APPENDIX - I

DESIGN OF ITK MIS AND MIS

Data Collection

Following data were used to design ITK MIS & MIS for summer groundnut and Cauliflower

Table I-1: Data for the Design of ITK MIS & MIS

Crop:	Summer groundnut	Cauliflower
Field size, m x m	100 x 100	100 x 100
Infiltration rate, mm/hr	14	14
Row spacing, m	0.45	0.45
Crop spacing,m	0.15	0.60
Reference crop evapotranspiration,ETo mm/day	6.34	4.64
Crop coefficient, Kc	1.11	0.95
Field application efficiency, %	98	98

Design of ITK MIS

Crop: Summer groundnut

Crop water requirement

Net Irrigation depth, NI = ETc ... ... (1)

where,

ETc = Crop Evapotranspiration rate, mm/day

Max Evapotranspiration Rate, ETc = Kc x ETo ... ... (2)

where,

ETo = reference crop evapotranspiration, mm/day

Kc = crop coefficient

ETc = 1.11x 6.3
= 7.04 mm/day

Gross Irrigation Depth, (GID) = ETc / Ea ... ... (3)

where,

Ea = application efficiency

Assuming application efficiency of system (Ea) = 98 %

GID = 7.04 / 0.98
= 7.18 mm/day

Microtube spacing, Sm = 0.9 $(q_i / i)^{0.5}$ ... ... (4)

where,

i = infilteration rate , mm/hr

q_i = microtube discharge, lph

considering discharge of microtube , q_i = 6 lph

Average infiltration rate, i = 14 mm/hr

Sm = 0.9 $(6 / 14)^{0.5}$
= 0.589 m
Say 0.60 m

Operation time

Operation Time for the summer groundnut is calculated as follow;

$$T = \frac{\text{Volume of water required to meet crop water requirement}}{\text{Microtube discharge}}$$

$$= \frac{\dfrac{ETc}{Ea} \; \dfrac{0.90\ (q_i / i)\text{^}0.5 \;\; Sm \cdot Sl}{Sl}}{q_i} \quad \ldots \quad \ldots \quad (5)$$

where,

Sl = lateral spacing ,m

T = (((7.18 x 0.9 x ((6/14)^0.5) x 0.6 x 0.45)/0.45)/6)
= 0.423 hr
= 25.38 min
Say 26 min

Number of sets

Considering the energy scenario in rural india it can be assumed that power is available for 12 hrs. Therefore,

No. of sets = power available (hr) / operation time

= 12 / 0.423

= 28.36

Say 28 nos.

Crop : Cauliflower

Net Irrigation depth, NI = ETc ... ... (6)

where,

ETc = Crop Evapotranspiration rate, mm/day

Max Evapotranspiration Rate,

ETc = Kc x ETo ... ... (7)

where,

ETo = reference crop evapotranspiration, mm/day

Kc = crop coefficient

ETc = 0.95 x 4.64

=4.408 mm/day

Gross Irrigation Depth, (GID) = ETc / Ea ... ... (8)

where,

Ea = application efficiency

Assuming application efficiency of system (Ea) = 98 %

GID = 4.408 / 0.98
= 4.497 mm/day

Microtube spacing $Sm = 0.9 (q_i / i)^{0.5}$ ... ... (9)

where,

i = infilteration rate , mm/hr

q_i = microtube discharge, lph

Assuming discharge (q_i) of microtube = 6 lph

$Sm = 0.9\ (6 / 14)^{0.5}$

$= 0.589$ m

Say 0.60 m

Operation time

Operation Time for the row cops are calculated as follow;

$$T = \frac{\text{Volume of water required to meet crop water requirement}}{\text{Microtube discharge}}$$

$$= \frac{\dfrac{ETc}{Ea}\ \dfrac{0.90\ (q_i / i)^{0.5}\ Sm\ Sl}{Sl}}{q_i} \quad \dots \quad \dots \quad (10)$$

where,

Sl = lateral spacing ,m

T = (((4.497 x 0.9 x ((6/14)^0.5) x 0.6 x 0.45)/0.45)/6)

= 0.265 hr
= 15.9 min
Say 16 min

Number of sets

Considering the energy scenario in rural india it can be assumed that power is available for 12 hrs. Therefore,

No. of sets = power available (hr) / operation time

= 12 / 0.265

= 45.28

Say 44

Though operation time and no. of sets for summer groundnut and cauliflower are different selecting the same number of sets. i.e. 20, the remaining design of ITK MIS is same for both the crops.

Layout and design

Fig 6.1 shows the ITK MIS layout for summer groundnut and cauliflower.

