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Performance Assessment of Existing Drips Irrigation Systems' Parameters (Uniformity, Efficiency and Adequacy Degree Installed In Selected Sites of Peshawar Valley

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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 uniformity, efficiency, adequacy and estimated design discharge by Dadex were compared with physical need based CROPWAT software estimation were evaluated. The emission uniformity in Charsadda farm range from 99.1 to 99.7%. In Malakand Agency farm it range between 96.1 to 97.9% while in Nowshera it range from 86.1 to 100%. Statistical uniformity calculated in Charsadda farm range from 99.3-99.8%. In Malakand Agency it is between 96 –97.3% and 82.8 to 100% in Nowshera farm. Application efficiency of drip system in Charsadda farm is between 88 to 100%. In Malakand it ranges from 67 to 83% while in Nowshera farm it is from 36 to 62%. The storage efficiency is maximum (80.3%) in Malakand Agency farm and minimum in Nowshera farm (24.9%). Charsadda farm has 62.5% average storage efficiency. Adequacy of irrigation having full irrigation of 2.4cm which is he desired depth of application. The adequacy of irrigation for the field in figure 21 is 52.5 percent, since 52.5 percent of the field receives the desired depth of application or more.

Keywords: Performance, Drip Irrigation, Application Efficiency, Uniformity, Statistical Uniformity, Coefficient of Global Variation.

INTRODUCTION

Water in Pakistan is a scarce resource and is available in inadequate amount to be optimally utilized. Hence there is a need to find other options of irrigation application methods to reduce the consumption of water for agricultural purposes. Most recommended strategies to avert an impending water crisis emphasis on increased irrigation efficiency is only possible to switch over from the traditional flooding method of irrigation to high efficiency irrigation system. The high efficiency irrigation system includes sprinkle and drip irrigation systems. Within the sphere of high efficiency and its applicability, the sprinkle irrigation system is not so preferred when compared to the highly efficient drip system. Although only about 1% of the total irrigated land (world wide) is currently under drip irrigation (Postel, 2003), but meanwhile considerable research has been conducted in this domain with much successes (Baqui and Angeles, 1994; Polak et al., 1997; Bissrat et al., 2001; Anon., 2002; Masimba, 2003). The assessment of an irrigation system aims to understand the system adequacy and determining the necessary procedures for improving the system performance. The assessment is always carried out soon after the system's establishment in the field, and then periodically repeated, especially when considering trickle irrigation systems, due to their sensitivity to operational conditions with the passage of time (Keller and Blisner, 1990). In an overall assessment, many aspects are taken into account, resulting, in a new project and system calculations, based on real rather than empirical data (Martín-Benito, 1993). 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).

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MATERIALS AND METHODS

Sites varying in soil types and crop grown were selected for studying the performance assessment of drip irrigation system, at Malakand, Charsadda and Nowshehra in Peshawar Valley, Pakistan. Irrigation uniformity of the systems was determined by means of three indices as follow:

a) **Emission Uniformity:** The emission uniformity as suggested by Keller and Karmeli (1974) is expressed in terms of the eq-11 as follow:

$$EU = \frac{\bar{q}_{25}}{\bar{q}} 100 \qquad 1$$

where EU is Emission uniformity (%), $\bar{q}_{25}$ is the average of the 25% lowest values of flow rate (l/h) and $\bar{q}$ is Average flow rates (l/h).

b) **Statistical Uniformity:** The statistical uniformity term was suggested by Wilcox and Swailes (1947) for the evaluation of sprinkling irrigation systems, with the emitters' precipitation as the random variable. Bralts et al. (1987) developed a similar statistical approximation for trickle irrigation systems, presenting the emitters' flow rate (q_i) or the volume (V_i) as the random variable, resulting in the following eq-12.

$$SU = \left(1 - \frac{S_q}{\bar{q}}\right) 100 \qquad 2$$

Where SU is Statistical uniformity (%) and S_q is Standard deviation of the emitters' flow rate (l/h).

c) **Coefficient of Global Variation:** It is measured during field tests, including hydraulic and manufacturing effects, and also those due to the clogging of the emitter. It is given by the eq-13.

$$CGV = \frac{S_q}{\bar{q}} 100 \qquad 3$$

Where CGV is Coefficient of global variation of the flow rate (%), S_q is Standard deviation of the emitters' flow rate (l/h) and $\bar{q}$ is Average flow rates (l/h).

