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Evaluating the Effects of Different Watering Intervals and Prepared Soilless Media Incorporated with a Best Weight of Super Absorbent Polymer (SAP) on Growth of Tomato

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Abstract - *Super Absorbent Polymers (SAPs) have been used as water retaining materials in agricultural fields. They can release stored water and nutrients slowly as required by the plants. The aim of the present study was to evaluate the effects of a constant weight of SAP(3g/lkg of growth media) named GAM-sorb from Vietnam, on growth of tomatoes in three differently prepared soilless media and watering at five intervals. . Fifteen treatments were arranged according completely Randomized Design with three replicates. Experiment design was a two factor factorial. Experiment involved, three different soilless media mixtures; coir dust: paddy husks mixed in the ratios of 1:1, 1:2, and 1:4. 500g of each mixture was added 500 g of cattle manure to potting media. Additionally Five watering intervals were applied; daily, 1 day, 2 days, 3 days and 4 days. Data was analyzed by using Minitab 14 version. The analysis of data indicated that the interaction effect of number of flowers per plant, Relative Water Content (RWC), plant height, amount of chlorophyll (SPAD values) and percentage of dry weight / fresh weight and yield had no significance. All the treatments yielded an average of 10-12 fruits per plant. However, results indicated that media with 1:1; coir dust: paddy husk watered daily and 1 day interval produced a high yield (150 g/plant). Blossom end rot symptoms resulted in ones experimented with 2, 3 and 4 days watering intervals and coir dust: paddy husk media (4:1). Coir dust: paddy husk (1:1) media watered daily and 1 day interval added with SAP was the best for growth of tomato.*

Key words: *Watering intervals, Soilless media, Super Absorbent Polymer, Tomato*

1 INTRODUCTION

Super Absorbent Polymers (SAPs) are compounds that absorb water and swell into many times than their original size and weight. They are lightly cross-linked networks of hydrophilic polymer chains. The network can swell in water and hold a large amount of water, while maintaining physical dimension structure (Buchholz and Graham, 1997, Mahdavinia et al 2004). It was known that commercially used water-absorbent polymeric materials employed are partial neutralization products of cross linked polyacrylic acids, partial hydrolysis products of starch acrylonitrile copolymers and starch acrylic acid graft copolymers. Most authors agree that when super water absorbent polymers are incorporated in the soil, the following can be observed; control of soil erosion and water runoff (Wallace and Wallace, 1990), increasing infiltration capacity (Zhang and Miller, 1996), increasing soil aggregate size (Wallace et al, 1986), reducing soil bulk density (Al-Harbi et al, 1999), increasing water retention (Johnson, 1984; Bres et al, 1993), improving the survival of seedlings subjected to drought (Huttermann et al, 1999)), lengthening shelf-life of pot plants (Gehring et al, 1980), improving nutrient recovery from applied fertilizers (Smith et al, 1991; Bes et al, 1993), improving nutrient uptake by plants grown in poor soil, minimizing nutrient losses through leaching under highly leached conditions, (Mikkelsen, 1994) and reducing irrigation frequency (Taylor et al, 1986).

At present urban people all over the world are interested in practicing crop cultivation as a hobby and as a way to generate an income to support the economy of the family. One of the major problems faced by the urban agriculturists in Sri Lanka is difficulty in finding good quality soils. Daily watering has also become a concern due to their busy life and costly water bill. SAPs are becoming popular as commonly applied in soil cultivations to overcome the water scarcity. Hence, there is a possibility to apply SAPs to soilless culture too. According to Bres et al. (1993), SAPs could be used to find out the influence of gel additives on nitrate, ammonium and water retention ability and better growth of tomato in soilless medium.

The present study focused to evaluate the effects of growth of tomato on different moisture in growth media prepared by adding five watering intervals and three soilless media incorporated with the best weight of Super Absorbent Polymer(SAP) named GAM-sorb, (imported from Vietnam) under plant house.

2 LITRETURE REVIEW

2.1 Super Absorbent Polymers

Super Absorbent Polymers (SAPs) were first introduced into the agriculture and diaper industries about four decades ago (Omidianet al., 2005). Since then, where an excellent water-holding property was of primary concern, SAPs extended their applications to other industries.

