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Research Paper :

Development of software design of drip irrigation system

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ABSTRACT

Drip irrigation is the application of controlled quantity of water and nutrients in the vicinity of each plant such that the crop water and nutrients needs are almost matched with irrigation water supplies. There are large number of consideration, which must be taken into account in the design of micro irrigation system including field topography, soil type, crop to be grown, weather condition, availability of labour, energy, available technology and financial resources. Drip irrigating software provides interaction at all stages of the design process and a solution based on individuals own capabilities and the information base available within the software. The individual not only can suit to his requirements but can also compare his design with several other alternate designs resulting from the application of the software with different possible inputs. This software will provide tools that can help farmers, industrialist, marketing executive, extension specialist and researchers who design drip irrigation system. The software has been tested at developer's level. Results obtained using software was compared with on-paper calculation and the results were found satisfactory.

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Key words : Design, Drip irrigation system, Software

Water is a precious natural resource, a basic human need and a prime national asset. The extent to which water is plentiful or scarce, clean or polluted, beneficial or destructive, profoundly influence the extent and quality of human life. Rapid development of human civilization and advances of scientific and technological innovations are changing the condition of life on earth, giving rise to basic transformations of the environment. The relentless increase in population and the resulting spurt in the demand for water require careful planning and management of the limited water resources. In India, the growth of population is about 2% per year. It is essential that food production should increase about 2.5% per year to provide a better food intake.

Drip irrigation is one of the latest methods of irrigation, which is becoming increasingly popular in areas having water scarcity and moderate salt problems. In micro irrigation, water is directly applied to the root zone of plants and it permits the irrigator to apply the volume of water closely matching the consumptive use of plant. Design of micro irrigation system depends on several parameter including topography, soil type, crop to be irrigated, weather conditions, technological and financial resources. Different criteria are available for designing the drip irrigation system for widely spaced row crops such as orchard and vegetables for supplying the water to individual plants with the help of a single or a set of dripper based on their rooting pattern and canopy area. In this situation, there is no need to apply water to the entire land area and laterals are generally spaced along the plant rows. For closely spaced field crops, the entire land area needs to be wetted and the drip irrigation system needs to be designed on the basis of meeting the water requirement of the total cultivated area. To overcome this problem the project of development of software for drip irrigation system was carried out.

METHODOLOGY

This chapter deals with the methodology used to design drip irrigation system. It includes different formulae and theoretical consideration those are used while developing the software. It also encapsulates the configuration of the system and information about the language used to develop software.

Configuration of the systems:

Notebook System
Intel® Centrino Duo®, 1.66GHz
512 MB DDR SD- RAM
TOSHIBA® 60 GB &@)) rpm Hard disk

Intel® 82801GBM (ICH-M) LPC interface Controller-27B9 Series Motherboard

Intel Graphics Media Accelerator driver for mobile

Microsoft® Windows™ XP Home edition version 2002 Service Pack 2

Microsoft® Visual Basic 6.0 (SP6) Enterprise Edition for 32-bit Windows Development

Microsoft® Access 2000 (9.0.2720)

About the platform :

The software for design of drip irrigation system was developed using Microsoft Visual Basic 6.0 Enterprise edition with Service pack 6, for 32-bit Windows Development and Microsoft Access 2000 (9.0.2720) for backend.

Design of drip irrigation system :

Following parameters were computed while designing of an irrigation system by the developed software

Estimation of crop water requirement :

As the first step in the proper design of irrigation system, it is necessary to know the crop water requirement. In general the term crop water requirement is equivalent to the rate of evapotranspiration, necessary to sustain optimum crop growth.

