International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Modeling of Water Movement of Tomato under Organic and Inorganic Conditions in a polyhouse

IqraMehraj[1], Junaid Nazir Khan[1] , Rohitashw Kumar[1]

[1]*College of Agricultural Engineering and Technology, SKUAST-K, Shalimar (J&K)-190025, India*

ABSTRACT

The present investigation entitled "Modeling of Water Movement of tomato under Organic and Inorganic conditions in a polyhouse" was carried out on tomato Hybrid Vijetaat Experimental Farm (34.145° N latitude and 74.87° E longitude and 1605m) of SKUAST-Kashmir, Shalimar during Kharif season of 2015.Modeling of water movement inside the polyhouse requires description of soil water content within the soil profile. The AquaCrop model was used to investigate the soil water content in both the treatments at a depth of 25cm in the soil profile which emphasis the water movement as active root zone is in this depth. Maximum movement of water was seen from the month of July to October. In these months temperature increased tremendously and the crop had the most active period for development of plant and formation of fruits demanding more water requirement inside the polyhouse. The trend of soil water content was seen same in both organic (FYM) and inorganic treated soil. However the soil water content in organic (FYM) treated soil (26.4 % to 34.8 %) was more than inorganic treated soil (24.7 % to 33.3 %).

***Key words**: AquaCrop, Polyhouse, Tomato, Water movement.*

I. INTRODUCTION

Tomato, a popular fruit vegetable particularly rich in pigments and secondary metabolites like lycopene (red pigment in tomato fruit) - a strong anti-carcinogen and Vitamin C [1] is widely grown across the globe. The consumption and preparation methods although differ in various countries but the improved flavor and shelf life are the driving force for the increased demand for greenhouse grown tomatoes. Currently, greenhouse tomato fruit are more visible than ever before at the produce section of many grocery stores.

Water is useful in the process of plant growth. Deficiency of water in the root zone of soil results in reduced plant growth and affects the crop yield, thus objective of irrigation is to maintain adequate moisture content in the root zone, such that crop yield is not affected adversely [2,3].Information about crop water requirement and root water uptake pattern by different crops is essential for sound irrigation management. Analysis of moisture dynamics in the soil-plant-atmosphere continuum is an important aspect of the crop water management [4, 5]. Modeling moisture dynamics in soil-plant-atmosphere continuum is a difficult task, due to the complexity of the various processes involved in the system. The polyhouse technology can contribute to solve global issues such as shortage of water, environmental problems and instability of ecological system in various ways. The field experiment was carried out on tomato (*Solanum Lycopersicum*) to simulate water movement within the soil profile using the software AquaCrop.

AquaCrop is a crop water productivity simulation model developed by the Food and Agriculture Organization (FAO) of the United Nations. It simulates crop yield response to water, and is particularly suitedto address conditions where water is a key limiting factor in crop production. The modelevolved from the concepts of crop yield response to water developed by [6]. AquaCrop attempts to balance accuracy, simplicity, and robustness.It uses a relatively small number of explicit and mostly intuitive parameters and input variables requiring simple methods for their derivation.Simulations of crop growth and development are executed with daily time steps, usingeither thermal time, i.e., growing degree days (GDDs) or calendar days. The ability ofAquaCrop to simulate yields for different crops has been extensively tested by severalresearchers around the globe in diverse environments and all have reported positiveresults. Besides simulating crop yield, AquaCrop also simulates soilwater content using basic soil and weather data.