As shown in fig 6.1, field of 100 x 100 m is divided into 20 sets of each 10 m x 25 m.

Length of lateral = 10 m

Length of manifold = 25 m

Length of blind pipe = 75 m

Length of main = 90 m

Design of Lateral :

Assuming diameter of lateral, D = 20 mm

Thickness of lateral, tk

= (D / 15) + 0.55 mm

= (20 / 15) + 0.55

= 1.35 mm

Hence internal diameter (D_i),

= D_i - (2 x tk)

= 20 – (2 x 1.35)

= 16.23 mm

=0.01623 m

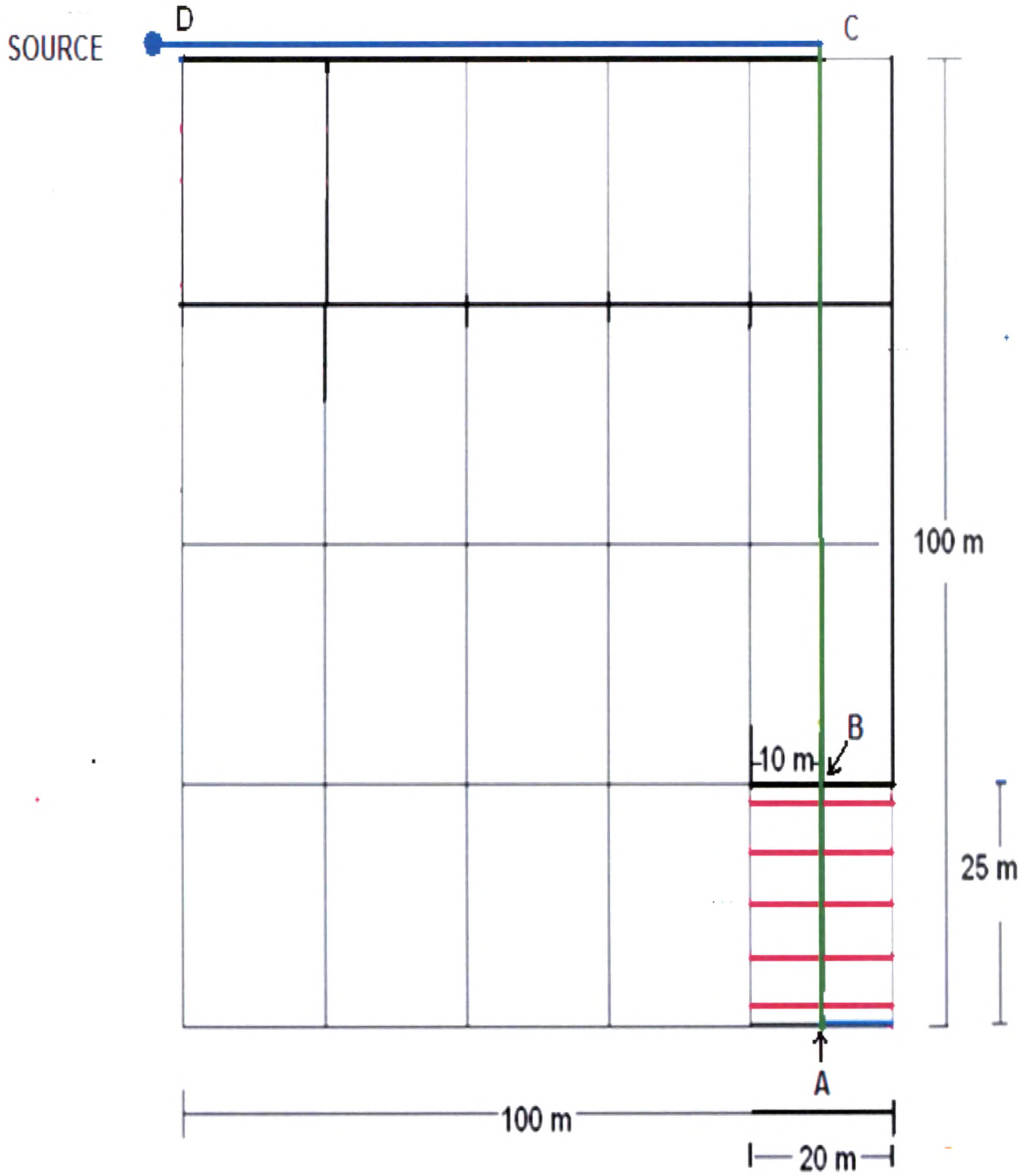

Fig.I-1: ITK MIS layout for summer groundnut and cauliflower

Legends:

Lateral, 20 mm diamter

Source

Manifold, 63 mm diameter

Main, 63 mm diameter

Length of lateral = 10 m

Assuming one lateral will serve 4 rows of crop.