Irrigation Efficiency

The irrigation efficiency has been evaluated through different approaches. In this study, the application efficiency (Ae), storage efficiency (Se), and adequacy degree (a) was used, assuming normal distribution of the data, according to the methodology described by Anyoji and Wu (1994).

Comparison of Routine Applied Irrigation to Different Design

For the assessment of design flow data at the start of the system is based on some assumptions from some typical areas. During the implementation of the system specific schedule is given on weekly or monthly basis. In order to confirm the design criteria of the applied system with other standards are CROPWAT computed estimation and need based practical or physical applications.

RESULTS AND DISCUSSION

Irrigation Uniformity and Efficiency of the Systems

The data on Emission and Statistical uniformities, Global variation, Application and Storage efficiencies and Adequacy degree has been analyzed which is presented below.

Emission Uniformity

Figure.1 shows that the emission uniformity recorded for the selected sites in Charsadda farm are ranging from 99.1 to 99.7%. In Malakand farm it is between 96.1 to 97.9% while it is range from 86.1% to 100% in plot No.1 and 3. The over all emission uniformity lies under the acceptable range is 90-95% for uniform and 85-90% for steep or undulating soil topography (ASAE) 1985. The reduced emission uniformity in plot No.1 of Nowshera farm is due to high variation in flow rates.

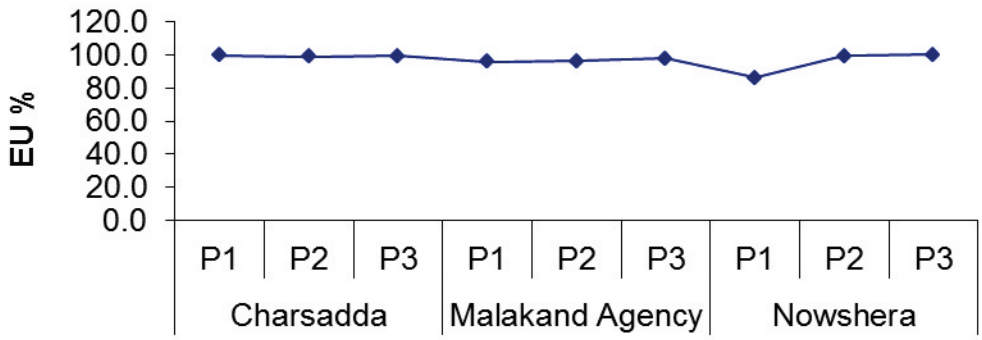

Figure 1 Emission Uniformity of Three Plots in Each of the Study Area

Statistical Uniformity

Figure.2 shows that statistical uniformity in Charsadda farm is in the range of 99.3 to 99.8%. In Malakand farm it is between 96 –97.3% and 82.8 to 100% in Nowshera farm. Statistical uniformity is the reverse of Cv of emitters flow rates, which lies under the excellent range given by ASAE, which is 95-100%. The reduced statistical uniformity in plot No.1 of Nowshera farm is under the average range of uniformity. The overall systems statistical uniformity is excellent according to ASAE standards.

