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EFFECT OF HYDRAULIC HEADS ON WATER APPLICATION RATE, VARIATION AND UNIFORMITY COEFFICIENT ON DRIP IRRIGATION SYSTEM.

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Abstract

The study evaluated the performance of drip irrigation system under different hydraulic heads using drip giving set as emitter. A plot was equally divided into three sub-plots and three lateral each with 2.4m length were laid on the ground. A plastic tank reservoir was provided to each plot with metal stands which suspended the tank from the ground surface. The height of the tank were varied from 0.5m, 1.0m, and 1.5m for plots A,B and C respectively, so as to vary the hydraulic head as well as hydraulic pressure. The system performance was tested for its water application rate, uniformity coefficient, manufacturing coefficient of variationand discharge relationship. The study reveal that, the maximum discharge rate of 0.410,0.210 and 0.200 lt/hr for plot A, b and C respectively were obtained in the drip arrangement which falls within the acceptable range of 0.2 to20Ltrs/hr as recommended for micro-irrigation system by many literatures.Coefficient of uniformity of 68, 74 and 99 percent for plot C, B and A respectively were obtained for the system also falls within the acceptable range except manufacturing coefficient of variation which is marginal to unacceptable range of drip irrigation system.

Key Words: Drip irrigation, Plots, Uniformity, Hydraulic heads.

INTRODUCTION

In the developing Countries like United States of America, United Kingdom and Turkey etc, several modern irrigation methods such as sprinkler, trickle, bubbler, and sub- surface irrigation are now in practice, which have high irrigation application efficiencies and produce high yields. Trickle irrigation provides prescribed amount of water to plant, lowers soil moisture tension, improves fertilizer application efficiency, reduces weed growth, ensures uniform water distribution, and increases water application efficiency. Trickle irrigation, also known as drip irrigation, is among the latest micro-irrigation methods and is quite popular in areas with water scarcity and textured soils having infiltration rate. But due to high installation cost, it is yet to to be found in some countries. However, this method stands a bright future in the water scarce areas such as Thar Desert, Kohistan, and tail reaches of irrigation network of the country. The method consist 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 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 in unpleasant condition (Bhatnagar and Srivastava, 2003). Since, frequent application near the plants is ensured (Youngs *et al.*,1999) hence; the conveyance and the other conventional losses such as deep percolation, runoff and soil water evaporation are minimal as water is conveyed through a network of pipes.

Ideally, a well designed system applies nearly equal amount of water to each plant, meets its waterrequirements, and is economically feasible. However, due to manufacturing variations, pressure differences, emitter plugging, aging, frictional head loss, irrigation water temperature changes, and emitter sensitivity results in flow rate variations even between two identical emitters (Mizyed and Kruse, 2008). Uniform distribution of water application means that all the plants receive an equal amount of water. In poorly designed system, one cannot get uniform supply of water, thus there would be either under irrigation or over irrigation. Under both cases, plants will either suffer the dry or the moisture stresses. Through a properly designed trickle system, uniform distribution of water is ensured which results in better yields. 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 sub units system. With uniformity coefficient of at least 85 percent is considered appropriate for standard design requirements. Such a high uniformity coefficient is only possible through properly designed system network that provide steady discharge to all emission points. However, the distribution uniformity (DU) and the uniformity coefficient are function of hydraulic heads and slope of lateral and sub-main 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 percent (Ella *et al*, 2009). Water application efficiency (Ea) is another important parameter for system selection, design, and irrigation management. The ability of an irrigation system to apply and efficiently to the irrigated area is a major factor influencing agronomic and economic viability of the farming enterprise. With well design trickle irrigation system, it is possible to attain efficiencygreater than 90 percent (Solomon, 2003). The system efficiency is associated with application uniformity and water losses that can be evaluated by direct measurements of emitter flow rates. If, the water losses are high or distributed uniformly is poor, it would result in low application efficiency. However, the distribution of water as measure in the field does not really represent the distribution of moisture in the soil. As a matter of fact, the true moisture distribution is the result of some side movement of water the soil away from the emission point. Therefore, it is possible to irrigate with a much lower uniformity coefficient under many conditions without suffering from reduction in yield. The uniformity coefficient might be affected by the length of lateral itself. Longer laterals result pressure drop in the line and cause poor uniformity towards the tail ends. Distribution of moisture under trickle irrigation depends upon the uniformity of application, one of the critical factors for the designers and farmers. However, proper design guidelines are prerequisite for a better system performance. As soon as the system has been installed in the field, the evaluation must be carried and periodically repeated with time if the best performance is desired (Keller and Blisner, 1990). The study was aimed at evaluating the performance of locally made emitters used in trickle sub-units.

