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Performance Evaluation of Drip Irrigation System for Green Pepper (*Capsicum annum*, L.) Production in the Tamale Metropolis of Ghana

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ABSTRACT

Performance evaluation is a diagnostic tool used to identify problem areas in an irrigation system and to indicate where improvements can be made in an existing irrigation system. Performance evaluation enables irrigation managers to redesign, improve upon the design and the irrigation strategies used. This study was carried out to assess the performance of a drip irrigation system installed and managed by Motor-King Company Limited in the Tamale Metropolis. The drip irrigation system consisted of two (2) reservoirs; 1500 litres and 1000 litres polytanks mounted at 1.2 m and 3.6 m high respectively. The drip irrigation system had a 32 mm main line and 16 mm lateral line with 2.7 l/h emitters spaced at 0.3 m. Three (3) laterals and nine (9) emitters were randomly selected in each plot. Emitter discharge was measured using catch cans. Five (5) performance indicators such as emitter flow variation, co-efficient of emitter flow variation, application efficiency, distribution uniformity and statistical uniformity were assessed. From the results, co-efficient of variation (7%) was rated good, emitter flow variation (18%) was rated acceptable, application efficiency was excellent (97.0%), low quarter distribution uniformity was good (87.2%), statistical uniformity was excellent (93.0%). These results imply that the drip irrigation performed satisfactorily and can still be used to produce vegetables with minimal losses.

INTRODUCTION

In recent times, the availability and quality of water resources for irrigated agriculture has been greatly affected by many factors. These include the growth in world population, land use change, climate change and the increasing demand for water from activities which are not related to agriculture (Geneille *et al.*, 2016). A key question that is currently being addressed in irrigated agriculture is how to cultivate sufficient food from limited water resources. The solution to this lies in increasing the efficiency and productivity of water use (Steduto *et al.*, 2012). Some water management and use options such as drip irrigation and deficit irrigation hold a lot of promise and potential in achieving high water productivity and use efficiency in many areas in the arid and semi-arid regions.

Drip irrigation has been recognized as the most efficient irrigation method in recent times. This is largely due to its accurate and precise delivery of water to the root zone of crops. In literature, it has been reported to achieve water use efficiency of up to about 90 % (Dasberg and Or, 1999). There is a growing interest in the use of drip irrigation in the cultivation of both field crops and vegetables. Several studies have investigated the effects of drip irrigation on crops such as maize, banana, cowpea, tomato, eggplant, pepper and okra. In all these studies, drip irrigation has been noted to produce higher yields compared to furrow, basin and flood irrigation (Asif *et al.*, 2016).

However, if drip irrigation is not well designed and maintained, it may not give its desired and expected benefits. This is why performance evaluations of drip irrigation systems are often undertaken in the field to diagnose the issues affecting its performance and to provide solutions. Some of the indicators used to evaluate the performance of drip irrigation systems, as outlined by Merriam and Keller (1978) and Ali (2010b) are the distribution or emission uniformity, the manufacturer's coefficient of variation, coefficient of emitter flow variation and the statistical uniformity. The standards against which these are evaluated have been developed by the American Society of Agricultural engineers (ASAE). This study was carried out to assess the performance of a drip irrigation system for green pepper production in the Tamale Metropolis of the Northern Region of Ghana.

MATERIALS AND METHODS

Study Area

The study was conducted at the experimental farm (Hydro Farm) of Motor-King Company in Nyohini, one of the suburbs of the Tamale Metropolis, located within latitudes 9°16′N and 9°34′N and longitudes 0°34′W and 0°57′W (Figure 1). The vegetation within Tamale Metropolis is of Guinea Savanna agro-ecological zone of Ghana, which is characterised by large areas of grassland interspersed with trees. Common trees such as Azadiracta indica (Neem), Parkia biglobosa (Dawadawa) and Vitellaria paradoxa (Sheanut trees) are found in the study area. The topography is generally flat and the elevation is about 166 m above sea level. The geology of the area is defined by the paleozoic consolidated sedimentary rocks developed mainly from sandstone, shale and mudstone (Mensah *et al.*, 2014). The major soil groups in this area are stagnic plinthosol and planosols (Agyare, 2004). The soils in the area are predominantly sandy loams with bulk density of 1.29 g/cm^3, pH of 6.5, organic carbon of 0.66 %, nitrogen of 0.06 %, phosphorus of 9.54 mg/kg, potassium of 82.7 mg/kg and cation exchange capacity of 4.18 cmol+/kg.