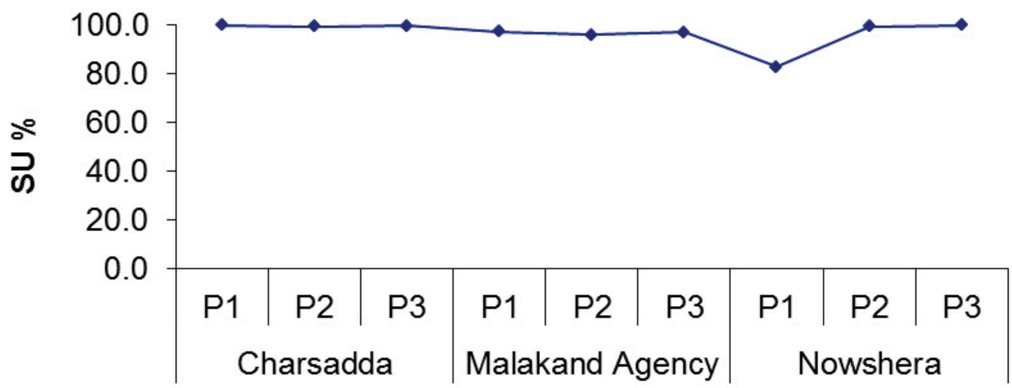

Figure 2 Statistical Uniformity of Emitter's Flow of Three Farms in Each of the Study Area

Coefficient of Global Variation

Figure.3 shows that the CGV and Cv parameters used for uniformity assessment are the same which shows uniformity of the drip systems. Theses parameters in the present case are excellent as per standard of ASAE. The over all global variation is below 5% except plot No.1 of Nowshera farm (17.2%) which is in the range of non acceptable limit.

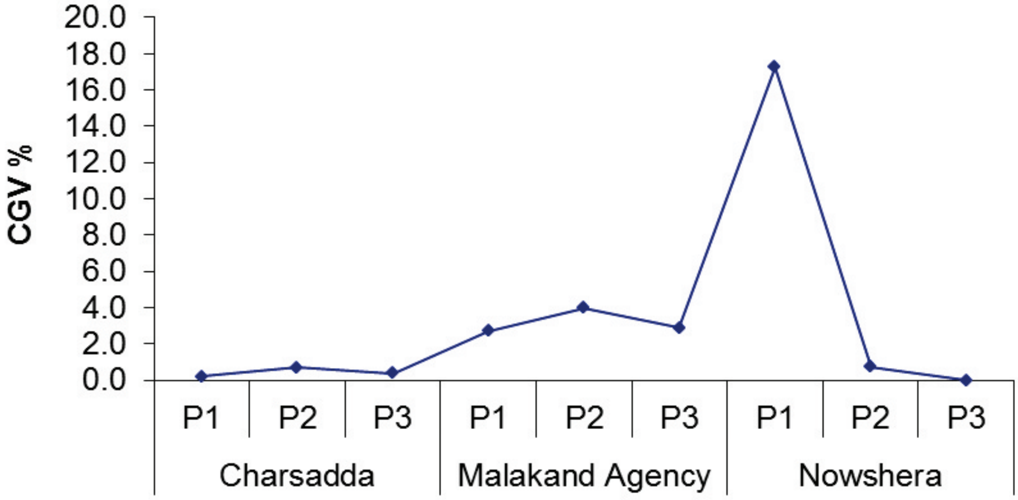

Figure 3 Coefficient of Global Variation of Three Plots in Each of the Study Area

Application Efficiency

Figure.4 shows that the application efficiency of drip system in the study area ranges from 88 to 100% in Charsadda Farm. In Malakand Agency Farm the application efficiency ranging from 67 to 83% while in Nowshera Farm it is from 36 to 62%. The minimum application efficiency is in Nowshera farm plot No.3 which is 36% and maximum is 100% in Charsadda farm plot No.2.