Microtube spacing = 0.592 m

Say 0.6 m

No of microtubes per row of crop ,

= length of lateral / microtube spacing

= 10 / 0.6

= 16.86

Say 18

Discharge of one lateral,

= no of rows served by lateral x no of microtubes per row of Crop x discharge of one microtube

= 4 x 18 x 6 lph

= 432 lph

= 0.00012 m^3/s

No. of polytubes :

Considering one polytube will serve 3 microtubes

No. of polytubes = no. of microtubes per row / microtubes served by one polytube

= 18 / 3

= 6

Reynold's number (Re),

Re = (V x d) / v ... ... (11)

where,

v (nu) = Kinematic viscosity

Considering mean temperature as (t) 27.7 °C.

Kinematic viscosity (*v*),

= $(4.712 \times 10^{-6}) \times (t^{-0.53})$

= $(4.712 \times 10^{-6}) \times (27.7^{-0.53})$

= 8.10×10^{-7} poise

$Re = ((q_i/A) \times d) / v$

$= (1.2 \times 10^{-4} / 0.0002068) \times (0.01623 / 8.103 \times 10^{-7})$

$= 1.1621 \times 10^{4}$

Churchil's equation is used to find the friction factor of lateral as it covers the entire regime of the flow.

friction factor (f) Using Churchill's equation:

$f = 8(((8/Re)^{12})) + (1 / (A+B)^{3/2})))^{1/12}$ ... ... (12)

where,

$A = (2.457 \log_e 1/ ((7/Re)^{0.9} + 0.27 (e/D_i)))^{16}$ ... ... (13)

$B = (37530/Re)^{16}$ ... ... (14)

Re = Reynold's number

e = surface roughness, m

D_i = Inner lateral diameter, m

$A = 2.5556 \times 10^{19}$

B = 139708871.9

f = 0.03006

$v = 8.103 \times 10^{-7}$ poise

Inner diameter = 0.0162 m

Roughness coefficient = 0.0000021 m

Length of lateral = 10 m

Area of lateral = 0.0002068 m^2

Head loss through lateral :

$H_f = ((f \times L \times Q^2) / (12.1 \times D_i^5)) \times \mathbf{F}$ ... ... (15)

where,

f = friction factor

L = length of lateral,m

Q = lateral discharge, m^3/sec

D_i = Inner lateral diameter, m

F = multiplying factor for multiple outlet pipe

H_f = ((0.03006 x 10) x (0.00012)^2) / (12.1 x 0.01623 ^{5})) x F

= 0.3176 x F

Row of crops are on both the side of laterals,

Now, considering combination for 1st first row of crop on one side of lateral ,

20 mm lateral

5 mm dia polytube

15 cm long polytube

15 cm long micromanifold

1.2 mm dia microtube

Required average pressure in lateral for discharge of 6 lph,P2

Using the power equation obtained from graphs of inlet pressure, P2 vs microtube discharge, q_i developed for the above mentioned combination, (Table 5.100)

Inlet pressure, P2

$P2 = 0.553 q_i^{1.282}$ ... ... (16)

$P2 = 0.553 \times q_i^{1.282}$

$= 0.553 \times 6^{1.282}$

= 5.50 mwc

Length of Microtube

Equations are developed to determine the length of microtube as per inlet pressure.(Table 5.101)

$L_{1.2} = 0.302\ P2 - 1.361$

where,

$L_{1.2}$ = length required for 1.2 mm diameter microtube

= 0.302 x 5.5 -1.361

= 0.3 m

To provide the uniform distribution of water at a given discharge, discharge variation should be < 10% and hence pressure variation between any two farthest points in a given set should be < 20%.

As the required average pressure for lateral is 5.5 mwc, the pressure variation should be less than 10% of 5.5 m. Hence pressure variation along the lateral should be 0.55 m.

Similarly pressure variation along the manifold should be 0.55.

For 20 mm dia lateral having the first outlet at half spacing & no of outlets = 6

F = 0.373 (from Table 5.27)

H_f = 0.3176 x F

= 0. 0.3176 x 0.373

= 0.1184 m < 0.55 m

Therefore, O.K.