SAPs are structurally cross-linked, highly swollen and hydrophilic polymer networks capable of absorbing a large amount of water or aqueous saline solutions, practically 10 to 1000 times of their original weight or volume (Ramazani-Harandiet al., 2006), in relatively short periods. SAPs are not dissolved in the media they are in due to their three-dimensional structure. Kabiriet al. (2003) and Ramazani-Harandiet al. 2006 described that the desired features of SAPs include high swelling capacity, high swelling rate and good strength of the swollen gel. The water absorbency of a SAP is greatly influenced by its composition, molecular weight, degree of cross linking, the molecular conformation of the polymer, and by the properties of liquids to be absorbed (Chen and Tan, 2006).

SAPs are commonly based on acrylic monomers such as acrylamide, acrylic acid and salts of the acid (Omidian et al., 1998). Commercially, SAPs are majorly produced with acrylic acid as a key component (Lanthong et al., 2006). The super-swelling characteristics of SAPs equipped them for use in water absorbing applications such as disposable diapers, feminine napkins, agriculture and cosmetic.

Recently, the diverse applications of superabsorbent polymers are still being expanded to many fields including agriculture and sealing composites, horticulture, drilling fluid additives, artificial snow, medicine, and so on (Li and Wang, 2005).

2.1 Applications of the Super Absorbent Polymer in Agricultural Field

In arid and semi-arid regions of the world, intensive research on water management is being carried out and use of Super Absorbent Polymers (SAP) may effectively increase water use efficiency in crops. The application of SAP for stabilizing soil structure resulted increasing infiltration and reducing water use and soil erosion in a furrow irrigated field (Lentz and Sojka, 1994, Lentz et al., 1998, Trout et al., 1995). The SAP can be used effectively in areas of rain fed agriculture and sprinkler irrigation (Ben - Hur et al., 1989; Levy et al., 1992; Shainbery and Levy 1994). Super absorbents use as soil additives to increase the water retention of soils, which can replace peat, the traditional moisture retention aid for soil (Barbucci et al., 2000). Generally, SAPs are applied to the soil at a concentration between 0.1 to 0.5% by weight (Buchholz and Graham 1998). Below this range, the effect of soil additive is negligible and above this range the soil can become too spongy when it is fully saturated. Miller et al., 1979; suggested that the performance of SAP as water-retaining additive is greater in soils that are well draining such as sand. When polymers are incorporated with soil, it is presumed that they retain large quantities of water and nutrients. These stored water and nutrients release as required by the plants. Thus, plant growth could be improved with limited water supply. Johnson et al.1984; reported 171 to 402% increase in the water retention capacity when polymers were incorporated in coarse sand. Addition of a polymer to peat decreased water stress and increased the time to wilt (Gehring and Lewis, 1980). Results from the literature also showed that increased water retention capacity attributed to polymer addition in to the soil significantly reduced irrigation frequency (Gehring and Lewis 1980; Flannery and Busscher, 1982) and total amount of irrigation water required (Taylor and Halfacre, 1986).

The use of hydrophilic polymers in soils to improve both the nutritional and water status of plants has attracted considerable interest recently. When used correctly, SAP have the potentials to improved soil physical properties, reducing soil erosion and nutrient loss, and improving runoff water quality (Shainberg et al., 1990, Shainberg et al., 1994), increasing seedling survival (Gray 1981), increasing crop growth and yield (Yazdani et al., 2007) and reducing the irrigation requirement for plants (Flannery and Busscher, 1982).

Blodgettv et al., (1993) found that adding SAP to the soil matrix increased the water holding capacity as well as water available to plants. The SAP also prolonged water availability for plant use when irrigation stopped (Huttermann et al., 1999). Use of SAP prolonged the time of the soil evaporation (El-Amir et al., 1993). The SAP usually has some effect on plant establishment with the greatest benefit for moisture loving plants planted under dryer condition. The use of hydrophilic polymer materials as carrier and regulator of nutrient release has shown promise for reducing undesired fertilizer losses, while sustaining vigorous plant growth (Mikkelsen, 1994).

