CHAPTER - 4

DATA COLLECTION AND ANALYSIS

4.1 General

Indigenous Technical Know-how Micro Irrigation System (ITK MIS) and micro irrigation system (MIS) are designed and installed on Training Cum Demonstration (TCD) farm, Water Resources Engineering and Management Institute (WREMI), Samiala, Taluka and District: Vadodara for two row crops viz. summer groundnut and cauliflower.

For the design and analysis of ITK MIS and MIS on field, various data like meteorological data, soil data, water data, and crops data are collected and are analyzed in detail.

4.2 Study Area

The Training Cum Demonstration (TCD) farm, Water Resources Engineering and Management Institute is situated at altitude 31.09 m above mean sea level and latitude 22° 15' N and 73° 06' E near village Samiala on Vadodara – Padra Road.

Fig. 4.1 shows actual image of WREMI campus and locations of plot 1 and 2 on the TCD farm. Micro irrigation system is installed on plot 1 and ITK MIS is installed on plot 2. Summer groundnut and cauliflower are raised on both the plots for three years.

4.2.1 Soil data and analysis

Soil Samples were collected from various depths in Plots 1 and 2. Root depth of summer groundnut is 90 cm. Entire root zone was divided in four layers each of 22.5 cm. Soil samples for summer ground nut was taken at depths 11.25, 33.75, 56.25 and 78.75 cm.

Fig. 4.1: Layout of WREMI campus and TCD farm, WREMI, Samiala

Root depth of cauliflower is 45 cm and divided into four layers each of 11.25 cm. Soil samples are taken from depths at 5.62, 16.87, 28.12 and 39.37 cm. Soil samples are analyzed and soil type, bulk density, ph, electric conductivity, soil moisture content at field capacity and permanent wilting point are determined. Bulk densities are determined using core cutter and field capacity & permanent wilting point are determined using pressure plate apparatus. Soil moisture holding capacity of each layer is determined. Salient soil particulars in plot -1 and plot – 2 are given in Table 4.1.

Table 4.1: Salient Soil Particulars of Samiala T.C.D. Farm

Sr.No.	Particular	Plot 1	Plot 2
1.	Soil Type	Silt loam	Silt loam
2.	pH	8.0	7.9
3.	Electric Conductivity, millimohs/cm	0.19	0.20
4.	Cation Exchange Capacity, meq/100 gms	22.00	23.20
5.	Exchangeable Sodium percentage	1.32	2.41
6.	Infiltration rate, cm/hr	0.14	0.19

Soil moisture content at field capacity and permanent wilting point and maximum soil moisture available in each plot for four different layers are shown in Table 4.2.

Table 4.2: Soil Moisture Contents at Field Capacity and Wilting Point at T.C.D. Farm, WREMI, Samiala

Plot No.	Soil depth below ground level cm	Field capacity (1/3 atm)				Permanent Wilting Point (15 atm)			
		W_1 gm	W_2 gm	W_3 gm	Moisture content %	W_1 gm	W_2 gm	W_3 gm	Moisture content %
Soil samples for summer groundnut									
1a	11.25	65.5	192	169	18.18	65.5	193	172.5	16.08
	33.75	65.5	190	165	20.08	65.5	189	169	16.19
	56.25	65.5	191	164	21.51	65.5	188	168	16.33
	78.75	53.5	190	159	22.71	53.5	185	163	16.73
1b	11.25	65.5	195	171.5	18.15	65.5	193.5	174	15.23
	33.75	53.5	190	167.5	16.48	65.5	189	169	16.19
	56.25	65.5	193.5	172	16.80	65.5	188	168.5	15.92
	78.75	65.5	200.5	179	15.93	53.5	185.5	163.5	16.67
2a	11.25	65.5	193	168	19.61	65.5	190	170.5	15.66
	33.75	53.5	190	163	19.78	65.5	188.5	168	16.67
	56.25	65.5	190	164.5	20.48	65.5	187.5	167	16.80
	78.75	65.5	195	164	23.94	53.5	189	165	17.71
2b	11.25	65.5	193	168	19.61	65.5	191	171	15.94
	33.75	65.5	192	167	19.76	65.5	190.5	170	16.40
	56.25	65.5	195	167	21.62	65.5	189	167.5	17.41
	78.75	53.5	194	163	22.06	53.5	185	164	15.97
Soil samples for cauliflower									
1a	5.6	65.5	192	167.5	19.37	65.5	190	171	15.26
	16.85	65.5	191	168	18.33	65.5	193	173	15.69
	28.1	65.5	195	172.5	17.37	65.5	192	174	14.23
	39.35	53.5	193	167	18.64	53.5	192.5	172.5	14.39
1b	5.6	65.5	191	167	19.12	65.5	193	173	15.69
	16.85	65.5	193	169	18.82	65.5	192	172	15.81
	28.1	65.5	195	170	19.31	65.5	194	174	15.56
	39.35	53.5	192	165	19.49	53.5	193.5	173	14.64
2a	5.6	65.5	191	168	18.33	65.5	192	172.5	15.42
	16.85	65.5	190	167	18.47	65.5	194	174	15.56
	28.1	65.5	189	165	19.43	65.5	195	176	14.67
	39.35	53.5	188	161	20.07	53.5	190.5	169	15.69
2b	5.6	65.5	189	165	19.43	65.5	191	172.5	14.74
	16.85	65.5	190.5	167	18.80	65.5	192.5	173	15.35
	28.1	65.5	193	168	19.61	65.5	194	174	15.56
	39.35	53.5	187	162	18.73	53.5	193	171	15.77

Maximum Soil Moisture Available in T.C.D. Farm, WREMI, Samiala					
Plot No.	Soil depth below G.L.	Moisture content at		Bulk Density	Max. soil moisture available cm
		Field capacity	Wilting point		
	cm	%	%	gm/cc	
Soil samples for summer groundnut					
1a	11.25	18.18	16.08	1.88	0.89
	33.75	20.08	16.19	1.85	1.61
	56.25	21.51	16.33	1.86	2.17
	78.75	22.71	16.73	2.03	2.72
				Total	7.40
					82.24 mm/m
1b	11.25	18.15	15.23	1.92	1.26
	33.75	16.48	16.19	2.03	1.77
	56.25	16.80	15.92	1.90	2.39
	78.75	15.93	16.67	2.00	2.72
				Total	8.14
					90.49 mm/m
2a	11.25	19.61	15.66	1.89	1.68
	33.75	19.78	16.67	2.03	1.42
	56.25	20.48	16.80	1.85	1.53
	78.75	23.94	17.71	1.92	2.69
				Total	7.32
					81.31 mm/m
2b	11.25	19.61	15.94	1.89	1.56
	33.75	19.76	16.40	1.88	1.42
	56.25	21.62	17.41	1.92	1.82
	78.75	22.06	15.97	2.08	2.86
				Total	7.66
					85.13 mm/m
Soil samples for cauliflower					
1a	5.6	19.37	15.26	1.88	0.86
	16.85	18.33	15.69	1.86	0.55
	28.1	17.37	14.23	1.92	0.68
	39.35	18.64	14.39	2.07	0.98
				Total	3.08
					68.34 mm/m
1b	5.6	19.12	15.69	1.86	0.72
	16.85	18.82	15.81	1.89	0.64
	28.1	19.31	15.56	1.92	0.80
	39.35	19.49	14.64	2.05	1.12
				Total	3.28
					72.81 mm/m