Now , considering combination for 2nd row of crop as follow:

20 mm lateral

5 mm dia polytube

45 cm long polytube

20 cm long micromanifold

1.2 mm dia microtube

Required average pressure in lateral based on the power equation developed, for the combination mentioned is (Table 5.118)

Preq. = $0.853 \times q_i^{1.159}$

= $0.853 \times 6^{1.159}$

= 6.8 mwc

Length of Microtube

Equations are developed to determine the length of microtube as per inlet pressure.(Table 5.119)

$L_{1.2}$ = 0.302 P2 – 1.361

where,

$L_{1.2}$ = length required for 1.2 mm diameter microtube

= 0.302 x 6.8 -1.361

= 0.692 m

To provide the uniform distribution of water at a given discharge, discharge variation should be < 10% and hence pressure variation between any two farthest points in a given set should be < 20%.

As the required average pressure for lateral is 6.8 mwc. The pressure variation should be less than 10% of 6.8 m. Hence pressure variation should be 0.68 m

Similarly, the pressure variation along the manifold should be 0.68 m.

For the combination of 2nd row of crops,

the multiplying factor, F is 0.438 (Table no. 5. 29)

$H_f = 0.31768 \times F$

$= 0.31768 \times \mathbf{0.438}$

$= 0.1391 \text{ m} < 0.68 \text{ m}$

Therefore, O.K.

Required pressure for the first row of crop is 5.5 mwc and for second row of crop is 6.8 mwc. Considering higher pressure of 6.8 mwc as average lateral pressure,

Pressure at the inlet of last lateral, A

$= H_a + 0.75$ (H_f for first row + H_f for second row)

$= 6.8 + 0.75\ (0.1184 + 0.1391)$

$= 6.993$ m

- **Design of manifold**

Loss of head permitted along the length of manifold is 0.68 m.

Considering diameter of manifold (Dm) = 63 mm

Hence internal diameter (Dm),

$= D - (2 \times \text{thickness})$

$= 0.063 - (2 \times 0.0035)$

$= 0.0560$ m

Kinematic viscosity (v),

= 8.1×10^{-7} poise

Length of manifold = 25 m

No. of rows to be served = length of manifold / crop spacing

= 25 / 0.45

= 55.55 nos.

Say 56

Four row of crops are served by one lateral.

For ITK MIS, no. of laterals = no.of rows / no. of rows served by one lateral

= 56 / 4

= 14

Discharge through manifold,

= no of laterals served both sides x discharge of one lateral

= 14 x 2 x 0.00012

= 0.00336 m^3/s

Reynold's number, Re

Re = (V x d) / v

= ((q_i /A) x d) / v

= ((0.00336) / ((Π/4) x 0.0560^2) x 0.0560) / (8.1×10^{-7})

= 9.431×10^4

Friction factor for manifold, f :

$$f = \alpha \, Re^{\beta} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (17)$$

where,

$\alpha = a \text{ dia}^{b}$

$\beta = c \text{ dia}^{d}$

Constant a,b,c,d (from the Table 3.25 by Shete (2000)) are as follow;

a = 0.135201; b = 0.106948; c = -0.174097; d = 0.048323

Hence,

$\alpha = 135201 \, (0.0560)^{0.106948}$

= 0.09933

$\beta = -0.174097 \, (0.0560)^{0.048323}$

= -0.15146

Therefore,

$f = \alpha Re \beta$

$= 0.09933473 (9.4317 \times 10^4)^{-0.151460706}$

$= 0.01752$

Head loss through manifold:

$H_f = ((f \times L \times Q^2) / (12.1 \times Dm^5)) \times \mathbf{F}$

For 63 mm dia, first outlet at half spacing & no of outlets = 14

(From Table - 3.14 Shete (2000)), F = 0.377

$H_f = ((0.01752 \times 25 \times (0.00336)^2) / (12.1 \times (0.0560)^5) \times \mathbf{0.377}$

$= 0.7422 \times \mathbf{0.377}$ m

$= 0.279$ m < 0.68 m

Therefore O.K.

Pressure at the inlet of manifold ,B

= inlet pressure at point A + head loss through manifold

= 6.993 + 0.279

= 7.2728 m

Design of blind pipe:

Considering the remaining portion of manifold as a blind pipe,

Discharge through blind pipe = discharge through manifold = 0.00336 m^3/s

Assume diameter of blind pipe (Dm) = 63 mm

Thus inner diameter. = 56 mm

= 0.0560 m

Friction factor for blind pipe, $f = \alpha Re^{\beta}$

$= 0.01752$

Head loss through blind pipe,

$H_f = ((f \times L \times Q^2) / (12.1 \times Dm^5))$

$= ((0.01752 \times 75 \times (0.00336)^2) / (12.1 \times (0.056)^5))$

$= 2.226$ m

Therefore pressure at point C,

= pressure at point B + head loss through blind pipe

= 7.2728 + 2.226

= 9.498 m

- **Design of main**

Considering main pipe diameter as 63 mm,

Thus inner diameter. = 56 mm

= 0.0560 m

Length of main = 90 m

Discharge through main is discharge through the manifold

= 0. 0.00336 m^3/s

Constants a,b,c,d (from the Table 3.27 by Shete (2000))

