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ORIGINAL ARTICLE

Evaluation of a novel semi-automatic drip irrigation system for water management in rooftop garden

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ABSTRACT

Rooftop gardening is popularizing day by day in urban areas of Bangladesh, although irrigation is the major limitation for this practice. Drip irrigation could be an efficient method of irrigation for rooftop gardening. Therefore, present study was aimed to prepare a novel semi-automatic drip irrigation system and to justify its effectiveness for tomato production on rooftop. BARI Tomato-3, a famous tomato variety, was used to grow on rooftop under (A) Drip Irrigation and (B) Conventional Irrigation following a Randomized Complete Block Design. Different growth parameters as well as yield contributing characters and yields were compared and it was observed that drip irrigation system enhanced all growth performances over control plants. Number of fruits per plant increased gradually by 11.3, 36.5, 32.4 and 35.2 % at 30, 45, 60 and 75 days after transplanting (DAT), respectively compared to control. Fruit weight per plant also increased significantly by 35.4, 40.6, 54.7 and 55.6%, respectively. Therefore, it can be concluded that drip irrigation system is an efficient water management technology for rooftop vegetable production in urban areas of Bangladesh.

INTRODUCTION

In light of population growth trends and concerns over food demand in urban centers, the production of agricultural products (vegetables, staple grains, dairy and meat) within the boundaries of an urban center, has received a great deal of interest (Tiwari et al. 1998). Urban agriculture varies greatly in scale and amount of investment, in part due to the resources available to urban farmers. Geography and climate also impact the forms of urban agriculture practiced. Rooftop gardening is one of the famous agricultural / horticultural method in urban areas of many countries including Bangladesh, while irrigation management is the major limitation for this practice.

Drip irrigation (sometimes called trickle irrigation) system, which works by applying irrigational water directly to the root zone, could be an efficient method to increase water use efficiency and irrigation management in the rooftop garden (Tiwari et al. 1998; Ayars et al. 2001; Al-Omran et al. 2005). The high efficiency of drip irrigation results from two primary factors; the first is that the water soaks into the soil before it can evaporate or runoff and the second is that the water is only applied where it is needed, (near to the root zone) rather than sprayed everywhere. Drip irrigation could be an efficient method of irrigation for rooftop gardening which has some advantages like reduces human effort for irrigation management in the rooftop garden, applies correct water amounts precisely when required to maintain optimum available soil moisture in the root zone (Malash et al. 2005), reduces management time required for observing plant water needs and manually controlling irrigation systems (Abdegawad et al. 2005), Prevent water puddling and splashing by applying water no faster than it will percolate into the soil, Reduce incidence of leaf mold, gray mold-rot and other foliage diseases and Reduce evaporation losses and fruit deterioration by keeping more soil surface dry (Phene et al. 1991). Tomato (*Licopersicon esculentum* Mill.) belongs to the Solanaceae family is one of the most popular and nutritious vegetable crops all over the world including Bangladesh. The total production of tomato in Bangladesh was about 137000 tons from 17900 hectares of land with an average yield of 7.65 t ha^{-1} (BBS, 2008)- back dated which is very low as compared to the other tomato producing countries. Moreover, the production of tomato in our country lags behind the demand. Conventional cultural practices and mere application of chemical fertilizers are not enough to fill-up the gaps between production and demand. Therefore, a sustainable and low cost technology for tomato cultivation is urgent in Bangladesh.

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Rooftop tomato cultivation is very common in Bangladesh and irrigation is one of major limiting factor for its production. Since irrigation demand is very high in rooftop due to high temperature and high evapotranspiration, many interested people (especially old and busy persons) are afraid to cultivate in over rooftop. Considering the necessity of rooftop gardening in urban areas and irrigation issue, the present research was, therefore, undertaken to develop a low cost semi-automatic drip irrigation system to be used for soil water management in rooftop garden, to evaluate profitability of rooftop tomato production and to improve production techniques for rooftop tomato production.

MATERIALS AND METHODS

Preparation of a Semi-automatic Drip Irrigation System

The present research aiming to prepare a novel semi-automatic drip irrigation system for irrigation management in rooftop garden. To fulfill the experimental requirements, a drip irrigation system has been prepared and installed on rooftop of Agronomy Farm, in the Department of Agronomy and Agricultural Extension, Faculty of Agriculture, Rajshahi University. A sketch diagram of a semi-automatic drip irrigation system used for the research is presented in Figure 1.

In this irrigation system, main water supply line was connected with water source and electric pump was used to pump the water to store in a water reservoir tank on rooftop. Water reservoir tank was placed on a stage or water reservoir basement (1m × 1m) at two meter height from rooftop.

