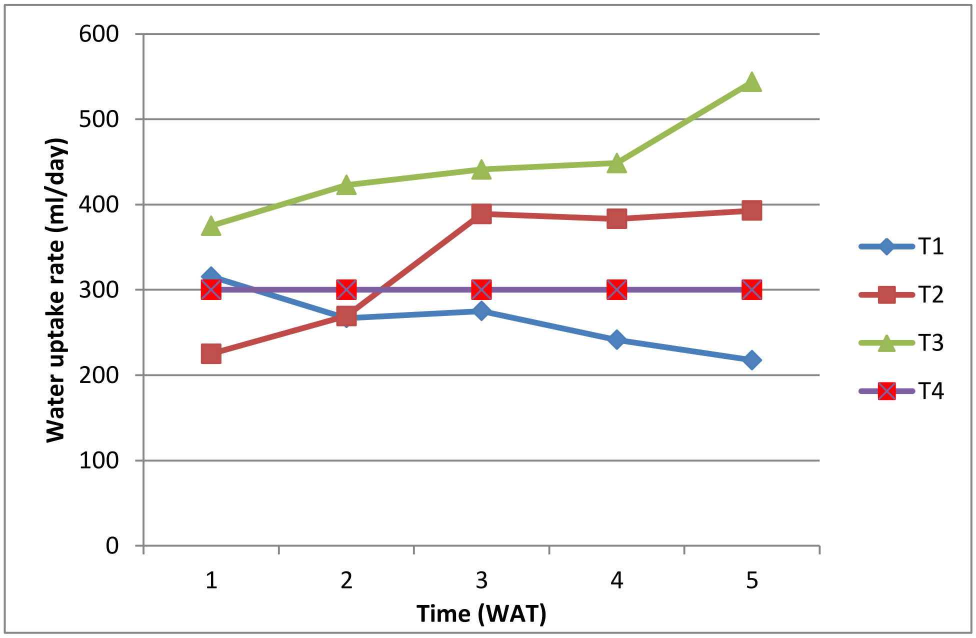


**Fig.8. Graphical representation of water uptake rate in season 2**

### 4.2 Moisture content.

Variation in moisture content of soil in each treatment was taken in an interval of two weeks.

#### 4.2.1 Moisture content in second week after transplanting

Moisture content of soil in different treatments at second week after transplanting is given in Table 6 and variation is shown in Fig.9.

**Table 6. Moisture content**

| Treatments | Moisture content (%) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 28.45 | 25.44 |
| T2 | 21.23 | 23.85 |
| T3 | 29.34 | 31.70 |
| T4 | 23.19 | 24.71 |

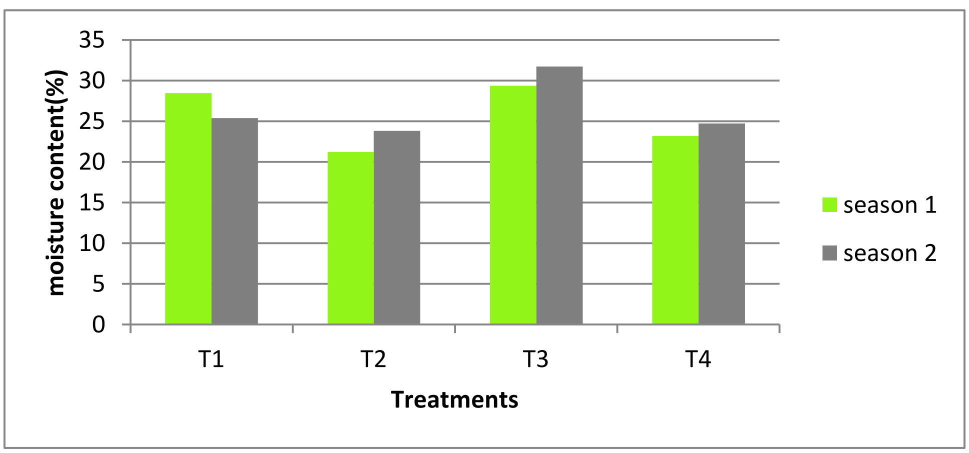


**Fig.9 Graphical representation of moisture content in second week.**

From Table 6, it is found that the moisture content is maximumin T3 (glass wool) that is 29.34 per cent in season 1 and31.70 per cent in season 2. The minimum moisture content is observed in T2 (silk wool) in season 1 and 2 that is 21.23 per cent and 23.85 per cent respectively.

### 4.2.2 Moisture content in fourth week after transplanting

Moisture content in different treatments at fourth week after transplanting is given in Table 7 and variations are shown in Fig.10.

**Table 7. Moisture content**

| Treatments | Moisture content (%) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 28.43 | 30.12 |
| T2 | 24.25 | 26.59 |
| T3 | 32.42 | 36.13 |
| T4 | 25.60 | 26.95 |

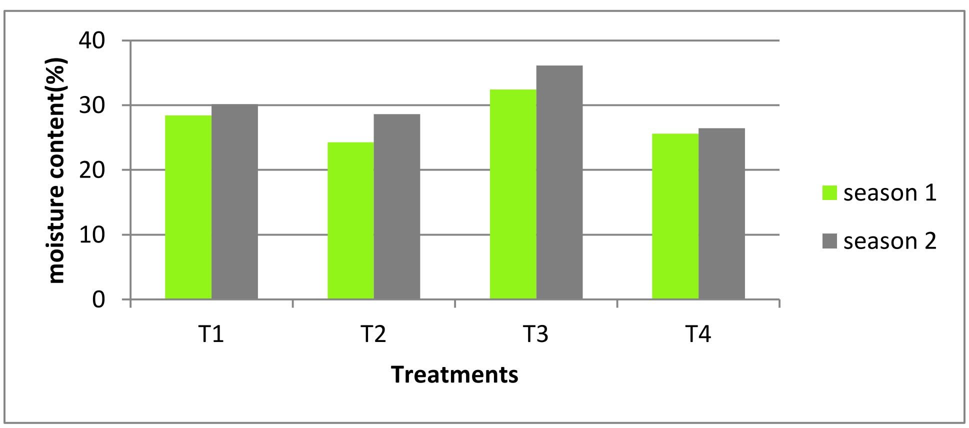


**Fig.10 Graphical representation of moisture content in fourth week**

From Table 7, it is found that the moisture content is maximum in T3 (glass wool) that is 32.42per cent in season 1 and 36.13% in season 2. The minimum moisture content of 24.25 per cent and 26.59 per cent were observed in T2 (silk wool) in season 1 and 2 respectively

### 4.2.3. Moisture content in sixth week after transplanting

Moisture content of soil in different treatments at sixth week after transplanting is given in Table 8 and variations are shown in Fig11.

**Table 8. Moisture content**

| Treatments | Moisture content (%) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 29.34 | 29.23 |
| T2 | 23.56 | 31.11 |
| T3 | 31.55 | 34.56 |
| T4 | 25.25 | 26.12 |

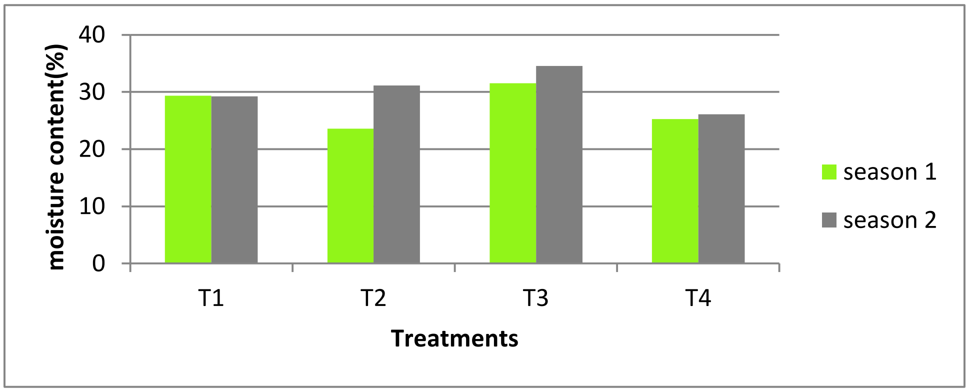


**Fig.11 Graphical representation of moisture content in sixth week**

From Table 8, it is found that the moisture content is maximum in T3 (glass wool) that is 31.35 per cent in season 1 and 34.56 per cent in season 2. The minimum moisture content of 23.56 per cent was observed from T2 (silk wool) in season 1 and 26.12 per cent from T4 (control) in season 2.

### 4.2.4. Moisture content in eight week after transplanting.

Moisture content of soil in different treatments at eight week after transplanting is given in Table 9 and variation is shown Fig.12.

**Table 9 Moisture content**

| Treatments | Moisture content (%) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 30.45 | 28.13 |
| T2 | 21.45 | 30.80 |
| T3 | 32.65 | 33.65 |
| T4 | 24.34 | 26.45 |

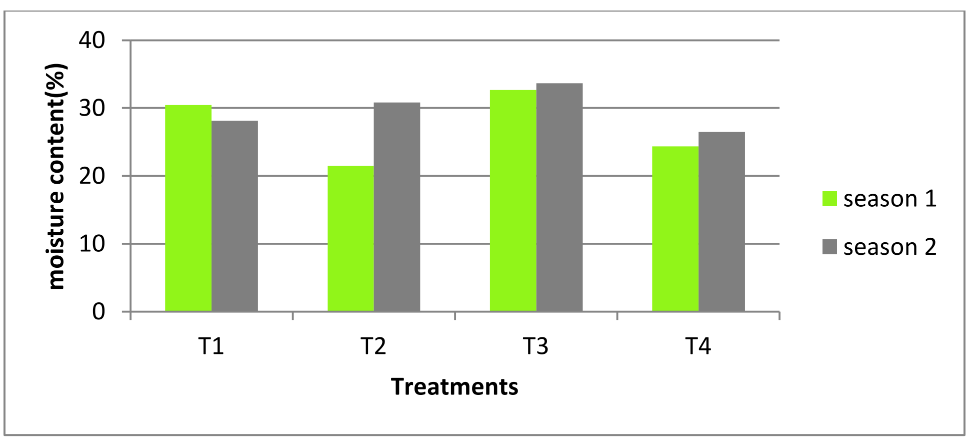


**Fig.12 Graphical representation of moisture content in eight week**

From Table 9, it is found that the water content is maximumin T3 (glass wool) that is 32.65 per cent in season 1 and 33.65 per cent in season 2. The minimum moisture content of 24.45 per cent was observed from T2 in season 1and 26.45 per cent from T4 (control) in season 2

#### 4.2.5. Moisture content in tenth week after transplanting.

Moisture content of soil in different treatments at tenth week after transplanting is given in Table 10 and variation is shown in Fig.13.

**Table 10. Moisture content**

| Treatments | Moisture content (%) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 31.35 | 28.65 |
| T2 | 26.65 | 31.54 |
| T3 | 34.76 | 36.76 |
| T4 | 25.06 | 26.98 |

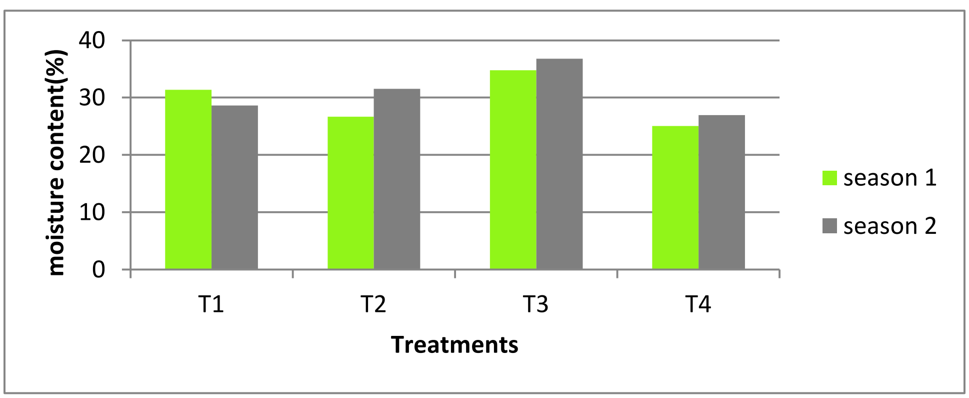


**Fig.13 Graphical representation of moisture content in tenth week**

From Table 13, it is found that the moisture content was maximum in T3 (glass wool) that is 34.76 per cent in season 1 and 36.76 per cent in season 2. The minimum moisture content of 25.06 per cent and 26.98 per cent were observed in T4 (control) in season 1 and 2 respectively

Fig.14 shows the comparison of moisture content of soil in different treatments in season 1. It is found that the moisture content was maximum in T3 (glass wool) and minimum inT2 (silk wool) during season 1.it is also showed that the moisture content in T1(cotton) was on par with T3 (glass wool).

Fig.15shows the comparison of moisture content of soil in different treatments in season 2.It is found that the moisture content was maximum in T3 (glass wool) and minimum inT4 (control) during season 2.