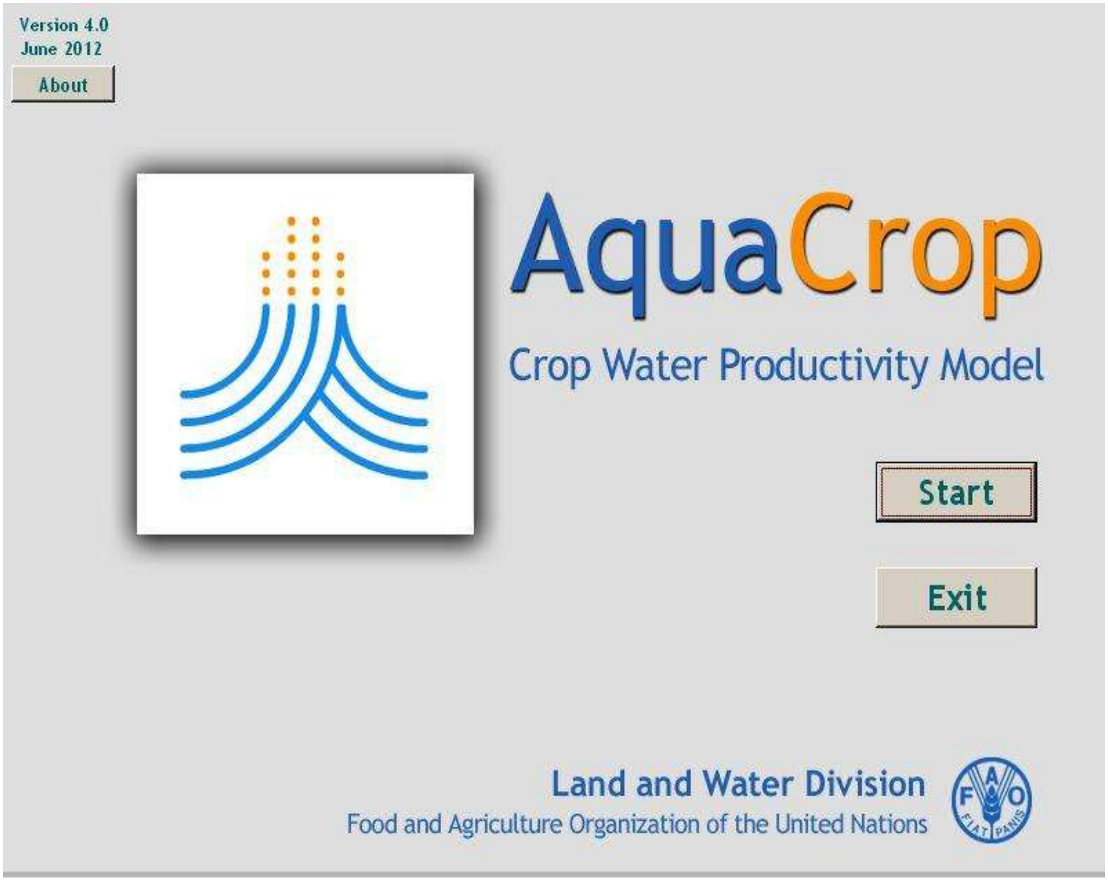

Fig.1 Opening Screen of AquaCrop Model

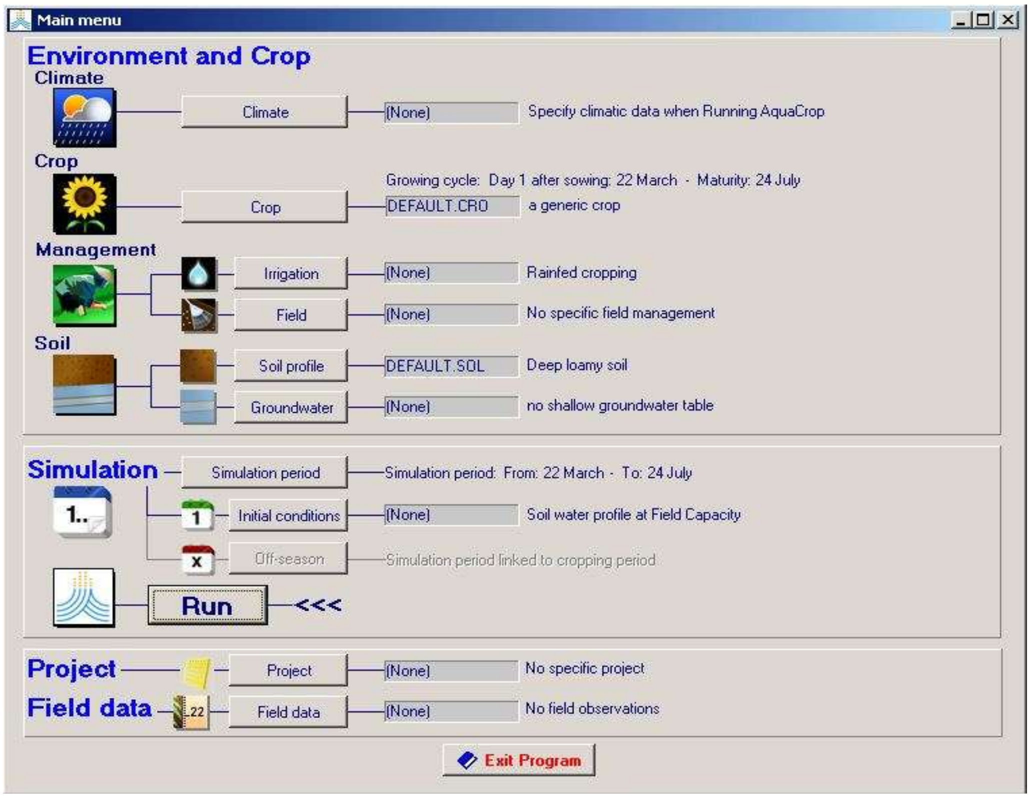

Fig.2 Main Menu of AquaCrop model

II. MATERIALS AND METHODS

The experimental farm at the Sher-e-Kashmir University of Agricultural Science and Technology, Shalimar campus, Srinagar is situated at 34.1° N latitude and 74.9° E longitude at an elevation of 1605m above mean sea level. The experiment carried in a greenhouse which was oriented in North-South direction with a dimension of 15×8×3.5m.The dailymeteorological data inside the polyhousewas recorded by Humidity and Temperature USB data logger (EL-USB-2). The seeds were sown in the raised nursery bed in the month of March and were transplanted in the well prepared land during the first week of May at a spacing of 60 cm × 45 cm. Other cultural practices were done as per the package of practices. Reference evapotranspiration (ETo) was calculated using PET calculator software byHargreaves(1985)method. Both, radiation and temperature are used as input data. Its main advantage is that no radiation has to be measured, since the model works with calculated extraterrestrial radiation.

The soil moisture sensors were installed to determine soil moisture tension at three different depths i.e. 60, 40 and 20cm in the plant root zone in both inorganic and organic (FYM) treated soil. The tension recorded was converted into volumetric moisture content (%) by using Van Genuchten (1980) equation.

2.1 Simulation of Soil water movement

AquaCrop model was used to describe accurately the retention and movement of water in the soil profile throughout the growing season. To describe accurately the retention and movement of water in the soil profile throughout the growing season, AquaCrop divides the soil profile into small fractions. The soil profile is divided into soil compartments (12 by default) with thickness Dz (0.10 m by default). However, after the crop selection AquaCrop will adjust the size of the compartments to cover the entire root zone if the maximum rooting depth exceeds 1.20 meter. In program settings the user has the option to overwrite the AquaCrop settings by adjusting the number and thickness of the soil compartments.

III. RESULTS AND DISCUSSION

The reference evapotranspiration is dependent on the microclimate of the greenhouse effecting the water requirement of crop. PET increased from the month of May to July (3.6 to 3.8 mm day^{-1}) and decreased in the month of September to 3.1 mm day^{-1}(Fig. 3). This is due to the reason that the vapour pressure deficit increases rapidly with increasing temperature and vice versa. The maximum and minimum monthly average values for potential evapotranspiration were 3.9 mm day^{-1} and 0.8 mm day^{-1} in the month of July and December respectively.