In most of the conventional drip irrigation systems, water reservoir is used to create water pressure in the drip hose. Under a positive hydraulic pressure system, the flow of water can be changed due to change in water level (h_1) in the reservoir. Thus, it is not possible to make a fixed flow using conventional drip irrigation system.

Water requirements of a particular crop can be changed due to evapotranspiration rate and crop demand at different growth stages. Therefore, it is necessary to make a pressure controller which will create a particular pressure potential in the drip hose. To maintain a fixed water flow, an additional pressure controller tank was used for this novel semi-automatic drip irrigation system (Figure 2).

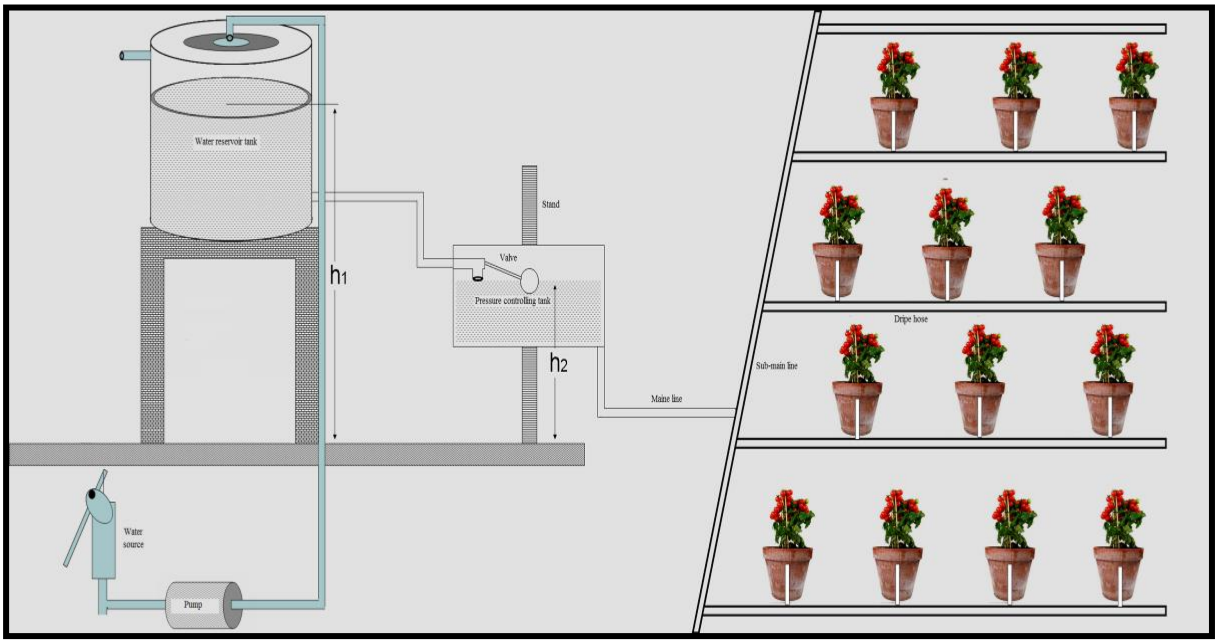

Figure1. Sketch diagram of the semi-automatic drip irrigation system

Pressure controlling tank (Figure 2) is small and it receives water from water reservoir tank. There is a small valve in the pressure controlling tank which controlled by an air containing balloon. This valve continuously maintains a particular height of water in the pressure controlling tank and it allows to intake water when level of water become lower than adjusted level.

The pressure controlling tank is clamped on a stand and it can be fixed at a particular height (h_2) to maintain optimum water pressure. It can also be changed as requirements of water during crop growth stages or stop at any moment. A main water outlet release water from pressure controlling tank which is connected to a sub-main line. Special types of drip hose, made by diatomic filter (Figure 3) used for this novel device which receive water from sub-main line (PVC pipe). Diatomic filters (drip hose) are installed at the bottom of each experimental pot (Figure 4) before soil filling. Pots were filled by 20 kilograms of air dried soil. Fertilizers were applied during soil filling at recommended rate.

Plant materials and growth conditions:

BARI Tomato-3, a famous Tomato Variety, collected (Seedlings) from Bangladesh Agricultural Research Institute, Gazipur was used for this experiment. The experiment comprised of two factors; (A) Drip Irrigation and (B) Conventional Irrigation. Pots were arranged in a Randomized Complete Block Design (Figure 5).