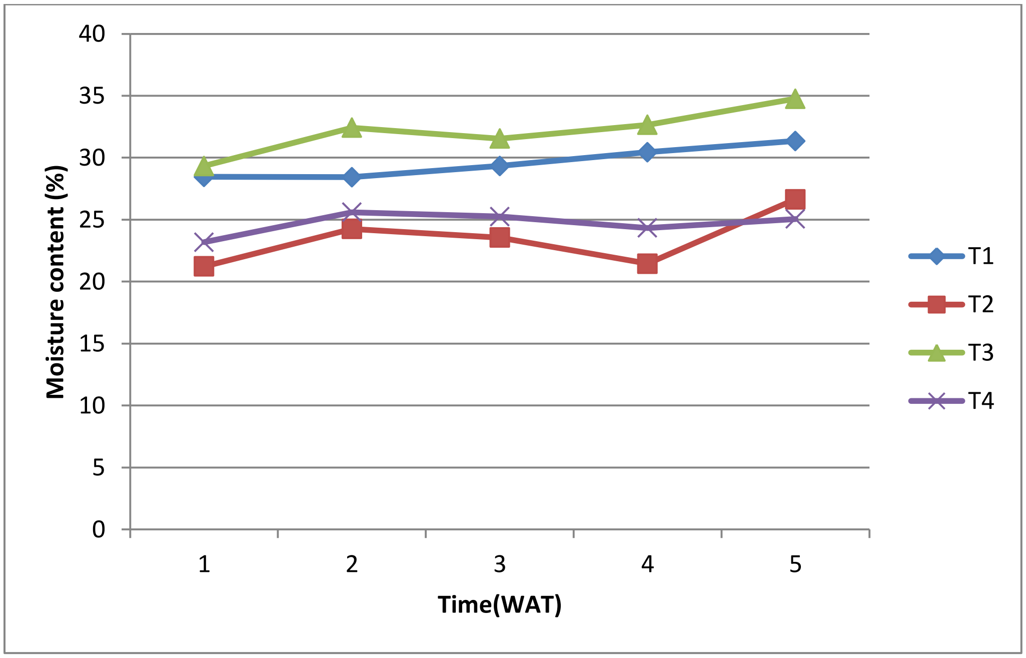


**Fig.14.Graphical representation of moisture content in season 1**

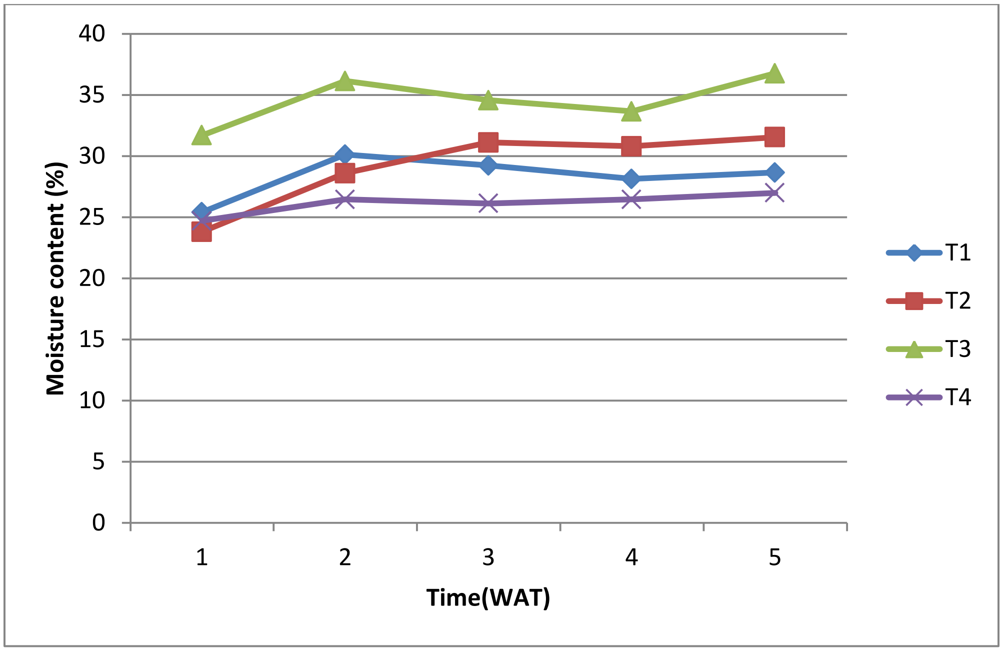


**Fig.15.Graphical representation of moisture content in different treatments during season 2**

### 4.3. MEASUREMENT OF BIOMETRIC PARAMETER

The biometric parameters such as plant height, stem girth, number of branches, root length and root distribution were observed in two seasons.

#### 4.3.1. Plant height

The height of the plant was measured during two seasons at 14 DAT, 28 DAT, 42DAT and 56 DAT.

##### 4.3.1.1. Plant height at 14 days after transplanting.

The average value of plant heights measured at 14 days after transplanting is given in Table.11 and comparison of its performance is shown in Fig.16.

**Table 11. Plant height (cm) 14 days after transplanting**

| Treatments | Plant height (cm) | |
|---|---|---|
| | **Season 1** | **Season 2** |
| T1 | 35.60 | 32.33 |
| T2 | 29.40 | 31.68 |
| T3 | 32.14 | 33.41 |
| T4 | 30.10 | 32.03 |

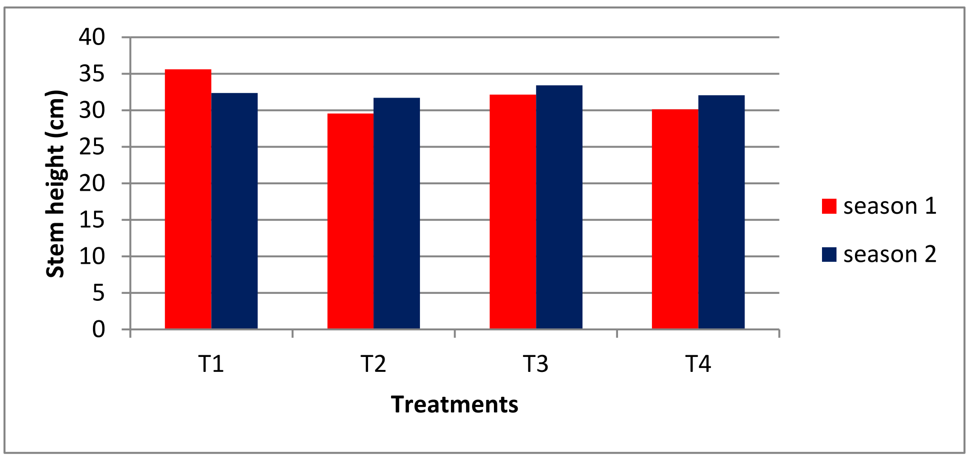


**Fig.16. Plant height measurement at 14 days after transplanting from various treatments**

From Table 11, it is found that the highest plant height of 35.6 cm was observed fromT1 (cotton) in season 1 and that of 33.4 cm is observed from T3 (glass wool) in season 2. It is also observed that the lowest plant height of 29.40 cm and 31.68 cm was observed from T2 (silk wool) in season 1 and 2 respectively.

#### 4.3.1.2 Plant height 28 days days after transplanting.

Plant heights measured 28 days after transplanting are given in Table 12 and comparison of its performance is shown in Fig.17.

**Table 12. Plant height (cm) 28days after transplanting**

| Treatments | Plant height (cm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 52.30 | 54.52 |
| T2 | 48.20 | 49.50 |
| T3 | 50.12 | 54.33 |
| T4 | 39.99 | 42.30 |

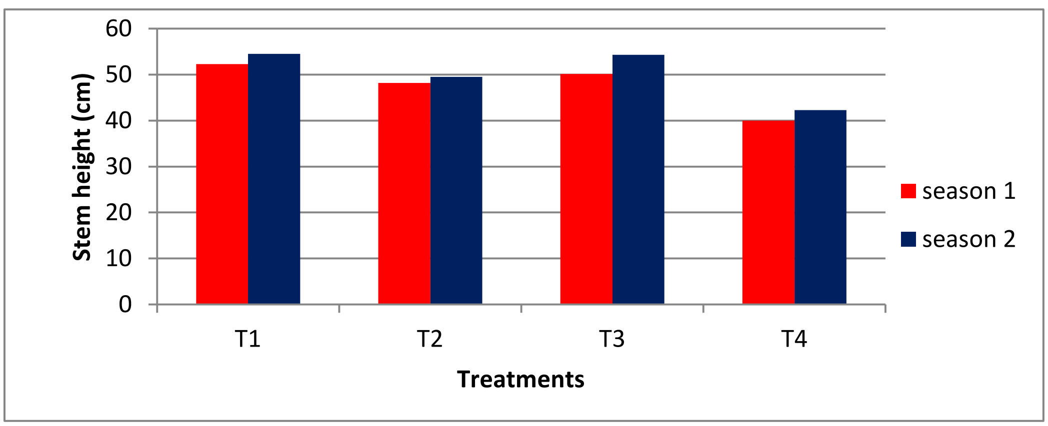


**Fig.17 Plant height measurement 28 days after transplanting from various treatments**

From Table 12, it is found that the highest plant height of 52.30 cm and 54.52 cm was observed from T1 (cotton) in season 1 and 2 respectively. The lowest plant height of 48.20 cm and 49.50 cm was observed from T2 (silk wool) in season 1 and 2 respectively.

#### 4.3.1.3 Plant height 42 days after transplanting

Plant heights measured 42 days after transplanting are given in Table 13 and comparison of its performance is shown Fig.18.

**Table 13. Plant height (cm) 42 days after transplanting**

| Treatments | Plant height (cm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 72.13 | 76.28 |
| T2 | 65.23 | 73.67 |
| T3 | 79.65 | 86.00 |
| T4 | 58.51 | 55.53 |

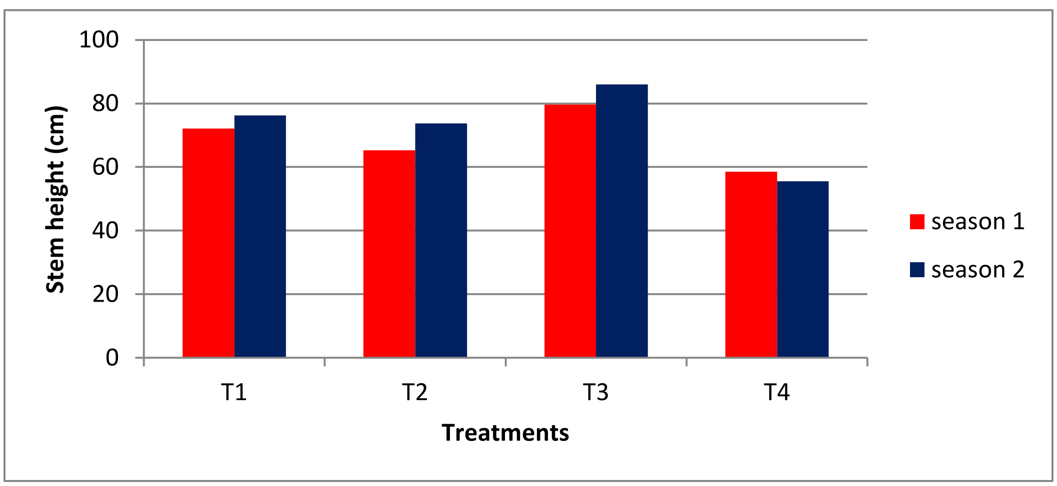


**Fig.18. Plant height measurement 42 days after transplanting from various treatments**

From Table 13, it is found that the highest plant height of 79.65 cm and 86.00 cm were observed from T3 (glass wool) in season 1and 2 respectively. The lowest plant height of 65.23 cm and 73.69 cm were observed from T2 (silk wool) in season 1 and 2 respectively

#### 4.3.1.4 Plant height 56 days after transplanting

Plant heights measured 56 days after transplanting are given in Table 14 and comparison of its performance is shown in Fig.19.

**Table 14. Plant height (cm) 56 days after transplanting**

| Treatments | Plant height (cm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 85.50 | 98.33 |
| T2 | 71.20 | 96.16 |
| T3 | 105.62 | 117.33 |
| T4 | 67.50 | 68.67 |

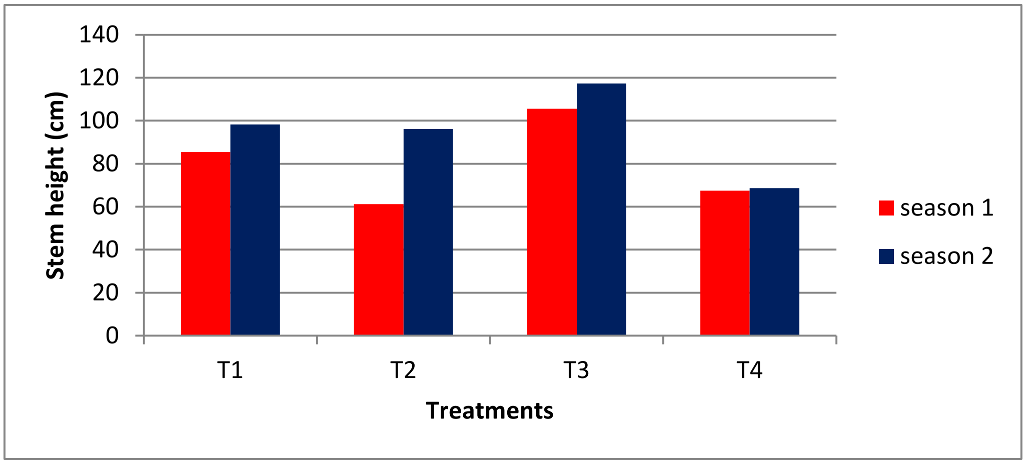


**Fig.19. Plant height measurement 56 days after transplanting from various treatments**

From Table 14, it is found that the highest plant height of 105.62 cm and 117.33 cm were obtained from T3 (glass wool) in season 1 and 2 respectively. The lowest plant height of 71.2 cm and 96.16 cm obtained for T2(silk wool) in season 1 and 2 respectively

From Fig.20 shows that the comparison of plant height. It could be seen that the plant height is better in T3 (glass wool) and it is on par with T1 (cotton). Whereas T2 (silk wool) and T4 (control) showed lower performance when compared with other treatments**.**

From Fig.21shows the comparison of plant height in season 2, it could be seen that the plant height is better in T3 (glass wool). Whereas in second season the performance of plant height in T2 (silk wool) is on par with T1 (cotton). The lower performance is showed by T4 (control).