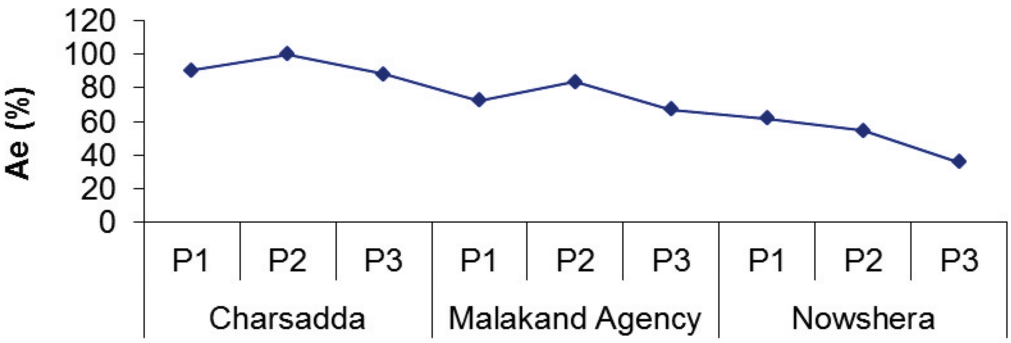

Figure 4 Application Efficiencies of Three Plots in Each of the Study Area

Storage Efficiency

Figure.5 shows that maximum (80.3%) storage efficiency is in Malakand Agency while minimum (24.9%) is in Nowshera farm. However Charsadda farm has 62.5% average storage efficiency. This depends upon the soil texture and root depth of tree. In Malakand Agency farm the soil is silt loam while Nowshera farm has mostly sandy loam, with lesser storage efficiency. But in Charsadda farm the soil is silty loam with an average efficiency.

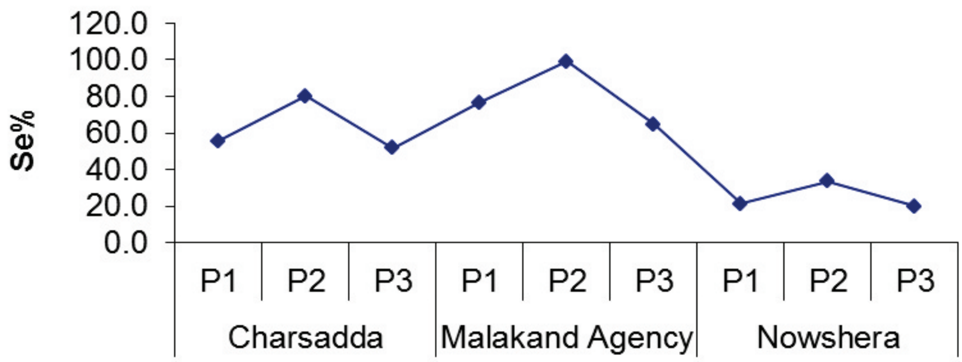

Figure 5 Storage Efficiencies of Three Plots in Each of the Study Area

Adequacy Degree

The adequacy degree of drip irrigation system is evaluated, using a cumulative frequency distribution like the one in figure 6. This figure shows the percent of the field (farm) receiving a given amount of water or more. The full irrigation is 2.4cm which is the desired depth of application. The adequacy of irrigation for the field in figure 21 is 52.5 percent, since 52.5 percent of the field receives the desired depth of application or more.

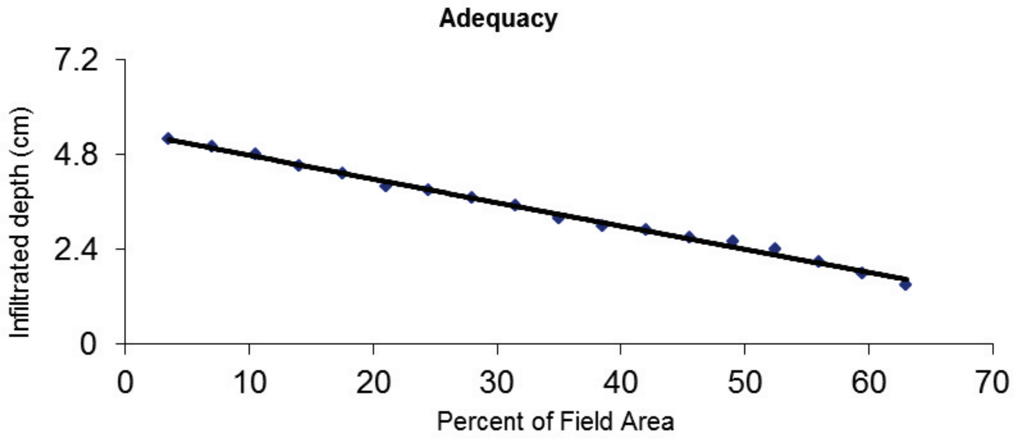

Figure 6 Cumulative Frequency Distribution Patters for Determining the Adequacy of Irrigation of All Three Farms and Their PloT