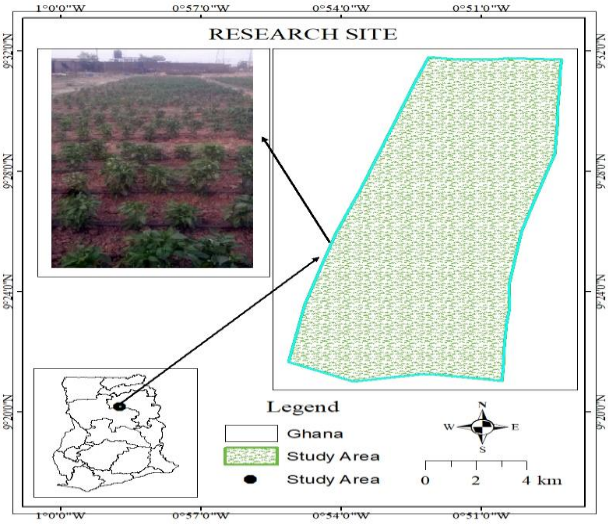

Figure 1: Map of the Study Area

Drip Irrigation Design and Layout

A surface drip irrigation system was used for the study. The drip irrigation system consisted of two (2) reservoirs; 1500 litres and 1000 litres polytanks mounted at 1.2 metres and 3.6 metres respectively, a 32 mm main line and a 16 mm lateral line with 2.7 l/h emitters spaced at 0.3 m as presented in Figure 2.

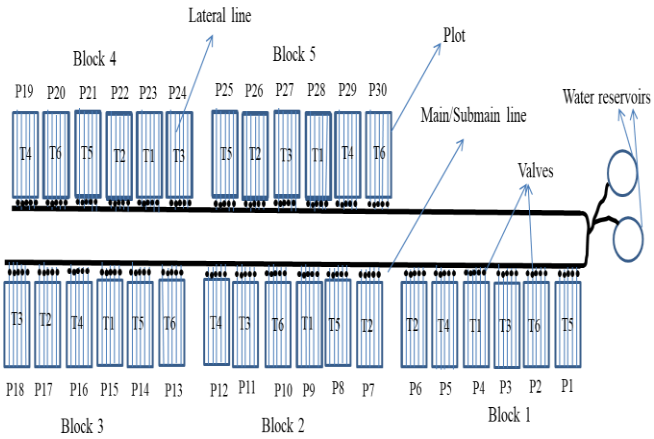

Figure 2: A schematic representation of the field layout of the drip irrigation system

Measurement of Performance Parameters

Sampling of emitters was done following the procedure described by Merriam and Keller (1978). In each plot, three (3) laterals were randomly selected, one each from the inlet end, 2/3 and the far end. The same procedure was followed in selecting the emitters. In effect, 3 laterals, 9 emitters; 18 laterals, 54 emitters and 90 laterals, 270 emitters were randomly sampled in each plot, block and the entire field respectively for emitter discharge measurements.

Measurement of Emitter Discharge

Emitter discharge was measured following the procedure used by Bajpai (2014). Catch cans measuring about 500 ml by volume were put under each sampled emitter to collect emitter discharge over a period of one minute as the system operated (Plate 1). This was taken three (3) times at each emitter and the average obtained. Emitter discharge was calculated using Equation 1 as given by Bajpai (2014):

Emitter discharge = $\frac{\text{Volume of water collected in catch can}}{\text{Time}}$ …… (1).