2a	5.6 16.85 28.1 39.35	18.33 18.47 19.43 20.07	15.42 15.56 14.67 15.69	1.86 1.85 1.83 2.00	0.61 0.60 0.98 0.98
				Total	3.17 70.34 mm/m
2b	5.6 16.85 28.1 39.35	19.43 18.80 19.61 18.73	14.741 15.354 15.564 15.771	1.8321815 1.8544347 1.8915234 1.9805362	0.96 0.72 0.86 0.66
					3.19 70.91 mm/m

N.B. Suffix a and b represent 2 different places where the samples are taken.

$$\text{Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad \ldots \quad \ldots \quad \ldots \quad (4.1)$$

Note : W_1 = Weight of empty container, gm

W_2 = Weight of wet soil + weight of empty container, gm

W_3 = Weight of dry soil + weight of empty container, gm

$$\text{Maximum soil moisture available, cm} = \sum_{i=1}^{N_s} \frac{F.C._i - W.P._i}{100} B.D._i \times Z_i \quad (4.2)$$

where,

$F.C._i$ = Moisture content at Field Capacity of i^{th} soil layer, %

$W.P._i$ = Moisture content at Wilting Point of i^{th} soil layer, %

$B.D._i$ = Bulk Density of soil in i^{th} layer, gm/cc

Z_i = Soil depth of i^{th} layer, m

N_s = Number of Soil layers

4.2.2 Water analysis

The source of water for Samiala campus is tube well. Tube well water was used for irrigation and drinking purpose. Water samples were collected and analyzed. Table 4.3 shows detailed analysis of water.

Table 4.3: Detailed Water Analysis of Samiala Tube well

Sr. No.	Particular	Value
1	Appearance	Normal
2	Odour	Odourless
3	pH	8.0
4	Total dissolved solids, ppm	960
5	Electric conductivity, millimohs/cm	1.72
6	Chloride, meq/l	120
7	Sodium, meq/l	284
8	Calcium, meq/l	20
9	Magnesium, meq/l	36
10	Carbonates, meq/l	Nil
11	Bicarbonate, meq/l	793
12	Residual sodium content, meq/l	9.0
13	Sulphate, meq/l	60

4.2.3 Meteorological data and analysis

Meteorological data were collected from meteorological station of Gujarat Engineering Research Institute, (Narmada and Hydraulics Division) Gotri, Vadodara. This meteorological station is established by the Government of Gujarat in 1971. The latitude, longitude and altitude of the station are N 22-05°, E 73-37° and 30 m respectively. This meteorological station is 10 km away from the training cum demonstration farm, WREMI, Samiala. Daily observed data for maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, sunshine hours, pan evaporation, wind velocity and rainfall are available from 1991-2007.

The data analysis based on the smallest period of time, i.e. a day, gives accurate results. Table 4.4 gives daily average values of the meteorological parameters from 1991-2004. The Table is given in the enclosed DVD.

4.3 Indoor ITK MIS Laboratory Data

Indoor ITK MIS laboratory data (discussed in chapter 3) were obtained by conducting various experiments.

4.3.1 Calibration of lateral inlet discharge

To determine discharge through 12 mm, 16 mm and 20 mm laterals , the pressure gauges , P1 at just downstream of screen filter, P2 at inlet of lateral

and P3 at the end of lateral were installed and corresponding discharge measured with the help of a measuring tank were obtained and given in Tables 4.5, 4.7 and 4.9. Model for determining discharge through 12 mm, 16 mm and 20 mm lateral and Summary of preparation and validation of models are given in table 4.6, 4.8 and 4.10.

These results were then used to determine the discharge through various laterals for given pressures.

Table 4.5: Calibration of Discharge Through 12 mm Lateral

P1	P2	P3	Q
Kg/cm^2	Kg/cm^2	Kg/cm^2	lph
1.40	1.37	0.00	599.64
0.50	0.70	0.55	139.24
0.13	0.15	0.00	161.51
1.40	0.24	0.00	219.06
1.38	0.27	0.00	211.64
1.30	1.10	0.90	102.11
0.10	0.13	0.00	167.08
1.65	1.88	1.35	116.96
1.40	1.33	0.00	595.93
1.65	1.85	1.42	233.92
0.18	0.12	0.00	150.37
1.59	0.75	0.00	412.14
1.70	1.50	1.10	105.82
1.20	0.55	0.40	100.25
0.62	0.72	0.48	144.80
0.38	0.10	0.00	124.38

70 % of the above data were used for model (regression equation) preparation and remaining 30 % data were used for model validation.

Table 4.6 Model for Determining Discharge Through 12 mm Lateral and Summary of Preparation and Validation of Model

Model for determining discharge through 12 mm lateral		
Q = **4.926**P1 + **346.893**P2 - **432.585**P3 + **118.9875**		
Summary of preparation and validation of model		
Particular	Model	Validation
R^2	0.96	0.88
r	0.98	0.94
D	1.00	0.88
R.M.S.E.	36.30	37.11

Table 4.7: Calibration of Discharge Through 16mm Lateral

P1	P2	P3	Q
Kg/cm^2	Kg/cm^2	Kg/cm^2	lph
1.60	1.00	0.75	405.00
1.60	1.10	0.80	459.00
1.55	1.50	0.80	540.00
1.75	1.70	1.40	594.00
1.50	1.70	1.50	351.00
1.50	1.30	1.05	540.00
1.55	1.40	1.15	540.00
1.55	1.20	0.95	540.00
1.55	1.10	0.85	486.00
1.60	0.90	0.65	351.00
1.60	0.80	0.55	432.00
1.62	0.70	0.50	351.00
1.55	0.60	0.45	270.00
1.55	0.50	0.35	243.00
1.55	0.40	0.25	189.00
1.55	0.30	0.20	162.00
1.60	0.10	0.10	162.00
1.45	1.20	1.15	432.00
1.45	1.10	1.00	351.00
1.45	1.00	0.85	270.00
1.45	0.90	0.70	243.00
1.45	0.80	0.65	216.00
1.40	0.60	0.40	297.00
1.40	0.40	0.30	162.00
1.40	0.30	0.25	135.00
1.65	1.60	1.60	486.00
1.65	1.60	1.60	486.00
1.55	1.50	1.55	378.00
1.65	1.60	1.40	540.00