2.4 Super Absorbent Polymer -GAM-Sorb

Vinagamma affiliated to Vietnam Atomic Energy Commission has recently successfully manufactured water super-absorbent namely GAM-Sorbs which, when combined with organic or micro organic fertilizers, may raise plant productivity from 10-30% more than usual. GAM-Sorb is made up from environmentally friendly and naturally born polymers, which may regenerate or degenerate in the soil. In order to make GAM-Sorb, manufacturers have to apply radiation techniques as physical agent to denature naturally born polymers (starch, for example), derivatives from cellulose, or poly-glutamic acid. The product may degenerate into humus, carbon dioxide, and water. GAM-Sorb, when combined with organic or micro organic fertilizers, may raise plant productivity from 10-30% more than usual, that is to say, without GAM-Sorb (http://www.vinagamma.com).

3 METHODOLOGY

3.1 Location and variety selection

The study was carried out in the plant house at the Open University of Sri Lanka during the period January to May 2014.Tomato variety "Bathiya" was selected for the experiment since it shows less vulnerability to diseases compared to other tomato varieties.

3.2 Preparing soil less media

Three soilless media were prepared. Each medium was prepared with mixing coir dust and paddy husk in the ratios of 1:1, 2:1, and 4:1. 500 g from each mixture and 500 g of sterilized powdered cattle manure were added to a pot and kept in a shady place for decomposing for four months.

Three different soilless media,

A - Coir dust: Paddy husk (1:1) + 500 of cattle manure

B - Coir dust: Paddy husk (2:1) + 500 of cattle manure

C - Coir dust: Paddy husk (4:1) + 500 of cattle manure

3.2.1 Analyzing samples

Initially powdered cattle manure was analyzed in the laboratory of Agriculture and Plantation Engineering, Faculty of Engineering Technology, the Open University, Nawala Nugegoda. pH was measured using pH meter. Electrical conductivity meter used to determine Electrical Conductivity (EC), phosphorus, potassium and nitrogen concentrations were evaluated using Palin test photometer.

3.3 Method and experimental design

Best selected SAP rate (3g per 1 kg of growth media from Fernando et al., 2012) was added to each pot. Five (05) watering intervals were applied; 1 day, 2 days, 3 days and 4 days and for the control water applied daily. Fifteen (15) treatments were used with three soilless media and five (05) watering intervals. Treatments were arranged in a completely randomized design with three replicates.

T1 - (3g SAP + A + Daily watering (C))

T2 - (3g SAP + A + 1 day)

T3 - (3g SAP + A + 2 days)

T4 - (3g SAP + A + 3 days)

T5 - (3g SAP + A + 4 days)

T6 - (3g SAP + B + C)

T7 - (3g SAP + B +1day)

T8 - (3g SAP + B +2 days)

T9 - (3g SAP + B +3 days)

T10 - (3g SAP + B +4 days)

T11 - (3g SAP + C +C)

T12 - (3g SAP + C +1day)

T13 - (3g SAP + C +2 days)

T14 - (3g SAP + C +3 days)

T15 - (3g SAP + C +4 days)

Two weeks after sowing one seedling was transplanted in each pot. After transplanting, plants were watered daily for seven (07) days to field capacity measured by pressure plate until plants were well established. Additional fifteen pots were placed inside the plant house without adding SAP and plants to determine the weight losses in growth media due to evaporation. They were watered following the watering intervals with three replicates. Before the watering the pots were weighted and confirmed the constant weight in all pots. According to the weight losses amounts of water required for each pot was calculated as follow,