Plate 1: Field measurement of emitter discharge

Coefficient of Emitter Flow Variation

The manufacturer's coefficient of variation (CV), which measures the deviation of emitter discharge obtained from emitters of the same make, size, model and design, was calculated using equation 2 given by Ali (2010b):

$$CV = \frac{S_{dm}}{X_m} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where: CV is the manufacturing coefficient of variation, Sdm and Xm are the standard deviation and the mean flow rate of the measured emitter discharges.

Emitter Flow Variation

The variation in emitter flow (EFV) was calculated using equation 3 (Ali, 2010b):

$$q_{var} = \left(\frac{q_{max} - q_{min}}{q_{max}}\right) \times 100 \ldots\ldots\ldots\ldots\ldots (3)$$

Where: qvar is emitter flow variation along the lateral line, qmin is minimum measured emitter flow rate along the lateral line (l/h), and qmax is maximum measured emitter flow rate along the lateral line (l/h).

Application Efficiency

Application efficiency (Ea) was determined using equation 4 (Ali, 2010b):

$$Ea = (1 - 0.4qce) \times 100 \ldots\ldots\ldots\ldots (4)$$

Where: Ea is Application efficiency, qcv is Coefficient of variation of emitter flow

Distribution Uniformity

Distribution uniformity (DU) was determined using equation 5 (Ali, 2010b):

$$DUlq = \frac{Q(25\%)}{Qn \times 100} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where: Q25% is the average flow rate of the 25% of the emitters with the lowest flow rate, and Qn is the average flow rate of all the sampled emitters.

Statistical Uniformity

Statistical uniformity (Us) was determined using equation 6 as given by Ali (2010b):

$$Us = (1 - qcv) \times 100 \ldots\ldots\ldots\ldots (6)$$

Where: Us is statistical uniformity, and qcv is coefficient of variation of emitter flow.

RESULTS AND DISCUSSION

Performance Indicators of the Drip Irrigation System

The key performance indicators namely mean emitter flow rate, manufacturer's coefficient of variation, emitter flow variation, low quarter distribution uniformity, application efficiency, and statistical uniformity of the drip irrigation system were determined and presented in Tables 1.