Table 4.8: Model for Determining Discharge Through 16 mm lateral and Summary of Preparation and Validation of Model

Model for determining discharge through 16 mm lateral		
Q = **96.868**P1 + **413.115**P2 - **152.288**P3 - **56.6969**		
Summary of preparation and validation of model		
Particular	Model	Validation
R^2	0.91	0.90
r	0.95	0.95
D	1.00	0.88
R.M.S.E.	42.30	102.22

Table 4.9: Calibration of Discharge Through 20 mm Lateral

P1	P2	P3	Q
Kg/cm^2	Kg/cm^2	Kg/cm^2	lph
2.00	1.80	1.80	999
0.66	0.35	0.32	1674
0.80	0.20	0.22	1404
1.70	1.38	1.30	1634
1.20	0.50	0.48	1458
1.40	1.00	0.90	1863
1.95	0.50	0.50	1458
1.10	0.65	0.50	2160
0.30	0.10	0.08	945
0.90	0.40	0.32	1809
0.40	0.13	0.18	1377
1.96	0.30	0.35	1188
2.00	0.10	0.10	1026
1.60	1.30	1.20	1688
1.70	0.70	0.65	1701
1.75	0.30	0.30	1647
1.00	0.55	0.45	2106
1.70	0.80	0.70	1728
0.75	0.35	0.30	1755
1.25	0.60	0.53	1620
1.80	1.50	1.50	1539
2.00	1.70	1.75	999
1.75	1.45	1.40	1647
2.06	1.80	1.75	1458
0.82	0.42	0.40	1863
0.60	0.30	0.26	1593
1.85	0.60	0.55	1620
1.96	0.20	0.25	1026
1.50	1.20	1.10	1755
1.85	1.55	1.55	1445
1.15	0.70	0.58	2025
1.76	1.48	1.45	1553
1.95	0.40	0.40	1269
1.30	0.70	0.65	1755
1.60	0.90	0.80	1755
1.45	1.10	1.00	1809
2.00	1.70	1.70	1377
0.50	0.20	0.20	1404
1.90	1.60	1.60	1472

Table 4.10: Model for Determining Discharge Through 20 mm Lateral and Summary of Preparation and Validation of Model

Model for determining discharge through 20 mm lateral		
Q = **-50.1372**P1 + **4617.291**P2 - **4694.24**P3 + **1506.956**		
Summary of preparation and validation of model		
Particular	Model	Validation
R^2	0.64	0.83
r	0.80	0.91
D	1.00	1.01
R.M.S.E.	192.50	108.40

4.3.2 Pressure Vs discharge data of ITK MIS

Pressure vs discharge data for 12 mm, 16 mm and 20 mm dia lateral were collected in indoor micro irrigation laboratory and were analyzed.

Table 4.11 contains data and analysis for 12 mm lateral – 4 mm diameter and 0.15 m long polytube (Sheets 1 to 27 contain tables of 12 mm Lateral - 4 mm dia and 0.15 m long polytube – 1 MT1.0-0.30, 1 MT 1.0-0.60, 1 MT 1.0-0.90, 1 MT 1.2-0.30, 1 MT 1.2-0.60, 1 MT 1.2- 0.90, 1 MT 1.5-0.30, 1 MT 1.5-0.60, 1 MT 1.5-0.90) and similarly for 2 MT , 3 MT and 4 MT and are given in enclosed DVD.

The above format is followed for 16 mm and 20 mm dia laterals.

N.B. MT - Microtube

1 MT 1.0-0.30 stands for 1 microtube having 1 mm diameter and 0.30 m length.

4 MT 1.5 - 0.90 stands for 4 microtubes having 1.5 mm diameter and 0.90 m length.

Tables 4.11 to 4.16 contain data and analysis for 12 mm lateral – 4 mm diameter and 0.15 m, 0.30 m,0.45 m, 0.60 m, 0.75 m, 0.90 m long polytube respectively and are given in enclosed DVD.

Tables 4.17 to 4.22 contain data and analysis for 12 mm lateral – 5 mm diameter and 0.15 m, 0.30 m, 0.45 m, 0.60 m, 0.75 m, 0.90 m long polytube respectively and are given in enclosed DVD.

Tables 4.23 to 4.28 contain data and analysis for 12 mm lateral – 6 mm diameter and 0.15 m, 0.30 m, 0.45 m, 0.60 m, 0.75 m, 0.90 m long polytube respectively are given in enclosed DVD.

Tables 4.29 to 4.34 contain data and analysis for 16 mm lateral – 4 mm diameter and 0.15 m, 0.30 m, 0.45 m ,0.60 m, 0.75 m, 0.90 m long polytube respectively are given in enclosed DVD.

Tables 4.35 to 4.40 contain data and analysis for 16 mm lateral – 5 mm diameter and 0.15 m, 0.30 m, 0.45 m, 0.60 m, 0.75 m, 0.90 m long polytube respectively are given in enclosed DVD.

Tables 4.41 to 4.46 contain data and analysis for 16 mm lateral – 6 mm diameter and 0.15 m, 0.30 m, 0.45 m, 0.60 m, 0.75 m, 0.90 m long polytube respectively are given in enclosed DVD

Tables 4.47 to 4.52 contain data and analysis for 20 mm lateral – 4 mm diameter and 0.15 m, 0.30 m, 0.45 m, 0.60 m, 0.75 m, 0.90 m long polytube respectively are given in enclosed DVD.

Tables 4.53 to 4.58 contain data and analysis for 20 mm lateral – 5 mm diameter and 0.15 m, 0.30 m, 0.45 m, 0.60 m, 0.75 m, 0.90 m long polytube respectively are given in enclosed DVD.

Tables 4.59 to 4.64 contain data and analysis for 20 mm lateral – 6 mm diameter and 0.15 m, 0.30 m, 0.45 m, 0.60 m, 0.75 m, 0.90 m long polytube respectively are given in enclosed DVD.

Tables 4.65 to 4.70 contain data and analysis for 20 mm lateral – 7 mm diameter and 0.15 m, 0.30 m, 0.45 m, 0.60 m, 0.75 m, 0.90 m long polytube respectively are given in enclosed DVD.

4.4 Field Experiment Data

Summer groundnut (Arachis hypogaea) and Cauliflower (Brassica oleracea L.) were raised on MIS and ITK MIS during years 2005, 2006 and 2007.