The accuracy of determination of crop water requirement largely depends upon availability of climatic data records. Water requirement can be calculated by following formula:

$$\text{Peak water requirement} = \frac{(A \times B \times C \times D)}{E}$$

where,

A – Potential evapotranspiration rate (mm/day)

B – Crop factor (depends on growth stage and foliage cover)

$$\text{C – Canopy Factor } \textit{i.e.} \quad \frac{\text{Area of plant shadow at 12 noon}}{\text{Plant spacing} \times \text{Row spacing}}$$

D – Area provided to plant (sq. meter)

E – Efficiency of system (drip irrigation - 90%)

Friction loss equation:

Both Darcy Weisbach equation for pipe flows and the William-Hazen empirical equation can be used to determine the friction drop along the lateral line and submain. In general, the friction drop equation for pipe flow as,

$$\Delta H = K\,(Q/C)^{1.852} \times D^{-4.871} \times L \times F$$

where,

ΔH- The head loss in pipe, m

K - Constant, 1.21×10^{10}

Q - The flow rate in the pipe, l/sec

C - The friction coefficient for continuous section of the pipe and depends on the pipe material

D - The inside diameter, mm

F - The outlet factor

L - The length of pipe, m

Selection of drippers :

The selection of drippers types and number of drippers per plant is depends on peak water requirement of the crop and the infiltration rate of the soil (soil texture). The emitter must supply enough water to the plant root zone to meet the crop water requirement. Normally 1/3rd to as much as 3/4th of the plant rooting volume should be supplied with adequate water. The larger the percentage of wetted rooting volume becomes relative to the total volume, the safer the design becomes. This allows for temporarily system breakdown, salinity problems and conversion from surface irrigation to drip irrigation on mature orchards. However, if the percentage wetted area becomes too large, many of the advantages of drip irrigation are lost. The wetted soil volume depends on emitter flow rate, irrigation duration and emitter spacing and soil type.

Selection and design of lateral :

Lateral carries water from sub main and feeds to the individual drippers. Generally, one lateral for each row or orchard plant and lateral for two rows of sugarcane or vegetables is used. The size and length of the lateral is decided by the discharge of the drippers and number of dripper on one lateral. The laterals are small diameter flexible pipes or tubes made up of low- density polyethylene (LDPE) or linear low-density polyethylene (LLDPE) of 12mm, 16mm and 20mm diameter. Their colour is black to avoid the algae growth and the effect of ultraviolet radiation. They can withstand the maximum pressure of 2.5 to 4 kg/cm^2. They are connected to the submain by using grommet and take off as per row spacing of the crop. On sloping ground the lateral are placed along the contour with 1% extra length for sagging purpose.

Selection and design of submain :

Submain is generally made up of PVC (poly vinyl chloride) pipes of 32mm, 40mm, 50mm, 63mm and 75mm in diameter.

The design of submain is based on both capacity and uniformity. Capacity means the submain size should

be large enough to deliver the required amount of water to irrigate the subsequent part of the field. Uniformity means the submain should be design to maintain an allowable pressure variation, so that flow into all lateral lines taking from it will have little variation.

Submain supplies water to individual lateral. Design of submain is similar to that of lateral; however it differs in that the spacing between outlets is greater and larger flow rates are involved. The size and length of submain is determined by number of laterals and distance between the laterals.

Usually in a plain field, the position of the submain should be located at the center of the plot. On sloping field, the lateral line should be laid along the contour and the submain along the slope, as far as possible.

Selection and design of mainline :

Generally the size of mainline is one size higher than submain. The size of the main line is decided by flow rate of the entire submain. The sizes of mainline are 40mm, 50mm, 63mm, 75mm, 90mm and 110mm etc.

Selection of pump :

Undermetioned formula is used;

Total Head of Pump = suction head + delivery head + filter losses + mainline loss + operating pressure + fitting loss + ventury head loss + elevation difference

Filter losses are assumed to be 2 m for screen filter (disc filter) and 2 m for sand filter

Operating pressure is about 1 kg/cm^2 (10 m.)

Fitting loss = 2 m

Ventury head loss = 5 m.

Required HP for the pump is calculated as-

$$H.P. = \frac{Q \times H}{75 \times a \times b}$$

where,

Q - The maximum flow rate of system, l/sec

H - The total head of the system, m

a - The motor efficiency, generally taken as 80%

b - The pump efficiency, generally taken as 75%

H.P.- The Horse Power.

RESULTS AND DISCUSSION

Software includes following steps for design of drip irrigation system

- Calculation of water requirement
- Selection of dripper
- Selection and design of lateral
- Selection and design of submain
- Selection and design of mainline
- Selection of pump
- Details of dimensions

For these steps the seven different forms are designed as shown in Fig. 1 to 7.