Healthy and uniform sized 25 days old tomato seedlings were transplanted to the experimental pots on 10 November 2012. Twenty four (24) pots were prepared where 12 pots were connected with drip irrigation system and 12 remained control or manually irrigated. Rotten cowdung @ 10 t ha^{-1} and other fertilizers (urea, triple super phosphate and muriate of potash @ 550, 450 and 250 kg ha^{-1}, respectively) were applied in soil (BARI, 2010). The full dose of cowdung was applied at the time of pot preparation. The total amount of triple super phosphate, muriate of potash and half of the amount of urea were mixed to the soil one day prior to seedling transplanting. The rest amount of urea was top dressed in two equal installments at 21 and 35 days after transplanting (DAT). Gap filling, weeding, irrigation, pest control and other intercultural practices were performed as and when necessary to optimize the growth and development of the crops.

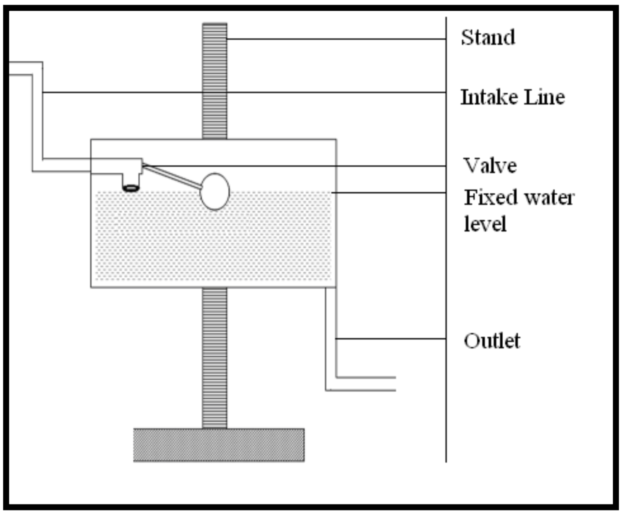

Figure 2. Sketch diagram of a pressure controlling tank

The data on morphological development like plant height, number of branches/plant and leaf area index (LAI) were measured at 15 days interval starting from 15 DAT to 75 DAT. Area of leaves were measured using digital image analysis method and LAI was calculated dividing total leaf are by soil area. The data on phonological development like days required to first flowering, first fruiting and first fruit maturity and days to end of fruit harvest were recorded. The number of flower clusters/plant, flowers/cluster, flowers/plant, fruit clusters/plant and fruits/cluster was counted. The number of fruits/plant was counted and weight of harvested fruits/plant was recorded at weekly interval during fruit development starting from 65 and 93 DAT, respectively. The yield components like number of fruits/plant, weight of individual fruit, weight of fruits/plant, and fruit yield were recorded.

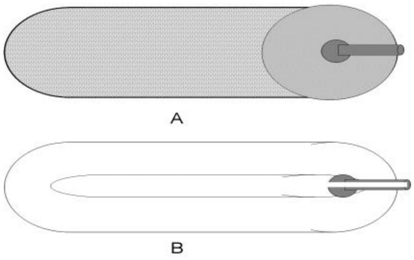

Figure 3. (A) External and (B) Internal view of diatomic filters or drip hose

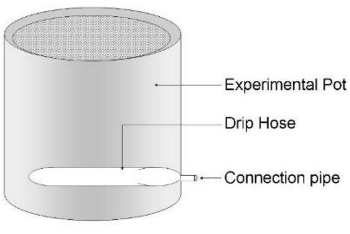

Figure 4. Position of diatomic filter or drip hose in the experimental pot

The data were compiled and analyzed using the Analysis of Variance (ANOVA) technique and the mean difference among the treatments were judged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) with the help of MS Static software.

Figure 5. Drip irrigation system

RESULTS AND DISCUSSION

A remarkable positive effect for growth, yield contributing characters and yield of tomato was observed under drip irrigation system. Plant height was found highest under drip irrigation system at all growth stages. Plant height increased by 13.4, 11.3, 12.5, 52.1 and 22.6% under drip irrigation system at 15, 30, 45, 60 and 75 DAT, respectively compared to control (Figure 6). Number of branches per plant also increased by 0.58, 37.5, 23.4, 22.8 and 15.3%, respectively at 15, 30, 45, 60 and 75 DAT (Figure 6). Similarly leaf expansion rate and leaf area index (LAI) also increased significantly although those effects were less obvious at earlier growth stages (Figure 6).

Number of fruits per plant / pot did not increased at 60 DAT since the fruits were mostly immature at the time, however it increased gradually by 11.3, 36.5, 32.4 and 35.2% at 30, 45, 60 and 75 DAT, respectively compared to control. Fruit weight per plant also increased significantly by 35.4, 40.6, 54.7 and 55.6%, respectively (Figure 7).

Considering the Phenological events, tomato plants grown under drip irrigation system showed early response compared to control except final harvest where plants grown under control pots died earlier (Figure 8).

