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Performance evaluation of drip irrigation systems

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Abstract
The field experiments were conducted to evaluate the performance of drip irrigation systems at Plasticulture Farm of Collage of Technology and Engineering, Udaipur Rajasthan during the year 2012 *kharif* season. The performance of drip system was evaluated on the basis of parameters like average discharge (Qavg), uniformity coefficient (CU), distribution uniformity (DU), distribution characteristic (DC), emission uniformity (EU). The average discharge value of 1.67 lph, and 1.79 lph, average application efficiency value of 83.23 and 85.09 percent for OE and NVPH were estimated respectively, average CU value of 96.24 percent for OE and 93.63 percent for NVPH, average DU value of 88.07 and 89.69 percent, average DC value of 50.84 and 54.06 percent, and average EU value of 90.45 and 89.99 percent for open environment and naturally ventilated poly house of the year were estimated. The designed drip irrigation system was operated excellently as the values of EU were nearly equal or more than to design criteria of 90 percent in each case.

Keywords: Performance evaluation, drip irrigation, Indian population

Introduction

Efficient use of available irrigation water is essential for increasing agricultural productivity for the alarming Indian population. As the population of India is increasing day by day, the pressure on agriculture is increasing in the same way. Rajasthan is the largest state of the country in term of geographical area. It is well endowed with the land and sunshine but is less fortune in available water resources. Ground water is main source of irrigation which is most precious and contributes only 2.9 percent of total ground resource of the country (Yadav and Singh, 2008) [12]. Root system of most the vegetables are confined only in upper layer of soil and required frequent irrigation. Thus, micro- irrigation/drip irrigation is an effective, efficient and economic viable method for irrigation in vegetables. Drip irrigation has the greatest potential for the efficient use of water and fertilizers. For minimizing the cost of irrigation and fertilizers, adoption of drip irrigation with fertigation is essential which maximize the nutrient uptake while using minimum amount of water and fertilizer (Roma and Arun, 2014) [9]. The drip irrigation adoption increases water use efficiency (60-200%), saves water (20-60%), reduces fertilization requirement (20-33%) through fertigation, produces better quality crop and increases yield (7-25%) as compared with conventional irrigation Kaushal *et al*., (2012) [6]. The method consists of water source, pumping unit, mixing chamber, mainline, sub-main, laterals and emitters. The main line delivers water to the sub-mains and they carry water into the laterals. Irrigation is accomplished by emitters or drippers made up of small diameter polyethylene tubes installed in the lateral lines at selected spacing near the plants. The emitters deliver water at a desired rate near the plants. Though, the system slowly and partially wets the soil near the plant root zone, but, it is practically difficult to apply the equal amount of water to all plants within a field unit. Therefore, in most cases, even a well designed system gives poor uniformity as a consequence the yields are pretentious (Bhatnagar and Srivastava, 2003) [2]. A best and desirable feature of trickle irrigation is that the uniform distribution of water is possible, which is one of the most important parameters in design, management, and adoption of this system. Ideally, a well designed system applies nearly equal amount of water to each plant, meets its water requirements, and is economically feasible. But, due to manufacturing variations, pressure differences, emitter plugging, aging, frictional head losses, irrigation water temperature changes and emitter sensitivity results in flow rate variations even between two identical emitters (Mizyed and Kruse, 2008) [8]. The uniform distribution is reflected by the values of uniformity coefficient (CU) which in turn suggests the variability in the amount of water received by a plant in a subunit system. A system with uniformity co-efficient of at least 85% is considered appropriate for standard design requirements.

However, the distribution uniformity (DU) and the uniformity coefficient (CU) are function of hydraulic head and slope of lateral and submain lines. The coefficient of uniformity generally follows a linear relationship either with head or slope. The CU and DU decrease substantially at sub-main slopes steeper than 30% (Ella *et al*., 2009) [5]. The experiment was undertaken with objective to evaluate the performance of drip irrigation systems laid down in the study area.

Materials and Methods

Study area

The field experiments were carried out at protected cultivation unit of College of Technology and Engineering, MPUAT., Udaipur, Rajasthan during the year of kharif season 2012. This district is located at Longitude 73.44° E and Latitude 24.35° N southern region of Rajasthan. Udaipur comes under dry, sub-humid agro-climatic region. It receives an average annual rainfall of 654.3 mm, most of the received during the period of July to September. May is the hottest and December is the coolest month of the year. The maximum temperature goes as high as 46 °C during summer and minimum as below as 5 °C during winter months. The atmospheric humidity is high from June to October. The meteorological data, *viz*., temperature, humidity, sunshine hours, wind velocity, rain, evaporation during the crop growing period. During the period of experiment, the weekly maximum and minimum temperature were 33.6 °C and 8.4 °C respectively.

