

Assessment of Coefficient of Variation of Emitters Flow Rate with Respect to Design, Manufacturer and Plugging in Installed Drip Irrigation Systems at Selected Sites of Peshawar Valley

Gul Daraz Khan[1], Akhtar Ali[1] and Farid Akbar[2]
1.Department of Water Management, The University of Agriculture, Peshawar, Pakistan.
2. Faculty of Water Resources Management, Lasbela University of Agriculture, Water and Marine Sciences, Uthal, District Lasbela
Corresponding Email. farid.baloch@hotmail.com

Abstract
The study was conducted to assess the performance of drip irrigation systems installed at Charsadda, Malakand Agency and Nowshera. The performance parameters of the drip irrigation system included the coefficient of variation of emitters flow rate with respect to design of manufacturer, hydraulics, grouping of the emitters, plugging, uniformity, efficiency, adequacy and estimated design discharge , measured Cv(H) values for all plots are less than 30%. Hydraulic design seems to be only one of the minor factors in the evaluation of overall uniformity of a micro-irrigation system. Having the Cv(HM) variations are only about 0-7% except plot No.1 of Nowshera farm that is 24.16%, expressed by Cv. micro-irrigation system can be designed hydraulically to maintain emitter flow uniformity within 10% or 20% emitter flow variations. Grouping variation of emitters flow is 0-4% in Charsadda and Malakand Agency farm. In plot No.1 of Nowshera farm its 20.60% while in plot No.2 and 3 it is 0%. The group coefficient is affected by emitters flow rate that is uniform. In Charsadda and Malakand Agency farm the overall effect of hydraulic, manufacturer and grouping are 0-7.11% and 0-1.02% in plot No.3 and 2 of Nowshera farm, in plot No.1 it is 31.75%. Among all the factors affecting the uniformity, plugging is the most significant factor. The Cv(P) is 0% resulted from partial plugging. 5-10% plugging could produce Cv(P) of 23-33%. This system has no plugging, which implies that the system is performing excellent. Cv(HMP) was evidently affected most by hydraulic and manufacture variation. The overall Cv(HMP) is maximum in Charsadda plot No.2 is 16.1% while in plot No.3 and 4 this range from 1.8 to 0.6%. In Malakand and Nowshera farm this overall variation give negative values due to more variation in the level of plugging and CV(HM). .
Keywords: Coefficient of Variation, Emitters, Plugging, Uniformity, Drip Irrigation

INTRODUCTION

Pakistan has one of the largest canal irrigation network in the world. About 14 million hectare of the land is irrigated with the canal system, which is nearly 60% of the total cultivated land in the country (FAO, 1997). Hence a lot of water is wasted in surface irrigation through seepage, leakage losses, deep percolation, runoff and evaporation. The over all efficiency of surface irrigation is ranging from 30-40%, having 60-70% losses adversely affecting crop quality and yield (James, 1993). The drip or trickle irrigation is one of the best methods with frequent, slow application of water either directly on the land or into the root zone of the crops rather than the entire land surface and maintaining the water content of the root zone at optimum level. Tests to determine functional attributes, related to resistance and durability, are generally defined through technical specification rules. The uniformity and general performance of micro irrigation systems are affected by hydraulic design, emitter manufacturer's coefficient of variation, grouping of emitters and emitter clogging among other factors (Frizzone, 1997). Factors examined include hydraulic and manufacture uniformity, plugging as it affects uniformity, and irrigation application amounts, as related to predicted maximum evapotranspiration. Irrigation application should increase until the marginal value of water equals the marginal value of yield, or until no yield reduction occurs in any part of the field. Improper maintenance of the irrigation system can cause the statistical uniformity coefficient to decrease to 60% or less, resulting in increased water application to compensate for decreased application uniformity or reduced yields (Sammis and Wu,1985). Flow rate sensitivity to change in pressure can established by determining CV value for emitters. No definite trend for non pressure compensating emitters where as a decreasing trend in values of CV with increase in pressure is available for pressure compensating emitter. A simplified statistical method for estimating the coefficient of variation was developed. This estimate was used to demonstrate a method of determining field uniformity for drip irrigation submain units. A graphical technique for estimating the statistical uniformity and the relative confidence limits of the proposed method were established (Bralts and Kesner, 1983).