Weight of dried soil + pot = W_1

Weight of dried soil + pot + added water to fulfilled the Field Capacity = W_2

Weight losses from evaporation = W_2-W_1

W2-W1 amount of water was added to each pot during watering. Every two weeks, equal volume of foliar fertilizer was applied to each plant. Following organic mixtures were used as fertilizer solutions to inhibit degradation of SAP with Inorganic fertilizer and nutrients deficiency. Diluted fermented cattle manure solution (1L per 7L tap water), diluted wormy wash solution, prepared by recommendation of department of Agriculture (1L per 5L tap water) and diluted fermented leaves mixture (fresh Gliricidia (Gliricidiasepium), IpilIpli (Leucaenaleucocephala) and UnduPiyaliya (Desmodiumtriflorum) in the ratio of 1:1:1) (1L per 7L tap water). Major nutrient element composition; nitrogen, phosphorus and potassium were estimated in all three diluted organic solutions using Palin test photometer. In addition, pH, Electric Conductivity of each solution was measured. During the period of seedling, flowering and fruiting, fermented leaves, cattle manure and wormy wash solutions were mixed respectively to the water used twice over the given period. Pests were controlled only when the infestation was seen to be a threat to normal plant growth. Hand weeding was done when necessary. Number of flowers per plant was recorded at seven (07) day intervals, Weight of the harvested fruits per plant was recorded at three (03) day intervals in grams (g), Leaf area was measured randomly selected mature five (05) leaves per plant using leaf area index, Chlorophyll content in plant leaves (SPAD values) were measured in randomly selected fully expanded five (05) leaves per plant using the SPAD meter, Relative water content (RWC) was measured on flag leaves. Immediately after cutting the base of lamina, leaves were sealed in plastic bags and quickly transferred to the laboratory. Fresh weights (FW) were determined within 1h after excision. Turgid weights (TW) were obtained after soaking leaves with distilled water in test tubes for 16 to 18 hours at room temperature under low light condition. After soaking, leaves were carefully blotted dry with bloating paper to determine turgid weight. Dry weights (DW) were obtained after oven drying for 72h at 70 0C. The RWC was calculated according to Schonfeld et al. (1988) as RWC= [(FW-DW)/ (TW-DW)]. A fruit defect (cracks, blossom end rot) per plant was recorded at two (02) day intervals. Ratio of dry weight/fresh weight of each plant was measured in grams (g). In addition, relative humidity and temperature was measured daily using wet and dry bulb thermometer inside the plant house in order to study the general climatic changes in the area. The pots were placed inside the plant house according to the Completely Randomized Design (CRD) with the recommended spacing of tomato 45 × 45 cm. Statistical analysis was carried out through Minitab 14 software version.

4 RESULTS

Tested cattle manure samples had the appropriate amount of nitrogen (295mol/l), phosphorus (95 mol/l), potassium (430 mol/l) and organic matter. Electric Conductivity (EC) and pH value were, 1.32 dS/m and 7.33 respectively. The average temperature and relative humidity of the research area was 35 0C and about 65%. The nutrient compositions of organic solutions used as liquid fertilizer were given in table 1. Average pH values of solutions were between 6.77 and 7.4 and EC was varied between 0.1 mS/m and 5.1 mS/m. According to the measured pH values and EC, all solutions were low in acidity and alkalinity. Moreover, all organic solutions were with high amount of nitrogen, and the highest was observed in wormy wash compared to other two organic solutions. Fermented leaf solution had the highest phosphorous level. Highest amount of potassium concentration was observed in cattle manure solution compared to other two solutions.

According to the results indicated in table 2, except number of flower per plant all other measured parameters; plant height, RWC of plant leaves, SPAD values, leaf area and percentage of (DW/FW) were not significant ($P>0.05$) for growth media. According to the watering intervals, there was a significant difference between number of flowers per plant, plant height and leaf area ($P<0.05$) other than RWC, SPAD values and percentage of (DW/FW). Further, the interaction effects of all measured parameters were not significant. According to results in table 3, number of flowers per plant, plant height, SPAD values of plant leaves and leaf area were highest at growth media having (1:1) coir dust: paddy husk. RWC and percentage of (DW/FW) of whole plant were highest in growth media having the ratio of (4:1) coir dust; paddy husk. According to watering intervals except RWC and SPAD values of plant leaves other measured parameters were highest in daily watering compared to other watering intervals. The variations of mean values for treatment combinations were shown in figure 1 to 6. (Mean values obtained from analysis data were manually categorized as a>ab>b>bc>c>cd>d for clear identification). According to these figures, except RWC and SPAD values other measured parameters were highest in treatment 1 which had (1:1) coir dust: paddy husk and daily watering added plant compared to other treatment combinations. Number of flowers per plant, SPAD values and leaf area were lowest in treatment added with (4:1) coir dust: paddy husk and after four day water added plant other than RWC, plant height and percentage of (DW/FW). Plants of all the experiments were yielded with 10-12 fruits per plant. Out of them, (1:1) coir dust: paddy husk applied and daily and 1 day after watering plants were high yielded (150 g/plant). Plants with 2 day, 3 day, 4 day watering intervals and (4:1) coir dust: paddy husk growth media, blossom end rot disease were observed.