a = 0.168037,b = 0.051846, c = -0.189928, d = 0.026560

Therefore,

$\alpha = 0.14471$

$\beta = -0.17593$

$Re = 9.431 \times 10^4$

Friction factor, $f = 0.144711643(9.4317 \times 10^4)^{-0.175930391}$

$= 0.01928$

Head loss through main pipe,

$Hf = ((f \times L \times Q^2) / (12.1 \times Ds^5))$

$= ((0.01928 \times 90 \times (.\ 0.00336)^2) / (12.1 \times 0.0560^5)$

= 2.941 m

Pressure at point D,

= Inlet pressure at C + Head loss through main

= 9.498 + 2.941

= 12.439 m

Pressure at source,

= pressure at point D + 10% of pressure at point D + 2 m (For minor appliances)

= 12.439 + 1.24 + 2

= 15.679 m < 40 m

Hence design is O.K.

Note: Though ETc for summer groundnut and cauliflower of 7.04 mm/day and 4.408 mm/day respectively are taken for design, while operating the system the designed operation time is reduced considering dual crop coefficient approach which is discussed in chapter 3.

Design of MIS

Crop: Summer groundnut

Crop water requirement

Net Irrigation depth, NI = ETc ... ... (18)

where,

ETc = Crop Evapotranspiration rate, mm/day

Max Evapotranspiration Rate, ETc = Kc x ETo ... ... (19)

where,

ETo = reference crop evapotranspiration, mm/day

Kc = crop coefficient

ETc = 0.95x 6.3

= 7.04 mm/day

Gross Irrigation Depth, (GID) = ETc / E_a ... ... (20)

where,

Ea = application efficiency

Assuming application efficiency of system (Ea) = 98 %

GID = 7.04 / 0.98

= 7.18 mm/day

Emitter spacing, Se = 0.9 $(q / i)^{0.5}$ ... ... (21)

where,

i = infilteration rate , mm/hr

q = Emitter discharge, lph

considering discharge of emitter , q = 4 lph

Average infiltration rate, i = 14 mm/hr

Se = 0.9 $(4 / 14)^{0.5}$

= 0.481 m

Say 0.5 m

Operation time

Operation Time for the row cops are calculated as follow;

$$T = \frac{\text{Volume of water required to meet crop water requirement}}{\text{Emitter discharge}}$$

$$= \frac{\frac{ETc}{Ea} \quad \frac{0.90\,(q/i)\text{^}0.5\ \ Se\ \ Sl}{Sl}}{q} \quad \dots \quad \dots \quad (22)$$

where,

Sl = lateral spacing ,m

T = (((7.18 x 0.9 x ((4/14)^0.5) x 0.5 x 0.45)/0.45)/4)

= 0.431 hr

= 25.90 min
Say 26 min

Number of sets

Considering the energy scenario in rural india it can be assumed that power is available for 12 hrs. Therefore,

- No. of sets = power available (hr) / operation time

  = 12 / 0.431

  = 27.84

  Say 26

Crop: Cauliflower

Net Irrigation depth, NI = ETc ... ... (23)

where,

ETc = Crop Evapotranspiration rate, mm/day

Max Evapotranspiration Rate,

ETc = Kc x ETo ... ... (24)

where,

ETo = reference crop evapotranspiration, mm/day

Kc = crop coefficient

ETc = 0.95 x 4.64

=4.408 mm/day

➢ Gross Irrigation Depth, (GID) = ETc / Ea ... ... (25)

where,

Ea = application efficiency

GID = 4.408 / 0.98

= 4.497 mm/day

emitter spacing $Se = 0.9 (q / i)^{0.5}$ ... ... (26)

where,

i = infilteration rate , mm/hr

q = emitter discharge, lph

Assuming discharge (q) of emitter = 4 lph

Average infiltration rate, i = 14 mm/hr

$Se = 0.9 (4/ 14)^{0.5}$

= 0.481 m

Say 0.5 m

➢ **Operation time**

Operation Time for the row cops are calculated as follow;

$$T = \frac{\text{Volume of water required to meet crop water requirement}}{\text{emitter discharge}}$$

$$= \frac{\dfrac{ETc}{Ea} \; \dfrac{0.90\,(q / i)^{0.5}\ Se\ Sl}{Sl}}{q} \quad \ldots \quad \ldots \quad (27)$$

where,

Sl = lateral spacing ,m

T = (((4.497 x 0.9 x ((4/14)^0.5) x 0.5 x 0.45)/0.45)/4)

= 0.270 hr

= 16.22 min

Say 17 min

Number of sets

Considering the energy scenario in rural india it can be assumed that power is available for 12 hrs. Therefore,

- No. of sets = power available (hr) / operation time

  = 12 / 0.270

  = 44.44

  Say 44

Though operation time and no. of sets for summer groundnut and cauliflower are different selecting the same number of sets. i.e. 20. The remaining design of MIS is same for both the crops.