MATERIALS AND METHODS

Three sites varying in soil types and crop grown were selected for studying the performance assessment of drip irrigation system, at Malakand, Charsadda and Nowshehra Peshwar valley, Pakistan. The design of drip irrigation systems is essentially centered on ensuring that water is conveyed to each emitter at a pre-determined pressure head that would cause satisfactory flow. The general design criterion is to limit the pressure and discharge variation in the system to within 30% (WU, 1997). The performance parameters used to assess drip irrigation systems, therefore expose the differences in discharges within the system. Differences in flow rates were reflected in discharge coefficients of variation. Five discharge coefficients of variation (WU, 1997) were conventionally used to assess micro-irrigation systems. These are: (a) Coefficient of variation of emitter flow caused by hydraulic design, Cv(H). (b) Coefficient of variation of emitter flow caused by manufacturer's variation, Cv(M).(c) Coefficient of variation of emitter's flow caused by hydraulic design and manufacturer's variation, Cv(HM). (d) Coefficient of variation of emitter's flow caused by hydraulic design, Manufacturer's variation and grouping Cv(HMG). (e) Coefficient of variation of emitter's flow caused by emitters plugging, Cv(P). (f) Coefficient of variation of emitter's flow caused by hydraulic design, Manufacturer's variation and plugging Cv(HMP). The head loss along the lateral was computed from eq-1 (Schwab et al., 1992).

RESULTS AND DISCUSSION

Variation Due to Different Performance Parameters

The data taken on coefficient of variation due to manufacturer, hydraulic design, grouping, plugging and their overall combination has been analyzed which is presented systematically.

Variation due to Manufacturer Cv(M)

Figure 1 shows that on the base of Coefficient of Variation (Cv) all the three Farms at three different sites of the study area were categorized as Excellent, Good, Average, Marginal and Unacceptable. Out of these the study area at Charsadda and Malakand Agency had excellent with Cv below 5% while the drip irrigation system at Nowshera having 17.24 % in plot No.1 is unacceptable. However in plot No.2 and 3 the Cv performance is excellent. Due to design fault having low pressure, the emitters could not maintain uniformity in flow rate in plot No.1 of the study area in Nowshera. The system was design having double laterals. Which had divided the available pressure head into lower amounts compare to plot No.3 which was same as plot No.1 but provided with single lateral per row to maintain the pressure to the required head?

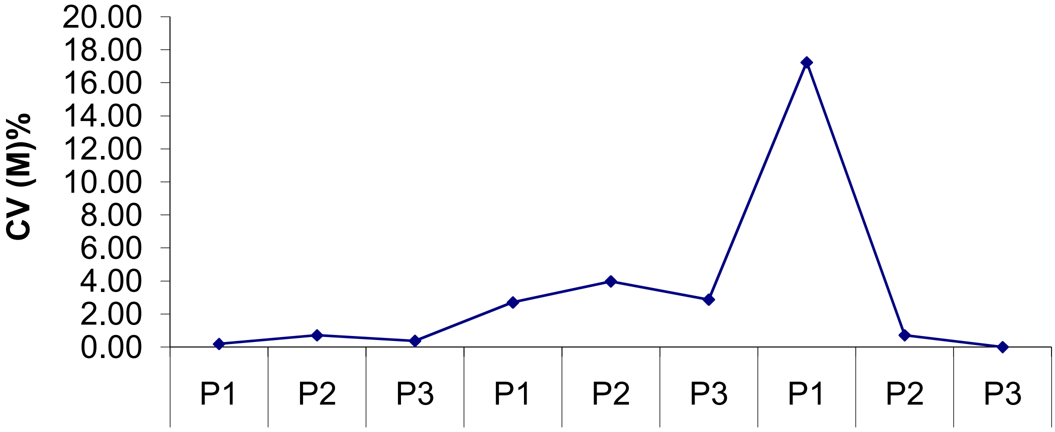

Figure 1 Coefficient of Variation of the Three Plots in Each of the Study Area With Respect to Manufacturer Design