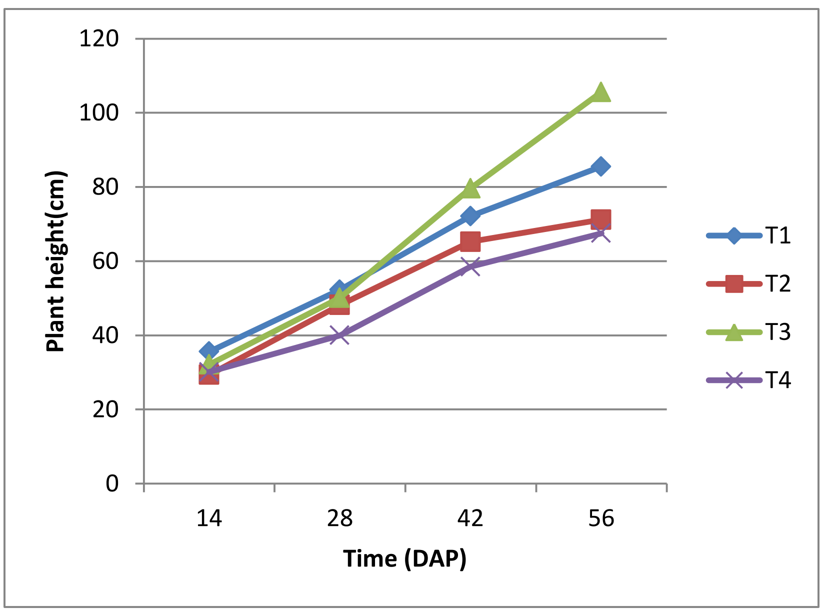


**Fig.20 Comparison of plant height measurement in season 1**

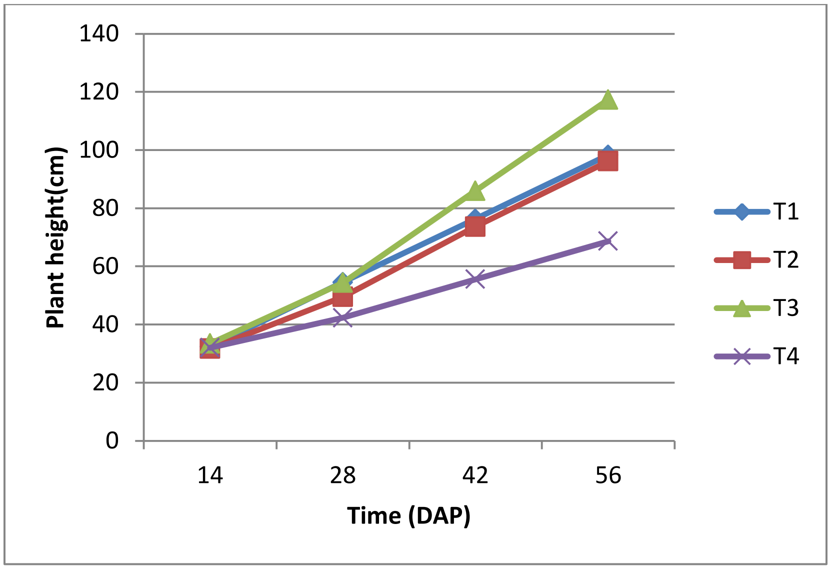


**Fig.21 Comparison of plant height measurement in season 2**

### 4.3.2. Stem girth

The stem girth of the plant was measured in two seasons at 14 DAT, 28 DAT, 42 DAT, and 56 DAT.

#### 4.3.2.1 Stem girth 14 days after transplanting

Stem girth measured 14 days after transplanting is given in Table 15, and the variations are shown in Fig.22.

**Table 15. Stem girth (cm) 14 days after transplanting**

| Treatments | Stem girth (cm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 1.81 | 1.93 |
| T2 | 1.50 | 1.70 |
| T3 | 1.79 | 1.91 |
| T4 | 1.62 | 1.72 |

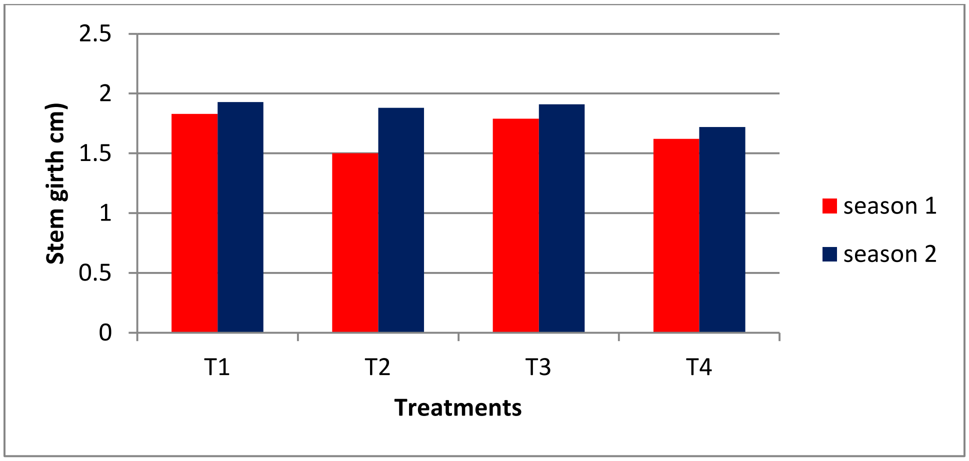


**Fig.22 Stem girth measurement 14days after transplanting from various treatments**

From Table 15, it is found that the highest stem girth of 1.81 cm and 1.93 cm were observed from T1(cotton) in season 1and 2 respectively. The lowest girth of 1.50 cm and 1.70 cm were observed for T2 (silk wool) in season 1 and 2 respectively.

#### 4.3.2.2 Stem girth 28 days after transplanting

Stem girth measured 28days after transplanting are given in Table 16, and the variations are shown in Fig.23.

**Table16. Stem girth (cm) 28days after transplanting**

| Treatments | Stem girth (cm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 2.45 | 2.65 |
| T2 | 2.23 | 2.45 |
| T3 | 2.37 | 2.41 |
| T4 | 2.10 | 2.25 |

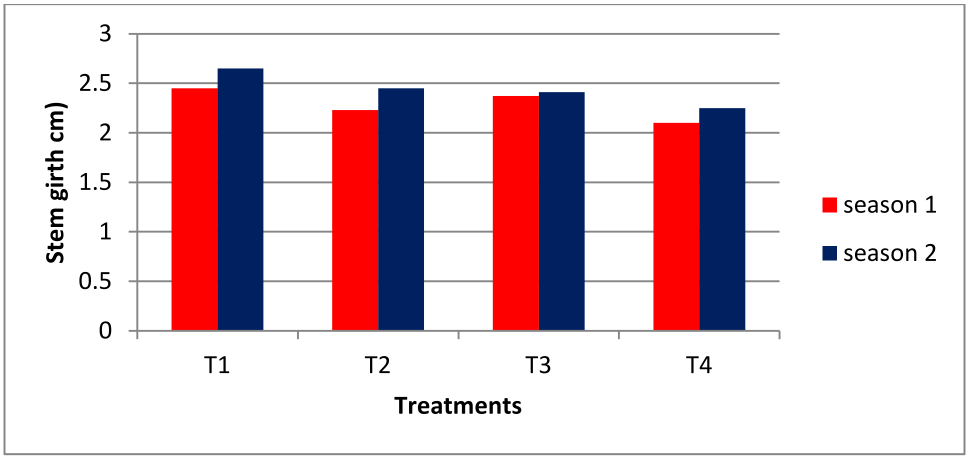


**Fig.23 Stem girth measurement 28days after transplanting from various treatments**

From Table1 6, it is found that the highest stem girth of 2.45 cm and 2.65 cm were observed from T1(cotton) in season 1and 2 respectively. The lowest girth of 2.23 cm and 2.45 cm obtained from T2 (silk wool) in season 1 and 2 respectively.

#### 4.3.2.3 Stem girth 42 days after transplanting

Stem girth measured 42days after transplanting are given in Table 17, and the variations are shown in Fig.24.

**Table 17. Stem girth (cm) 42 days after transplanting**

| Treatments | Stem girth (cm) | |
|---|---|---|
| | **Season 1** | **Season 2** |
| T1 | 3.30 | 3.33 |
| T2 | 3.22 | 3.24 |
| T3 | 3.12 | 3.35 |
| T4 | 3.01 | 3.21 |

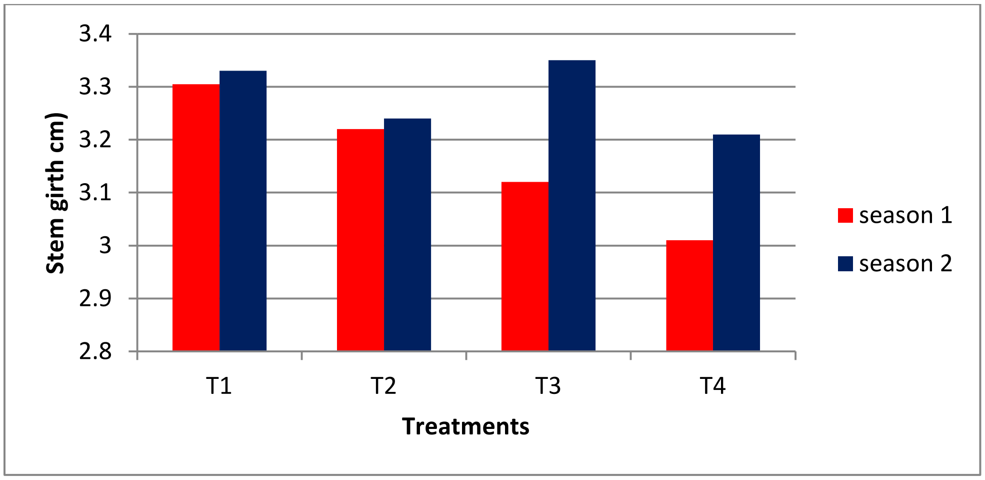


**Fig.24. Stem girth measurement 42 days after transplanting from various treatments**

From Table 17, it is found that the highest stem girth of 3.30 cm was observed from T1 (cotton) in season 1 and that of 3.33 cm was observed from T3 (glass wool) in season 2. The lowest girth of 3.01 cm and 3.21 cm observed from T4 (control) in season 1 and 2 respectively

### 4.3.2.4 Stem girth 56 days after transplanting

Stem girth measured 56 days after transplanting are given in Table 18, and the variation are shown in Fig.25.

**Table 18. Stem girth (cm) 56 days after transplanting**

| Treatments | Stem girth (cm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 4.13 | 4.58 |
| T2 | 3.38 | 3.95 |
| T3 | 4.32 | 4.41 |
| T4 | 3.01 | 3.56 |

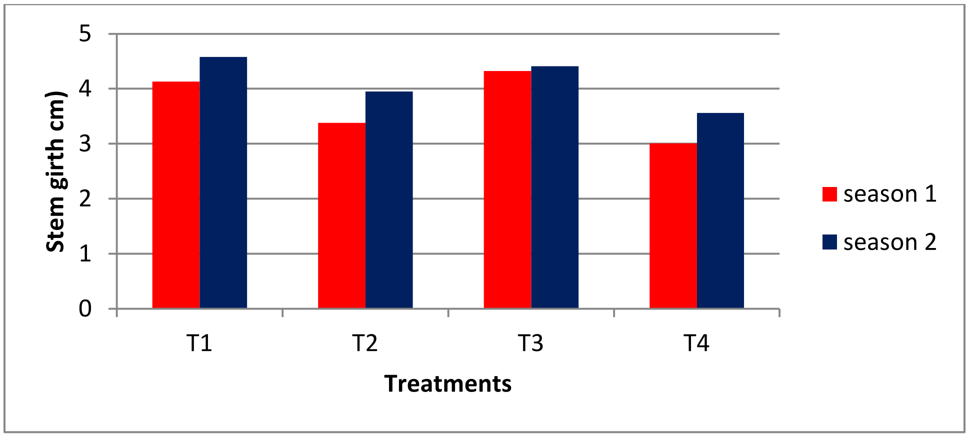


**Fig.25. Stem girth measurement 56 days after transplanting from various treatment**

From Table 18, it is found that the highest stem girth of 4.32 cm and 4.41 cm were observed from T3(glass wool) in season 1and 2 respectively. The lowest girth of 3.01 cm and 3.56 cm were observed for T2 (silk wool) in season 1 and 2 respectively.

Fig.26 shows the comparison of stem girth in season 1, it could be seen that the stem girth is maximum in T1 (cotton) and it is on par with T3 (glass wool). Whereas T2 (silk wool) and T4 (control) showed minimum performance compared with other two treatments.

Fig.27 shows the comparison of stem girth in season 2. It could be seen that the stem girth is maximum in T1 (cotton) and it is on par with T3 (glass wool). Whereas T2 (silk wool) and T4 (control) showed minimum performance compared with other two treatments.