Drip irrigation (sometimes called trickle irrigation) system, which works by applying irrigational water directly to the root zone, could be an efficient method to increase water use efficiency and irrigation management in the rooftop garden (Tiwari et al. 1998; Ayars et al. 2001; Al-Omran et al. 2005). Drip irrigation system is effectively used in many developed countries for vegetables and horticultural production (Sanders et al. 1989).

Most of the conventional drip irrigation systems, water flow is not constant and it changed due to change in water level of the reservoir (Islam et al. 2011 a, b). Water requirements of a particular crop can be changed due to evapotranspiration rate and crop demand at different growth stages. Therefore, it is necessary to create a particular pressure potential in the drip hose. In this novel semi-automatic drip irrigation system, an additional pressure controller tank was used which controlled the pressure continuously at a certain level and it was maintained manually depending on crop demand (Eneji et al. 2013).

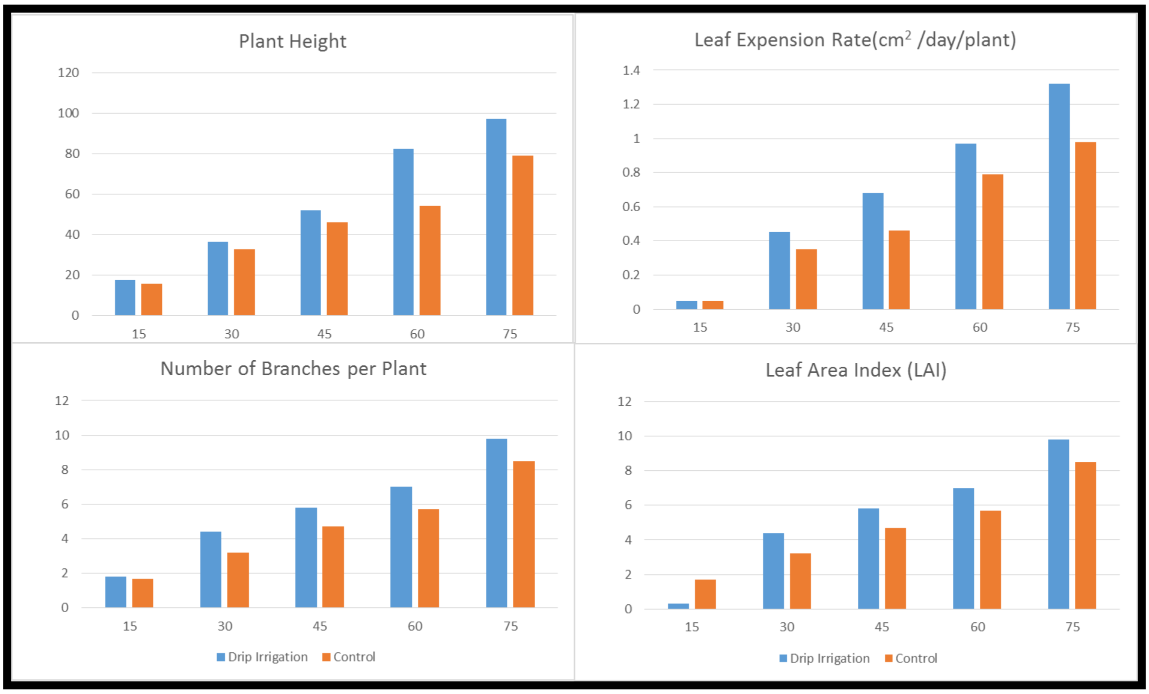

Figure 6. Influences of drip irrigation on different growth parameters of tomato

Figure 7. Tomato yield at different days

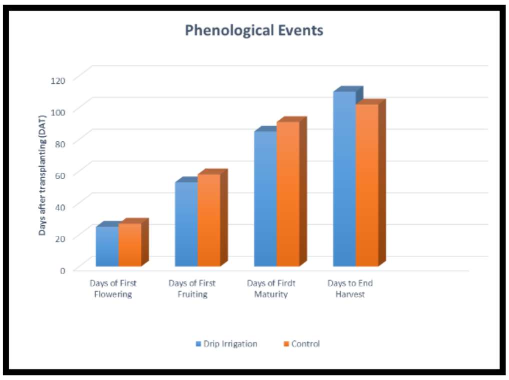

Figure 8: Phenological events, tomato plants grown under drip irrigation system

CONCLUSION

It can be concluded that drip irrigation system is an efficient water management technology for rooftop vegetable production in urban areas of Bangladesh. This irrigation system could change the irrigation strategy for rooftop gardening in urban areas of Bangladesh and therefore more people will attract on this gardening which could meet some vegetable requirement in the urban areas.

CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this paper.

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