Table 1. 1 PBP, BCR and IRR for Various Sizes of Gobar gas Plants

Size of the Plant	Discount Rate	Pay Back Period	BCR	IRR
1Cum.	12.5%	15Years	1.37	23.71
2Cum.	12.5%	7Years	1.90	38.62
3Cum.	12.5%	4Years	2.53	49.74
4Cum.	12.5%	3Years	2.75	51.66

➢ To make use of the Gobar gas available to marginal and scheduled caste farmers, who are actually in need of it, cost effective designs of Gobar gas digesters must be fabricated to meet the actual requirements of the target group.

➢ In some cases, even small problems like formations, clogging of inlets and outlets etc., forced many users abandoning the existing plants, which needs rectification and alternate solution to maneuver the problem.

➢ The analysis of BCR implies that as the size of the plant increases, the BCR also increases substantially, which suggests the construction of community Gobar gas plants to economies the dung use efficiency.

➢ Feed back information need to be collected then and there from the Gobar gas farmers to re-orient basic research towards the requirement and make the biogas programme location specific by giving weightage to construction and operation oriented problems.

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A computer model for design and evaluation of surge flow furrow irrigaion systems

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Abstract : Successful performance of Surge irrigation system depends chiefly on the design of Surge Cycle Timing parameters and prediction of the net Waterfront Advance times to reach the furrow tailends within the stipulated duration of irrigation. Extensive expermentation with different practical combinations of furrow inflow rates, furrow sizes, length and gradients for selected Surge Cycle Ratios and Numebr of Surges to complete irrigation has resulted in the development of a comprehensive computer model entitled as Surgemode. Validation of the model surgemode has also revealed that the predicted and the observed values of net waterfront advance times to reach furrow tailends lie in an acceptable range of 5to10% deviation while those of the soil moisture distribution efficiency lie in a range of 3to8%, making the developed model reliable for design and pre-evaluation of surge irrigation systems to suit the conditions prescribed in the text. *(Key Words : Surge flow, Cycle timing, Cycle Ratio, Surgemode, Model, Waterfront advance, Moisture distribution efficiency).*

In Tamilnadu, surface irrigation is accomplished through shortstrip furrow and checkbasin layouts for most crops. In addition to a significant loss of land for cultivation to the tune of 30% and more these layouts also lead to inevitable losses of irrigation water through deep percolation and run-off. The irrigation efficiencies under these conventional systems often lie below 65% owing to high rates of infiltration, uneven distribution of soil moisture after irrigation and longer waterfront advance times to reach the field tail ends. Surge Irrigation a relatively new technique of surface irrigation, coupled with a long furrow layout (furrow of length more than 50 m) has been found to minimize these land and water losses significantly (Humphreys, 1989) and to improve upon the overall irrigation efficiency. Surge irrigation involves intermittent applications of water at specified discharge rates in an On-Off cycling mode into individual furrows. This results in accelerated water front advance rates and minimum deep percolation losses (Coolidge et al., 1982 ; Duke et al., 1983) due to drastic reduction in the soil infiltration rates (Zohrab et al., 1985) during the cyclic flows. Thus a high order of irrigation application, storage and distribution efficiencies are possible under surge irrigation compared to continuous flow of irrigation as in the case of short strip furrows/checkbasin layouts. However, the most successful performance of a Surge Irrigation layout depends chiefly on the design of Surge Cycle Timing parameters and prediction of the net Water from Advance times to reach the furrow tailends within the stipulated duration of irrigation. Extensive experimentation with different precaution combinations of furrow inflow rates, furrow sizes, lengths and gradients for selected Surge Cycle Rations and Number of Surges to complete irrigation has resulted in he development of user friendly comprehensive computer model christened as "SURGEMODE", facilitating the design and pre-evaluation of long furrow surge irrigation layouts.

Development of Model ''SURGEMODE'':

The design and evaluation of surge irrigation systems warrants the determination of the following parameters :