Table 1. Performance indicators of the drip irrigation system at the plot level

Plot	EF(l/h)	CV	Class	Dulq	Class	qvar	Class	SU	Class	Ea	Class
plot 1	0.99	0.03	Excel.	96.1	Excel.	0.09	Desirable	97.20	Excel.	98.9	Excel.
plot 2	1.66	0.17	Poor	75.3	Fair	0.41	Unaccept.	83.1	Good	93.2	Excel.
plot 3	1.32	0.24	Unacc.	80.7	Fair	0.41	Unaccept.	76.3	Fair	90.5	Excel.
plot 4	1.01	0.02	Excel.	99.3	Excel.	0.06	Desirable	97.8	Excel.	99.1	Excel.
plot 5	0.99	0.04	Excel.	95.7	Excel.	0.10	Accept.	96.3	Excel.	98.5	Excel.
plot 6	1.02	0.04	Excel.	97.7	Excel.	0.10	Accept.	96.2	Excel.	98.5	Excel.
plot 7	1.04	0.05	Good	97.0	Excel.	0.15	Accept.	94.9	Excel.	98.0	Excel.
plot 8	1.10	0.06	Good	94.2	Excel.	0.09	Desirable	94.2	Excel.	97.7	Excel.
plot 9	1.04	0.04	Excel.	96.7	Excel.	0.10	Accept.	96.2	Excel.	98.5	Excel.
plot 10	1.36	0.16	Poor	82.4	Good	0.39	Unaccept.	83.9	Good	93.5	Excel.
plot 11	1.12	0.06	Good	95.9	Excel.	0.16	Accept.	94.5	Excel.	97.8	Excel.
plot 12	1.10	0.09	Good	88.4	Good	0.26	Unaccept.	91.1	Excel.	96.5	Good
plot 13	1.26	0.04	Excel.	96.1	Excel.	0.10	Accept.	96.2	Excel.	98.5	Excel.
plot 14	1.11	0.07	Good	92.5	Excel.	0.19	Accept.	92.8	Excel.	97.1	Excel.
plot 15	1.13	0.08	Good	90	Excel.	0.22	Unaccept.	91.6	Excel.	96.6	Excel.
plot 16	1.04	0.05	Good	95.3	Excel.	0.15	Accept.	95.0	Excel.	98.0	Excel.
plot 17	1.10	0.07	Good	92.4	Excel.	0.16	Accept.	93.5	Excel.	97.4	Excel.
plot 18	1.16	0.06	Good	93.2	Excel.	0.20	Accept.	93.6	Excel.	97.4	Excel.
plot 19	1.18	0.04	Exce.	95.7	Excel.	0.11	Accept.	96.5	Excel.	98.6	Excel.
plot 20	1.12	0.05	Good	93.4	Excel.	0.13	Accept.	95.0	Excel.	98.0	Excel.
plot 21	1.23	0.03	Exce.	96.8	Excel.	0.07	Desirable	97.5	Excel.	99.0	Excel.
plot 22	1.09	0.05	Good	95.1	Excel.	0.15	Accept.	94.8	Excel.	97.9	Excel.
plot 23	1.22	0.09	Good	88.0	Good	0.23	Unaccept.	90.6	Excel.	96.3	Excel.
plot 24	1.06	0.05	Good	95.0	Excel.	0.13	Accept.	95.2	Excel.	98.1	Excel.
plot 25	1.07	0.07	Good	93.6	Excel.	0.19	Accept.	92.5	Excel.	97.0	Excel.
plot 26	1.09	0.07	Good	92.4	Excel.	0.18	Accept.	92.5	Excel.	97.0	Excel.
plot 27	1.16	0.10	Good	88.4	Good	0.30	Unaccept.	90.1	Excel.	96.0	Excel.
plot 28	1.27	0.04	Exce.	93.5	Excel.	0.14	Accept.	95.8	Excel.	98.3	Excel.
plot 29	1.43	0.09	Good	90.3	Excel.	0.25	Unaccept.	90.9	Excel.	96.4	Excel.
plot 30	1.43	0.07	Good	93.3	Excel.	0.20	Accept.	93.0	Excel.	97.2	Excel.

EF-mean emitter flow, CV- coefficient of variation, Class-classification, DUlq-low quarter distribution uniformity, qvar- coefficient of emitter flow variation, SU-statistical uniformity, Ea-application efficiency, Unacc.-unacceptable, Excel.-Excellent, Accept.-acceptable.

Table 2. Within block and whole system performance indicators of the drip irrigation system

Block	EF (l/h)	CV	Class	Dulq	Class	qvar	Class	SU	Class	Ea	Class
1	1.16	0.09	Good	84.0	Good	0.18	Accept.	91.1	Excel.	96.5	Excel.
2	1.13	0.08	Good	89.0	Good	0.19	Accept.	92.5	Excel.	97.0	Excel.
3	1.13	0.06	Good	89.1	Good	0.22	Unaccept.	93.8	Excel.	97.5	Excel.
4	1.15	0.05	Good	91.0	Excel.	0.15	Accept.	94.9	Excel.	98.0	Excel.
5	1.24	0.08	Good	83.0	Good	0.17	Accept.	92.5	Excel.	97.0	Excel.
Overall	1.16	0.07	Good	87.2	Good	0.18	Accept.	93.0	Excel.	97.2	Excel.