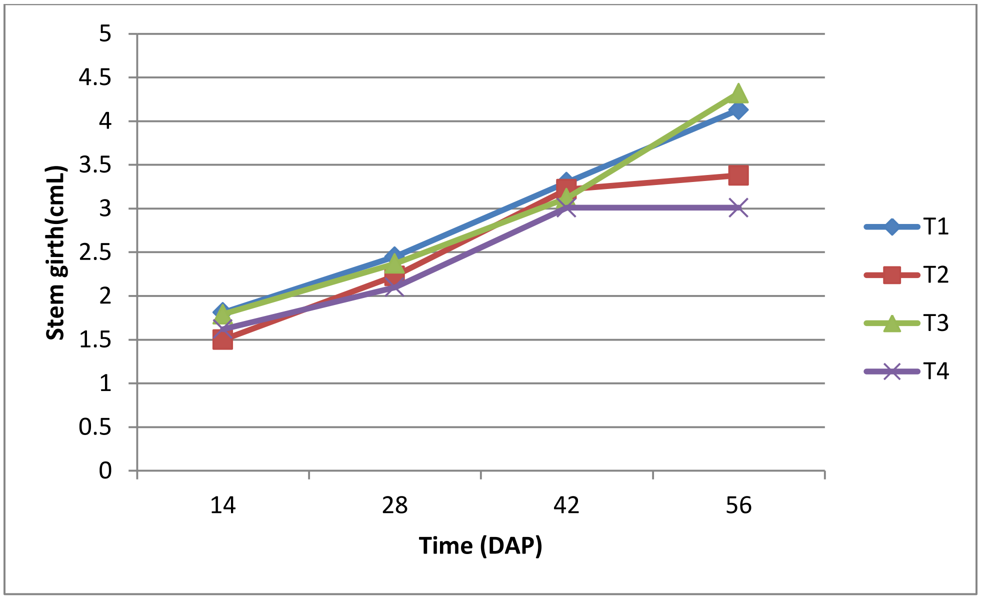


**Fig.26. Comparison of stem girth measurement in season 1**

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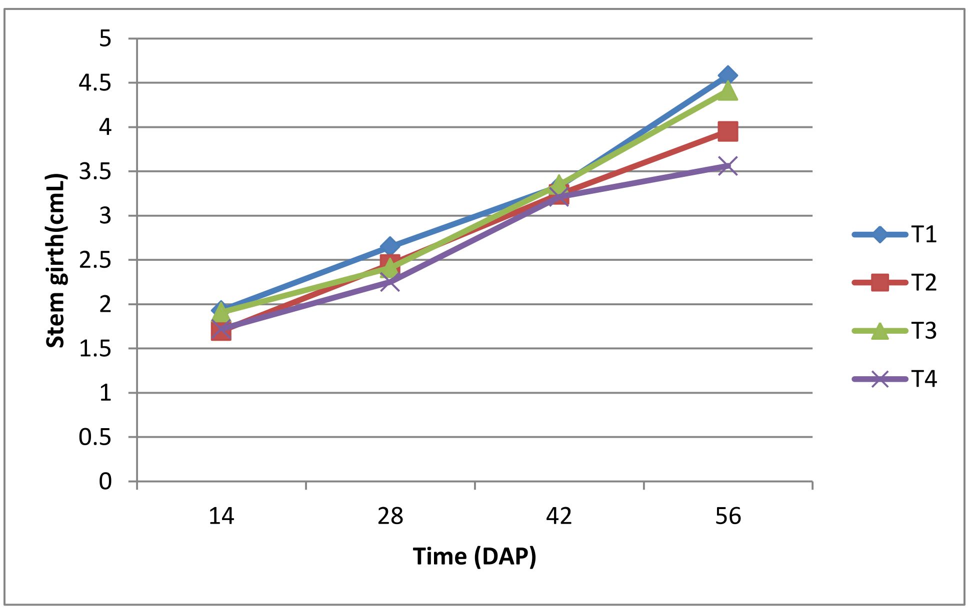


**Fig.27 Comparison of stem girth measurement in season 2**

### 4.3.3 Number of branches

The number of branches of the plant was counted in two seasons at 14DAT, 28DAT, 42DAT, and 56 DAT.

#### 4.3.3.1. Number of branches 14 days after transplanting

Number of branches counted in 14 days after transplanting are given in Table 19, and comparison of performance is shown in Fig.28.

**Table 19. Number of branches 14 days after transplanting**

| Treatments | Number of branches | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 6 | 7 |
| T2 | 5 | 8 |
| T3 | 7 | 8 |
| T4 | 7 | 7 |

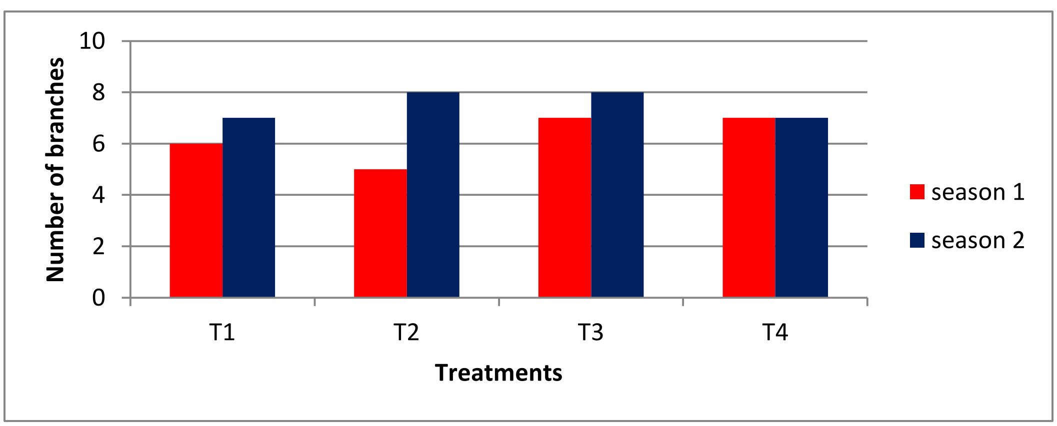


**Fig.28 Number of branches 14 days after transplanting from various treatments**

From Table 19, it is found that the highest number of branches is observed (7nos) from T3 (glass wool) and T4 (control) whereas it was found that lowest from T2 (silk wool) (5 nos.) in season 1.whereas in the case of season 2, highest number of branches (8 nos.) was observed from T2 (silk wool) and T3 (glass wool) and it is on par with T1 (cotton) and T4 (control) that is 7 nos. The lowest number of branches was observed in T2 in season 1 that is 5 nos. And in season 2 lowest number of branches are observed in T1 (cotton) and T4 (control)

#### 4.3.3.2 Number of branches 28 days after transplanting

Number of branches counted in 28 days after transplanting are given in Table 20, and its comparison between treatments is shown in Fig.29.

**Table 20. Number of branches 28 days after transplanting**

| Treatments | Number of branches | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 8 | 9 |
| T2 | 6 | 9 |
| T3 | 8 | 10 |
| T4 | 7 | 9 |

From Table 20, it is found that the highest number of branches i.e., (8 nos.) were observed from T1 (cotton) and T3 (glass wool) in season. In the case of season 2 highest number of branches (10nos.) was observed from T3 (glass wool) and it is also found that other treatments are on par with T3(glass wool).

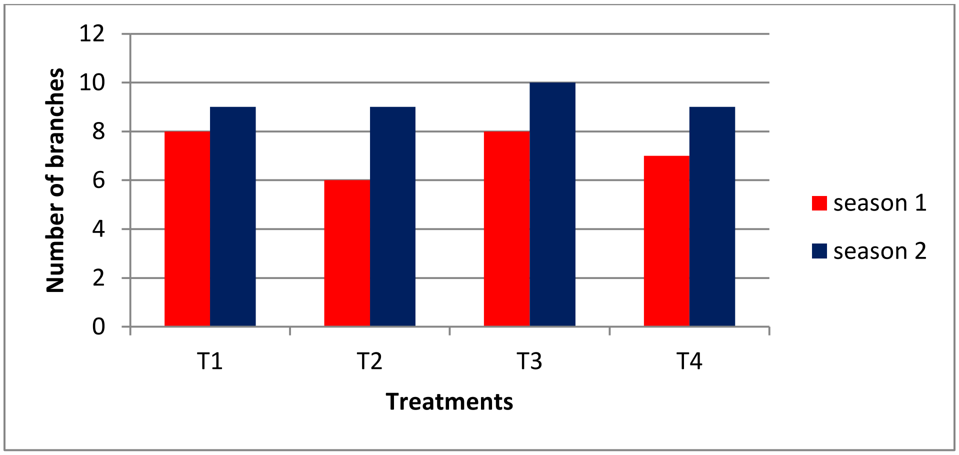


**Fig.31 Number of branches 28 days after transplanting from various treatments**

### 4.3.3.3 Number of branches 42 days after transplanting

Number of branches observed in 42 days after transplanting are given in Table 21 and its comparison between treatments is shown in Fig.30.

**Table 21. Number of branches 42 days after transplanting**

| Treatments | Number of branches | |
|---|---|---|
| | **Season 1** | **Season 2** |
| T1 | 14 | 16 |
| T2 | 8 | 13 |
| T3 | 12 | 15 |
| T4 | 11 | 13 |

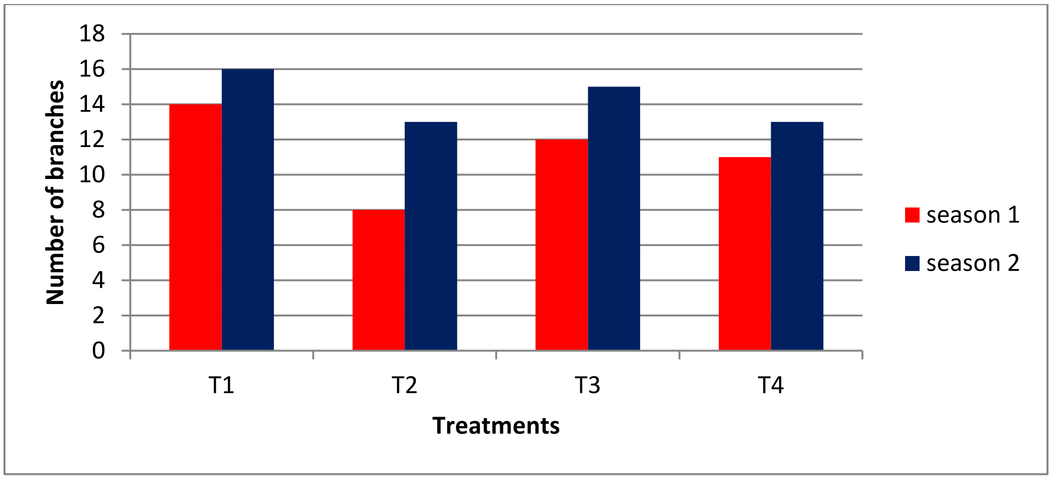


**Fig.30. Number of branches 42 days after transplanting from various treatments**

From Table 21, it is found that the highest number of branches ( 14nos.) and (16 nos.) were from T1(cotton) in season 1and 2 respectively. The lowest values (8nos.) and (13 nos.) were observed from T2 (silk wool) in season 1 and that of 13 nos. was observed from T2 (silk wool) and T4 (control) in season 2

### 4.3.3.4 Number of branches 56 days after transplanting

Number of branches counted in 56 days after transplanting are given in Table 22 and Fig.31.

**Table 22. Number of branches 56 days after transplanting**

| Treatments | Number of branches | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 17 | 20 |
| T2 | 16 | 22 |
| T3 | 19 | 23 |
| T4 | 15 | 18 |

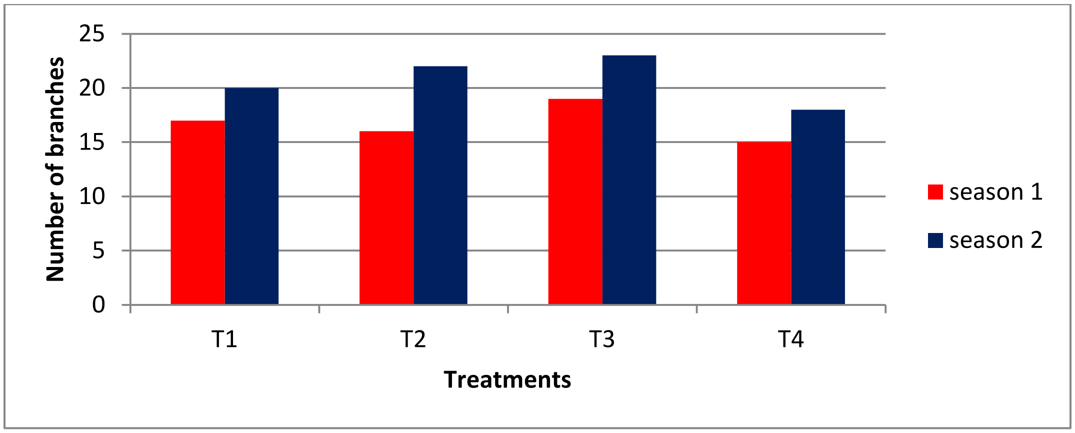


**Fig.31 Number of branches 56 days after transplanting from various treatments**

From Table 22, it is found that the highest number of branches, 19 nos. and 23 nos. were observed from T1 (cotton) in season 1and 2 respectively. The lowest values of 15 nos. and 18 nos. were observed from T4 (control) in season 1 and 2 respectively.