Monitoring of Routine Applied Data

During the study period the farmer routine was monitored in detail and the water applied by the farmer was calculated for study period. The designs of the drip irrigation systems selected for the study shows that these were poorly designed. During designing of the system for the given crops the estimated water requirement does not include the effective rain fall. This resulted in the over design of the drip irrigation system. For calculating water requirement the weather data is used for need based model design. Figure.7 shows the net irrigation requirement of Nowshera site proposed by the Need Based Model through CROPWAT computer software and the Farmer applied irrigation Water as per direction given by the Dadex. The results showed that Need Based irrigation requirements estimated through CROPWAT software from January to May are less as compared to two models. The Dadex and Farmer applications are nearly showing the same pattern due to the direction given by the firm for the operation of the system concerned.

During the month of May the irrigation requirements of all the three procedures of estimation of irrigation remained the same due to no rainfall in this month. As the rainfall during monsoon season starts, the distinct divergence comes into existence. In the month of July the farmer applied over irrigation than designed discharge by Dadex and CROPWAT. However in the month of August when no irrigation was needed at all, the farmer applied maximum discharge (2500 l/month). The similar was the application in the month of September with no rainfall factor to make a difference of Need Based Software and Dadex model. In the month of November and December the rainfall factor may be again the same reason as previously stated. The Dadex designed water requirement is 24653 l/year/plant, which according to the Need Based Model is 15306 l/year/plant while farmer applied 25549 l/year/plant. The net irrigation requirement of Malakand Agency site. The farmer application is absolutely highest ones than CROPWAT & Dadex model. However it is clear that net irrigation requirements are not as smoothly changing as estimated by Dadex.

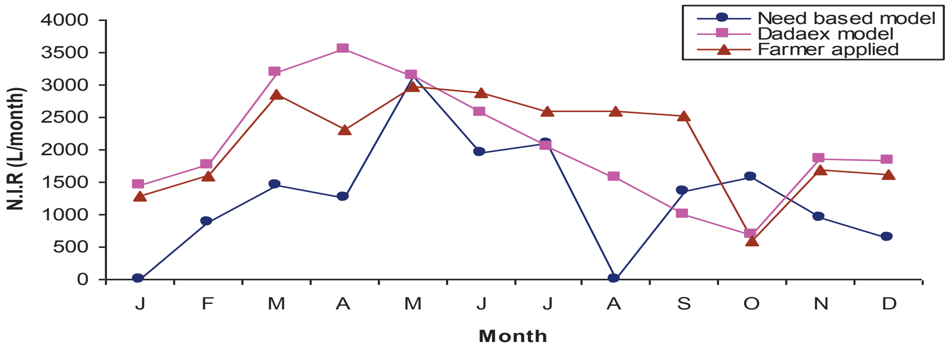

Figure 7 Showing Trends of Routine Applied Data with Respect to Dadex Design, Need Based and Farmer Applied Irrigation Volumes in l/month of Nowshera Study Area.

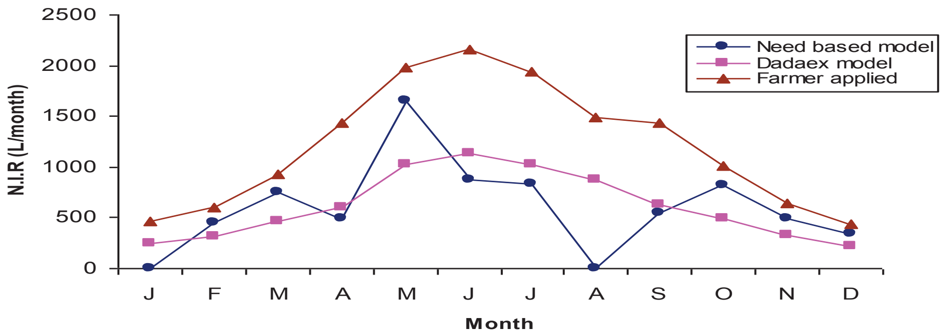

Figure 8 Showing Trends of Routine Applied Data with Respect to Dadex Design, Need Based and Farmer Applied Irrigation Volumes in l/month of Malakand Study Area

