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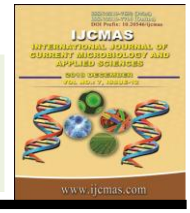

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Evaluation of Drip Fertigation System under Different Fertigation Levels for Okra Crop

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Drip fertigation is the technique of application of suitable quality of water for irrigation purpose along with fertilizer to provide water and fertilizer efficient condition for growth and development of plants. A study on field evaluation of drip fertigation system for Okra crop was conducted under sandy loam soil conditions of Ludhiana district of Punjab state (India). There were nine treatments consisting of combination of three fertilizer levels (60%, 80% and 100% of RDF) and three irrigation levels (0.6, 0.8 and 1.0 of IW/CPE ratio). Emitter discharge measured at 15 days interval for the entire crop season was used to check the performance of drip fertigation system by evaluating Christiansen Uniformity Coefficient (CUC) and Lower Quartile Distribution Uniformity (LQDU).Emitter discharge, CUC and LQDU varied from 0.81 lph to 1.2 lph, 92.1% to 95.6% and 83.1% to 88.7% respectively. It was observed that there was non-significant variation of emitter discharge, CUC and LQDU within the treatments although Emitter discharge, CUC and LQDU decreased with time intervals.

Introduction

Water is an essential requirement in agricultural production. Water resources in India at present face many challenges, including increasing demands in many sectors it is important to judiciously use the already existing water resources by using suitable irrigation technology that not only increases vegetable production per unit area but also per unit of water used. Thus, a scientific and efficient management of water is needed especially in hot dry months of pre-monsoon period, to enhance water productivity and yield of crop especially vegetables (Bozkurt and Ozekici, 2006; Changade *et al.*, 2009; Kaushal *et al.*, 2012 and Kumari, 2014).

Drip irrigation is the technique in which water is supplied to roots of plants at controlled rate. Application of water-soluble fertilizers in recommended quantities can also be done along with water in drip irrigation which is technically termed as ‘Drip Fertigation’. Drip fertigation technology is more suitable to save a substantial amount of water, fertilizers and helps to increase the productivity as reported by several researchers (Zhao *et al.*, 2012, Patel and Rajput 2007&Kumari 2014). Some potential advantages of fertigation are improved efficiency of fertilizer recovery, minimal fertilizer losses due to leaching, control of nutrient concentration in soil solution, flexibility in timing of fertilizer application in relation to crop demand based on development and physiological stage of crops. By minimizing fertilizer and water losses it gives economic benefit to the crop grower (Imtiyaz *et al.*, 2000; Okunade *et al.*, 2009; Woltering *et al.*, 2011; Rajaraman and Pugalendhi, 2013; Darouich *et al.*, 2014 and Kumari and Kaushal, 2015).

Uniformity of drip fertigation system is an important aspect of crop production as indicated by (Bralts *et al.*, 1981 and Arya *et al.*, 2017). Over as well as deficit irrigation conditions may occur due to low uniformity. Various studies on performance of emitters (Bralts *et al.*, 1979 and Chandra and Singh, 2018) indicated that there is decrease in uniformity due to several factors. Drip irrigation is known as the most efficient method of applying irrigation water. Drip fertigation involves use of fertilizers with water. So different fertigation treatments will have different concentrations of fertilizer in the irrigation water solution, which may affect uniformity of drip system and may cause clogging of emitters. So, to evaluate the performance of the drip fertigation system the present study was undertaken.

Materials and Methods

The field study was done in year 2014 at the Research Farm, Department of Soil and Water Engineering, PAU, Ludhiana, India (Latitude 30° 56' N, Longitude 75° 52' E and 247 meters above mean sea level). Soil textural classification of the experimental site was sandy loam. The crop grown was Okra (variety: Punjab-8).The nine treatments of the experiment consisted of combination of three irrigation and three fertilizer levels. Fertilizer levels consisted of F_1(60% of recommended fertilizer dose N), F_2 (80% of recommended fertilizer dose N) and F_3 (100% of recommended fertilizer dose N) based on recommended fertilizer dose (92 kgN per ha) mentioned in 'Package of practices for cultivation of vegetables, PAU, Ludhiana' (Anon. 2013). Irrigation levels consisted of Drip with IW/CPE (irrigation water/ cumulative pan evaporation) ratio I_1 (Drip with IW/CPE ratio 0.60), I_2 (Drip with IW/CPE ratio 0.80) and I_3 (Drip with IW/CPE ratio 1.00).