4.4.1 Crop: Summer groundnut

Summer groundnut (Arachis hypogaea) was raised on MIS and ITK MIS during years 2005, 2006 and 2007. Cultivation data are given in Table 4.71.

Table 4.71: Cultivation Data of Summer Groundnut

Crop	Summer groundnut
Variety	Cv. GG2
Crop spacings	0.15 m x 0.6 m 0.20 m x 0.45 m
Number of fields	2
Field size	57.6 m x 28.8 m
Size of each replication plot	14.4 m x 4.8 m
No. of replications	4
Date of sowing	8th February, 2005
Date of emergence	17th February, 2005
Date of harvesting	2nd June, 2005
Crop period	105 days
Cultivation cost	Rs. 13,552/ha – For MIS Rs. 13,568/ha – For ITK MIS
Yield	Shown in Table: 4.76
Selling price	Rs. 2600/quintal

Note: One seed each on both sides of lateral at every 15 cm were sown when the row spacing was 0.6 m. When row spacing was 0.45 m, one seed on both sides of the lateral were sown at 20 cm center to center. Thus seed rate was kept constant at 94 kg/ha.

Crop water requirement and irrigation scheduling

Table 4.72 shows various growth stages of summer groundnut, its period and the values of basal crop coefficient. Reference crop evapotranspiration ETo was calculated using software DSS_ET by FAO Penman-Monteith method. Table 4.73 shows ETo, ETc_dual crop and actual depth of irrigation applied to the field for the year 2005 and is enclosed in DVD. Fig. 4.2 illustrates the variation of Kcb, Kc_dual crop and Kc_adj with respect to crop period and Fig.

4.3 depict variation of ETo, ETc_dual crop and ETc_adj with respect to crop period. Table 4.74 and Fig. 4.4 illustrate irrigation scheduling for summer ground raised in 2005 and is enclosed in DVD.

Table 4.72: Crop Coefficient Kcb for Summer Groundnut Grown at T.C.D. Farm, WREMI, Samiala

Growth stages	Period, Days	RHmin, %	Basal crop coefficient, Kcb
Initial	25	34.5	0.15
Development	30	31.7	0. 63
Mid season	30	38.3	1.12
Late season	20	37.4	0.53
Total	105		

Fig. 4.2: Variation of Kcb, Kc_dual, Kc_adj and Ke w.r.t. crop period for summer groundnut at T.C.D. farm WREMI, Samiala in 2005

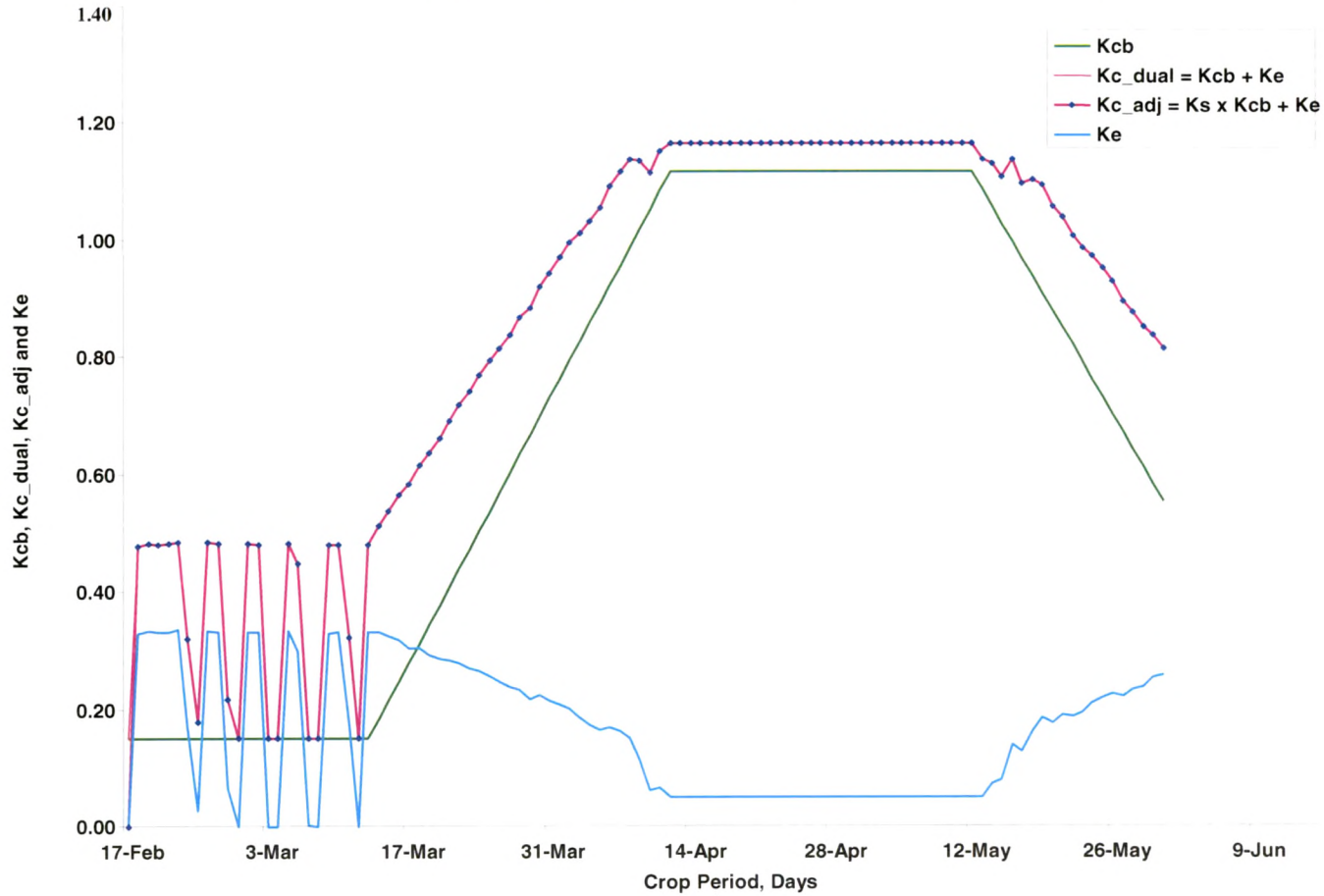


Fig. 4.3 : Variation of ETo, ETc_dual and ETc_adj w.r.t. crop period for summer groundnut at T.C.D. farm, WREMI, Samiala in 2005