Crop water requirement form:

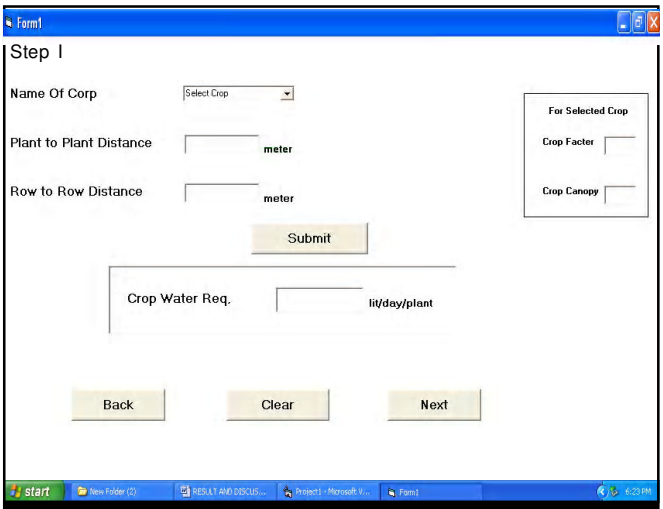

Fig. 1 : Crop Water requirement

How to use:

- Select the desired crop from the available crops in combo box.
- Enter plant to plant and row to row distance in meter.
- Click on Submit button to get crop water requirement in l/plant/day.
- The massage will display "This crop water requirement at maximum evapotranspiration rate and at higher maturity stage of crop."
- Click on Next >> button to get next form.

Selection of dripper form:

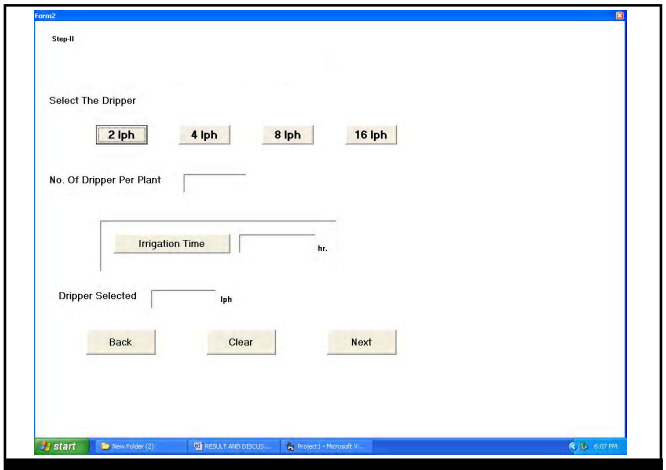

Fig. 2 : Selection of Dripper

How to use:

- Select the Dripper from the available list of dripper sizes *viz.,* 2 lph, 4 lph, 8 lph, 16 lph.
- Select the number of drippers per plant which are required.
- Click on Submit button to get irrigation time in hour.
- Click on Next >> button to get next form.
- To go to previous form click on <<Back button

Selection and design of lateral form:

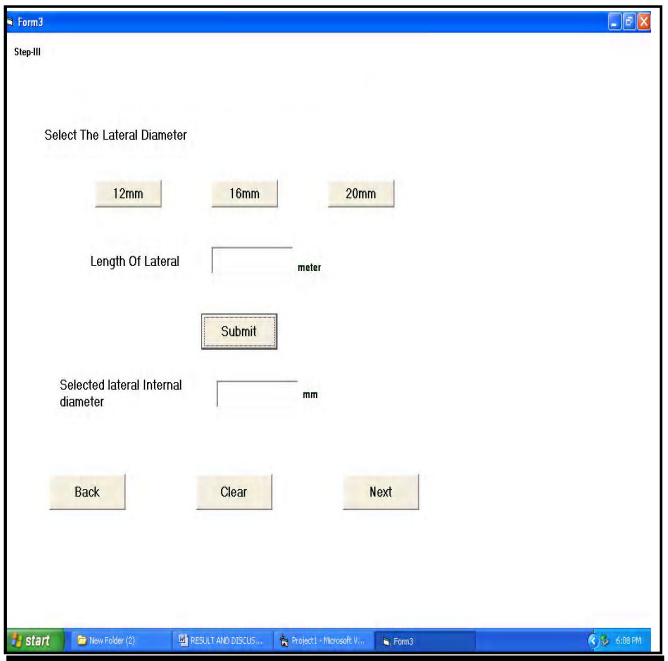

Fig. 3 : Selection of Design of Lateral

How to use:

- Select the lateral diameter from the available list *viz.,* 12mm, 16 mm, 20 mm.
- Enter the length lateral to be required in meter.
- Click on Submit button, if lateral fraction head loss is less than 2 meter then massage box will show "Your selected lateral size is good, the calculated head loss is sufficient to carry the flow, go to next." Otherwise massage box will display "your selected lateral size is wrong, the calculated head loss is not sufficient to carry the flow, change the diameter."
- Text box below shows the selected internal diameter of the lateral.
- Click on Next >> button to get next form.
- To go to previous form click on <<Back button

Selection and design of submain form:

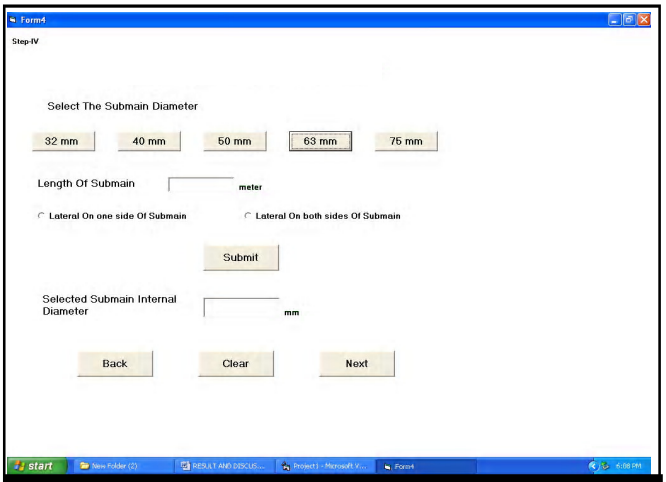

Fig. 4 : Selection and Design of Submain

How to use:

- Select the submain diameter from the available list *viz.,* 32mm, 40mm, 50mm, 63mm, 75mm.
- Enter the length submain to be required in meter.
- Select the lateral either on one side of submain or on two side of submain.
- Click on Submit button, if lateral friction head loss is less than 2 meter then massage box will show "Your selected submain size is good, the calculated head loss is sufficient to carry the flow, go to next." Otherwise massage box will display "your selected submain size is wrong, the calculated head loss is not sufficient to carry the flow, change the diameter."
- Text box below shows the selected internal diameter of the submain.
- Click on Next >> button to get next form.
- To go to previous form click on <<Back button

Selection and design of mainline form:

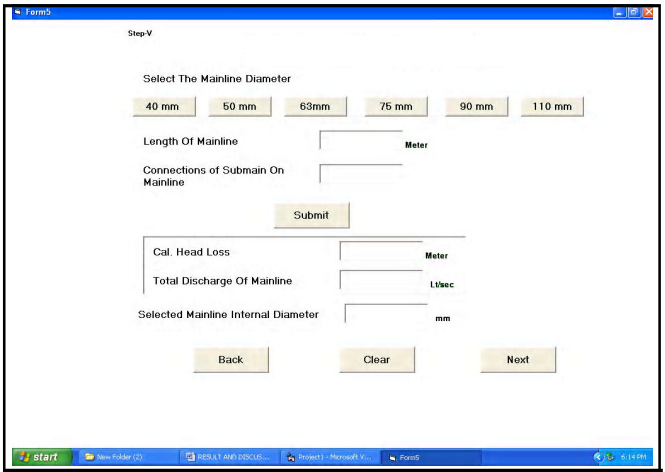

Fig. 5 : Selection and Design of Mainline

How to use:

– Select the mainline diameter from the available list viz. 40mm, 50mm, 63mm, 75mm, 90mm, 110mm.