Table 1 Characteristics of organic solutions

	De-ionized water	Wormy wash	Leaf solution	Cattle manure
pH	**7.0**	**6.77**	**7.4**	**7.1**
Electrical conductivity**(mS)**	**0.1**	**4.1**	**5.1**	**1.7**
Nitrogen (mg/l)	**-**	**360**	**300**	**320**
Phosphorous (mg/l)	**-**	**22**	**152**	**37**
Potassium (mg/l)	**-**	**360**	**60**	**450**
Relative density	**1.0**	**1.0**	**1.0**	**1.1**

Table 2 Variations of probability values on growth media, watering interval and its interaction on growth parameters

Term	No of Flowers	Plant height (cm)	RWC	SPAD Value	Leaf area cm^2	DW/FW (%)
Growth- meadia	0.006	0.494	0.397	0.063	0.215	0.569
Watering- intervals	0.000	0.000	0.295	0.610	0.009	0.289
Interaction	0.077	0.495	0.869	0.488	0.783	0.227

Table 3 Variation of minimum and maximum mean values of measured parameters according to the growth media and watering interval

Term	No of Flowers	Plant height (cm)	RWC	SPAD Value	Leaf area cm^2	DW/FW (%)
Growth media						
A	24	117.47	71.52	63.22	22.00	25.46
C	19	113.07	73.31	60.31	20.35	27.98
Watering- intervals						
Control	27	134.20	71.17	61.34	23.48	29.47
4 days	16	96.33	73.48	62.19	18.87	23.97

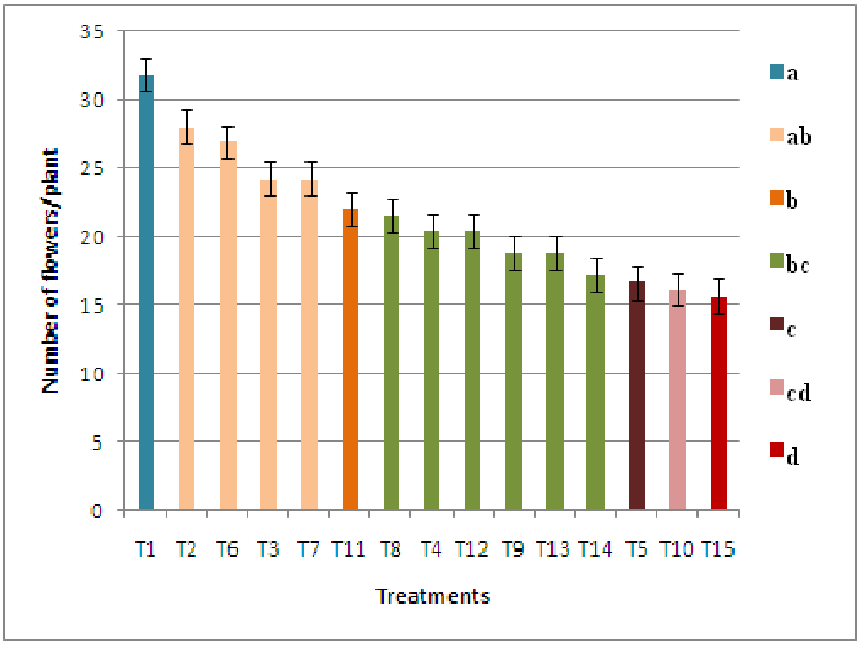

Figure 1 Variation of means of treatment combinations for number of flowers per plant