Layout and design

Fig 6.2 shows the MIS layout for summer groundnut and cauliflower.

As shown in fig 6.2, field of 100 x 100 m is divided into 20 sets of each 10 m x 25 m.

Length of lateral = 10 m
Length of manifold = 25 m
Length of blind pipe = 75 m
Length of main = 90 m

- **Design of lateral**

To provide the uniform distribution of water at a given discharge, discharge variation should be < 10% and hence pressure variation between any two farthest points in a given set should be < 20%.

As the emitter discharge water at pressure just above the atmospheric pressure i.e. 1 kg/cm^2 or 10 m head of water. Hence pressure variation should be < 20% of 10 m

= 0.2 x 10

= 2 m

As water flows through two different types of pipe i.e. lateral and manifold, therefore,

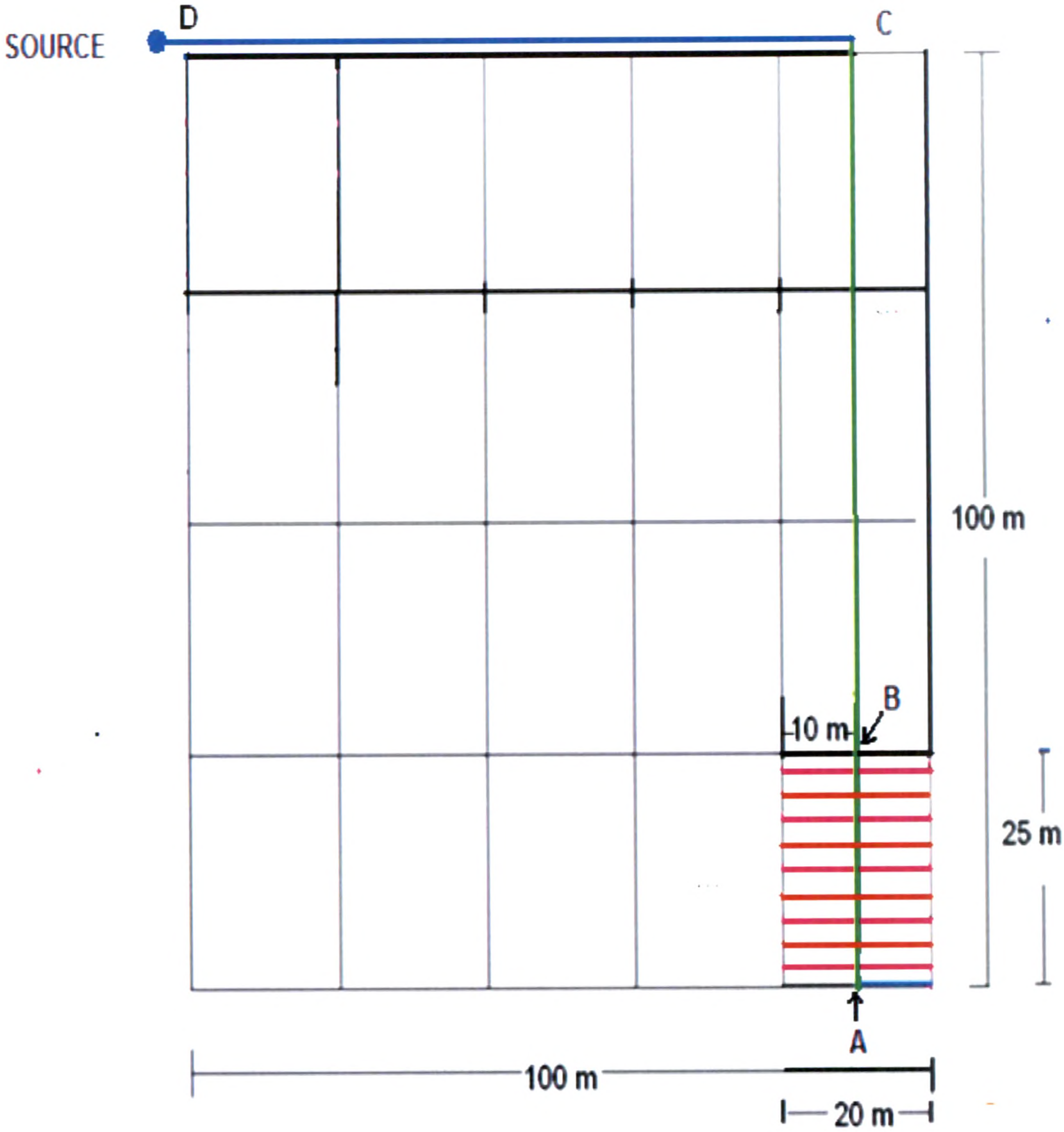

Fig. I-2: MIS layout for summer groundnut and cauliflower

Legends :

Red line	Lateral, 12 mm diamter
Green line	Manifold, 63 mm diameter
Blue line	Main, 63 mm diameter
●	Source

Loss of head permitted through lateral = 2 / 2

= 1 m

Loss of head permitted through manifold = 2 / 2

= 1 m

Taking diameter of lateral (D_l) = 12 mm

So thickness, tk

= (D / 15) + 0.55 mm

= (12 / 15) + 0.55

= 1.35 mm

Hence internal diameter (D_i),

= D - (2 x tk)

= 12 – (2 x 1.35)

= 9.3 mm

= 0.0093 m

Assuming mean temperature as (t) 27.7 °C.

Kinematic viscosity (v),

= $(4.712 \times 10^{-6}) \times (t^{-0.53})$

= $(4.712 \times 10^{-6}) \times (27.7^{-0.53})$

= 8.1×10^{-7} poise

Length of lateral = 10 m

No of emitters on lateral,

= length of lateral / emitter spacing

= 10 / 0.5

= 20

Discharge of one lateral,

= no of emitters x discharge of one emitter

= 20 x 4 lph