– Enter the length mainline to be required in meter.

– Enter the number of connections of submain on mainline.

– Click on Submit button, if lateral friction head loss is less than 4 meter then message box will show "Your selected mainline size is good, the calculated head loss is sufficient to carry the flow, go to next." Otherwise massage box will display "your selected mainline size is wrong, the calculated head loss is not sufficient to carry the flow, change the diameter."

– Text box below shows the calculated head loss in meter and selected internal diameter of the mainline.

– Click on Next >> button to get next form.

– To go to previous form click on <<Back button

Selection of pump form:

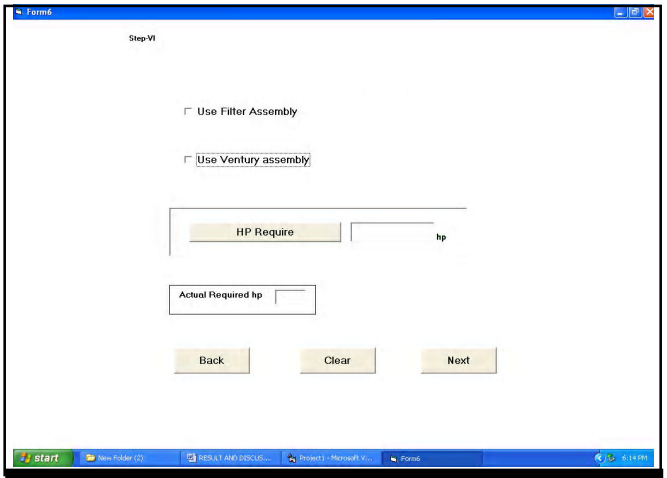

Fig. 6 : Selection of Pump

How to use:

– Select the use of filter assembly or/and use of ventury assembly.

– Click on the button "HP Required", which will show the motor size to be required for the system.

– To go to previous form click on <<Back button.

– Click on Next >> button to get next form.

Your drip irrigation system design form:

How to use:

– Click on label 'Your Drip Irrigation System Design' will show the all design parameters on screen.

– Click on print button will print the paper copy of design details for the drip irrigation system.

– Clicking on clear button will delete all the values of design details form.

– To go to previous form click on <<Back button.

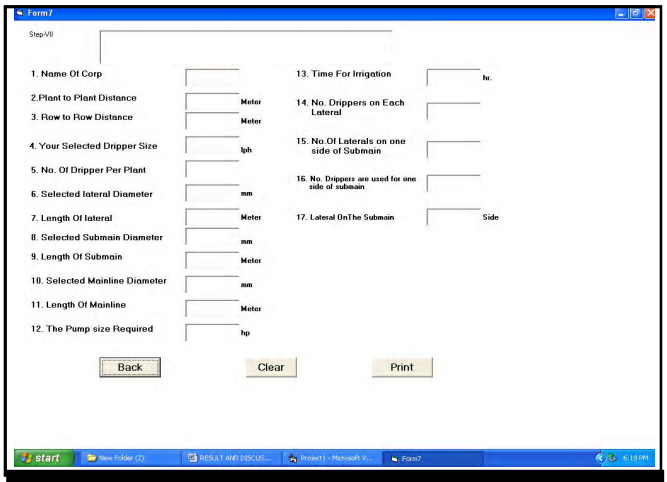

Fig. 7 : Your Drip Irrigation System Design

Rajput and Patel (2003) developed a software designing drip irrigation system at I.A.R.I., New Delhi.

Conclusion:

– The software was developed to design of drip irrigation system, with taking onto calculation of crop water requirement, friction head loss of main line and operating pressure of system, which are very important for drip irrigation system design.

– The software was developed in a way not to accept any incorrect information.

– Facility to crop canopy and crop factor was provided with software. Thus it can be used for calculating crop water requirement of any crop.

– Design of system obtained by software was tested with on-paper calculation at developer's level and results were found satisfactory.

– Minimum input are provided to software and tested to size of laterals, sub mains and main lines with their lengths and friction head loss.

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