Fig.34 shows the comparison of different treatment in season 1, it could be seen that the number of branches is maximum in T3 (glass wool) and it is on par withT1 (cotton). Whereas T2 (silk wool) showing lower performance compared with other treatments

Fig.35. Shows the comparison of different treatment in season 2, it could be seen that the number of braches is maximum in T3 (glass wool). T1 (cotton) and T2 (silk wool)are on par with each other. The lower value was observed from T4 (control).

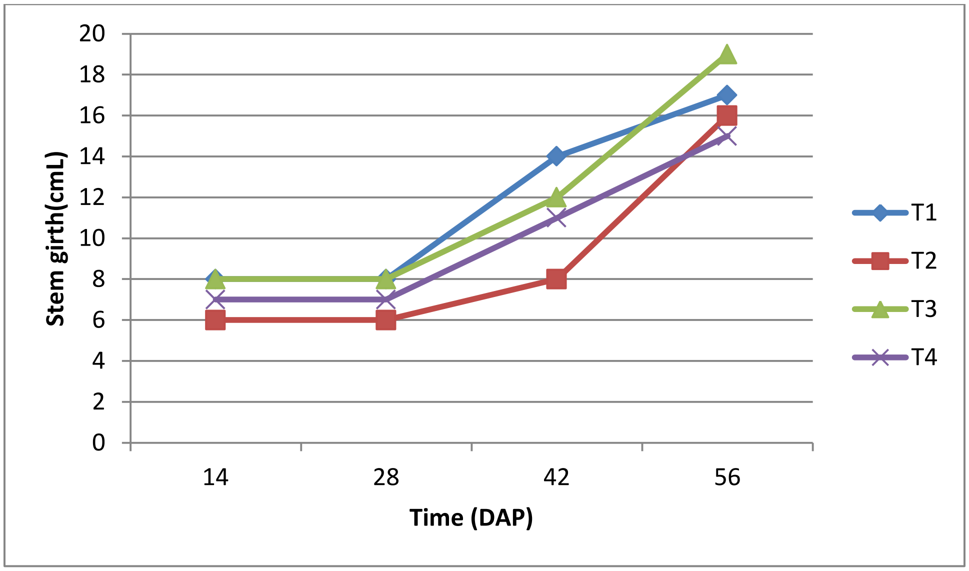


**Fig.32 Comparison of number of branches obtained in season 1**

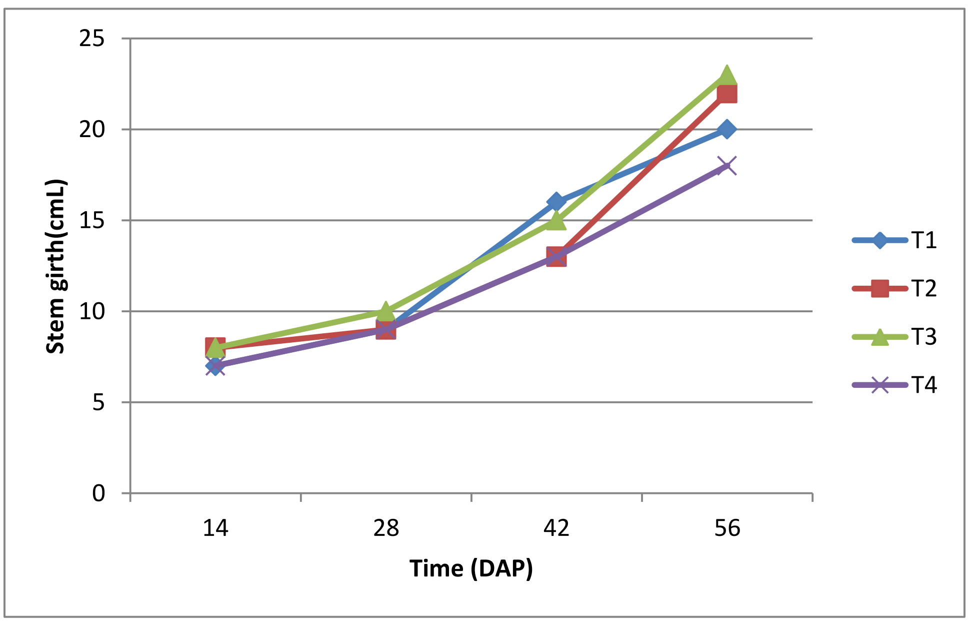


**Fig.33 Comparison of number of branches obtained in season 2**

### 4.3.4 Root length

The length of the root was measured after harvest to analyse the extent of root growth from different treatments and the data are given in Table 23 and the variation of root length is shown in Fig.34.

**Table 23 Root length of various treatments**

| Treatments | Root length (cm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 32.83 | 31.25 |
| T2 | 25.20 | 34.56 |
| T3 | 51.92 | 62.50 |
| T4 | 24.75 | 26.35 |

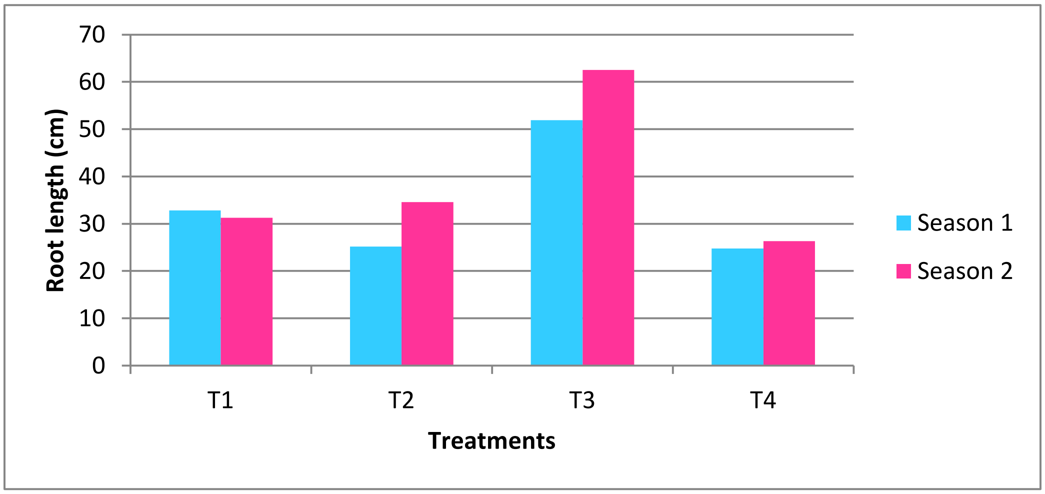


**Fig 34 Root length of various treatments**

. From Table 23, it is found that the maximum root length of 51.92 cm and 62.50 cm were observed from T3 (glass wool) in season 1 and 2 respectively. The lowest root length of 24.75 cm and 26.35 cm were observed from T4 (control) in season 1 and 2 respectively. The root system of tomato plant after complete harvest from different treatments was shown in plate 9-12.


**Plate 9. Root length and Distribution of Glass wool**


**Plate 10. Root length and Distribution of Silk wool**


**Plate 11. Root length and Distribution of cotton**


**Plate 12.Root length and Distribution of Control**

### 4.3.4 Root distribution

The lateral distribution of the root from different treatments was measured after harvest to analyse the extent of root growth from different treatments are given in Table. 24 and variation of lateral root distribution is shown in Fig .35.

**Table 24 Lateral root distribution**

| Treatments | Lateral root distribution (cm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 8.69 | 6.75 |
| T2 | 4.30 | 6.31 |
| T3 | 10.25 | 11.52 |
| T4 | 6.88 | 7.52 |

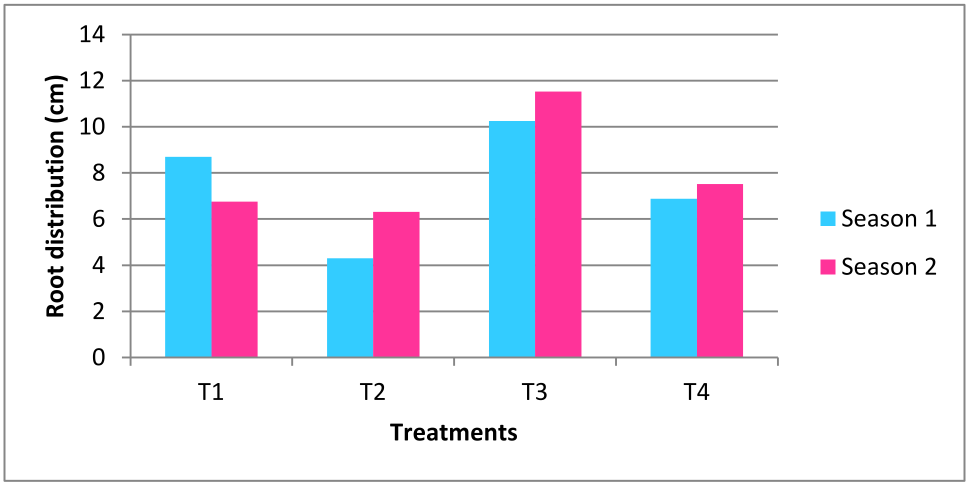


**Fig 35. Lateral root distribution of various treatments**

From Table 24, it is found that the highest lateral root distribution of 10.25 cm and 11.52 cm were observed from T3 (glass wool) in season 1 and 2 respectively. The lowest root distribution of 4.30cm and 6.31cm were observed from T2 (silk wool) in season 1 and 2 respectively

### 4.3.5 Root wet weight

The wet weight of the root was measured immediately after uprooting the plant to analyse the extent of root growth are given in Table.25 and variation is shown in Fig.36.

**Table 25 Root wet weight**

| Treatments | Root wet weight (gm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 7.35 | 6.47 |
| T2 | 4.16 | 5.88 |
| T3 | 6.45 | 6.95 |
| T4 | 5.62 | 5.87 |

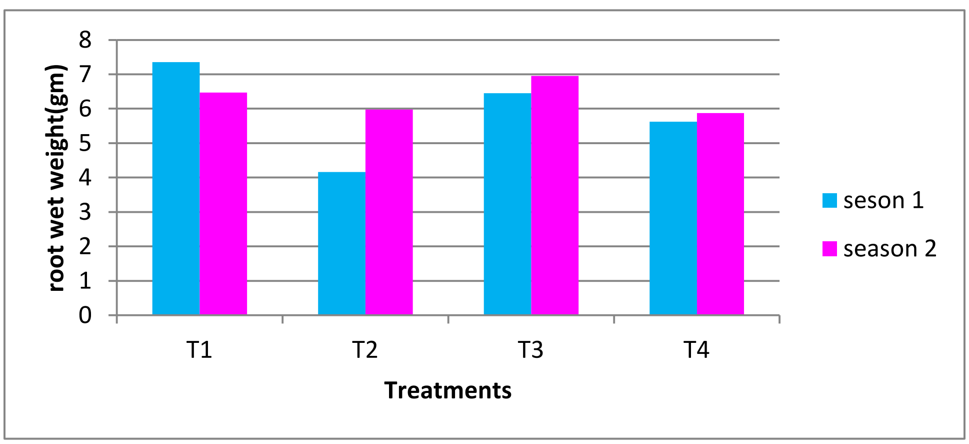


**Fig 36 Root wet weight of various treatments**

From Table 25, it is found that the maximum root wet weight of 7.35 g and 6.47 g were observed from T1 (cotton) in season 1 and 2 respectively. The lowest root wet weight of 4.16 g and 5.88 g were observed from T2 (silk wool) in season 1 and 2 respectively

### 4.3.6 Root dry weight

The dry weight of the root was measured to analyse the extent of root growth are given in Table.26 and variation is shown in Fig.37.

**Table 26. Root dry weight**

| Treatments | Root dry weight(gm) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 2.78 | 2.16 |
| T2 | 1.08 | 0.95 |
| T3 | 1.96 | 1.58 |
| T4 | 1.34 | 1.52 |

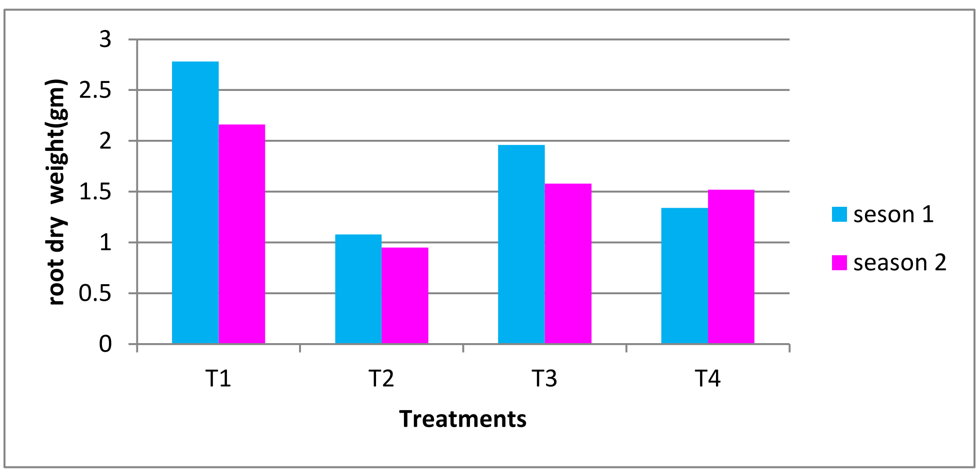


**Fig 37. Root dry weight of various treatments**

From Table 26, it is found that the maximum root dry weight of 2.78 g and 2.16 g were observed from T1 (cotton) in season 1 and 2 respectively. The minimum root dry of 1.08 g and .95 g were observed from T2 (silk wool) in season 1 and 2 respectively

## 4.4. MEASUREMENT OF YIELD PARAMETER

The yield parameters such as total yield, number of fruits and fruit diameter were observed in both seasons.