1. The size or spacing between the furrows (W) in cm
   - *the practical sizes adopted in Tamilnadu are 60cm, 75cm, 90cm and 120cm (paired row furrows).*
2. Length of the furrow (L) in metres.
   - *the practical long furrow should have lengths more than 50m upto 200m.*
3. Furrow Gradient (G) in percentage.
   - *in order to curtail erosion and sedimentation the optimal furrow gradient are selected in the range of 0.1% to 0.6%.*
4. Furrow inflow rates (Q) in lit/sec
   - *the furrow inflow discharges are selected in the non-erosive and non-silting range of 0.5% lit/sec to 2 lit/sec.*
5. Design depth of irrigation (D) in cm to saturate the rootzone
   - *given by the product of Available Water Holding Capacity in cm of the Effective Rootzone of the crop and the Allowable Soil Moisture Depletion in percentage.*
6. Net (T_n) and Gross (T_g) durations of irrigation in min
7. Surge Cycle Ratio (Rc)
   - *the ratio of Surge Cycle ON time (T_{ON}) to the Cycle time (T_c)*
   - *the practically possible cycle ratio are 1/4, 1/3, 1/2 and 2/3*
8. The Number of Surge Cycles (N) to complete irrigation
   - *the practically feasible number of surges to complete irrigation within the design duration of irrigation for any surge layout is limited in the range of 5 to 10. If N is less than 5 or more than 10 the surge flow mode becomes ineffective as it closely approaches continuous flow characteristics.*
9. On-Off times (T_{ON} and T_{OFF})
10. Surge Cycle Time (T_c)
    - *given by the summation of On and Off times*
11. Infiltration Rate of the soil (I) and its reduction pattern during the process of surging
12. Net Waterfront Advance time (T_a) to reach furrow tail end
13. The ultimate Soil Moisture Distribution Efficiency (η_d)
    - *is an integrated effect of deep percolation and run-off losses, Application Efficiency (η_a) and Storage Efficiency (η_d)*
14. Irrigation Water use Efficiency (WUE)
    - *ratio of crop Yield to the Consumptive Water Use, in tonnes/ha/cm of water.*

Based on the above design considerations, the Model was developed in three phases (Senthilvel, 1995) as follows :

Phase I : *Surge Cycle Timing parameters :*

(a) Net Duration of Irrigation (T_n) = (W*L*D)/(600*Q) -------------- (1)

(b) Surge Cycle ON time (T_{ON}) = T_a/N ------ (2)

(c) Surge Cycle OFF time (T_{OFF}) = (1-Rc)* T_{ON}/Rc ------------ (3)

(d) Surge Cycle Time (T_c) = (T_{ON}+T_{OFF}) --------- (4)

(e) Gross Duration of Irrigation $(T_g) = (N*Tc) - T_{OFF}$
$= N*T_{ON} + (N-1)*T_{OFF}$ ------------ (5)

Phase II : *The Net Waterfront Time (Ta) in min to reach the furrow tail end :*

Extensive experimental trails on Sandy Clay Loam soils in a Factorial Randomized Block Design (FRBD) and a Multiple Regression Analysis yielded the following Waterfront Advance Prediction Model of the Cobb-Douglas log-linear form :

The Surge Water from Advance model (Senthivel, 1995) originally developed for empty furrows on a reference gradient of 0.3% was modified (Senthilvel et al., 1998) by incorporating two factors viz., the slope gradient factor (Fg) and the crop resistance factor (Fr) in order to account for the effects of furrow gradient and crop growth stages (root proliferation).

The modified water front advance model is presented as :

$$Ta = (0.00253)\frac{L^{1.189} * N^{1.206} * T_{ON}{}^{1.389} * Fr * Fg}{W^{0.489} * Q^{0.0205} * Rc^{0.206}} \qquad (6)$$

where,

Ta = Net Waterfront Advance time to reach furrow tail end, min.

L = Length of the furrow, m
W = Size (Spacing) of the furrow, m
Q = Furrow inflow discharge, lit/sec
N = Number of Surge cycles
Rc = Surge cycle ratio
T_{ON} = Surge Cycle ON time, min

The value of Fg was found to vary from 1 to 0.93 for slope gradients of 0.3% to 0.6% and that of Fr varied from 1 to 1.64 for empty furrow condition to the maturity stage of crop growth (Co. 1 Maize as test crop). The factors are to be arrives at for other crops.

Phase III : *The Ultimate Soil Moisture Distribution Efficiency (hd):*

Soil moisture distribution patterns before and after irrigation were studied by using a calibrated Neutron Soil Moisture Probe and the different irrigation efficiencies were worked out. The ratios of (Ta/Tn) are found to have a good correlation with (h_d) values. The relation is depicted as,

$(\eta_d) = 95 - 27* (Ta/Tn)$ for surge flow ----- (7)

The Computer Model Surgemode comprises all the above relations and is programmed in Basic language as a user friendly package Fig.1 shows the flow chart depicting the structure of the Model.