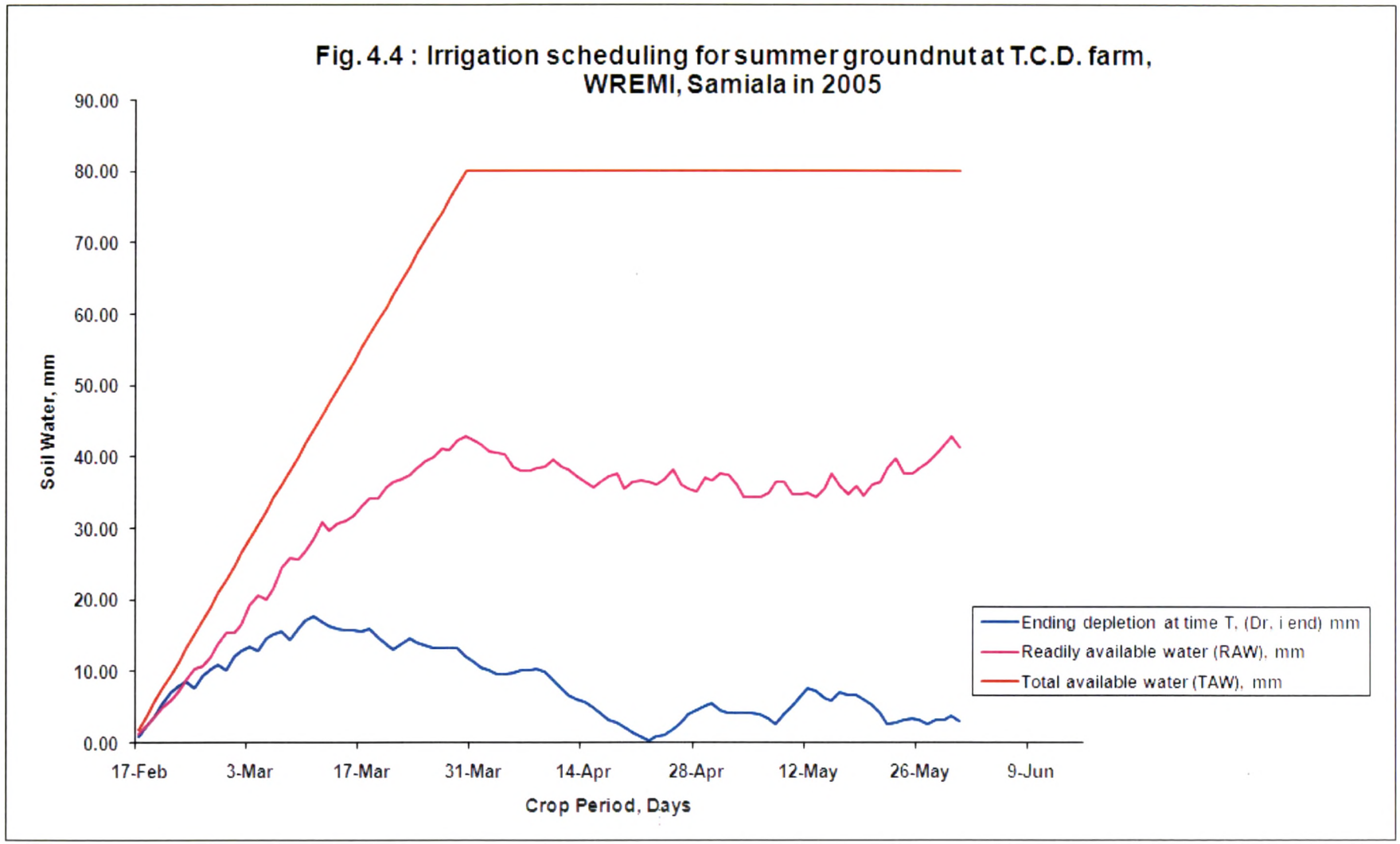


Fig. 4.4 : Irrigation scheduling for summer groundnut at T.C.D. farm, WREMI, Samiala in 2005
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Soil Water, mm
17-Feb
3-Mar
17-Mar
31-Mar
14-Apr
28-Apr
12-May
26-May
9-Jun
Crop Period, Days
Ending depletion at time T, (Dr, i end) mm
Readily available water (RAW), mm
Total available water (TAW), mm

Cultivation cost

The cultivation cost of summer groundnut is shown in Table 4.75.Yields of summer groundnut grown in year 2005, 2006 and 2007 are given in Table 4.76

Table 4.75: Cultivation Cost of Summer Groundnut Raised at T.C.D. Farm, WREMI, Samiala

Sr. No.	Particular	Rate Rs./unit	Quantity	Cost, Rs.
1.	Cultivation			
i)	Ploughing	600/ha	1 ha	600
ii)	Cultivating	700/ha	1 ha	700
iii)	Seeds	44.50/kg	94 kg	3854
iv)	Sowing	300/ha	1 ha	300
2.	Fertilizers and manures			
i)	D.A.P.	485/50 kg	30 kg	485
ii)	Farm yard manure	200/tonne	8 tonnes	1600
iii)	Ryzobium culture	6 /packet	12 packet	96
iv)	Urea	255/50 kg	10 kg	50
v)	Fertilizers and manures appl.	750/ha	1 ha	750
3.	Pesticides and herbicides			
i)	Foret, Rogor	51/kg	20 kg	1023
ii)	Pesticides and herbicides appl.	1200/ha	1 ha	1200
4.	Energy cost			
i)	Fixed charges	10/BHP/month	10/2/4 months	80
ii)	Energy charges for entire consumption	Rs.0.50/Kwh	No. of unit consumed	
	a) For ITK MIS		1151.547	536
	b) For MIS		1087.139	520
5.	Harvesting	1500/ha	1 ha	1500
6.	Packing			
i)	Empty gunny bags	6/bag	25 bags	150
ii)	Sutali	20/kg	1.5	30
iii)	Filling, weighing, packing etc.	6/bag	25 bags	150
7.	Transportation	16.5/quintal	28.34 quintal	464
8	Total cultivation cost for MIS			13552
	Total cultivation cost for ITK MIS			13568

Table 4.76: Yield Data of Summer Groundnut Grown in Years 2005,2006 and 2007 at T.C.D. Farm, WREMI, Samiala

Irrigation systems	Crop spacing m	Expected yield of summer groundnut, quintal/ha											
		2005			2006			2007			Mean		
		T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
MIS	B_1 = 0.60	**21.03**	20.11	18.60	**23.37**	22.18	20.90	**23.98**	20.91	19.83	**22.79**	21.07	19.78
	B_2 = 0.45	**28.41**	25.67	23.75	**29.31**	26.22	23.76	**27.30**	25.28	21.67	**28.34**	25.72	23.06
ITK MIS	B_1 = 0.60	**20.59**	20.41	18.79	**23.10**	21.92	20.72	**22.50**	20.83	19.38	**22.06**	21.05	19.63
	B_2 = 0.45	**26.06**	25.88	23.47	**28.77**	26.65	24.11	**26.69**	24.06	22.49	**27.17**	25.53	23.36

N.B. B_1 = 0.60 m crop spacing
B_2 = 0.45 m crop spacing

T_1 = 75 % of Crop Water Requirement
T_2 = 100 % of Crop Water Requirement
T_3 = 125 % of Crop Water Requirement

4.4.2 Crop : Cauliflower

Cauliflower (Brassica oleracea L.) was raised on MIS and ITK MIS during years 2005, 2006 and 2007. Table 4.77 gives cultivation data of Cauliflower.