EF-mean emitter flow, CV- coefficient of variation, Cl-classification, DUlq-low quarter distribution uniformity, qvar- coefficient of emitter flow variation, SU-statistical uniformity, Ea-application efficiency Unacc.-unacceptable, Excel.-Excellent, Accept.-acceptable

Mean Emitter Flow Rate

As presented in Tables 1, the mean discharge rate of the emitters at the plot and block levels ranged from 0.99 l to 1.66 l/h and from 1.13 l to 1.24 l/h respectively. With respect to the whole drip irrigation system, the mean emitter discharge rate recorded was 1.16 l/h indicating that all the sampled emitters discharged about 57 % less water compared to the manufacturer's design discharge of 2.7 l/h. Emitter discharge rate and frequency of irrigation are two very important parameters which determine the availability of water in the soil and the pattern of plant water uptake (Asenso, 2011). The low emitter discharge recorded in this study could be attributed to a number of factors including pressure losses, emitter clogging, temperature effects and poor hydraulic design of the drip irrigation system (Al-Ghobari, 2007). Pressure is one of the most important parameters which influences emitter discharge in drip irrigation systems. In fact, it has been established in many studies that pressure has a direct relationship with emitter discharge rate (Phocaides, 2000; Sarker *et al*., 2019). The average emitter discharge recorded in drip irrigation system at a given time therefore depends on the operating pressure head. The lower emitter discharge rate recorded in this study could therefore be as a result of the fact that the polytanks which supplied water to the field were mounted at relatively low elevations; 1.2 m and 3.6 m for the 1500 litres and 1000 liters polytanks. Also, it has been noted that emitter discharge rates are influenced by pressure losses which occur as a result of friction losses in the pipes and fittings, water moving uphill or downhill in a pipe network (Smajstrla *et al.,* 2018). The reason for the low emitter discharge reported in this study could also therefore be attributed to pressure losses, emitter clogging, temperature effects and poor hydraulic design.

Manufacturer's Coefficient of Variation

From Tables 1, the results showed that the mean manufacturer's coefficient of variation (CV) ranged from 0.02 to 0.17 at the plot level and from 0.05 to 0.09 at the block level. Overall, a CV value of 0.07 was recorded for the drip irrigation system. This was classified as good based on the classification used by Zamaniyan (2014). The results further indicated that the CVs recorded in about 30 % of the plots could be classified as excellent (CV < 0.05) while CVs recorded in 63.3% of the plots could be classified as good (0.05 – 0.10). Only two plots representing 6.7 % of the plots recorded CVs which were classified as poor based on the classification used by Zamaniyan *et al.* (2014). At the block level, the CVs recorded in all the blocks were classified as good. This indicates that about 93.3 % of the emitters discharged water with variation within the acceptable limit of the manufacturer's coefficient of variation. This indicates that the performance of the drip irrigation system fell within acceptable standards and was satisfactory and suitable for the cultivation of vegetables. These results are comparable to the results of Sarker *et al*. (2019) who found a CV value of 0.06 for a newly developed 89 low-pressure emitter in a drip irrigation system installed on a land with 0 % slope and at 1.5 m head.

Emitter Flow Variation

The coefficient of emitter flow variation within the plots and blocks ranged from 0.06 (excellent) to 0.41 (unacceptable) and 0.15 (good) to 0.22 (unacceptable) respectively (Tables 1). Overall, the results showed that for an average emitter discharge of 1.16 l/h, the emitter discharge varied from 0.99 l to 1.66 l/h giving an average coefficient of emitter flow variation of 0.18. This was rated as good based on the classification used by Al-Ghobari (2007). Further, the results indicate that about 22 plots (73.3 %) had coefficient of emitter flow variation within acceptable limits while 26.7 % had unacceptable coefficient of emitter flow variations. At the block level, coefficient of emitter variation in 4 out of 5 blocks was classified as good.