The experimental design was split plot design with nine treatments and three replications for each treatment. Pre-sowing irrigation (rauni) with the depth of about 80 mm was applied. Well rotten farm yard manure @ 50 tonnes per hectare was incorporated in experimental area, 15 days before sowing to enable it to properly mix with the soil. The land area was tilled, planked and then levelled properly. 50 cm wide beds were prepared with a spacing of 50 cm in between each bed. In the experiment, the drip system consisted of laterals of 12mm diameter having inline emitters with manufacturing discharge of 1.3 lph and emitter size of 0.3mm.

In each experimental treatment and replication, tumblers were placed below emitters at four locations of each lateral (at first emitter, at 1/4thlateral length, at 3/4thlateral length and at last emitter) for measuring the discharge of emitter to evaluate the performance of drip fertigation system, which was repeated after every 15days interval.

From observed emitter discharges of every replication and treatment Christiansen Uniformity Coefficient and Lower quartile distribution uniformity were calculated after every 15 days interval during the whole of crop season to evaluate the variation in emitter flow rate due to fertigation.

The Christiansen uniformity coefficient give information related to uniformity of water application through drip fertigation system, the values were calculated as per the equation (1.) given below (Bralts and Wu, 1979 and Bralts *et al.,* 1987):

$$CUC=100\left\{1-\frac{\Delta\bar{q}}{\bar{q}}\right\} \qquad (1.)$$

Where, CUC = Christiansen uniformity coefficient (%)

$\Delta\bar{q}$ = Mean absolute deviation of the emitter flow from the mean value (lph)

$\bar{q}$ = Average discharge (lph)

Lower Quartile Distribution Uniformity (LQDU) was calculated as given below by equation (2.) as given below (ASAE, 2003):

$$LQDU= 100\ (Q_{LQ} / \bar{q}) \qquad (2.)$$

Where, LQDU = Lower Quartile Distribution Uniformity (%),

Q_{LQ}= The average of lowest 1/4th of the emitter flow rate (lph),

$\bar{q}$ = Average discharge (lph)

The data analyzed from the field experiment was subjected to statistical analysis using split-plot design and using analysis of variance (ANOVA) techniques at 5% level of significance, by using CPCS1 software.

Results and Discussion

The results show that decrease in discharge is minimum in F_1I_1 followed by all other treatments as illustrated in figure 1. Among the drip fertigation treatments, discharge decreased from 8 to 11% and varied from 0.81 lph to 1.2 lph. In all the treatments emitter discharge decreased as the experiment progresses but there was non-significant difference between all the treatments. This may be due to the solubility of the Urea fertilizer with water.

The results are in accordance with that of (Samani and Nasab, 2012; Bozkurt and Ozekici, 2006).

Christiansen Uniformity Coefficient (CUC) results are presented in Table 1, as seen from it, CUC has high values as per the typical characteristics of a good drip irrigation system (Keller and Karmeli, 1974; Hills *et al.*, 1989; Mane *et al.*, 2008; Zamaniyan *et al.*, 2013 and Arya *et al.*, 2017) and it is minimum in F_3I_2 i.e. 92.1% and maximum in F_1I_1 i.e. 95.6%. In all the treatments CUC decreased with time which is in accordance with Hills *et al.*, (1989) and Arya *et al.*, (2017) but there was non-significant difference between all the treatments.

Lower Quartile Distribution Uniformity (LQDU) results are shown in Table 2 and as per good drip system design criteria it is having a high value which ranges from 83.1% to 88.7% (Zamaniyan *et al.*, 2013). There was non-significant difference between all the treatments. In all the treatments LQDU decreased with time which is in accordance with Zamaniyan *et al.*, (2013) and Arya *et al.*, (2017) but there was non-significant difference between all the treatments.

From the above study it is concluded that for different fertigation treatments there was non-significant variation on Emitter discharge, Christiansen Uniformity Coefficient (CUC) and Lower Quartile Distribution Uniformity (LQDU) and the performance of drip fertigation system was excellent.