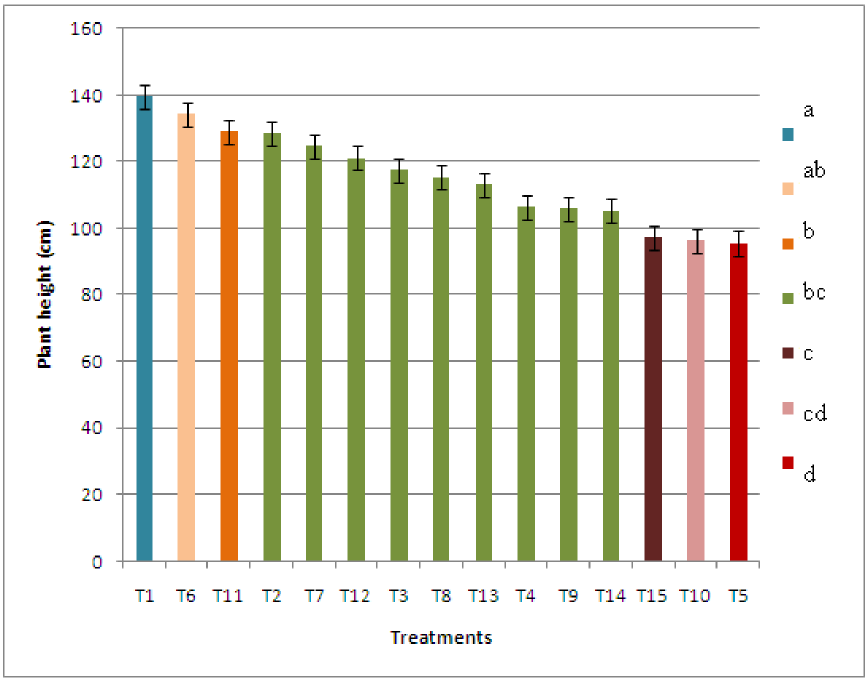

Figure2 Variation of means of treatment combinations for plant height

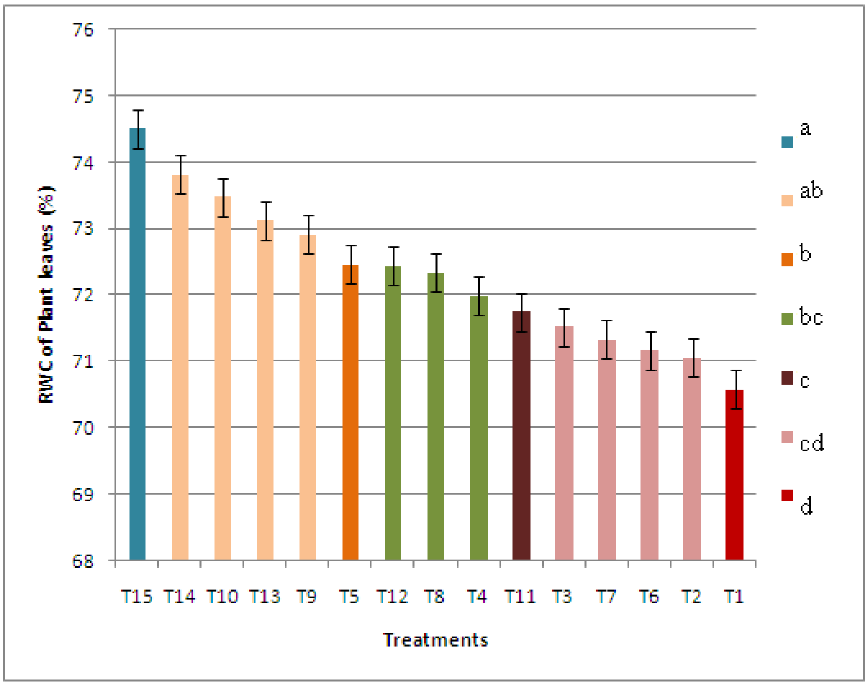

Figure 3 Variation of means of treatment combinations for RWC of plant leaves

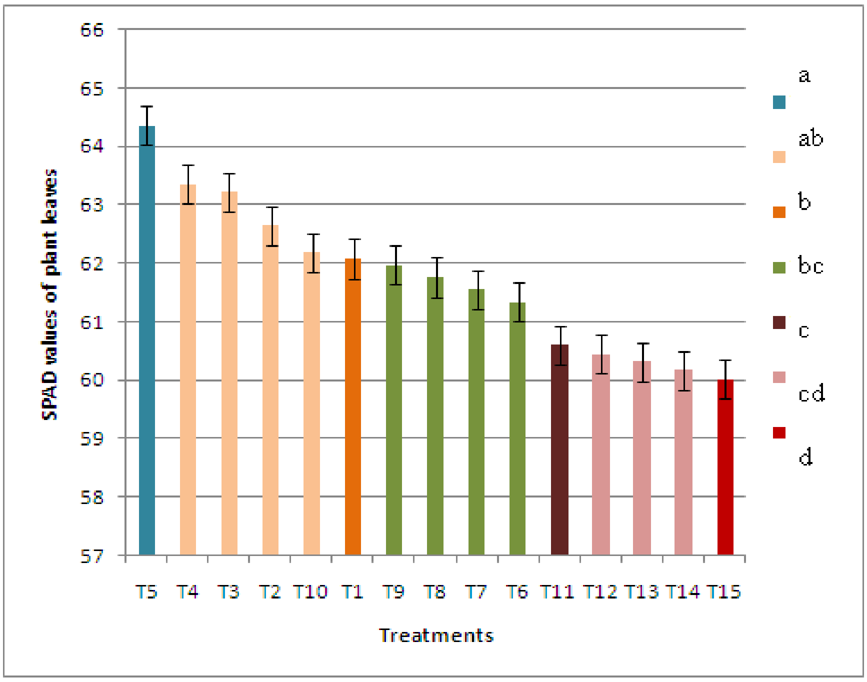

Figure 4 Variation of means of treatment combinations for number of flowers per plant