Validation of the model surgemode

Experimental trials were taken up in the field No.36 (Sandy Clay Loam soils) of the Eastern Block of TNAU campus for different combinations of furrow inflows, surge cycle ratios, number of surges and furrow gradients under a furrow size of 60 cm over a furrow length of 125 m, raising Co. 1 Maize as the test crop. The observed values and predicted values from the Surgemode model of Net Waterfront Advance times to reach furrow tailends and the ultimate Soil Moisture Distribution efficiencies were compared (Tables 1,2 and 3). It is found that the observed values the Surgemode computer programme, in an acceptable limit of less than 10%. A similar trend was also observed in respect of the soil misture distribution efficiency (h_{slo}), the values of which deviated from the predicted ones (h_{dp}) in the permissible limit of less than 8%.

Conclusions

- It is concluded that the empirical regression model Surgemode incorporated with factors for flow resistance and furrow slope gradient can be used satisfactorily for the design and pre-evaluation of Surge irrigation layouts on sandy clay loam soil when irrigation is scheduled at 50% ASMD.
- The strength of the model Surgemode lies on the premise that it combines the advantages of an analytical approach to determine the Surge Cycle timing parameters and regression analysis of extensive field experimental data to arrive at the prediction part on the chief evaluation criteria for surge irrigation viz., the net waterfront advance times to reach the furrow tailend and the consequent soil moisture distribution efficiency.
- The comprehensive computer package (Surgemode) replaces the consuming and laborious manual calculations of the design and evaluation parameters for surge irrigation.
- The validity of the model Surgemode is applicable only to Co.1 Maize. For all other varieties of maize and other row crops such as sugarcane, cotton, vegetables and flower crops the same needs to be validated and the correction co-efficient Fr needs to be arrived at.
- The model Surgemode is valid for application only on sandy clay loam soils having a specific

infiltration rate. For all other soil textures, the model needs to be revalidated, incorporating the relevant infiltration equations.

- The model Surgemode performs satisfactorily for commencing irrigations at antecedent soil moisture levels corresponding to 50% ASMD of the available water holding capacity of the effective rootzones of sandy clay loam soils only. for all other permissible levels of depletion on different textures of soil the model needs revitalization.
- Surgemode does not incorporate Wateruse Efficiency inasmuch as water production functions need to be evolved for different kinds and varieties of crops.

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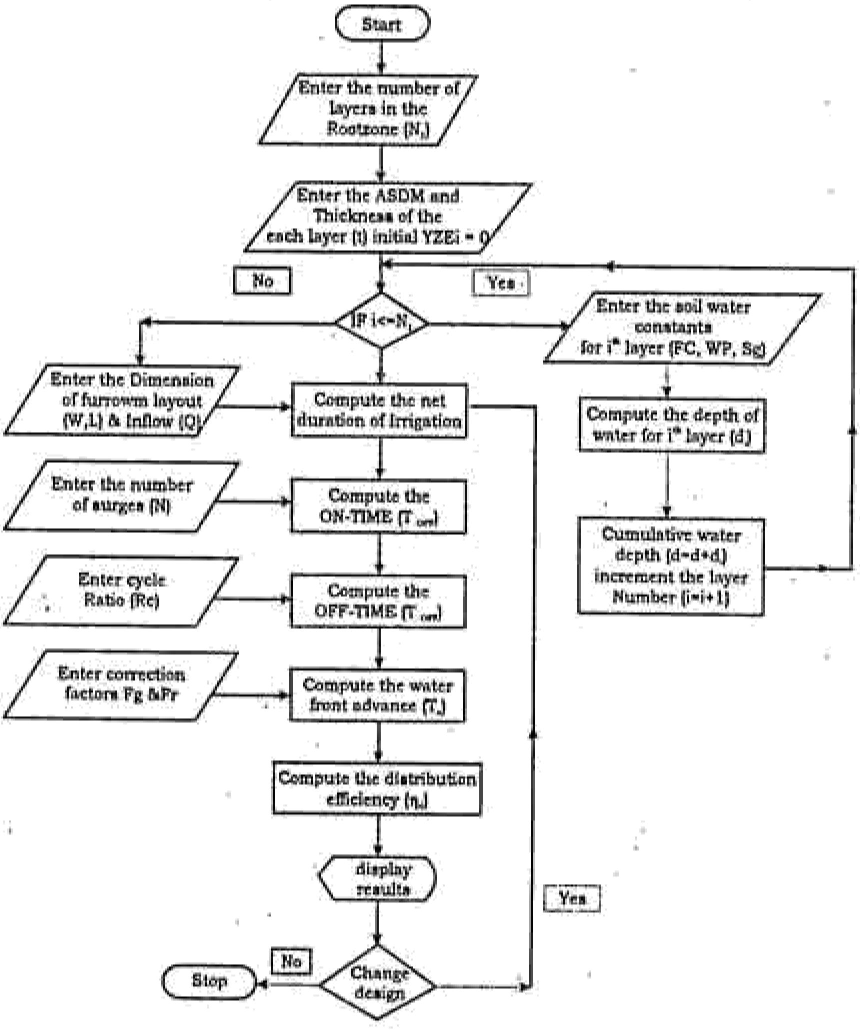