Similar result was obtained by Sarker *et al.*, (2019) who reported coefficient of emitter discharge variation of 21.1 %, 18.1 % and 20.5 % for a 1.5 m, 2.0 m and 2.5 pressure heads respectively at 0 % slope. The results of this study is however relatively higher than that of Camp *et al.*, (2015) who obtained coefficient of emitter discharge variation of 0.12 for emitters with 2.5 l/h manufacturer's specified CV. The values of the qvar reported in this study could have been influenced by the manufacturer's coefficient of variation. This is because the manufacturer's coefficient of variation is noted as one of the major factors influencing the coefficient of emitter flow variation (Khairy *et al.,* 2016). Since the performance of the drip system was rated as good 90 in terms of the qvar, it could have accounted for the relatively good distribution uniformity recorded in this study.

Low Quarter Distribution Uniformity

Low quarter distribution uniformity of emitter discharge at the plot and block levels ranged from 75.33 to 99.30 % and from 82.86 to 90.86 % respectively. The results of this study conformed to that of Al-Ghobari (2007) who recorded the distribution uniformity values ranging from 54.2 to 96.05 % for a drip irrigation system. At the whole system level, low quarter distribution was 87.2 % which was classified as good according to the classification presented by Merriam and Keller (1978). This is in agreement with the results of Arya *et al*. (2019) who recorded distribution uniformity values of 89.5 % for a drip irrigation system in a naturally ventilated polyhouse. It is however, relatively lower than the values reported by Camp *et al.* (2015) (96.6 %) and Arya *et al.* (2017) (93.5 % and 96.0 %). The relatively low value of DUlq recorded could have been influenced by the emitter discharge variation, pressure variation, temperature changes of the water, friction head losses and emitter clogging (Omofunmi *et al.,* 2019). Distribution uniformity is one of the most important performance indicators of drip irrigation systems (Ali, 2010a). It serves as a good indication of the proportion of the irrigation field which is over and under irrigated.

Application Efficiency

As presented in Tables 1, the application efficiency of the drip irrigation system at the plot and block levels ranged from 90.0 to 99.1 % and from 96.46 to 97.96 % 91 respectively. The average application efficiency of the whole system was 97.2 %. This means that 97.2 % of water applied at the source was delivered to the root zone of the crop. This is far more than the range (90 - 95 %) most often quoted for drip irrigation in the literature (Phocaides, 2000; Ali, 2010a). The high irrigation water application efficiency recorded in this study demonstrates that there was very minimal loss of water along the main, submain and the lateral lines. This could be attributed to the fact that the joints and connection points of the lines were well sealed and secured to prevent leakages. Also, there was no or very little loss of water through deep percolation since there was no over irrigation in any part of the field. This could have contributed to the high-water use efficiency recorded in this study.

Statistical Uniformity

The statistical uniformity recorded at the plot level ranged from 76.30 to 97.80 % (Table 1) and from 91.1 to 94.94 % at the block level (Table 1). Based on the classification used by Omofunmi *et al.* (2019), the statistical uniformity recorded in all the blocks were rated as excellent. Further, the results indicated that the overall statistical uniformity of the drip irrigation was 93.0 % (Table 1) which also fell within the range classified as excellent according to the classification used by Omofunmi *et al.,* (2019). This result compares favourably with the results of Arya *et al.* (2017) who found the statistical uniformity of drip a system in a naturally ventilated polyhouse and environmentally controlled polyhouse to be 92.2 % and 94.3 % respectively. Similarly, Selvaperumal *et al.* (2019) obtained statistical uniformity values of 97 % for drip irrigation systems in India. Sarker *et al*. (2019) in a study in Bangladesh to evaluate an emitter of a 92 low-pressure drip irrigation system also obtained statistical uniformity values of 94.02 %, 95.53 % and 94.34 % for 1.5, 2.0 and 2.5 pressure heads respectively.

Soil Moisture Content under the Various Treatments

The daily soil moisture content under the various treatments is presented in Figure 3. As clearly noted in the Figure 3, treatment 1 which is one-time application of 100 % ET_c recorded the lowest soil water potential over the entire irrigation period whereas treatments 5 and 6; split application of 80 % ET_c and split application of 60 % ET_c, recorded the highest soil water potential. This indicates that under treatment 1, there was almost no water stress and the plants did not experience difficulty in accessing water for their metabolic activities. Under treatments 5 and 6, the high soil water potential recorded showed that some amount of water stress was experienced by plants. In terms of water application regime, the soil water potential under one-time application was lower compared to split application as (Parkash, *et al* (2020).