### 4.4.1 Fruit yield

Harvesting was started from one month after transplanting. The yield responses were highly remarkable under different treatments. Total yield obtained from different treatments are given in Table.27 and the same is represented graphically in Fig.38.

**Table 27. Fruit yield**

| Treatments | Fruit yield (gm/plant) | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 954.56 | 859.80 |
| T2 | 354.20 | 483.20 |
| T3 | 1020.00 | 884.90 |
| T4 | 479.25 | 463.00 |

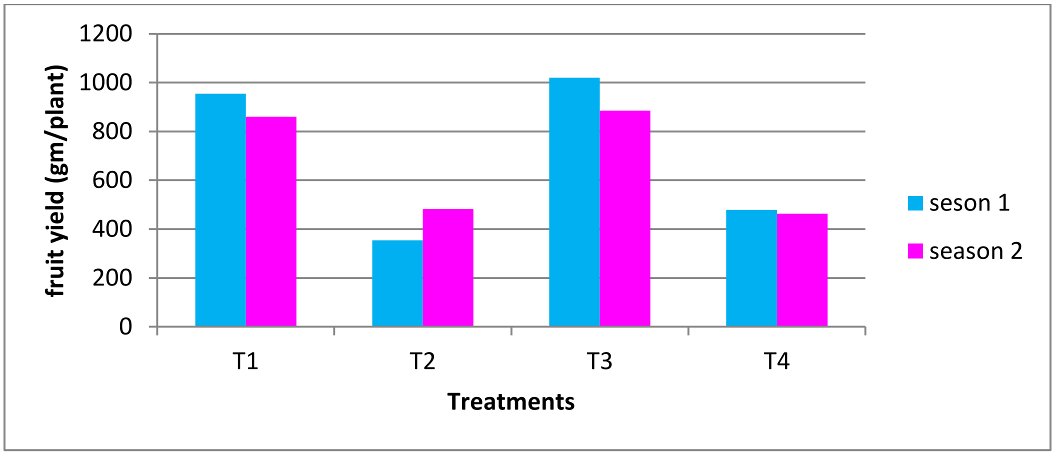


**Fig.38 Graphical representation of fruit yield from different treatments**

From Table 27, it is found that the maximum average fruit yield was obtained from T3 (glass wool) that is 1020.00 gm. in season 1 and 884.90 gm. in season 2. The minimum fruit yield of 354.20 gm was obtained from T2 (silk wool) in season 1 and 463.00 gm was obtained from T4 (control) in season 2.the total yield is shown in plate 13.

**Plate 13 fruit yield**

### 4.4.2 Number of fruits

The number of fruits harvested from each treatment was found to be highly remarkable under different treatments. The average number of fruits harvested from various treatments was shown in Table 28 and the same is represented graphically in Fig.39.

**Table 28. Number of fruits**

| Treatments | Number of fruits /plant | |
|---|---|---|
| | Season 1 | Season 2 |
| T1 | 56 | 43 |
| T2 | 52 | 48 |
| T3 | 61 | 47 |
| T4 | 46 | 38 |

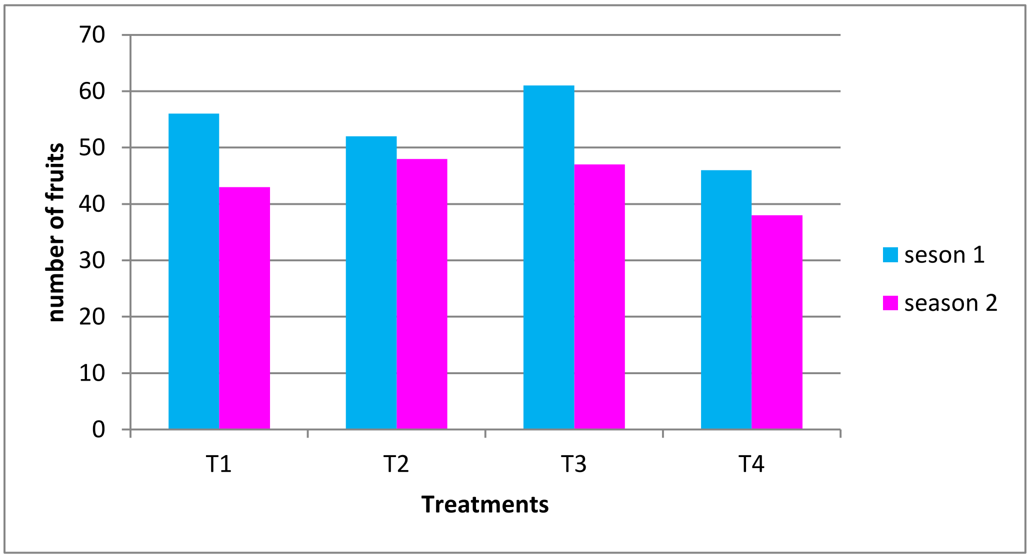


**Fig. 39 Graphical representation of number of fruits from different treatments**

From Table 28, it is found that the maximum number of fruit (61 nos.) was obtained from T3 (glass wool) in season1 and 48(nos.) was from T2 (silk wool) in season 2 which is on par with T3 (glass wool). The minimum number of fruits were obtained from T4 (control) in both seasons (46 and 38 nos. respectively).

### 4.4.3 Fruit diameter

The diameter of fruits harvested from each treatment was observed and the average diameter from various treatments was given in Table 29 and the same is represented graphically in Fig. 40.

**Table 29. Fruit diameter**

| **Treatments** | **Fruit diameter (cm)** | |
|---|---|---|
| | **Season 1** | **Season 2** |
| T1 | 10.75 | 11.20 |
| T2 | 6.21 | 7.38 |
| T3 | 8.42 | 9.60 |
| T4 | 10.59 | 11.16 |

From Table 29, it is found that the highest average fruit diameter obtained from T1 (cotton) that is 10.75cm in season 1 and 11.16 cm in season 2. The lowest fruit diameter is obtained from T2 (silk wool) that is 6.21 cm in season 1 and 7.38 cm in season 2. Fruit harvested from different treatments are shown in Plate 14-17

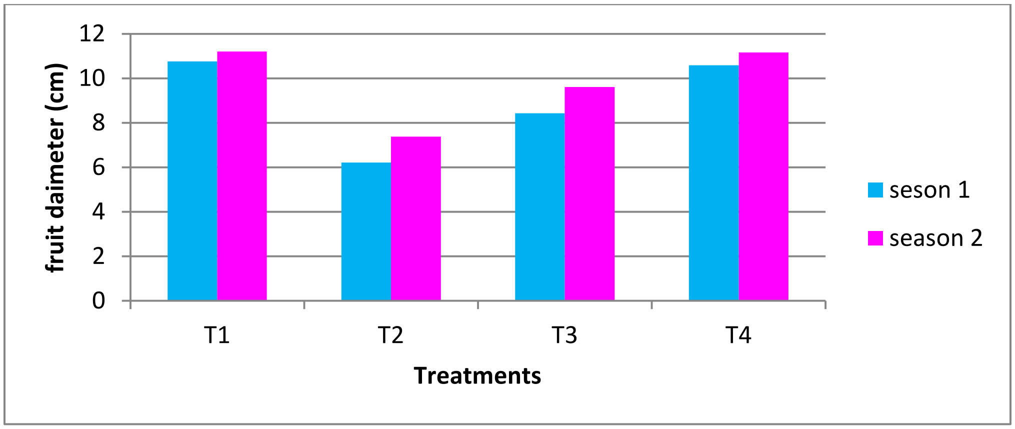


**Fig.40 Graphical representation of diameter of fruits from different treatment**


**Plate 14. Fruit yield from T1**


**Plate 15. Fruit yield T2**

**Plate 16. Fruit yield from T3**


**Plate 17. Fruit girth of fruit from different treatment**

### 4.5 Cost analysis of wick irrigation system

Cost of wick irrigation system includes installation cost, cost of wick, labour cost, cost for fertilizers and chemicals. The details of the cost analysis are given below**;**

**Table .30 Comparison of cost economics of different treatments**

| SI NO | Item | Cotton (RS) | glass wool (RS) | silk wool (RS) | Control |
|---|---|---|---|---|---|
| 1 | seedlings | 12 | 12 | 12 | 12 |
| 2 | wick | 72 | 90 | 90 | - |
| 3 | Manual fertiliser + chemical | 15 | 15 | 15 | 15 |
| 4 | Total labour cost (weeding+ fertilizer application+harvesting) | 530 | 530 | 530 | 1436 |
| 5 | Total cost of cultivation | 629 | 647 | 647 | 1463 |
| 6 | Yield/treatments (kg) | 5.7 | 6.2 | 2.8 | 3.0 |
| 7 | Yield (RS)@ RS 30/kg | 171.0 | 186.0 | 84.0 | 90 |
| 8 | Benefit cost ratio | 0.323 | 0.28 | 0.130 | 0.064 |

From Table 30, it could be seen that the benefit-cost ratio of cotton is maximum i.e., 0.323 as compared to other two treatments. The BCR of glass wool is on par with cotton i.e., 0.28. The BCR of control is minimum i.e., 0.06.

Thus the wick irrigation system using wick made up of cotton is evaluated as cost effective, as compared to other two treatments.

# CHAPTER 5

# SUMMARY AND CONCLUSION

A field study was conducted to determine the performance of wick irrigation system and to compare the performance of different materials used for making wick. The biometric parameters, yield parameters, water uptake rate, and moisture content of the soil were observed to evaluate the performance of wick materials in wick irrigation. The experiment was conducted in two seasons for evaluating the durability of each wick material.

The field experiment was conducted in rain shelter located in the KVK premises, inside the KCAET campus, Tavanur. The experiment was laid out in complete block design (CBD) having four treatments and six replications.

The study revealed that there was marked difference in the yield and growth parameters of tomato crop under various treatments. The results obtained from the present study can be summarized as follows.

- Maximum yield was obtained from the treatment with wick made up of glass wool (T3) in both seasons which is on par with T1 (cotton). The minimum yield was observed from T2 (silk wool) in season1 and T4 (control) in season 2. The number of fruits harvested for the treatment with wick made of silk wool (T2) was found to be maximum and T4 (control) was found to be minimum in both seasons

- Fruit diameter recorded was maximum from the treatment with wick made of cotton (T1) and minimum was recorded from the treatment with wick made up of silk wool (T2) in both seasons.

- Maximum plant height was observed from the treatment with wick made up of glass wool(T3) in both seasons and the lowest height was observed from T2, the wick made of glass wool in season 1and T4, the control, in season 2.

- Stem girth recorded was maximum from the treatment with wick made of cotton (T1) and minimum from T2, wick made up of silk wool, in both seasons.
- The number of branches recorded was highest from the treatment T3 (glass wool) in both seasons. The lowest value was observed from T2 (silk wool) in first season and from control (T4) in second season.
- Maximum root length was observed from the treatment with wick made up of glass wool (T3) in both seasons and the lowest root length was observed for T2 (silk wool) in season 1 and from T4 in season 2.
- Maximum root distribution was observed for the treatment with wick made up of glass wool (T3) in both seasons and the lowest root distribution was observed for T2 in season one and T4 in season two.
- Maximum root dry weight was observed for the treatment with wick made up of cotton (T1) in both seasons and the lowest root wet weight was obtained for T2 in in both seasons.
- Maximum root wet weight was obtained for the treatment with wick made up of cotton (T1) in both seasons and the lowest root dry weight was obtained for T2 in in both seasons.
- Water uptake rate (ml/day) is considered to be most important parameter to evaluate performance of a wick. The water uptake rate was maximum in wick made up of glass wool (T3) in both seasons and the lowest water uptake was observed from wick made up of silk wool (T2) in season 1 and from wick made up of cotton (T1) in season 2.

- Moisture content of the soil is considered to be another important parameter to evaluate performance of a wick. The moisture content was maximum in wick made up of glass wool (T3) in both seasons and the lowest moisture distribution is observed from wick made up of silk wool (T2) in season 1and in wick made up of cotton (T1) in season 2.

This study concluded that the wick irrigation system is very easy, efficient and water saving irrigation method for grows bag vegetable cultivation in homesteads, especially for terrace vegetable cultivation in urban areas. This irrigation method does not require daily irrigation or manpower for irrigation. It requires filling of water in bottles once in 3 to 5 days, which will be more advantage for the cultivars who engaged in their hectic work load.

It is also observed that the wick made up of glass wool (T3) showed better performance in biometric and yield parameters, water uptake rate and soil moisture on the soil and these results are on par with the results from wick made up of cotton (T1). However, the glass wool shows better performance, it has some disadvantages such as

- It creates some allergic (itching) problem to man who associated with its making.
- Availability of glass wool is less when compared to cotton, that increases the cost of glass wool wick.

Considering the easy availability, ecofriendly nature of cotton, this study is suggested that the cotton is used as an alternative material for glass wool.

