Rehabilitation of Underutilized Sandy soils - Development of Micro irrigation Systems for Afforestation of Tin-tailings and Bris Soils*

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Introduction

Irrigation systems are well known for their low efficiencies. Efforts must be made to conserve water resources in view of a greater competition from domestic, industrial and other sectors of the economy. Since a micro irrigation system can achieve very high application efficiency, it should be further explored even for supplemental irrigation in a humid tropical country like Malaysia. Marginal sandy soils such as tin-tailings and bris soils can be developed for agriculture when provided with conducive environment to retain moisture and nutrients. A very successful technique is through micro-irrigation systems and fertigation where irrigation water is applied together with fertilisers. Malaysia has a large area under ex-tin mining and bris soils. A subsurface micro-irrigation system which saves water that otherwise would be lost through evaporation is ideal for resource conservation. Continuous application of water and nutrients via a pressurised irrigation system will ensure a very conducive environment for crop growth in sandy soils. Subsurface micro-irrigation systems have been tried in arid areas with considerable water saving.

Porous pipes are being used for several installations such as on the surface, under plastic, buried, in straight lines, winding, and following specific shapes for trees or potted plants, whether in green houses, flower beds with lawns, trees, plant nurseries and fruit trees or other plantations. The investment cost for porous pipe may be high compared to other irrigation systems. However the advantages as claimed by the manufacturers such as an increased water use efficiency, a continuous wetted strip, and less weed growth due to dry soil surface for subsurface application give a good reason why subsurface porous pipe irrigation is worth considering. However very little information is available about the discharge uniformity and operating characteristics of porous pipe irrigation laterals especially for Malaysian soil conditions. The research was carried out with the following objectives: To study the performance of two types of porous pipes as a micro-irrigation lateral line; to study the moisture distribution pattern of a subsurface micro-irrigation lateral in sandy soil; and to develop an integrated computer aided design tool for micro-irrigation systems.

Materials and Methods

An experimental set-up was constructed at the Engineering Faculty UPM Irrigation and Drainage Laboratory. The performance of the selected irrigation system was evaluated to determine the hydraulic characteristics of two types of porous pipes, one made from recycled rubber tyres and the other a geotextile hose. One manufacturer of a porous pipe claims that their porous pipe or "CT12-poritex exudating hose" is a special and unique type of micro irrigation component manufactured from plastic material made into woven plastic, which acts as a conduit and emitter. They claim that any debris trapped in the hose can be easily flushed by simply removing the end plug. Thus this property makes "poritex" suitable for use with dirty irrigation water. They also claim that the porous pipe can last 8 years with minimal sign of deterioration after more than 5 years in the field (Creaciones Tecnicas, 1995). The normal operating pressure is from 20 to 80 kPa or 2-8 metres of water column. Another type of porous pipe known as "precision porous pipe", soaker hose or leaky hose is made from recycled rubber and polyethylene (2/3 recycled rubber and 1/3 polyethylene). It is an extruded membrane that allows water to pass through the pores of the wall even at very low pressure. The tiny pores are made automatically during the manufacturing process. Irrigation is localised in a wetted strip whether it is buried or laid on the ground surface (Precision Porous Pipe). Several lengths of the imported porous pipes were subjected to various upstream pressure inputs to determine the average discharge along the lateral and the associated pressure losses due to pipe friction. The pressure-discharge relationships were obtained to seek design data for use in the porous pipe micro-irrigation lateral design work. The soil moisture distribution pattern was studied in a sandy soil media. Samples of tin-tailing soil from around UPM campus were collected and brought back to the laboratory. A soil bin measuring 2m X 2m X 2m was constructed to observe the moisture distribution pattern from the porous pipes buried at 30 cm depth in the sandy tin-tailing soil. The computer program for the design tool was written in Visual Basic (version 6.0) and it runs in Windows environment. A user-friendly interface is provided to give more flexibility to the user. This program uses menu bar and toolbar, which takes the user to all data entry and results dialogs. Additionally, it was designed for an extensive use of tables and graphics.

Results and Discussion

The discharge from the porous pipes was found to be highly pressure sensitive with discharge exponents between 1.0 and 1.5. This means a large variation in discharge was caused by a small variation in pressure along the lateral as a result of hydraulics or elevation differences. The emitter flow from the "precision" porous pipe was found to be highly sensitive to pressure with discharge exponent ranging from 0.93 to 1.04. The discharge exponent x increases as the length decreases. This means that the standard design procedure of 10% discharge variation allows only 10% pressure variation in the lateral. Consequently this will result in only a short lateral length for a high degree of irrigation uniformity. A comparison was made between the "precision" and "poritex" porous pipe. The values for the "poritex" porous pipes range from 1.07 to 1.67 (Amin, et al., 1998). This shows that the thicker "precision" porous pipe gives less variable discharge with changes in pressure head as compared to the thinner geotextile "poritex" pipe. The most likely explanation is that the pores at the pipe wall expand or enlarge together with the increasing pipe diameter as the pressure increases. The pores of the thinner geotextile pipe expand more than those in the thicker rubber porous pipe.