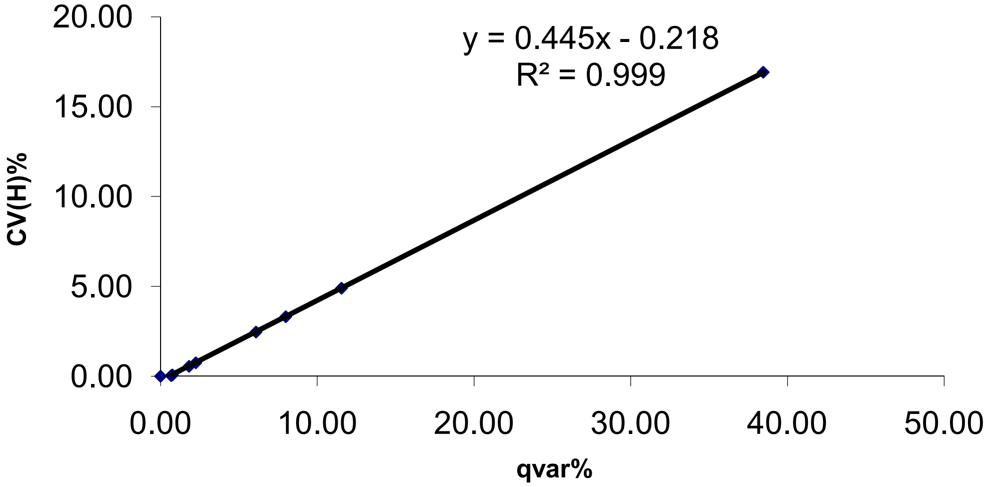

Figure 2 Effect of Hydraulic Variation over Emitters Flow Variation

Variation due to Hydraulic Design Cv(M)

Figure.3 shows that the relationship between the coefficient of variation due to hydraulic design and emitters discharge variation. The high correlation between qvar and Cv(H) justifies the use of the pressure compensating emitters for the micro-irrigation system design. The coefficient of variation of 5% increase in hydraulic design is affecting the flow in emitters by 10% for a maximum variation of 18% in hydraulic design leads to a maximum discharge variation of 38% in continuous flow drip system. From the Fig 3 measured Cv(H) values in the present study for all plots are less than 20%. However Wu (1997) reported that a Cv(H) value of not more than 30% could yield spatial uniformities greater than 80%, which are characteristic of a standard drip systems. Hence the present Cv(H) values indicate an acceptable performance of the drip irrigation systems.

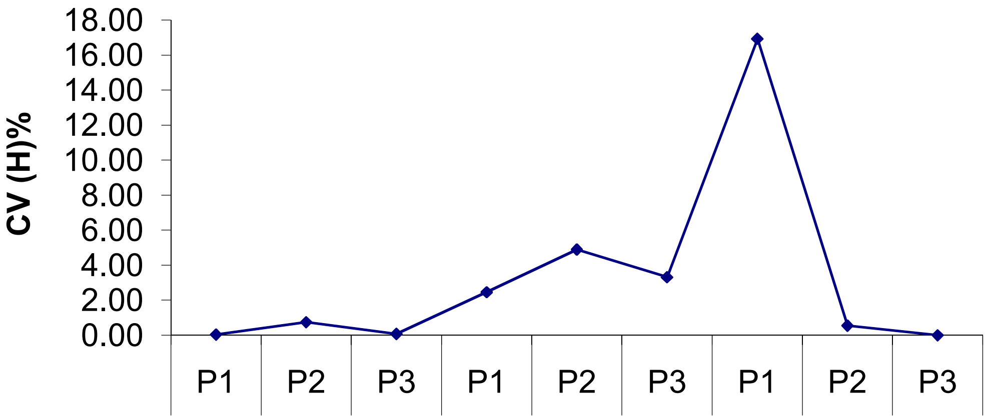

Figure 3 Coefficient of Variation of the Three Plots in Each of the Study Area With Respect to Hydraulic Design