MATERIALS AND METHODS

The experiment was conducted at Kashim Ibrahim College of Education Maiduguri Research Farm, Department of Agricultural Technology, which lies on the coordinates of 12^0N 14^0E. The soil at the experimental site is characterized as sandy loam, (Ministry of land and survey, 2008).

MATERIALS USED

Plastic pipes, Plastic water tank, Plastic bucket, Plastic connectors, Measuring cylinder, Measuring tape, Ruler, Moisture cans and Drip giving set.

EXPERIMENTAL PROCEDURE

Three drip irrigation layouts with different plastic tank reservoirs were constructed with a metal stands to suspend the tanks from the ground surface, the height of the tanks were varied from 1.5,1.0 and 0.5m C,B and A respectively so as to vary the hydraulics heads as well as the hydraulic pressure.The water flows, distribution pattern, uniformity coefficient, field application efficiency, and percolation losses have been set as the performance indicators.Water flows in to the emitters from the plastic reservoirs of 220liters capacity to the crop in drops. It is a micro-irrigation method system that is adapted to take advantage of the benefits of the gravity system without requiring an expensive water pressure system. A gate valve was placed at outlets of each reservoir is to maintain a constant operating pressure head. The system main lines were made of plastic pipe with an average internal diameter of 0.0254m was connected to the sub-main of 0.0154m internal diameter pipe by a plastic union joint and 2.4m lateral lines were connected to sub-main by means of plastic T-joint.

Six emitters were fitted to each lateral line of intervals at 0.3m to coincide with the planting crop distance (spacing).The pipe network of the system comprising the main line sub-main line and the laterals were suspended at 0.015m above the ground surface by a metal pegs.

SYSTEM PERFORMANCE IN TERMS OF UNIFORMITY

Micro-irrigation lateral are designed to maintain an acceptable variation in discharge along their length. According to Michael (2008), the performance of irrigation system is presented by its measured levels of achievements in terms of one or several parameters chosen as indicators of the system goal. The most widely accepted hydraulic performance parameters for assessing micro-irrigation system in water distribution are; emitter flow rate variation (qav). Discharge coefficient of variation (cvq), chritiansens coefficient of uniformity (Du). These are given respectively by:

$Qav = qmax - qmin / Qmax \times 100$ (Michael 2008).

Where;

Qmax = maximum emitter flow.

Qmin = minimum emitter flow.

$Cvq = s/qa \times 100$(Michael 2008).

Where;

Cvq = discharge coefficient of variation in percentage.

qa = average flowrate

s = standard deviation of the emitter discharges.

OPERATION OF THE SYSTEM

The operation line for the drip system starts with opening the control valve of the storage tank allowing water to flow through the main line. The water moves through the sub-main lines into the field laterals and is discharges through the emitters to the soil in drops where the plant grown. At the end of the irrigation period, the value at the storage tank is closed all the inlet values are also closed.

RESULTS AND DISCUSSION

The parameters used to determine the performance of the system includes the manufacturing coefficient of emitters' variation (Cvg), the statistical uniformity (Us), system application uniformity (Eu), Christiansen uniformity of coefficient (Cu), and the emitters' coefficient.