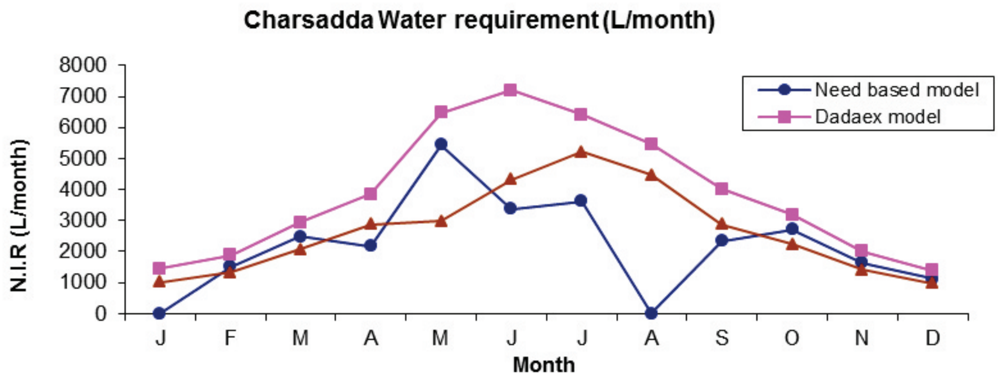

Figure 9 Showing Trends of Routine Applied Data with Respect to Dadex Design, Need Based and Farmer Applied Irrigation Volumes in L/Month

CONCLUSION

The Application efficiencies range from 50 to 85% while Storage Efficiency ranges from 19.8 to 99.2%.Adequacy of all three drip irrigation systems are 52.5%. In the drip irrigation systems of Nowshera and Charsadda 38% and 43% water can be saved with respect to design. However in the drip irrigation system of Malakand Agency the design is mostly perfect but the operation directed is 50% more than required. Adequacy of irrigation having full irrigation of 2.4cm which is he desired depth of application. The adequacy of irrigation for the field in figure 21 is 52.5 percent, since 52.5 percent of the field receives the desired depth of application or more.

REFRENCES

Anon, 2002. Affordable drip irrigation for small scale farmers. Communications of the Arid Lands Information Network (ALIN). ALIN(EA).

Polak, P., N. Bob and A. Deepak. 1997. A low Cost Drip Irrigation System for Small Farmers in Developing Countries. Journal of Applied Irrigation Science. 32(1), 105-112

Postel, L. Sandra. 2003. Securing water for people, crops, and ecosystems. New mindset and new priorities. The global water policy project. Vol. 27. U.N. 89-98.

Masimba, B. 2003. Drip Irrigation helps Smallholders. In: “African Farming and Food

Processing” July/August 2003 edition. (J. Phelan ed.). Alain Charles Publishing Ltd. London.

Martin _ Benito, J.M. T. 1993. La aplicacon del agua el riego Y Su evaluation. In: O.

Keller, J. and Bliesner, R.D. 1990. Sprinkle and trickle irrigation. Van Nostrand Reinhold, New York. 427-602

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

Keller, J., and D. Karmeli. 1974. Trickle irrigation design parameters. Transactions of the ASAE (American Society of Agricultural Engineers) 17(4): 678-684

Bralts, V.F. Edwards, D.M. and Wu, I. P. 1987. Drip irrigation design and evaluation based on the statistical uniformity concept. In: Hillel, D. (ed.). Advances in irrigation. Massachusetts: Academic press, Inc. Amherst. 67-117.

Wilcox, J. C. and Swailes, G.E. 1947. Uniformity of water distribution by some undertree orchard sprinklers. Scientific Agriculture, 27, 565-583.

Wu, I.P. and Gitlin, H.M. 1974. Drip irrigation design based on uniformity. Trans. ASAE, 17(3): 4299432.

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