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# APPENDICES

## Appendix I. Water uptake rate (ml/day)

| Treatments | Repli-cation | II WEEK | | IV WEEK | | VI WEEK | | VII WEEK | | IX WEEK | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Season 1 | Season 2 | Season 1 | Season 2 | Season 1 | Season 2 | Season 1 | Season 2 | Season 1 | Season 2 |
| COTTON | T1 | 245.6 | 300.2 | 275.6 | 246.3 | 285.5 | 215.6 | 215.5 | 195.6 | 300.2 | 300.2 |
| | T2 | 256.2 | 295.6 | 254.5 | 251.4 | 218.2 | 235.2 | 275.8 | 247.2 | 295.6 | 225.5 |
| | T3 | 289.5 | 315.6 | 260.3 | 235.1 | 242.2 | 229.5 | 270.5 | 263.3 | 315.6 | 310.2 |
| | T4 | 274.0 | 360.5 | 210.2 | 289.6 | 257.5 | 174.0 | 245.2 | 175.5 | 360.5 | 285.6 |
| | T5 | 220.1 | 325.2 | 261.5 | 195.5 | 245.5 | 230.7 | 260.5 | 154.2 | 325.2 | 270.4 |
| | T6 | 254.2 | 260.0 | 215.3 | 180.2 | 246.3 | 194.2 | 255.3 | 256.6 | 325.1 | 250.2 |
| SILK WOOL | T1 | 80.25 | 245.6 | 175.5 | 175.6 | 215.6 | 215.6 | 180.2 | 275.5 | 245.6 | 310.2 |
| | T2 | 110.2 | 215.3 | 118.2 | 154.5 | 244.5 | 226.3 | 210.2 | 218.2 | 256.2 | 285.6 |
| | T3 | 190.2 | 218.9 | 152.2 | 160.3 | 270.3 | 228.9 | 290.2 | 252.2 | 289.5 | 356.2 |
| | T4 | 145.3 | 235.4 | 142.5 | 210.2 | 210.2 | 215.4 | 245.3 | 242.5 | 274.0 | 360.5 |
| | T5 | 80.5 | 210.3 | 135.5 | 161.5 | 271.5 | 220.3 | 180.5 | 235.5 | 220.1 | 315.2 |
| | T6 | 100.2 | 246.3 | 280.5 | 115.3 | 215.3 | 224.3 | 200.2 | 256.3 | 254.2 | 260.0 |
| GLASS WOOL | T1 | 295.6 | 275.6 | 300.2 | 215.5 | 365.5 | 284.5 | 310.2 | 300.2 | 295.6 | 445.6 |
| | T2 | 300.2 | 254.5 | 325.5 | 265.8 | 350.5 | 296.6 | 296.4 | 295.6 | 300.2 | 545.6 |
| | T3 | 245.5 | 260.3 | 310.2 | 280.5 | 362.2 | 245.7 | 258.5 | 315.6 | 245.5 | 415.3 |
| | T4 | 275.6 | 210.2 | 285.6 | 245.2 | 259.9 | 258.3 | 264.4 | 360.5 | 275.6 | 518.9 |
| | T5 | 230.5 | 261.5 | 270.4 | 230.5 | 255.5 | 248.3 | 297.5 | 325.2 | 230.5 | 335.4 |
| | T6 | 290.1 | 215.3 | 250.2 | 250.3 | 296.6 | 256.3 | 345.2 | 260.0 | 290.1 | 410.3 |
| CONTROL | T1 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 |
| | T2 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 |
| | T3 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 |
| | T4 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 |
| | T5 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 |
| | T6 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 |

## Appendix II.Moisture content (%)

| Treatment | Replication | II WEEK | | IV WEEK | | VI WEEK | | VII WEEK | | IX WEEK | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Season 1 | Season 2 | Season 1 | Season 2 | Season 1 | Season 2 | Season 1 | Season 2 | Season 1 | Season 2 |
| COTTON | T1 | 25.50 | 20.10 | 26.00 | 30.11 | 23.01 | 29.58 | 30.13 | 20.13 | 32.26 | 23.23 |
| | T2 | 26.01 | 24.36 | 23.36 | 29.88 | 26.33 | 31.02 | 32.56 | 26.15 | 38.90 | 20.13 |
| | T3 | 29.50 | 28.30 | 20.01 | 27.30 | 27.00 | 31.12 | 38.01 | 28.56 | 31.12 | 27.60 |
| | T4 | 18.50 | 28.22 | 27.00 | 29.01 | 25.30 | 27.90 | 31.11 | 24.13 | 37.00 | 20.16 |
| | T5 | 17.25 | 28.54 | 25.50 | 25.63 | 26.70 | 36.50 | 30.12 | 28.01 | 30.12 | 27.33 |
| | T6 | 26.10 | 18.01 | 28.00 | 20.33 | 25.36 | 30.13 | 37.63 | 20.00 | 30.00 | 20.00 |
| SILK WOOL | T1 | 24.26 | 21.01 | 23.01 | 25.33 | 22.23 | 23.00 | 20.16 | 32.4 | 30.33 | 25.30 |
| | T2 | 18.30 | 29.50 | 20.00 | 26.30 | 20.33 | 25.69 | 18.69 | 33.60 | 25.69 | 30.12 |
| | T3 | 24.50 | 24.50 | 18.60 | 27.00 | 20.15 | 25.13 | 19.63 | 27.40 | 20.17 | 36.50 |
| | T4 | 20.50 | 26.00 | 25.60 | 21.00 | 20.81 | 27.70 | 18.01 | 34.70 | 27.63 | 37.36 |
| | T5 | 25.00 | 28.45 | 19.01 | 25.50 | 28.56 | 20.13 | 23.01 | 36.96 | 20.13 | 30.58 |
| | T6 | 26.20 | 23.50 | 28.36 | 26.00 | 26.33 | 23.69 | 20.13 | 30.18 | 20.24 | 30.12 |
| GLASS WOOL | T1 | 30.12 | 32.56 | 30.00 | 35.33 | 33.60 | 30.13 | 20.14 | 33.12 | 28.30 | 31.63 |
| | T2 | 29.95 | 33.89 | 32.01 | 39.01 | 39.01 | 30.89 | 32.13 | 38.23 | 33.63 | 39.12 |
| | T3 | 39.00 | 30.15 | 27.30 | 29.63 | 28.02 | 32.96 | 30.14 | 35.60 | 38.96 | 40.13 |
| | T4 | 28.80 | 29.01 | 45.01 | 32.00 | 18.90 | 35.63 | 35.60 | 39.30 | 33.66 | 30.13 |
| | T5 | 30.12 | 36.12 | 35.70 | 30.18 | 36.00 | 38.01 | 29.33 | 36.11 | 35.63 | 30.45 |
| | T6 | 33.02 | 28.85 | 29.50 | 30.13 | 30.12 | 31.22 | 29.16 | 20.13 | 30.12 | 30.17 |
| CONTROL | T1 | 26.00 | 20.01 | 20.00 | 20.00 | 26.30 | 20.16 | 24.00 | 28.30 | 28.35 | 26.00 |
| | T2 | 26.30 | 28.30 | 21.18 | 21.08 | 28.01 | 20.73 | 25.00 | 20.13 | 24.50 | 23.23 |
| | T3 | 25.00 | 26.00 | 25.01 | 23.00 | 19.06 | 28.30 | 20.13 | 23.02 | 29.50 | 20.13 |
| | T4 | 26.50 | 24.50 | 23.80 | 26.00 | 20.13 | 19.01 | 20.18 | 20.00 | 20.30 | 25.33 |
| | T5 | 17.50 | 18.20 | 19.50 | 24.36 | 25.63 | 25.63 | 19.63 | 23.69 | 25.30 | 20.98 |
| | T6 | 23.32 | 22.00 | 20.89 | 23.56 | 24.01 | 27.30 | 20.23 | 23.01 | 20.13 | 25.36 |

## Appendix III.Biometric observations 14 DAT

| Treatments | Replication | Stem height(cm) | | Stem girth (cm) | | Number of branches | |
|---|---|---|---|---|---|---|---|
| | | Season1 | Season 2 | Season 1 | Season 2 | Season 1 | Season 2 |
| COTTON | R1 | 41.50 | 30.00 | 2.50 | 2.20 | 5.00 | 8.00 |
| | R2 | 40.80 | 39.55 | 2.10 | 2.20 | 4.00 | 10.00 |
| | R3 | 38.40 | 45.00 | 2.30 | 1.50 | 3.00 | 8.00 |
| | R4 | 41.50 | 33.00 | 2.50 | 1.60 | 6.00 | 10.00 |
| | R5 | 42.20 | 29.00 | 2.40 | 2.10 | 5.00 | 8.00 |
| | R6 | 43.10 | 27.50 | 2.20 | 2.00 | 5.00 | 7.00 |
| SILK WOOL | R1 | 39.66 | 39.40 | 2.03 | 2.00 | 3.00 | 7.00 |
| | R2 | 39.40 | 38.40 | 2.02 | 2.30 | 3.00 | 10.00 |
| | R3 | 41.10 | 39.70 | 2.10 | 2.40 | 4.00 | 9.00 |
| | R4 | 39.20 | 37.50 | 2.40 | 1.60 | 3.00 | 7.00 |
| | R5 | 37.60 | 20.10 | 2.10 | 1.10 | 3.00 | 5.00 |
| | R6 | 40.40 | 28.60 | 2.00 | 1.90 | 4.00 | 5.00 |
| GLASS WOOL | R1 | 42.00 | 30.50 | 2.28 | 2.30 | 4.00 | 5.00 |
| | R2 | 41.30 | 27.50 | 2.23 | 1.60 | 5.00 | 7.00 |
| | R3 | 45.60 | 33.50 | 2.30 | 1.60 | 4.00 | 8.00 |
| | R4 | 39.50 | 50.20 | 2.34 | 2.40 | 6.00 | 7.00 |
| | R5 | 35.20 | 30.54 | 2.40 | 2.00 | 4.00 | 8.00 |
| | R6 | 42.20 | 36.35 | 2.15 | 1.60 | 3.00 | 7.00 |
| CONTROL | R1 | 40.80 | 29.10 | 2.34 | 2.20 | 4.00 | 5.00 |
| | R2 | 42.50 | 29.20 | 2.40 | 2.00 | 6.00 | 6.00 |
| | R3 | 39.70 | 39.50 | 2.30 | 1.50 | 3.00 | 8.00 |
| | R4 | 40.10 | 36.20 | 2.32 | 1.60 | 4.00 | 10.00 |
| | R5 | 43.60 | 35.70 | 2.40 | 1.70 | 4.00 | 6.00 |
| | R6 | 39.10 | 35.40 | 2.30 | 1.50 | 3.00 | 9.00 |

## Appendix IV.Biometric observations 28 DAT

| Treatments | Replication | Stem height(cm) | | Stem girth (cm) | | Number of branches | |
|---|---|---|---|---|---|---|---|
| | | Season1 | Season 2 | Season 1 | Season 2 | Season 1 | Season 2 |
| COTTON | R1 | 59.30 | 58.60 | 2.50 | 2.80 | 7.00 | 13.00 |
| | R2 | 61.90 | 56.10 | 2.30 | 2.80 | 8.00 | 16.00 |
| | R3 | 60.30 | 71.60 | 2.40 | 2.40 | 8.00 | 11.00 |
| | R4 | 64.33 | 46.50 | 2.60 | 2.60 | 7.00 | 11.00 |
| | R5 | 58.60 | 46.00 | 2.60 | 2.60 | 9.00 | 12.00 |
| | R6 | 60.15 | 48.50 | 2.30 | 2.70 | 6.00 | 12.00 |
| SILK WOOL | R1 | 60.25 | 57.80 | 2.03 | 2.10 | 6.00 | 11.00 |
| | R2 | 56.50 | 48.70 | 2.20 | 3.10 | 5.00 | 7.00 |
| | R3 | 54.25 | 69.80 | 2.30 | 3.00 | 6.00 | 13.00 |
| | R4 | 59.35 | 38.60 | 2.50 | 2.40 | 5.00 | 10.00 |
| | R5 | 59.20 | 36.80 | 2.30 | 1.90 | 8.00 | 7.00 |
| | R6 | 57.30 | 49.30 | 2.10 | 2.20 | 6.00 | 8.00 |
| GLASS WOOL | R1 | 59.30 | 46.40 | 2.28 | 2.80 | 7.00 | 11.00 |
| | R2 | 58.16 | 48.00 | 2.32 | 2.60 | 6.00 | 7.00 |
| | R3 | 62.10 | 63.00 | 2.20 | 2.20 | 8.00 | 10.00 |
| | R4 | 65.30 | 85.20 | 2.40 | 2.60 | 7.00 | 12.00 |
| | R5 | 59.20 | 41.70 | 2.50 | 2.50 | 8.00 | 9.00 |
| | R6 | 57.80 | 43.40 | 2.20 | 1.80 | 9.00 | 8.00 |
| CONTROL | R1 | 62.00 | 34.60 | 2.34 | 2.40 | 8.00 | 7.00 |
| | R2 | 60.20 | 30.80 | 2.60 | 2.10 | 7.00 | 7.00 |
| | R3 | 58.30 | 36.40 | 2.40 | 2.10 | 7.00 | 10.00 |
| | R4 | 64.20 | 52.50 | 2.50 | 2.20 | 7.00 | 12.00 |
| | R5 | 62.50 | 47.10 | 2.60 | 2.50 | 6.00 | 11.00 |
| | R6 | 59.10 | 54.30 | 2.40 | 2.20 | 7.00 | 10.00 |