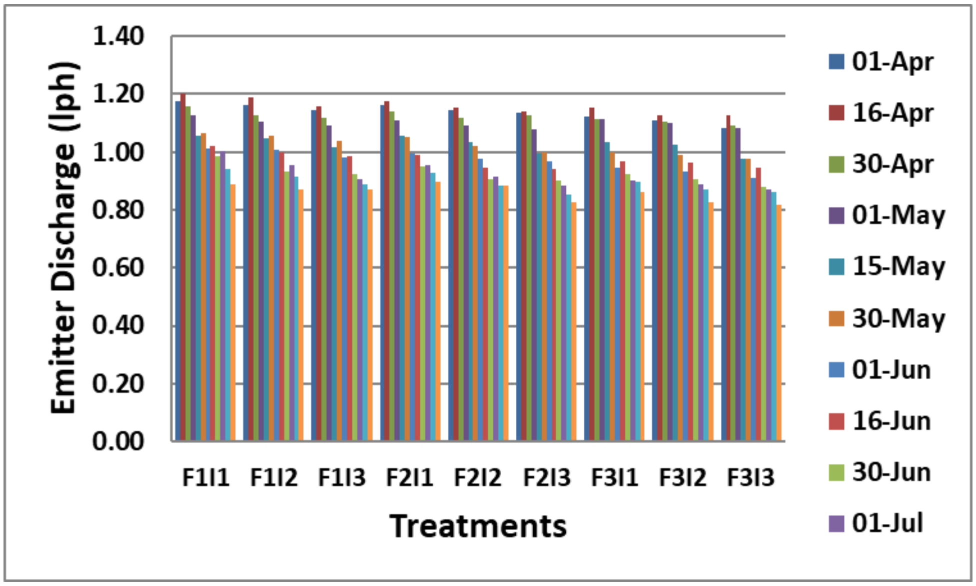
Table.1 Christiansen uniformity coefficient of drip fertigation system for different treatments

Christiansen Uniformity Coefficient (%)												
Treatments	**Dates**											
	01-Apr	**16-Apr**	**30-Apr**	**01-May**	**15-May**	**30-May**	**01-Jun**	**16-Jun**	**30-Jun**	**01-Jul**	**16-Jul**	**30-Jul**
F1I1	95.2	95.6	94.7	94.7	94.5	93.5	94.2	94.8	93.7	94.7	93.9	93.8
F1I2	95.1	94.3	94.6	94.5	94.5	94.9	93.9	94.8	94.9	93.5	93.6	93.5
F1I3	94.5	93.7	95.3	94.6	94.8	94.8	94.7	93.4	93.8	94.0	93.7	93.3
F2I1	93.2	93.4	94.3	94.4	93.9	95.1	95.0	94.9	94.7	93.9	93.6	92.9
F2I2	94.4	94.5	95.5	93.7	93.8	93.4	95.1	94.4	94.6	93.4	93.9	93.6
F2I3	94.3	94.2	93.9	93.9	94.7	93.9	94.5	94.7	94.8	94.8	94.7	93.5
F3I1	93.1	92.4	94.7	93.7	94.1	94.7	93.7	93.9	93.4	94.7	92.8	93.1
F3I2	93.4	94.4	94.8	94.8	93.8	92.1	94.7	95.0	93.5	95.2	93.8	93.7
F3I3	94.6	94.5	95.2	94.2	94.2	93.7	94.1	92.8	94.8	93.8	93.9	93.9
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F1 (60% of RDF), F2 (80% RDF) and F3 (100% RDF); I1 (0.6 IW/ CPE),I2(0.8 IW/CPE) and I3(1.0 IW/CPE)												

Table.2 Lower quartile distribution uniformity of drip fertigation system for different treatments

Lower Quartile Distribution Uniformity (%)												
Treatments	**Dates**											
	01-Apr	**16-Apr**	**30-Apr**	**01-May**	**15-May**	**30-May**	**01-Jun**	**16-Jun**	**30-Jun**	**01-Jul**	**16-Jul**	**30-Jul**
F1I1	88	88.3	87.5	86.1	86.2	84.8	84.3	87.2	86	84.9	84.5	84.6
F1I2	88.4	88.7	86.4	86.9	85.6	88.5	84.8	86.7	86.1	86.2	85.9	83.9
F1I3	86.6	87.3	86.4	87.4	84.3	85.6	86.5	88.2	87.2	86.1	85.1	84.6
F2I1	87.1	86.2	87.4	87.2	86.1	84.9	83.5	87.2	86.1	85.2	84.1	84.2
F2I2	86.1	88.1	87.5	88	85.1	87.5	84.8	85.8	88.2	85.4	84.9	84.2
F2I3	87.8	88	87.1	87.5	88.2	84.4	86.7	86.7	87.2	85.5	83.7	84.7
F3I1	87.9	87.4	86.4	88.1	87	84.3	85.7	85.8	85.2	86.3	84.2	83.1
F3I2	88.3	87.7	87.3	87.3	86.5	84.6	83.5	86.3	86.3	86.2	84.5	83.6
F3I3	87.9	88.5	86.3	86.3	87.1	83.8	83.5	85.9	85.1	83.2	83.1	83.4
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F1 (60% of RDF), F2 (80% RDF) and F3 (100% RDF); I1 (0.6 IW/ CPE),I2(0.8 IW/CPE) and I3(1.0 IW/CPE)												

Figure.1 Emitter discharge of drip fertigation system for different treatments



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