= 80 lph

= 80 / (1000 x 3600) m^3/s

= 2.22×10^{-5} m^3/s

Reynold's number (Re),

$Re = (V \times d) / v$

$= ((Q/A) \times d) / v$

$= (4 \times Q) / (\Pi \times d \times v)$

$= (4 \times 2.22 \times 10^{-5}) / (\Pi \times 0.0093 \times 8.1 \times 10^{-7})$

$= 3752.27$

$= 3.752 \times 10^3$

Find friction factor(f):

$f = \alpha \, Re^{\beta}$

where, $\alpha = a \, dia^{b}$

$\beta = c \, dia^{d}$

For lateral, and $Re = 3.752 \times 10^3$

From Table 3.24 by Shete (2000)

a = 0.405180; b = 0.033715; c = -0.276124; d = 0.016033

Hence,

$\alpha = 0.405180 (0.0093)^{0.033715}$

$= 0.346$

and

$\beta = -0.276124 (0.0093)^{0.016033}$

$= -0.256$

Therefore,

$f = \alpha \, Re^{\beta}$

$= 0.346 (3.752 \times 10^3)^{-0.256}$

$= 0.0420$

Head loss through lateral:

$H_f = ((f \times L \times Q^2) / (12.1 \times D_i^5)) \times \mathbf{F}$

where,

F = multiplying factor

For 12 mm dia, first outlet at half spacing (F2), no of outlets = 20

From Table 3.5 by Shete (2000), F = 0.378

$H_f = ((0.0420 \times 10 \times (2.22 \times 10^{-5})^2) / (12.1 \times (0.00932)^5) \times \mathbf{0.378}$

$= 0.2432 \times 0.378$

$= 0.0932 < 1$ m

Therefore, O.K.

Pressure in last lateral, A

= average pressure + 75% of head loss through Lateral

$= H_a + 0.75\ H_f$

$= 10.0 + (0.75 \times 0.0932)$

= 10.069 m

Design of manifold

Loss of head permitted along the length of manifold,

= 2 - head loss through lateral

= 2 – 0.0932

= 1.906 m

Taking diameter of manifold as (Dm) = 63 mm

Hence internal diameter,

= D - (2 x tk)

= 63 – (2 x 3.5)

= 56 mm

= 0.0560 m

Length of manifold = 25 m

No of laterals on manifold,

= length of manifold / lateral spacing

= 25 / 0.45

= 55.5 no.