Table 4.77: Cultivation Data of Cauliflower

Crop	Cauliflower
Variety	Vishnu
Crop spacings	0.45 m x 0.60 m 0.60 m x 0.45 m
Number of fields	2
Field size	57.6 m x 28.8 m
Size of each replication plot	14.4 m x 4.8 m
No. of replications	4
Date of sowing	26th September 2005
Date of emergence	11th October 2005
Date of harvesting	9th January 2005
Crop period	90 days
Cultivation cost	Rs.14,300/ha – For MIS Rs.14,292/ha – For ITK MIS
Yield	Shown in Table: 4.82
Selling price	Rs. 800/quintal

Crop water requirement and irrigation scheduling

Table 4.78 shows the values of basal crop coefficient for various growth stages of cauliflower. Reference crop evapotranspiration ETo was calculated using software DSS_ET by FAO Penman-Monteith method. Table 4.79 gives ETo, ETc_dual crop and actual depth of irrigation applied to the field for the year 2005 and is enclosed in DVD. Fig. 4.5 illustrates the variation of Kcb, Kc_dual crop and Kc_adj with respect to crop period and Fig. 4.6 shows variation of ETo, ETc_dual crop and ETc_adj with respect to crop period . Table 4.80 and Fig. 4.7 illustrate irrigation scheduling for Cauliflower in 2005 and is enclosed in DVD.

Table 4.78: Crop Coefficient Kcb for Cauliflower Grown at T.C.D. Farm, WREMI, Samiala

Growth stages	Period, days	RHmin, %	Basal crop coefficient, Kcb
Initial	20	47.55	0.15
Development	30	46.62	0. 55
Mid	25	50.20	0.95
Late	10	54.83	0.85
Total	90		

Fig. 4.5 Variation of Kcb, Kc_dual, Kc_adj and Ke w.r.t. Crop Period for Cauliflower at T.C.D. Farm, WREMI, Samiala in 2005

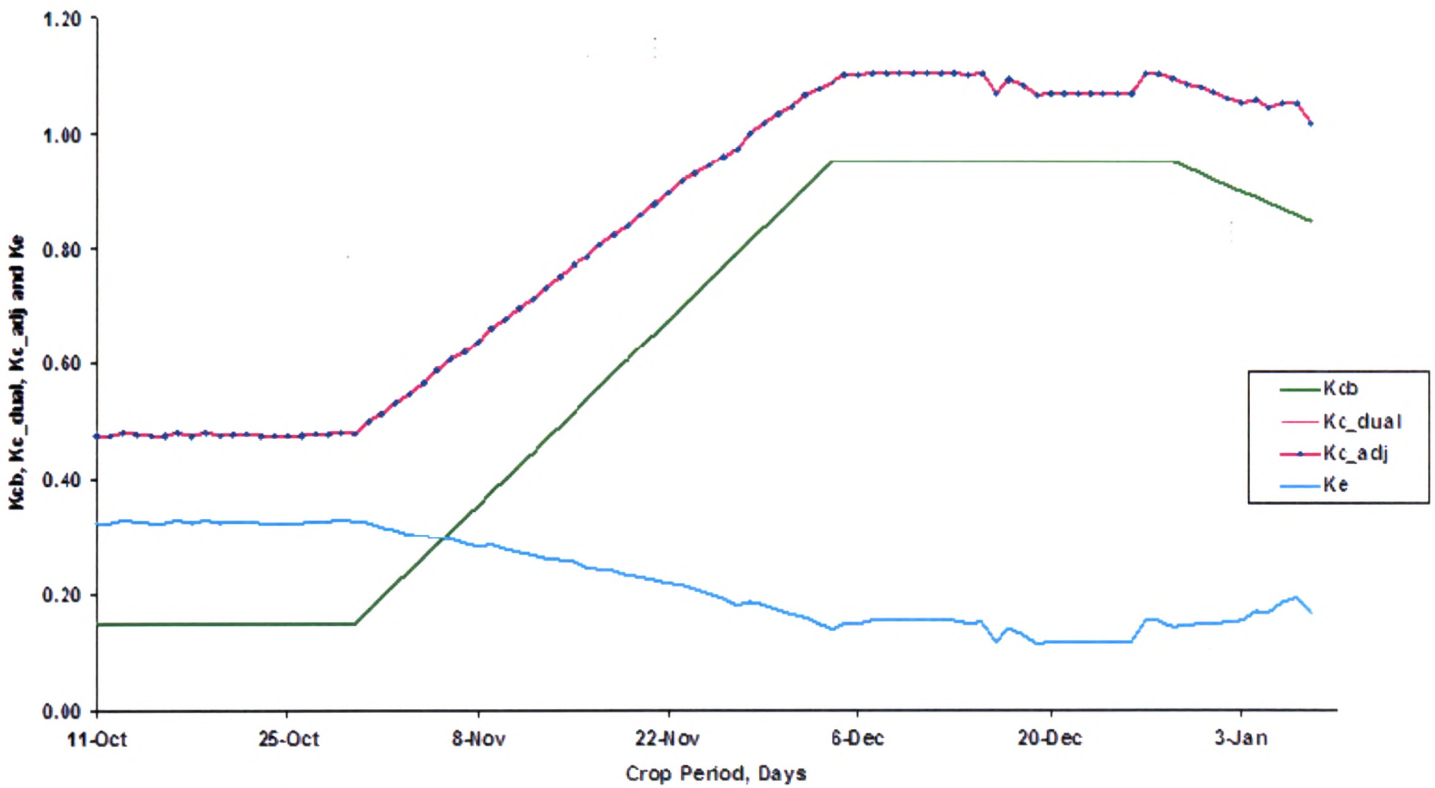


Fig. 4.6 : Variation of ETo, ETc_dual and ETc_adj w.r.t. Crop Period for Cauliflower at T.C.D. Farm, WREMI, Samiala in 2005