Hydraulic Design and Manufacturer's Variation Cv(HM)

Figure. 4 shows that a micro-irrigation system can be designed hydraulically to maintain emitter flow uniformity within a range from 10% to 20% for the emitters flow variations (Wu and Gitlin, 1974). The variations are only about 0-7% in all the plots except plot No.1 of Nowshera (24.16%). The manufacturer's variation of emitter flow for micro-irrigation emitters already discussed is in a range 0-20%. The cumulative effects indicate that the effect of hydraulic design will be less significant in the case when the emitters have high manufacturer's variations. That is evident from the fig.10 for hydraulic design with discharge.

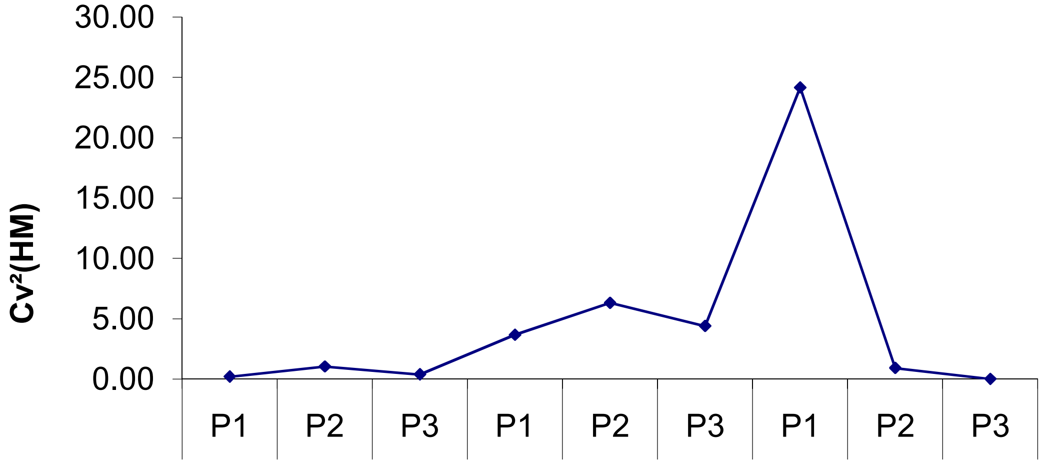

Figure 4. Coefficient of Variation of the Three Plots in Each of the Study Area With Respect to Manufacturer and Hydraulic Design

Variation Due to Grouping Cv(G)

Figure.5 shows that grouping variation of emitters flow is 0-4% in Charsadda and Malakand Agency farm. In plot No.1 of Nowshera farm group variation is 20.60% while in plot No.2 and 3 it is 0%. The group coefficient is affected by the amount of emitters flow rate which in this case remains uniform when distributed through a group of increased number of emitters instead of a single emitter. The manufacturer variation of up to 20% is in acceptable range which gives an excellent range of less than 5% as indicated by ASAE (1996). The increase as discussed before.

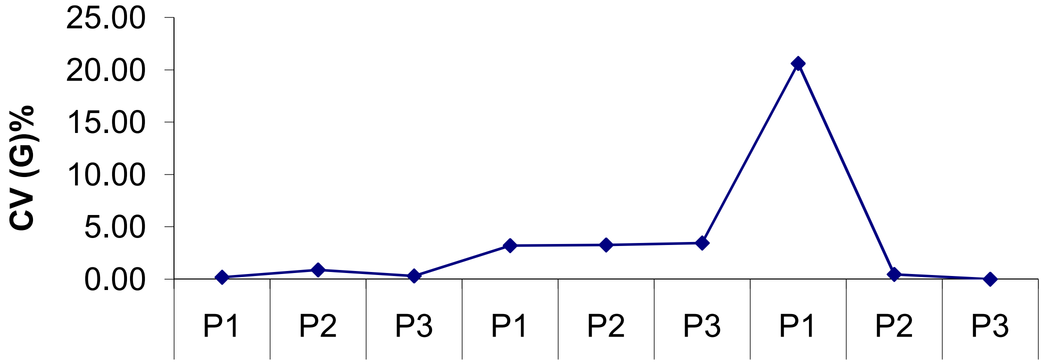

Figure 5 Coefficient of Variation of the Three Plots in Each of the Study Area With Respect to Grouping of Emitters.