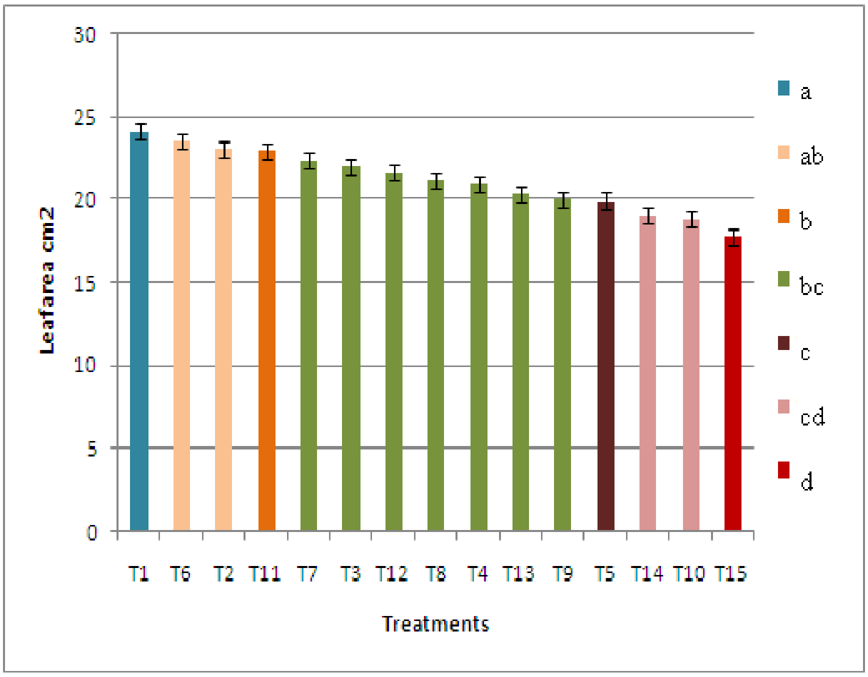

Figure 5 Variation of means of treatment combinations for Leaf area

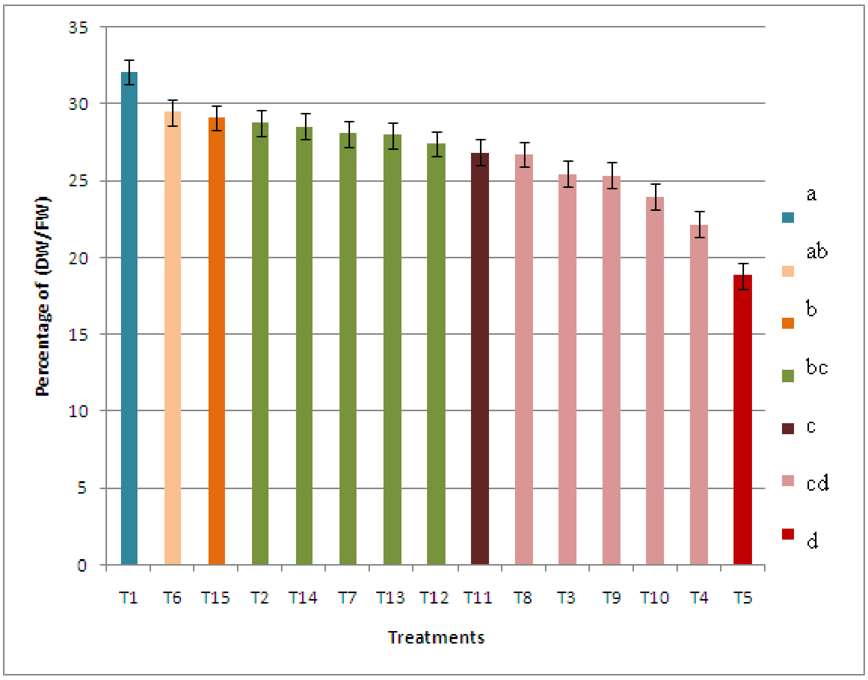

Figure 6 Variation of means of treatment combinations for percentage of (DW/FW)

Plate1 Symptom appeared in fruits affected with blossom end rod

5 DISCUSSION

SAPs have been used in agricultural and horticultural fields (Johnson, 1984; Mikkelsen, 1994; Yazdani et al., 2007) due to their ability to retain water and nutrients when incorporated into the soil. The stored water and nutrients are released slowly in required amounts to the plant rihzosphere, making them available to the plants under limited water supply conditions (Huttermann et al., 1999). Yazdani et al., 2007, have reported that the yield, harvesting index, canopy height, total dry weight, number of flowers per plant, leaf area and crop growth rate increased when irrigation interval was 6 days compared to 8 and 10 days . The Ghasemi et al., 2008; reported that using hydrophilic gels had positive and significant effect on number of flowers per plant, leaf area, plant height, root/shoot proportion and coverage area in drought stress in 5 day watering intervals using 0.8% of hydrogel. However, results of the present study indicated that not only best weight of SAP but also condition of soilless media and watering intervals were affects that caused highest yield with highest number of flowers per plant, plant height, leaf area, percentage of (DW/FW) on (1:1) coir dust: paddy husk added to growth media and daily and 1 day watered treatments compared to other treatments. Morphological parameters observed during fruiting stage did not show significant difference in all three growth media (all plants showing nearest value). According to the results of Vidana Arachchi et al., 1997 incorporated rates of coir dust