= Say 56

Discharge through manifold,

= no of laterals x discharge of one lateral

$= 56 \times 2 \times 2.22 \times 10^{-5}$

$= 2.489 \times 10^{-3}\ m^3/s$

Reynold's number (Re),

$Re = (V \times d) / v$

$= ((Q/A) \times d) / v$

$= ((2.489 \times 10^{-3} / 0.00246) \times (0.056)) / 8.1 \times 10^{-7})$

$= 6.986 \times 10^{4}$

Find friction factor(f):

$f = \alpha \, Re^{\beta}$

where, $\alpha = a \, dia^{b}$

$\beta = c \, dia^{d}$

For manifold, and $Re = 6.9865 \times 10^{4}$

From Table 3.25 by Shete (2000),

a = 0.135201; b = 0.106948; c = -0.174097; d = 0.048323

Hence,

$\alpha = 0.135201 \, (0.0560)^{0.106948}$

$= 0.09933$

And

$\beta = -0.174097 \, (0.0560)^{0.048323}$

$= -0.15146$

Therefore,

$f = \alpha \, Re^{\beta}$

$= -0.15146 \, (73.041 \times 10^{3})^{-0.151460706}$

$= 0.01833$

Head loss through manifold:

$H_f = ((f \times L \times Q^2) / (12.1 \times d^5)) \times \mathbf{F}$

where,

F = multiplying factor

For 63 mm dia, first outlet at half spacing (F2), no of outlets = 56

From Table - 3.19 Shete(2000), F = 0.359

$Hf = ((0.01833 \times 25 \times (2.489 \times 10^{-3})^2) / (12.1 \times (0.0560)^5) \times \mathbf{0.359}$

$= 0.153 \text{ m} < 1.9 \text{ m}$

Therefore O.K.

Pressure in manifold, B

= inlet pressure at point A + head loss through manifold

= 10.069 + 0.153

= 10.222 m

Design of blind pipe

Considering the remaining portion of manifold as a blind pipe,

Discharge through blind pipe = discharge through manifold = $2.489 \times 10^{-3}\ m^3/s$

Assuming diameter of blind pipe(D) = 63mm

Hence internal diameter (D_i),

= D - (2 x tk)

= 63 – (2 x 3.5)

= 56 mm

= 0.0560 m

Length of blind pipe = 75 m

Find friction factor(f):

$f = \alpha\ Re^{\beta}$

f = 0.01833

Head loss through blind pipe:

$H_f = ((f \times L \times Q^2) / (12.1 \times D_i^5)$

$Hf = ((0.01833 \times 75 \times (2.489 \times 10^{-3})^2) / (12.1 \times (0.0560)^5)$

= 1.278 m

Pressure in blind pipe,C

= inlet pressure at point B + head loss through blind pipe

= 10.222 +1.278

= 11.50 m

Design of main

Taking diameter of main, D = 63 mm

Hence internal diameter ,

$= D - (2 \times tk)$

$= 63 - (2 \times 3.5)$

$= 56$ mm

$= 0.0560$ m

Length of main = 90 m

Discharge through main,

$= 2.489 \times 10^{-3}\ m^3/s$

Reynold's number (Re),

$Re = (V \times d) / v$

$= ((Q/A) \times d) / v$

$= ((2.489 \times 10^{-3} / 0.00246) \times (0.056)) / 8.1 \times 10^{-7})$

$= 6.986 \times 10^4$

Find friction factor(f):

$f = \alpha\ Re^{\beta}$

Where, $\alpha = a\ dia^{b}$

$\beta = c\ dia^{d}$

For main, and $Re = 6.9865 \times 10^4$

a = 0.168037; b = 0.051846; c = -0.189928; d = 0.026560

(From Table 3.27 by Shete (2000))

Hence,

$\alpha = 0.168037\ (0.0560)^{0.051846}$

$= 0.1447$

And

$\beta = -0.189928\ (0.0560)^{0.026560}$

$= -0.1759$

Therefore,

$f = \alpha\ Re^{\beta}$

$= 0.144711643\ (6.9865 \times 10^4)^{-0.175930391}$

$= 0.02033$

Head loss through main:

$H_f = ((f \times L \times Q^2) / (12.1 \times D_i^5))$

$Hf = ((0.02033 \times 90 \times (2.489 \times 10^{-3})^2) / (12.1 \times (0.0560)^5)$

= 1.7012 m

Pressure in main, D

= inlet pressure at point C + head loss through main

= 11.50 +1.701

= 13.20 m

Pressure at source,

= pressure at point D + 10% of pressure at point D + 6 m (for screen and sand filters etc.)

= 13.20 + 1.32 + 6

= 20.52 m < 40 m

Hence design is ok.

Note: Though ETc for summer groundnut and cauliflower of 7.04 mm/day and 4.408 mm/day respectively were taken for design, while operating the system the designed operation time was reduced considering dual crop coefficient approach which is discussed in chapter 3.