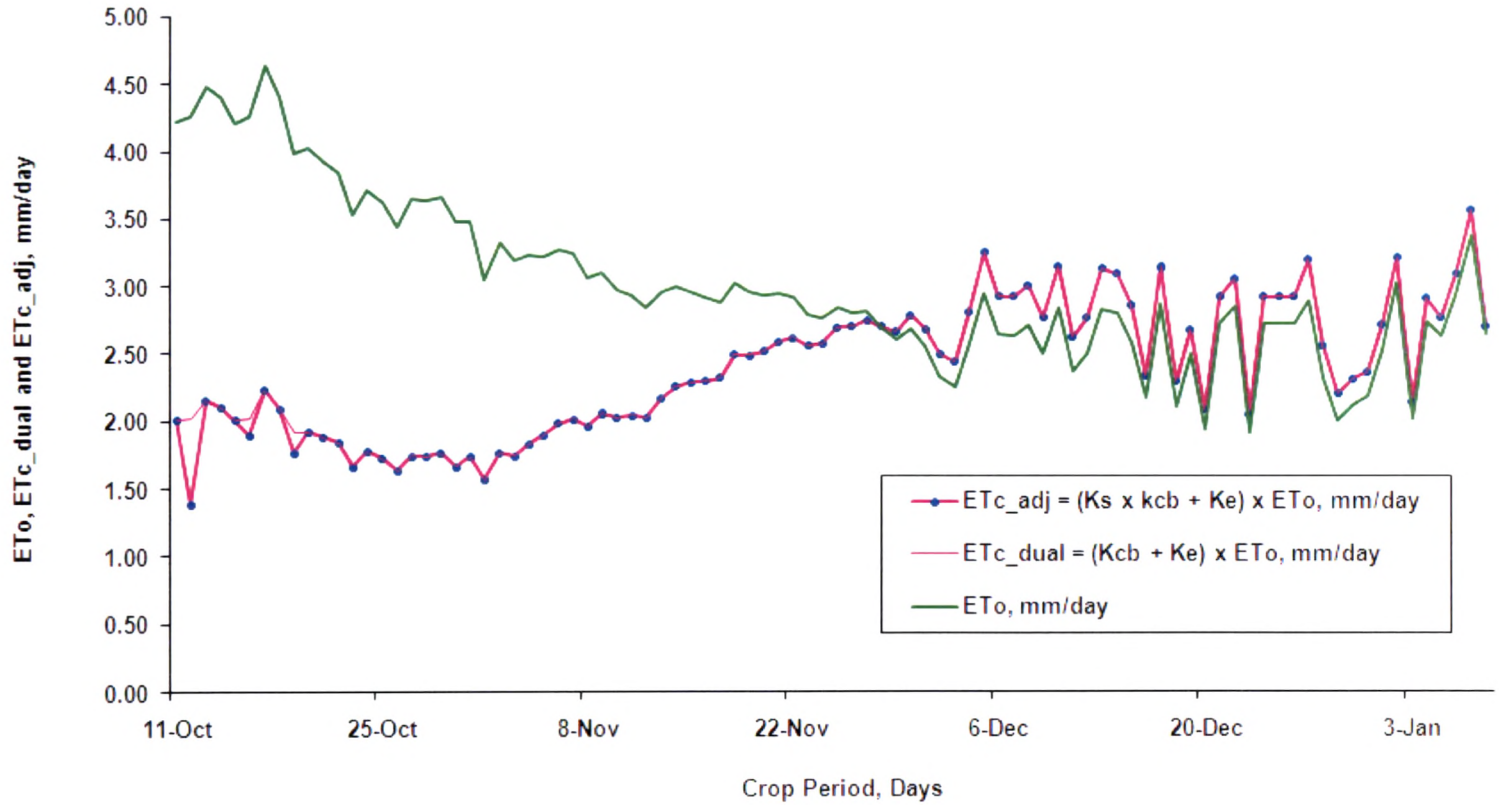
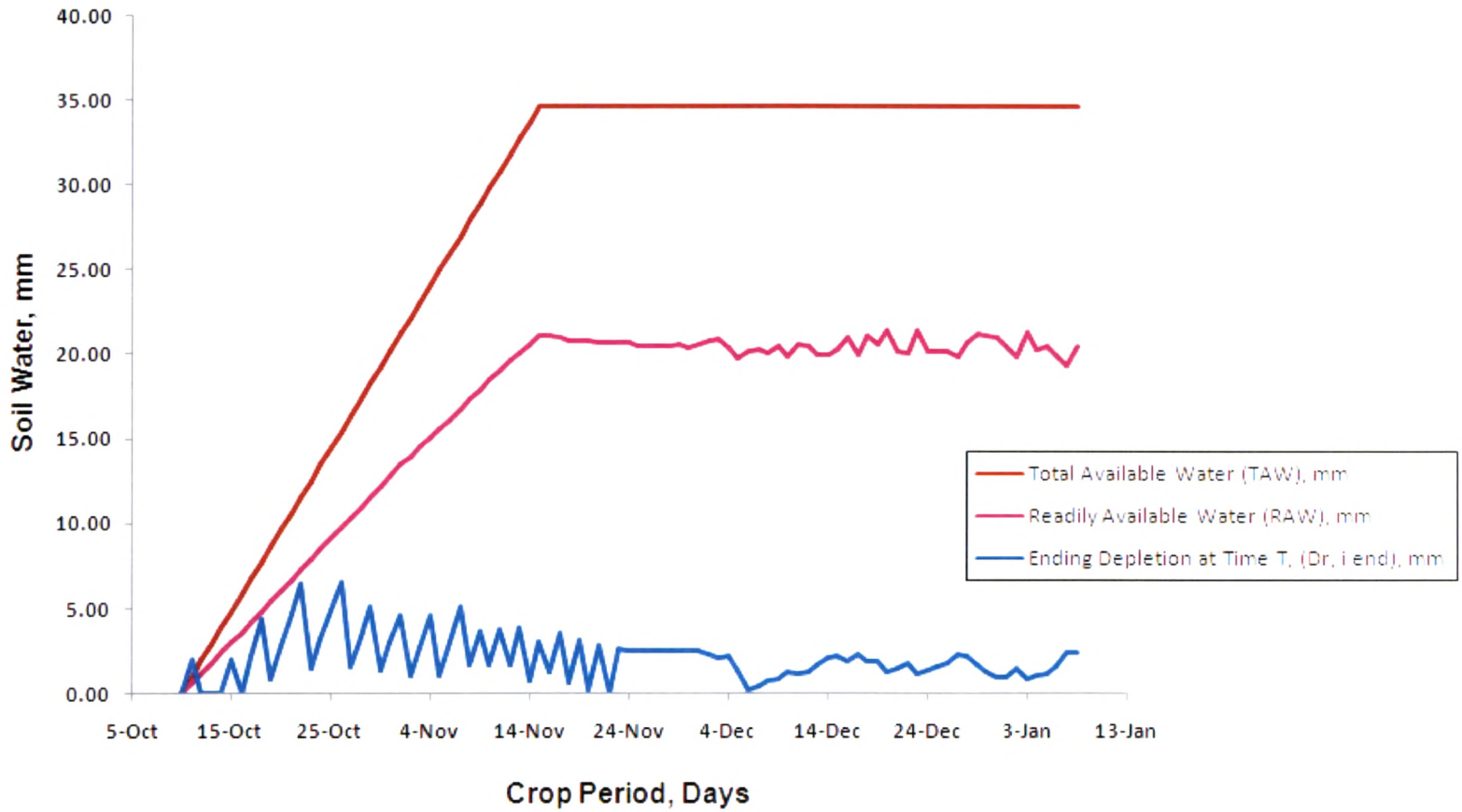