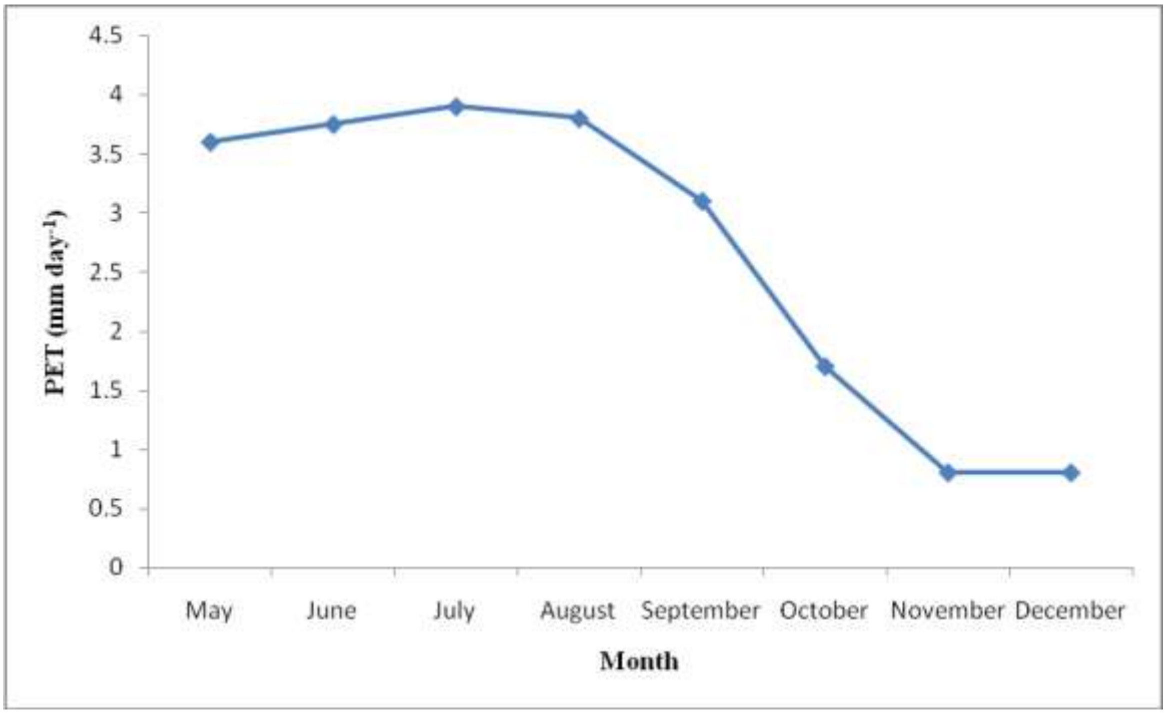

Fig.3Daily Potential Evapotranspiration of Tomato during whole growing period inside the polyhouse

The soil water suction recorded at three different depths was converted into volumetric moisture content (%) by Van Genuchten (1980) equation as:

$$\theta = \Theta(\theta_s - \theta_r) + \theta_r$$

Where, Θ is the effective saturation and is defined as:

$$\Theta = \left[\frac{1}{1 + \|\alpha_v h\|^{n_v}} \right]^m$$

$$m = (1 - \frac{1}{n_v})$$

Where,

α_v and n_v are unsaturated soil parameters.

The soil treated with organic matter retains more moisture content or water content as compared tosoilstreated with inorganic matter. The water content for inorganic and organic treated soil at a depth of 20, 40 and 60cm are 25%, 23.70% and 21.0% and 27.60 %, 25.30 % and 20.10 % respectively(Fig. 4 and Fig. 5). This is due to the reason that the increased levels of organic matter and associated soil fauna lead to greater pore space with the immediate result that water infiltrates more readily and can be held in the soil.