Fig 1. Flow Chart for Surgemode

Table 1. Validation of Surgemode for waterfront Advance and Soil Moisture Distribution efficiencies - (a) Non-Vegitative Furrows (Fr=1)

W=60 cm. L=125 m. d=5 cm. at 50% ASMD G=0.3 (Fg=1)

Q	Rc	N	T_{on}	T_{off}	Ta_p	Ta_o	%dev	η_{dp}	η_{do}	%dev
1.0	1/3	5	12.5	25	31	32	3.23	81.6	85.00	4.17
		10	6.25	12.5	27.33	29.5	7.94	83.19	80.00	3.83
	1/2	5	12.5	12.5	28.54	27.3	4.34	82.67	78.00	5.65
		10	6.25	6.25	25.14	27	7.4	84.14	87.40	3.87
2.0	1/3	5	6.25	12.5	11.68	10.7	8.39	84.91	86.00	1.28
		10	3.13	6.25	10.23	11	7.53	86.11	83.00	3.61
	1/2	5	6.25	6.25	10.74	10.5	2.23	85.72	81.30	5.16
		10	3.13	3.13	9.46	9.5	0.42	86.82	88.30	1.70

Table 2. Validation of Surgemode for waterfront Advance and Soil Moisture Distribution efficiencies - (b) Vegitative Furrows 60 DAS (Fr=1.5)

W=60 cm. L=125 m. d=5 cm. at 50% ASMD G=0.1 (Fg=1.1)

Q	Rc	N	T_{on}	T_{off}	Ta_p	Ta_o	%dev	η_{dp}	η_{do}	%dev
1.0	1/3	5	12.5	25	51.19	53.2	3.78	72.89	77.25	5.64
		10	6.25	12.5	45.09	47.5	5.07	75.52	77.52	2.24
	1/2	5	12.5	12.5	47.09	45.2	4.18	74.66	72.35	3.19
		10	6.25	6.25	41.48	43.25	4.09	77.08	73.55	4.80
2.0	1/3	5	6.25	12.5	19.27	21.25	9.32	78.35	77.25	1.42
		10	3.125	6.25	16.97	15.65	8.43	80.33	75.15	6.98
	1/2	5	6.25	6.25	17.73	18.85	5.94	79.69	80.3	0.76
		10	3.125	3.125	15.61	16.74	6.75	81.51	79.35	2.72

Table 3. Validation of Surgemode for waterfront Advance and Soil Moisture Distribution efficiencies - (c) Vegitative Furrows 85 DAS (Fr=1.64)

W=60 cm. L=125 m. d=5 cm. at 50% ASMD G=0.6 (Fg=0.89)

Q	Rc	N	T_{on}	T_{off}	Ta_p	Ta_o	%dev	η_{dp}	η_{do}	%dev
1.0	1/3	5	12.5	25	45.28	48.33	6.31	75.44	77.3	2.41
		10	6.25	12.5	39.88	42.55	6.27	77.77	75.33	3.24
	1/2	5	12.5	12.5	41.65	39.5	5.44	77.01	72.55	6.15
		10	6.25	6.25	36.69	39.25	6.52	79.15	80.25	1.37
2.0	1/3	5	6.25	12.5	17.05	18.33	6.98	80.24	77.75	3.24
		10	3.125	6.25	15.02	14.24	5.48	82.03	80.24	2.23
	1/2	5	6.25	6.25	15.68	17.25	9.10	81.45	78.5	3.76
		10	3.125	3.125	13.81	14.55	5.09	83.07	81.25	2.24

Ta_p = Predicted Waterfront Advance time to reach furrow tail end
Ta_o = Observed Waterfront Advance time to reach furrow tail end
η_{dp} = Predicted Distribution Efficiency
η_{dp} = Observed Distribution Efficiency