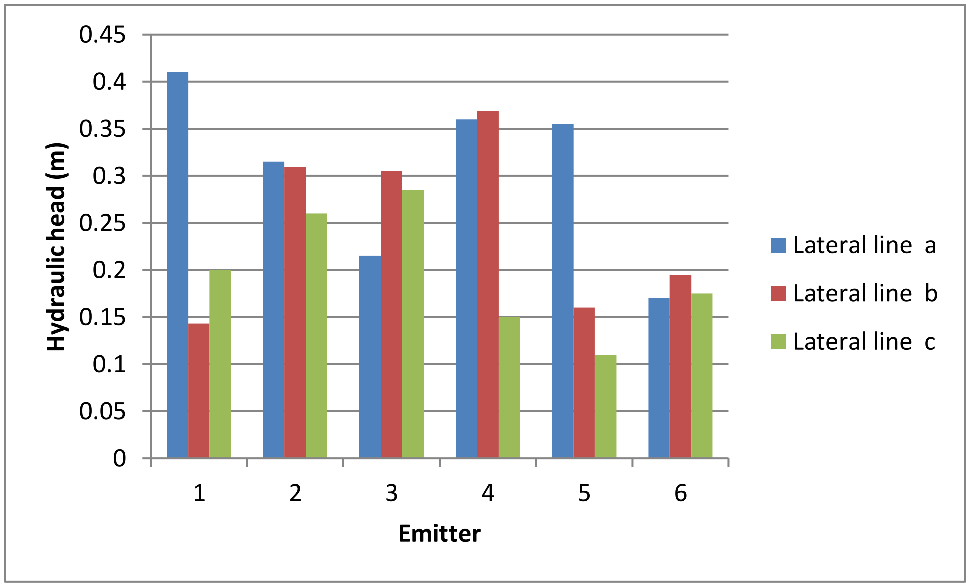

Figure 1: Emitter discharge rate for plot A

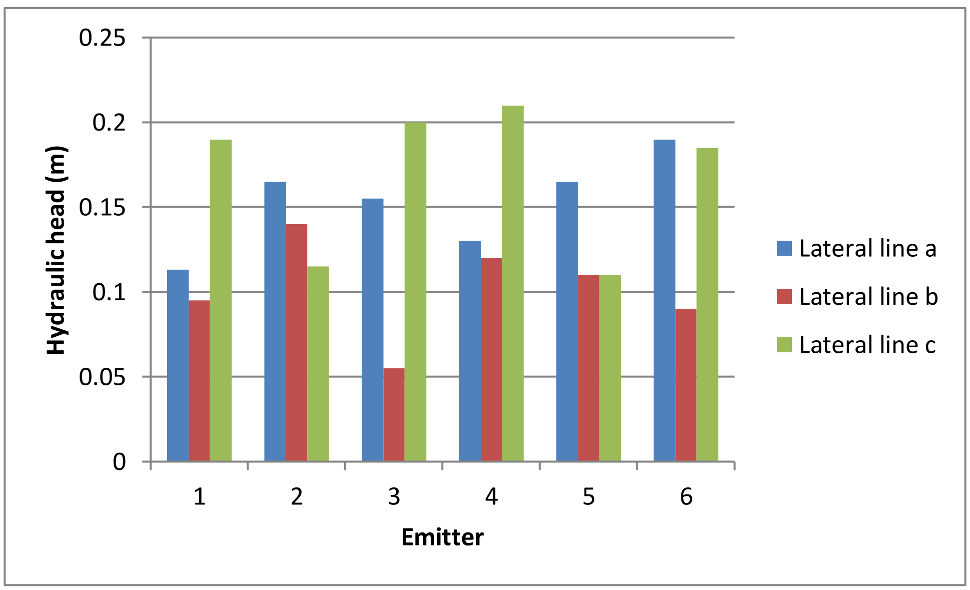

Figure 2: Emitter discharge rate for plot B

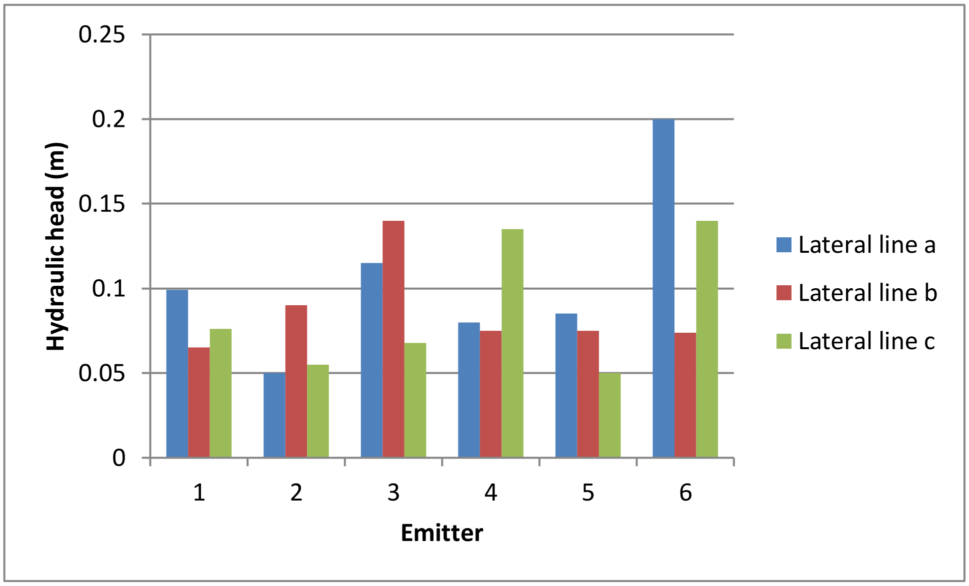

Figure 3: Emitter discharge rate for plot C

The result of the discharge rate per hour of the emitters is presented in tables 1, 2 and 3 for plot A, B and C respectively. The maximum discharge rate of 0.410, 0.210, and 0.200 for plot A, B and C respectively obtained in the drip arrangement which falls within the acceptable ranges of 0.2 – 20lt/hr as recommended for micro-irrigation systems byBraklts and Kesner, 2003.

Emitter flow rate variation of more than 20% is acceptable for micro-irrigation system. Result from the study revealed that the emitter flow rate variation 90%, 80% and 65% for plot A, B, and C respectively were obtained, thus signifying that the developed drip kit arrangement is satisfactory in terms of uniformity of flow. Average value of Christiansen uniformity coefficient falls within the recommended value for drip irrigation(ASAE, 2004).

Low uniformity implies that some areas of the field received less water than other areas. Values of statistical coefficient of uniformity of 90%, 80%, and 65% for plot C, B, and A was obtained for this system also falls within the acceptable limits. Braklts and Kesner,2003, define the statistical uniformity (%) as perfect for 95-100%, good for 85-95% and unacceptable for 64%and below. (ASAE, 2004).