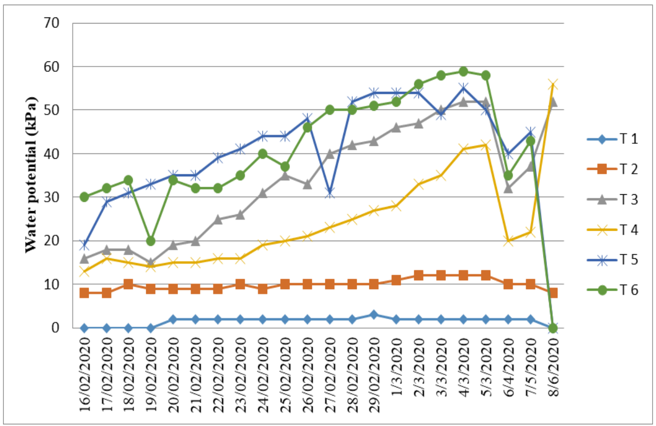

Figure 3: Daily soil moisture recorded under each treatment

Effect of Different Drip Irrigation Water Application Regimes and Irrigation Schedule on the Growth and Yield Parameters of Green Pepper

Number of Fruits per Plant

The average number of fruits per plant under the different treatments is presented in Figure 4. As shown in Figure 4, T6 (split application of 60 % ET_c) recorded the highest average number of fruits per plant (4.18) while T2 (one-time application of 80 % ET_c) recorded the lowest average number of fruits (2.58). Generally, average number of fruits was higher under split application of irrigation water compared to one-time application. This result is supported by Arshad *et al*. (2017) who found that the number of fruits of green pepper was higher under irrigation treatments involving more than one irrigation application per day compared to one-time irrigating in a day. This, they attributed to the fact that optimum amount of water plays a vital role in metabolism and nutrient uptake which boost up the vigorous growth of sweet pepper and increases the number of fruits per plant. Through an analysis, of variance ($p \leq 0.05$), it was revealed that there was a highly significant effect of irrigation schedules ($p = 0.008$) on the number of fruits per plants. The irrigation water application regimes however, did not have significant effects on the number of fruits ($p = 0.32$). Results of Duncan's multiple range test showed that T6 differed remarkably from T2 and T3 and only slightly from T1, T4 and T5. No significant differences were found between T2 and T3 and among T1, T4 and T5. The difference observed between the irrigation schedules may be attributed to the fact that at shorter intervals of irrigation, water is made more available and accessible to plants which helps them to quickly recover from the high daytime temperatures and other environmental stresses (Paku, 2016). The application of irrigation in the evening in particular is reported to have great influences on the fruit number and diameter of green pepper. For example, Paku (2016) found that green pepper irrigated with 100 % ET_c, 90 % ET_c and 80 % ET_c in the evening produced higher fruit number and fruit diameter than those irrigated with same irrigation regimes in the morning. The irrigation application regimes did not significantly influence the number of fruits probably due to the fact that the water stress imposed on the plants was well within the tolerance limit of the plants (Parkash and Singh, 2020).