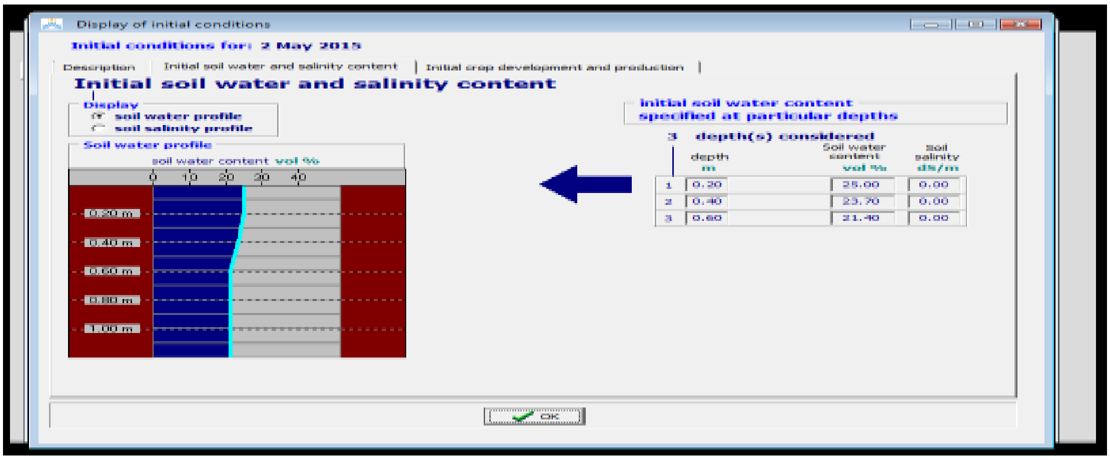

Fig.4 Soil water content of inorganic soil

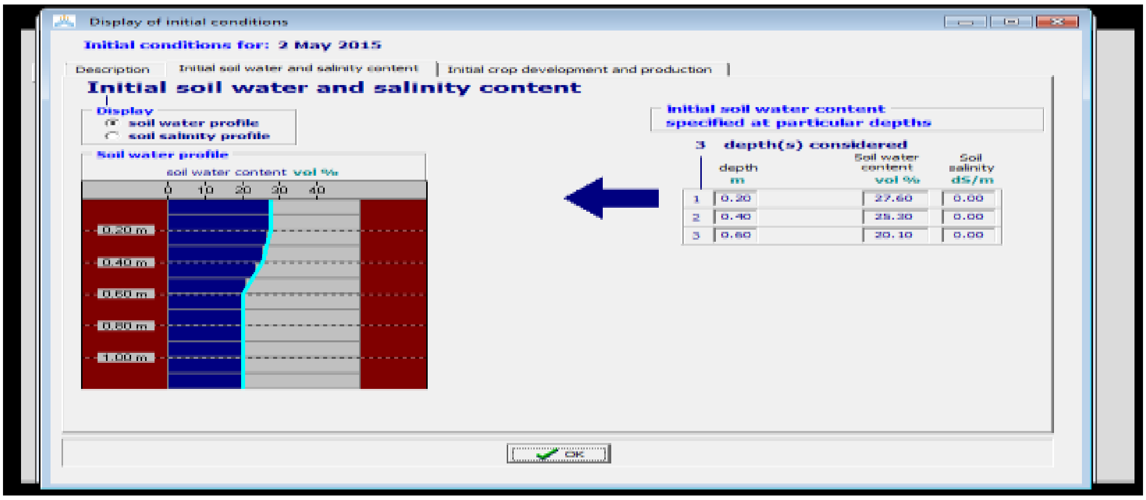

Fig.5Soil water content of organic (FYM) soil

3.1Simulation of Soil water movement

Plants have the ability to preferentially uptake water from portions of the root zone where water is more freely available [7,8,9,10].The retention and movement of water in the soil profile throughout the growing season at a depth of 25 cm was simulated using the AquaCrop model. The results were obtained in terms of numerical outputs which have been presented graphically.

3.2Soil water content status for organic and inorganic treated soil

The soil water content during initial stage shows a decreasing trend resulting in downward movement of water (Fig. 6 and 7). This is because the canopy cover of the crop is less initially and the soil being unsaturated simulates the downward movement of water resulting in less moisture depletion[4,11]. As the crop enters in to the crop development stage and mid stage, the water requirement is increased causing more soil moisture depletion. At the end stage where water is not a limiting factor, less moisture depletion occurs resulting in decreased water content. The simulated soil water content for organic (FYM) and inorganic treated soil ranged from 24.9 to 39.3% and 23.2 to 37.9% respectively.

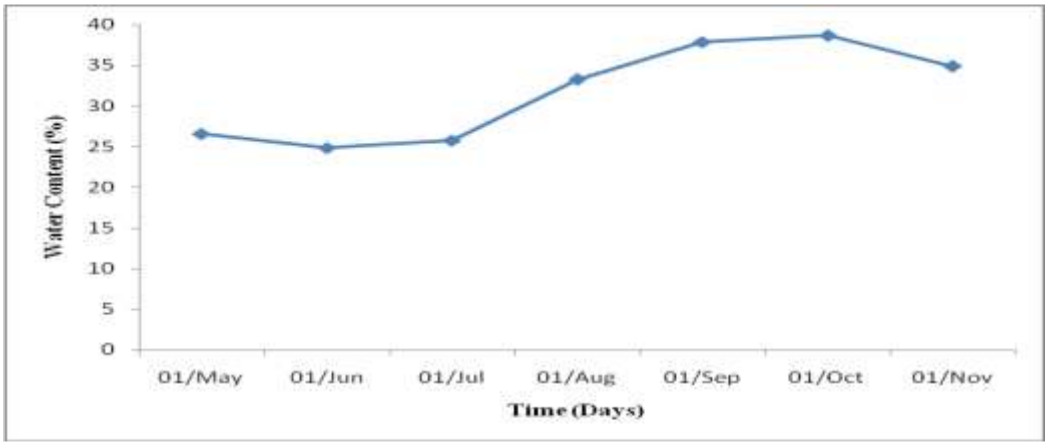

Fig.6 Soil Water Content trend for organic (FYM) soil during whole crop growing period