Value of manufacturer coefficient of variation Cv obtained from system was 37, 31, and 42% for plot C, B, and A respectively. The results of this study were above the recommended range and marginal to unacceptable as required for micro-irrigation. Cv value of less than 10% is good, 10-20% is average and greater than 20% is marginal to unacceptable.

CONCLUSION

The result of coefficient of variation values of less than 10% is good, 10-20% ia average and greater than 20% is marginal to unacceptable.

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Table :1 Emitter discharge rate of plot A (Laterals Line And Discharge Ql/Hr)

(Laterals line and discharge Ql/hr)			
EMITTER	1	2	3
1	0.410	0.143	0.200
2	0.315	0.310	0.260
3	0.215	0.305	0.285
4	0.360	0.369	0.150
5	0.355	0.160	0.110
6	0.170	0.195	0.175
TOTAL	1.825	1.481	1.180

Table 2: Emitter discharge rate of plot B (Laterals line and discharge Ql/hr)

(Laterals line and discharge Ql/hr)

EMITTER	1	2	3
1	0.113	0.095	0.190
2	0.165	0.140	0.115
3	0.155	0.055	0.200
4	0.130	0.120	0.210
5	0.165	0.110	0.110
6	0.190	0.090	0.185
TOTAL	0.918	0.610	1.010

Table 3: Emitter Discharge Rate of plot C (Laterals line and discharge Ql/hr)

(Laterals line and discharge Ql/hr)

EMITTER	1	2	3
1	0.099	0.065	0.076
2	0.050	0.090	0.055
3	0.115	0.140	0.068
4	0.080	0.075	0.135
5	0.085	0.075	0.050
6	0.200	0.074	0.140
TOTAL	0.629	0.519	0.524