to the sandy soil increased moisture retaining ability. However lowest rate of coir dust consisting of (1:1) coir dust: paddy husk media has more porosity compared to other soilless media. When applying water daily and at one day interval, water infiltration and nutrient wash-off ability may increase. Due to this highest yield and growth parameters obtained with (1:1) coir dust: paddy husk and daily and 1 day watered media.

Additional, plants showed blossom end rot diseases symptoms in less porosity media having the ratio of (4:1) coir dust: paddy husk media and in media applied with higher watering intervals; 2 day, 3 day and 4 day. The reason could be the nutrient imbalance and physiological stress incurred due to water scarcity. Another reason for blossom end rot is lack of calcium in the fruits, by reducing cell membrane permeability leading to swelling of the cells followed by leakage and destruction of the membrane structure (Blossom-End Rot of Tomato, Pepper, and Eggplant, HYG-3117-96, 2013). There is also a reduction in growth of new cells. This causes the characteristic dark, sunken areas. A similar problem can arise when fertilizer is added to dry soil closer by around the plants, because the concentrated nutrients in the soil water will restrict water uptake by the plant. Additionally, some fertilizer ingredients - ammonium salts for example - compete with calcium to access the plant roots, further exacerbating the calcium deficiency (Vidana Arachchi et.al, 1997).

6 CONCLUSIONS

Condition of soilless media and watering intervals may affect growth of tomato with SAP. Growth environment of (1:1) coir dust: paddy husk and daily and 1 day watered treatment may result in good tomato yield without infestation of blossom end rod and other toxic diseases.

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