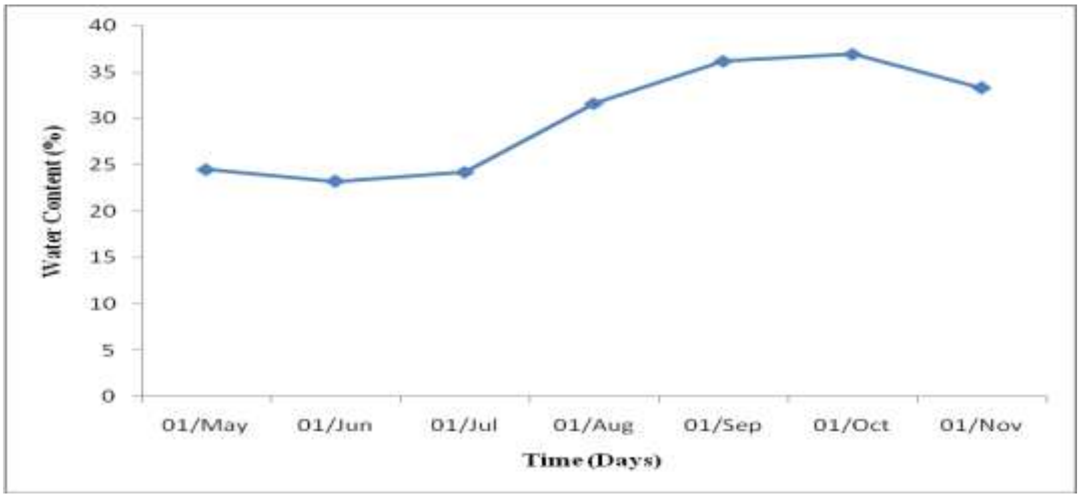

Fig.7Soil Water Content for inorganic soil during whole crop growing period

IV. CONCLUSIONS

The study provides an insight into the behavior of plant soil atmosphere continuum and helps in understanding the movement of water in the root zone of plant inside the polyhouse. For this purpose AquaCrop model is used where weather data, crop, irrigation and field management, and soil characteristics define the environment in which the crop will develop as input. Also the planting day, the simulation period and the initial conditions at the start of the simulation period are input. The soil water content or soil moisture content at a depth of 25cm is modeled for tomato crop inside the polyhouse. Maximum water requirement was seen in the month of July, August, September and October. In these months the crop have most active period for development inside the polyhouse. The soil moisture content in organic treated soil is more than inorganic treated soil. The soil water content for organic (FYM) and inorganic treated soil ranged from 26.4 % to 34.8 % and 24.7 % to 33.3 % respectively, reached maximum value of 39.5 % and 37.9 % in the month of October respectively.

REFRENCES

[1] Sams, C., Panthee, D.R., Charron, C. S., Kopsell, D. A. and Yuan, J. S. 2011. Selenium regulates gene expression for glucosinate and carotenoids in Arabidopsis. *Journal of the American Society for Horticultural Science***136**: 23- 34.

[2] Green S.R., Kirkham M.B. and Clothier B.E. 2006. Root uptake and transpirationfrom measurements and models to sustainable irrigation. *Journal of Agricultural Water Management***86** :165-176.

[3] Kumar, R., Jat, M.K. and Shankar, V. 2012. Methods to estimate reference crop evapotranspiration-A review.*Water Science and Technology***66:** 525-535.

[4] Kumar, R., Shankar, V. and Jat, M. 2013.Efficacy of nonlinear root water uptake model for a multilayer crop root zone. *Journal of Irrigation and Drainage Engineering***139**(11): 898-910.

[5] Kumar, R., Shankar, V. and Jat, M. 2014.Evaluation of nonlinear root uptake model for uniform root zone vis-à-vis multilayer root zone. *Journal of Irrigation and Drainage Engineering***140**(2): 4-10.

[6] Doorenbos, J. and Kassam, A.H. 1979. Crop yield response to irrigation.*Irrigation and Drainage Division FAO-Rome*, Paper No. 33.

[7] Sala, O.E., Lauenroth, W. K., Parton, W. J. and Trlica, M. J. 1981.Water status of soil and vegetation in a short grass steppe. *Oecologia***48:** 327-331.

[8] Green, S.R. and Clothier, B.E. 1995. Root water uptake by kiwifruit vines following partial wetting of the root zone. *Plant Soil***173:** 317-328.

[9] Green, S.R., Clothier, B.E. and McLoud, D.J. 1997. The response of sap flow in apple roots to localised irrigation. *Agricultural Water Management***33:** 63-78.

[10] Huang, B., Duncan, R.R. and Carrow, R.N. 1997. Drought-resistance mechanisms of seven warm-season turf grasses under surface soil drying: II. Root Aspects. *Crop Science***37:** 1863-1869.

[11] Shankar, V., Hari Prasad, K.S., Ojha, C.S.P. and RaoGovindaraju, S. 2012.A model for non-linear root water uptake parameter. *Journal of Irrigation and Drainage Engineering***138**(10): 905-917.