## Appendix V.Biometric observations 42 DAT

| Treatments | Replication | Stem height(cm) | | Stem girth (cm) | | Number of branches | |
|---|---|---|---|---|---|---|---|
| | | Season 1 | Season 2 | Season 1 | Season 2 | Season 1 | Season2 |
| COTTON | T1 | 78.20 | 75.50 | 3.60 | 2.60 | 10.00 | 15.00 |
| | T2 | 75.50 | 81.50 | 3.01 | 3.30 | 12.00 | 15.00 |
| | T3 | 77.50 | 90.50 | 3.10 | 2.80 | 11.00 | 19.00 |
| | T4 | 79.90 | 68.00 | 3.40 | 3.30 | 11.00 | 13.00 |
| | T5 | 71.20 | 73.00 | 3.23 | 3.50 | 12.00 | 18.00 |
| | T6 | 74.50 | 69.20 | 3.50 | 3.00 | 10.00 | 17.00 |
| SILK WOOL | T1 | 71.50 | 75.00 | 2.90 | 3.30 | 9.00 | 14.00 |
| | T2 | 73.20 | 70.50 | 2.80 | 3.36 | 7.00 | 12.00 |
| | T3 | 74.60 | 86.50 | 3.40 | 3.80 | 10.00 | 16.00 |
| | T4 | 76.80 | 71.50 | 3.12 | 2.40 | 8.00 | 14.00 |
| | T5 | 79.20 | 68.00 | 3.50 | 2.10 | 7.00 | 10.00 |
| | T6 | 75.80 | 69.00 | 3.60 | 2.30 | 8.00 | 12.00 |
| GLASS WOOL | T1 | 76.20 | 74.50 | 3.90 | 3.00 | 10.00 | 16.00 |
| | T2 | 79.40 | 74.00 | 3.50 | 2.60 | 9.90 | 12.00 |
| | T3 | 76.30 | 105.10 | 2.80 | 2.80 | 10.00 | 12.00 |
| | T4 | 78.80 | 115.50 | 3.40 | 3.10 | 12.00 | 22.00 |
| | T5 | 74.60 | 87.90 | 3.40 | 2.40 | 11.00 | 12.00 |
| | T6 | 75.20 | 60.15 | 3.80 | 2.10 | 13.00 | 14.00 |
| CONTROL | T1 | 78.30 | 47.90 | 3.60 | 2.80 | 11.00 | 9.00 |
| | T2 | 79.00 | 46.20 | 3.40 | 2.40 | 12.00 | 10.00 |
| | T3 | 79.30 | 47.70 | 3.20 | 2.50 | 10.00 | 14.00 |
| | T4 | 77.50 | 61.50 | 2.89 | 2.60 | 10.00 | 13.00 |
| | T5 | 80.30 | 56.00 | 3.23 | 2.30 | 9.00 | 15.00 |
| | T6 | 79.40 | 75.00 | 3.40 | 3.00 | 10.00 | 16.00 |

## Appendix VI.Biometric observations 56 DAT

| Treatments | Replication | Stem height(cm) | | Stem girth (cm) | | Number of branches | |
|---|---|---|---|---|---|---|---|
| | | Season 1 | Season 2 | Season 1 | Season 2 | Season 1 | Season2 |
| COTTON | T1 | 102.60 | 93.70 | 4.39 | 5.00 | 23.00 | 24.00 |
| | T2 | 96.20 | 107.30 | 3.80 | 4.10 | 12.00 | 27.00 |
| | T3 | 98.40 | 110.00 | 4.00 | 4.20 | 22.00 | 26.00 |
| | T4 | 95.69 | 90.60 | 4.10 | 5.00 | 15.00 | 24.00 |
| | T5 | 100.20 | 100.20 | 4.30 | 5.10 | 16.00 | 20.00 |
| | T6 | 95.60 | 90.90 | 4.20 | 4.10 | 12.00 | 19.00 |
| SILK WOOL | T1 | 96.50 | 85.50 | 3.50 | 3.70 | 24.00 | 19.00 |
| | T2 | 91.20 | 93.70 | 3.80 | 4.30 | 10.00 | 29.00 |
| | T3 | 97.60 | 104.40 | 3.56 | 4.50 | 19.00 | 22.00 |
| | T4 | 94.50 | 105.50 | 4.30 | 3.70 | 18.00 | 24.00 |
| | T5 | 95.20 | 100.20 | 3.70 | 3.50 | 17.00 | 20.00 |
| | T6 | 92.30 | 90.90 | 4.20 | 4.10 | 10.00 | 15.00 |
| GLASS WOOL | T1 | 99.50 | 103.40 | 4.50 | 5.00 | 20.00 | 19.00 |
| | T2 | 102.10 | 100.50 | 4.30 | 4.20 | 11.00 | 27.00 |
| | T3 | 97.50 | 105.70 | 4.10 | 3.50 | 13.00 | 19.00 |
| | T4 | 102.50 | 145.00 | 3.90 | 4.10 | 10.00 | 18.00 |
| | T5 | 97.20 | 135.10 | 4.50 | 5.10 | 10.00 | 31.00 |
| | T6 | 98.20 | 79.90 | 3.89 | 4.60 | 16.00 | 19.00 |
| CONTROL | T1 | 95.60 | 60.60 | 4.42 | 3.10 | 9.00 | 12.00 |
| | T2 | 94.50 | 62.90 | 4.00 | 3.40 | 12.00 | 14.00 |
| | T3 | 97.10 | 59.20 | 4.40 | 3.30 | 23.00 | 21.00 |
| | T4 | 98.60 | 70.50 | 4.70 | 3.40 | 14.00 | 15.00 |
| | T5 | 91.80 | 65.00 | 3.80 | 3.50 | 19.00 | 20.00 |
| | T6 | 99.40 | 96.90 | 4.60 | 4.70 | 21.00 | 22.00 |

## Appendix VII.Biometric observations

| Treatments | Replications | Root length(cm) | | Lateral root distribution (cm) | | Root wet weight(gm) | | Root dry weight(gm) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Season 1 | Season 2 | Season 1 | Season2 | Season 1 | Season 2 | Season 1 | Season 2 |
| COTTON | T1 | 30.00 | 34.00 | 9.00 | 4.50 | 5.03 | 5.80 | 1.34 | 2.31 |
| | T2 | 24.50 | 23.5 | 8.75 | 6.32 | 7.35 | 8.20 | 2.21 | 3.57 |
| | T3 | 87.50 | 20.10 | 7.90 | 10.25 | 6.45 | 7.10 | 2.00 | 2.54 |
| | T4 | 15.20 | 25.85 | 15.00 | 12.10 | 5.00 | 5.00 | 1.81 | 0.81 |
| | T5 | 20.00 | 15.45 | 6.10 | 4.65 | 5.52 | 4.00 | 1.45 | 1.55 |
| | T6 | 21.00 | 22.65 | 5.40 | 6.43 | 7.05 | 8.05 | 1.95 | 3.99 |
| SILK WOOL | T1 | 18.00 | 21.10 | 4.50 | 3.36 | 8.074 | 9.10 | 1.91 | 5.91 |
| | T2 | 21.25 | 25.62 | 2.25 | 4.52 | 3.45 | 2.90 | 0.83 | 0.83 |
| | T3 | 19.20 | 20.13 | 4.25 | 8.56 | 4.65 | 6.00 | 1.00 | 1.99 |
| | T4 | 20.14 | 9.89 | 6.75 | 1.53 | 4.59 | 4.20 | 0.95 | 1.95 |
| | T5 | 9.02 | 21.12 | 1.10 | 4.78 | 4.74 | 4.60 | 1.21 | 1.21 |
| | T6 | 28.00 | 19.20 | 7.00 | 8.65 | 2.54 | 1.80 | 0.59 | 0.59 |
| GLASS WOOL | T1 | 70.30 | 36.42 | 11.00 | 10.25 | 11.58 | 12.00 | 2.73 | 4.79 |
| | T2 | 79.30 | 42.36 | 14.00 | 9.65 | 10.36 | 9.00 | 2.38 | 5.38 |
| | T3 | 35.00 | 52.26 | 6.35 | 7.58 | 4.04 | 4.05 | 1.01 | 1.01 |
| | T4 | 34.50 | 41.20 | 8.15 | 9.54 | 7.12 | 9.00 | 1.09 | 4.96 |
| | T5 | 18.65 | 85..32 | 3.96 | 8.78 | 3.04 | 5.00 | 0.95 | 2.35 |
| | T6 | 31.25 | 45.62 | 12.50 | 12.25 | 8.96 | 8.66 | 1.98 | 2.65 |
| CONTROL | T1 | 28.00 | 15.44 | 9.42 | 8.54 | 5.21 | 5.40 | 1.01 | 1.99 |
| | T2 | 30.50 | 25.00 | 11.30 | 14.52 | 7.45 | 7.10 | 1.29 | 2.39 |
| | T3 | 27.00 | 14.53 | 6.50 | 3.25 | 3.56 | 6.40 | 0.98 | 2.98 |
| | T4 | 29.65 | 26.45 | 7.50 | 8.56 | 7.42 | 7.45 | 1.34 | 3.34 |
| | T5 | 19.02 | 19.56 | 3.25 | 4.00 | 4.58 | 3.65 | 1.00 | 1.01 |
| | T6 | 15.00 | 22.00 | 2.75 | 6.32 | 4.00 | 8.10 | 1.91 | 3.91 |

## Appendix VIII.Biometric observations

| Treatments | Replication | Fruit diameter(cm) | | Number of fruits | | Total yield(gm) | |
|---|---|---|---|---|---|---|---|
| | | Season 1 | Season 2 | Season 2 | Season 2 | Season 1 | Season 2 |
| COTTON | T1 | 11.10 | 6.95 | 46.00 | 43.00 | 620.59 | 759.25 |
| | T2 | 8.10 | 8.20 | 45.00 | 44.00 | 601.00 | 459.23 |
| | T3 | 9.20 | 7.59 | 66.00 | 45.00 | 928.29 | 910.00 |
| | T4 | 10.65 | 11.20 | 58.00 | 38.00 | 782.00 | 723.12 |
| | T5 | 7.61 | 10.91 | 50.00 | 37.00 | 760.00 | 865.23 |
| | T6 | 6.80 | 9.10 | 41.00 | 38.00 | 595.20 | 798.56 |
| SILK WOOL | T1 | 6.12 | 4.49 | 43.00 | 40.00 | 456.23 | 398.80 |
| | T2 | 5.50 | 5.23 | 50.00 | 46.00 | 361.21 | 456.01 |
| | T3 | 6.20 | 6.50 | 53.00 | 49.00 | 485.89 | 410.00 |
| | T4 | 7.12 | 7.01 | 48.00 | 40.00 | 301.20 | 385.00 |
| | T5 | 4.20 | 5.15 | 47.00 | 39.00 | 324.10 | 480.12 |
| | T6 | 5.10 | 7.00 | 43.00 | 36.00 | 423.00 | 345.03 |
| GLASS WOOL | T1 | 9.11 | 8.25 | 48.00 | 47.00 | 995.24 | 846.15 |
| | T2 | 8.20 | 9.19 | 62.00 | 39.00 | 945.26 | 763.00 |
| | T3 | 7.25 | 7.13 | 44.00 | 48.00 | 856.23 | 685.23 |
| | T4 | 8.45 | 8.23 | 41.00 | 45.00 | 756.00 | 920.00 |
| | T5 | 6.20 | 6.59 | 58.00 | 44.00 | 954.24 | 650.00 |
| | T6 | 5.95 | 7.55 | 66.00 | 38.00 | 1020.00 | 673.08 |
| CONTROL | T1 | 11.01 | 7.95 | 41.00 | 36.00 | 524.01 | 500.00 |
| | T2 | 10.51 | 8.20 | 48.00 | 42.00 | 450.60 | 452.09 |
| | T3 | 9.82 | 11.21 | 47.00 | 40.00 | 485.25 | 430.00 |
| | T4 | 8.10 | 9.89 | 49.00 | 39.00 | 49.20 | 323.00 |
| | T5 | 7.95 | 9.01 | 44.00 | 48.00 | 142.25 | 460.33 |
| | T6 | 11.20 | 10.25 | 42.00 | 32.00 | 254.10 | 479.25 |

## ABSTRAT

Irrigation plays an important role in various development project of our country. The existing method of surface irrigation method is less efficient and we are confronted with many problems regarding soil and water. Expansion of irrigation system is also essential for increasing food production. Now the adoption of micro irrigation systems has started in areas having water scarcity, poor quality water and undulating terrain.

Micro irrigation, which includes mainly drip irrigation and micro sprinklers, is an effective tool for conserving water resource. The micro irrigation has so many potential benefits,but it has certain limitations such as high initial cost, problems related to clogging, salt accumulation etc. With the objective of solving these problems, a user-friendly irrigation method ‘wick irrigation’ was developed for vegetable cultivation in homesteads especially terrace cultivation by Centre for Water Resources Development and Management (CWRDM) during the past many years. This method is cheap and at the same time water efficient. The scientific principle behind this irrigation method is capillary action.

This field study is conducted to evaluate the performance evaluation of different wick materials in wick irrigation system. The performance is compared on the basis of water uptake rate, moisture content, biometric observation such as plan height, stem girth, number of branches, root length, lateral root distribution, root wet weight, root dry weight and the yield parameters like total yield, number of fruits, and diameter of fruit.From the study, it could be concluded that the wick made up of glass wool (T3) showed better performance in biometric and yield parameters, water uptake rate and soil moisture on the soil. It also observed that the wick made up of cotton (T1) was on par with the results from glass wool (T3). Considering the easy availability, ecofriendly nature of cotton and analysis of cost effectiveness, the cotton canbe used as an alternative material for glass wool.