Variation Due to Manufacturer, Hydraulic and Grouping Cv(HMG)

Figure.6 shows that the grouping effect total coefficient of variation caused by both hydraulic design and manufacturer's variation can be reduced if the emitters are grouped together in a unit (Wu et al., 1988a). Cv(HMG) from Fig. 6 shows that a change of Cv(HMG) is form 0 to1.02% in 3rd and 2nd plot of Nowshera farm. In plot No.1 it is 31.75%. This increase in plot No.1 is affecting all the parameters for assessment which is out of the acceptable range of 20%. In Charsadda and Malakand farms the overall effect of hydraulic, manufacturer and grouping is 0-7.11%.

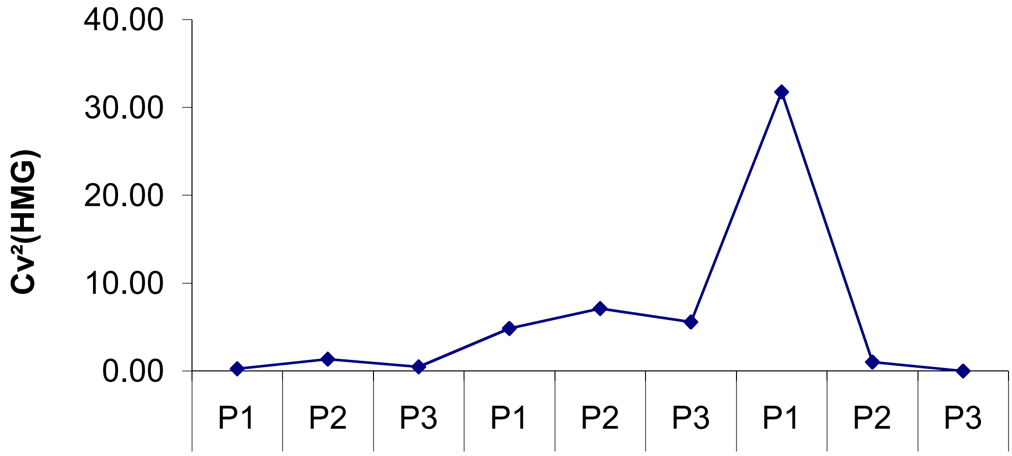

Figure 6 Coefficient of Variation of the Three Plots in Each of the Study Area With Respect to Hydraulic, Manufacturer and Grouping of Emitters

Variation Due to Plugging Cv(P)

No complete plugging has been identified anywhere in any system of the study area. All were just partial plugging. The level of partial plugging was reckoned by the degree of discharge reduction from each emitter. That the operational capacity is much satisfied as primary and secondary filtration units are concerned. The Cv(P) at 0% resulted from the partial plugging in all systems. The observation reported by Wu (1997) recorded that a 5-10% plugging could produce Cv(P) of 23-33%. This system has no plugging, which implies that the system is performing excellent.

Variation Due to Hydraulic, Manufacturer and Plugging Cv(HMP)

Figure.7 shows that the overall discharge coefficient of variation caused by hydraulic design, manufacture and plugging Cv(HMP) was evidently affected most by hydraulic and manufacture variation. The overall Cv(HMP) is maximum in Charsadda plot No.2 is 16.1%. However in plot No.3 and 4 these are1.8 and 0.6%. In Malakand and Nowshera farms these overall variation give negative values due to more variation in the level of plugging and Cv(HM). These values were considered to be zero. When the level of plugging gets increased and Cv(HM) decreased, the overall variation Cv(HMP) give negative value.