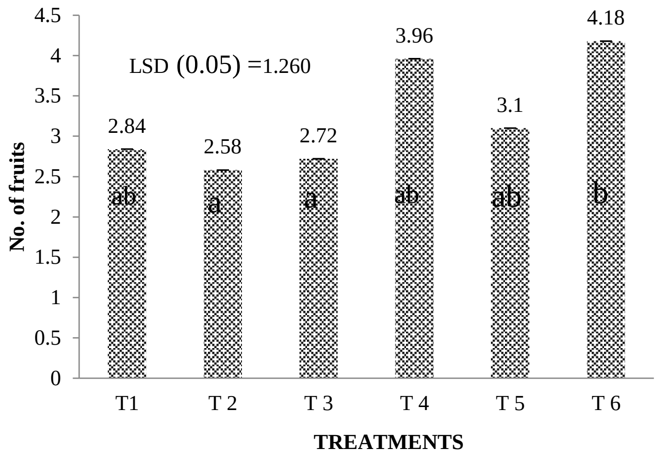

Figure 4: Effect of drip irrigation water application regimes and irrigation schedule on the number of fruits of green pepper

Fruit Yield

The effect of different irrigation water application regimes and irrigation schedule on the yield of green pepper planted under the drip irrigation system is presented in Figure 5. As shown in the Figure 5, 60 % ET_c split irrigation produced the highest fruit yield (11686.93 kg/ha) followed by 100 % ET_c split irrigation (11099.12 kg/ha). The lowest fruit yield was recorded under 60 % ET_c one-time irrigation (6811.84 kg/ha). In a similar study, Dimple *et al*. (2017) also found that 80 % ET gave the highest yield (2604.57 kg/ha) followed by 100 % ET. 60 % ET recorded the lowest yield (1719.47 kg/ha). The results further reveal that fruit yield was higher under split irrigation application compared to one-time irrigation application. This is corroborated by Arshad *et al*. (2017) who observed that irrigating green pepper more than once in a day resulted in higher fresh fruit yield compared to one-time application. The higher fruit yield recorded under split irrigation could be attributed to increased vegetative growth and chemical composition of fruits which resulted in higher fruit length, fruit weight and fruit yield (Arshad *et al*., 2017). Analysis of variance ($p \leq 0.05$) showed highly significant difference between the irrigation schedules ($p=0.007$). However, no significant differences were found among the irrigation water application regimes ($p=0.376$) and interaction effects of the factors ($p=0.493$). Through Duncan's multiple range test, it was revealed that T6 differed only slightly from T1, T4 and T5 (which did not differ from one another) and markedly from T2 and T3 (Which also did not differ from each other). This again may be due to the fact that the various treatments provided nearly the same optimum soil moisture range or that the transpiration rates of the plants were low, thus, reducing the degree of water stress under the treatments (Debbarma *et al*., 2019; Anjum *et al*., 2011).

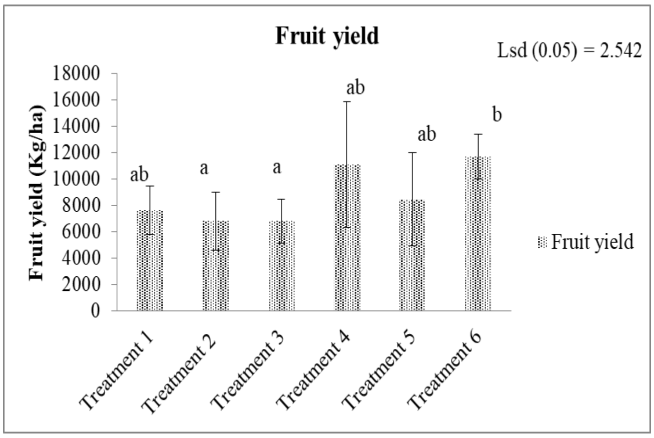

Figure 5: Effect of drip irrigation regimes and mode of irrigation on the fruit yield of green pepper

CONCLUSION

The drip irrigation system designed and used in this study performed satisfactorily and met the performance standards developed by the ASAE. Coefficient of variation was rated as good (7 %), emitter flow variation was rated acceptable (18 %), low quarter distribution uniformity was good (87.2 %), statistical uniformity was excellent (93.0 %), emission uniformity excellent (97.1 %), application efficiency excellent (97.0 %) and Christiansen's uniformity coefficient was also rated excellent (100 %).

CONFLICT OF INTEREST

The authors declared that there is no competing interest regarding the publication of this paper

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