Performance of drip irrigation system

Performance evaluation of drip irrigation system installed at open environment (OE) and naturally ventilated poly house (NVPH) was made for the efficient working of the system. three laterals were selected from head, middle and tail end laterals on the submain. Similarly, the discharge of emitters was measured in catch can for 2 minutes from the emitters at the head, middle and tail end laterals on each selected lateral. The constant operating pressure of 1.0 kg/cm2 was maintained throughout the period of application. Evaluation of the system was done by the equations as suggested by different scientists.

In our system evaluations, a high emission uniformity was evident in systems that were maintained properly, which includes servicing filters, flushing drip hoses, and using appropriate chemical treatments. In a very few instances, poor system design was the culprit, requiring major changes in underground pipe or drip lines to improve emission uniformity.

Drip systems having good to excellent emission uniformity indicate that water and injected fertilizer are distributed evenly throughout the vineyard.
Emission Uniformity Rating 90 - 100% Excellent 80 - 90% Good 70 - 80% Fair Less than 70% Poor

Uniformity Coefficient (CU)

To determine the uniformity coefficient in drip irrigation the depth of water in the formula (Christiansens, 1942) [4] was replaced by discharge rate of drip as suggested by Wu and Gitlin (1974). The discharge of emitter was measured by volumetric method at head, middle and tail end of the laterals. The measurements were taken for fifteen minutes. The uniformity coefficient was calculated using equation.

CU (%) = 100 [1- D/M]

Where, D = Average absolute deviation from the mean discharge rate, M = mean discharge rate.

Application efficiency (Ea)

The application efficiency is defined as the ratio of water required in the root zone to the total amount of water applied and can be expressed as, Ea (%) = 100 [Q_{min}/Q_{avg}]

Where, Ea=application efficiency, %, Qmin= minimum emitter flow rate (l/h), Qavg= average emitter flow rate (l/h).

Distribution Uniformity (DU)

Distribution uniformity indicates the degree to which the water is applied uniformly over the area and was determined by using the following relationship.

DU (%) = (Average low quarter depth of water caught) / (Average depth of water caught)

Value of DU above 0.7 is considered as acceptable.

Distribution Characteristic (DC)

This term characterizes the distribution of drip device. It was calculated by using the following relationship.

DC (%) = (Area receiving more than average depth) / (Total wetted area)

Emission Uniformity (EU)

This term has generally been used to describe the emitter flow variation for a micro irrigation unit. The discharges collected at each emitting device as per procedure for developing pressure-discharge relationship was used for determining the emission uniformity of the system. The following equation as suggested by Keller and Karmeli (1974) [7] was used.

EU (%) = 100 [qn / qa]

Where, EU = emission uniformity, percent, q_n = average of the lowest 1/4 of the emission point discharges for field data, lph, and q_a = average emission point discharge of test sample operated at the reference pressure head, lph.

Results and Discussion

The various parameters to evaluate the performance of drip irrigation system viz., average discharge (Qavg), uniformity coefficient (CU), application efficiency (Ea), distribution uniformity (DU), distribution characteristics (DC), and emission uniformity (EU) were calculated for both the environments separately and depicted in table 1.

It is observed from the table 1 that the average discharge rate of emitters was 1.67 lph for OE and 1.79 for NVPH during the year 2012.

The uniformity coefficient or distribution efficiency values were 96.24 percent for OE and 93.63 percent for NVPH during the year 2012. The distribution uniformity values were 88.07 percent for OE and 89.69 percent for NVPH during the year 2012. The distribution characteristics values were 50.84 percent for OE and 54.06 percent for NVPH during the year 2012. The emission uniformity values were 90.45 percent for OE and 89.99 percent for NVPH during the year 2012. Similarly, the application efficiencies were 83.23 percent for OE and 85.09 percent for NVPH during the year 2012.

Table 1: Performance parameters to evaluate drip irrigation system in the study area

Environment	Q_{avg} lph	CU %	DU %	DC %	EU %	Ea %
OE	1.67	96.24	88.07	50.84	90.45	83.23
NVPH	1.79	93.63	89.69	54.06	89.99	85.09

In conclusion, as per the results of different parameters like field emission uniformity (EU), application efficiency (Ea), average discharge (Q_{avg}), uniformity coefficient (CU), distribution uniformity (DU) and distribution characteristics (DC) of drip irrigation system installed in both the environments, the good performance of drip irrigation system was found meeting ASAE standards. As per the recommendation of Keller and Karmeli (1974) [7], it can be apprehended from the data that the designed drip irrigation system was operated excellently as the values of EU were nearly equal or more than to design criteria of 90 percent in each case.

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