Results showed that good irrigation uniformity in a 200 m long lateral line is obtained only with a very low average discharge (~ 1L/h/m) from the available sizes of porous pipes. For larger flow rates, bigger pipe sizes need to be manufactured. The discharge from the shorter porous pipes was higher than the longer pipe at the same pressure head. At 10 m inlet head, the total discharge could be as high as 320 L/h for a pipe length of 150 m, and 200 L/h for 60 m length. Considering the spatial uniformity of outflows along the length to be kept say ± 10 % of the mean value, then (with the discharge exponent in the H-Q relationship in excess of 1.5 for short lengths of porous pipe) the pressure variation along the pipe must be limited to ± 7%. This is equivalent to limiting the head loss to about 14 % of the inlet pressure. This criterion allows designers to specify upper limits of lengths and discharge above which the performance of a porous pipe lateral will be unacceptable.

To simplify the use of the H-q curves, graphs were developed to show the average discharge versus pipe length for various pressure heads. It was found that the H-Q power function provided the best fit. These curves make design work easier for landscaping, orchards or row crops since the average design discharge was easily determined for any length of the porous pipe with a certain inlet pressure head. However for high irrigation uniformity, designers should be guided by the allowable head loss for the lateral.

The moisture distribution from a porous pipe buried in a sandy medium was very limited. Installation of an impervious trough underneath the lateral could increase the wetted strip by as much as 50 percent. For the sandy tin-tailing soil, larger wetted strip was more economically obtained by laying two pipelines than having an impermeable trough buried underneath the lateral line. Future studies involving field trials could confirm the usefulness of porous pipe irrigation lateral line made from recycled rubber tyres. An attempt to use it as a subsurface drainage material was not successful due to the very tiny pores at the pipe wall. Local manufacturers need to be convinced to manufacture various sizes of the porous pipe made from recycled rubber tyres for various applications.

The developed computer program is divided into two integrated models, one for planning, and the other for designing. The main features of the planning model are the computation of crop reference evapotranspiration from available climatic data using FAO Penman-Monteith method, computation of crop water requirement during the whole crop-growing season and the estimation of irrigation requirement. All data input and the obtained results can be displayed in tabular or graphical forms. The microirrigation system design model is capable of performing analysis of either a lateral or a submain unit. Emitter flow along a lateral or in a submain unit can be calculated. The maximum and minimum emitter flows and their locations can be determined. Emitter flow variation and pressure variation along a lateral or in a submain unit are computed. Tables and graphics were also provided, and the overall laterals' layout and emitter flow profile could be displayed on the screen. The developed program is considered as a tool for preliminary design of microirrigation systems.

Conclusions

The discharge from the porous pipes was found to be highly sensitive to pressure variations with discharge exponents between 1.0 and 1.5. Good irrigation uniformity in a long lateral line is obtained only with a very low average discharge (~ 1L/h/m). For larger flow rates, bigger pipe sizes need to be manufactured. The moisture distribution from porous pipes discharge in a sandy soil is a very narrow wetted strip. A wider wetted strip is more economically obtained by laying two pipelines than by having an impermeable trough buried underneath the lateral lines. A continuation of the project with field scale trials in drought-prone oil palm plantations, and fruit orchards on bris soils or tin-tailing areas will be useful. However fertigation must be included and larger porous pipe sizes from recycled rubber should be manufactured. The developed integrated computer program for planning and designing is user-friendly. Micro-irrigation sub-main unit is designed based on computations of irrigation water requirement. Emitter flow variation and pressure variation along a lateral or in a submain unit are computed, and the overall laterals' layout and emitter flow profile can be displayed on the screen.

Benefits from the study

An increase of agricultural production from sandy areas is possible when provided with an irrigation infrastructure with fertigation. Using porous pipes for high value crops grown in marginal soils or drought prone areas can bring abandoned land or underutilised sandy areas into productive agricultural land. More efficient use of water and fertiliser in crop production is achieved. Complete reduction of evaporation loss from irrigation water is possible unlike watering by sprinklers or other surface methods. Pollution reduction by reducing contamination of groundwater from heavy fertiliser input or reducing fertiliser runoff into the drainage system (rivers, lakes, etc) otherwise causing eutrophication. Recycling of old rubber tyres will reduce environmental pollution caused by used vehicle tyres. The beneficiaries of this project are oil palm plantations, fruit orchards and vegetable plots with sandy soils. Manufacturer of porous pipes can expect wider usage of this pipe when properly sized and priced. Micro-irrigation design engineers can use the MICROPRO computer program to ease their planning and design work.

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