Fig. 4.7: Irrigation scheduling for cauliflower at T.C. D. farm, WREMI, Samiala in 2005



Cultivation cost

The cultivation cost of cauliflower is shown in Table 4.81. Table 4.82 shows average yield data of cauliflower grown in year 2005, 2006 and 2007.

Table 4.81: Cultivation Cost of Cauliflower Raised at T.C.D. Farm, WREMI, Samiala

Sr. No.	Particular	Rate Rs./unit	Quantity	Cost, Rs.
1.	Cultivation			
i)	Ploughing	600/ha	1 ha	600
ii)	Cultivating	700/ha	1 ha	700
iii)	Seeds	150/packet	10 packets	1500
iv)	Sowing	300/ha	1 ha	300
2.	Fertilizers and manures			
i)	Farm yard manure	200/tone	8 tonnes	1600
ii)	Ammonium Sulphate	500/50 kg	50 kg	500
v)	Fertilizers and manures appl.	750/ha	1 ha	750
3.	Pesticides and herbicides			
i)	Foret	48/kg	20 kg	960
ii)	Rogor	63/ lit	1 lit	63
iii)	Monocrotophos	350/ lit	1 lit	350
iv)	Fenvalenete	300/ lit	1 lit	300
v)	Pesticides and herbicides appl.	1200/ha	1 ha	1200
4.	Energy cost			
i)	Fixed charges	10/BHP/month	10/2/4 months	80
ii)	Energy charges for entire consumption	Rs.0.50/ Kwh	No. of units consumed	
	a) For ITK MIS		628	289
	b) For MIS		594	297
	Harvesting	1500/ha	1 ha	1500
6.	Packing			
i)	Clothes for packing (pieces of aathar)	25/no.	20 no.	500
ii)	Sutali	20/kg	5	100
iii)	Filling, weighing, packing etc.	Lumsum	500	500
7.	Transportation	Lumsum	350 quintal	2500
8	Total Cultivation cost of ITK MIS			14292
	Total cultivation cost of MIS			14300

Table 4.82: Yield Data of Cauliflower Grown in Year 2005, 2006 and 2007 at T.C.D. Farm, WREMI, Samiala

Irrigation systems	Crop spacing m	Expected yield of summer groundnut, quintal/ha											
		2005			2006			2007			Mean		
		T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
MIS	B_1 = 0.60	**240.35**	238.76	182.60	**194.10**	190.02	184.81	**307.76**	256.25	209.96	**250.93**	223.14	197.39
	B_2 = 0.45	**283.32**	256.33	253.98	**221.63**	211.50	205.18	**382.23**	355.80	259.51	**301.93**	283.65	232.34
ITK MIS	B_1 = 0.60	**242.39**	226.44	193.11	**195.58**	193.64	188.05	**350.58**	230.93	279.35	**273.08**	212.29	233.70
	B_2 = 0.45	**289.79**	255.79	200.74	**223.63**	208.63	206.66	**475.41**	377.46	304.53	**349.52**	293.04	255.59

N.B. B_1 = 0.60 m crop spacing
B_2 = 0.45 m crop spacing

T_1 = 75 % of Crop Water Requirement
T_2 = 100 % of Crop Water Requirement
T_3 = 125 % of Crop Water Requirement

4.5 Energy Cost

Total energy cost to raise summer groundnut and cauliflower are shown in Table 4.83 and 4.84

Table 4.83: Energy Cost for Summer Groundnut of ITK MIS & MIS Raised at T.C.D. Farm, Samiala

Crop	Summer ground nut	
	ITK MIS	MIS
Discharge required , m^3/sec	0.00336	0.002489
Pump head , m	15.68	20.52
Operation time per set, hr	0.42	0.431
Operation time per set, min	25.38 say 26	25.90 say 26
No. of sets	20	20
Total operating time, hr	= 20 x (26/60) = 8.66	= 20 x (26/60) = 8.66
Power consumed per day , Kwh	= ((1000 x 0.00336 x 15.68/75) x (1/0.5) x 0.7355 x 8.66) = 8.948	= ((1000 x 0.002489 x 20.52/75) x (1/0.5) x 0.7355 x 8.66 = 8.675
Crop period, days	120	120
Power consumed per season, Kwh	= 8.948 x 120 = 1073.76	= 8.675 x 120 = 1041
Total variable charges per season	= 1073.76 x 0.50 = 536.88	= 1041 x 0.50 = 520.5
Fixed charges	= 10 x 2 x 4 = 80	= 10 x 2 x 4 = 80
Total energy cost	= 536.88 + 80 = 616.88	= 520.5 + 80 = 600.5

Table 4.84: Energy Cost for Cauliflower of ITK MIS & MIS Raised at T.C.D. Farm , WREMI, Samiala

Crop	Cauliflower	
	ITK MIS	MIS
Discharge required , m^3/sec	0.00336	0.002489
Pump head , m	15.68	20.52
Operation time per set, hr	0.265	0.271 hr
Operation time per set, min	15.9 say 16	16.22 say 17
No. of sets	20	20
Total operating time, hr	= 20 x (16/60) = 5.33	= 20 x (17/60) = 5.66
Power consumed per day , Kwh	= (1000 x 0.00336 x 15.68/75) x (1/0.5) x 0.7355 x 5.33 = 5.5076	= (1000 x 0.002489 x 20.52/75) x (1/0.5) x 0.7355 x 5.66 = 5.669
Crop period, days	105	105
Power consumed per season, Kwh	= 5.5076 x 105 = 578.3	= 5.669 x 105 = 595.33
Total variable charges per season	= 578.3 x 0.5 = 289.15	= 595.33 x 0.5 = 297.66
Fixed charges	= 10 x 2 x 4 = 80	= 10 x 2 x 4 = 80
Total energy cost	= 289.15 + 80 = 369.15	= 297.66 + 80 = 377.66