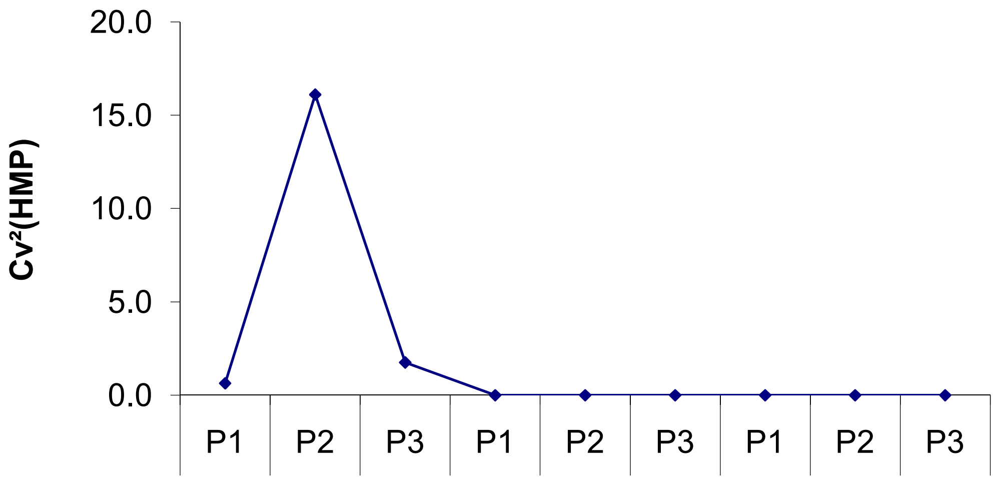

Figure 7 Coefficient of Variation of the Three Plots in Each of the Study Area With Respect to Hydraulic, Manufacturer and Plugging of Emitters

Conclusion

Based on the coefficient of variation criteria the systems' performance are regarded as excellent with respect to manufacture, global criteria while hydraulic, grouping and overall variations are within the safe limit. In plot no.1 at Nowshera all the parameters relating to manufacture, hydraulic and composite design of emitters were mismatching the required standard. However no plugging in all systems was observed due to 100% efficiency of best quality primary filters.The emission and statistical uniformities in general are from 96 to 100%. However these Low uniformities are 86.1% and 82.8% at Nowshera in plot No.1 of the study area.

References

ASAE, 1996. ASAE Standards engineering practices data. 43rd edition, MI, USA. 864.

Bralts, V.E. and C.D. Kesner. 1983. Drip irrigation field uniformity estimation. Transactions of the ASAE American Society of Agricultural Engineers. 26(5): 1369-1374.

Bralts, V.F., D.M. Edwards and C.D. Kesner. 1985. Field evaluation of drip-trickle irrigation submain units. Drip/trickle irrigation in action. I(1): 274-280.

FAO. 1997. Irrigation in the Near East region in figures, p. 188. Rome.

Frizzone, J. A. 1997. Uniformidade e eficiencia da irrigacao. Departmento de Engenharia Rurual, ESALQ, Serie didatica, piracicaba. 2-18.

Glay, M.A. and R.F. Zelenka. 1988. Economic variations in drip irrigation systems with different types of emitters. Proceedings 15th ICID European Regional Conference. No. 3, 45-54.

James, L. 1993. Principles of farm irrigation system design. Kriegner publishing company. USA. Chapter. 2. 86.

Sammis, T.W. and I.P. Wu. 1985. Effect of drip irrigation design and management on fruit trees yield. Transactions of the ASAE American Society of Agricultural Engineers. 28(3): 832-838.

Schwab, et al. 1992. Soil and water conservation engineering. John wiley and sons, Inc. Singapore. Chapter. 21. 462.

Wu, I. P. 1997. An assessment of hydraulic design of micro-irrigation systems. Agric. Water Manage.32(3):275-284.