CHAPTER-4

METHODOLOGY AND EXPERIMENTAL DESIGN

4.1 Experimental Set up

With a view to analyse environmental impacts of irrigation for Wheat and Greengram crops by blending sewage water with groundwater and surface water, the experiments were designed with seven irrigation treatments having different blending ratios (Table 4.1) and three fertilizer treatments with varying levels of application of nitrogenous fertilizer (Table 4.2).

Table 4.1 Irrigation Treatments

Treatment	Sewage water	Ground water	Surface water
T1	100 % of In	0 % of In	0 % of In
T2	66.66 % of In	33.33 % of In	0 % of In
T3	33.33 % of In	66.66 % of In	0 % of In
T4	0 % of In	100 % of In	0 % of In
T5	66.66 % of In	0 % of In	33.33 % of In
T6	33.33 % of In	0 % of In	66.66 % of In
T7	0 % of In	0 % of In	100 % of In

Table 4.2 Fertilizer Treatments

Treatment	Nitrogenous fertilizer
N1	100 % of recommended dose
N2	75 % of recommended dose
N3	50 % of recommended dose

Note: In = Nos. of Irrigations

4.2 Experimental Layout

According to seven irrigation treatments and three fertilizer treatments, the experimental layout consists of 21 plots as shown in Fig. 4.1. With a view to avoid effect of seepage of irrigation water from one plot to another plot, a gap of 1m was provided between plots. Table 4.3 shows plots under experiment. It was decided to replicate the same experiment for three successive years i.e year 2002-03, 2003-04 and 2004-05. The Table 4.4 shows schedule of experiments which were conducted at Nirma University Campus Site during three successive years.

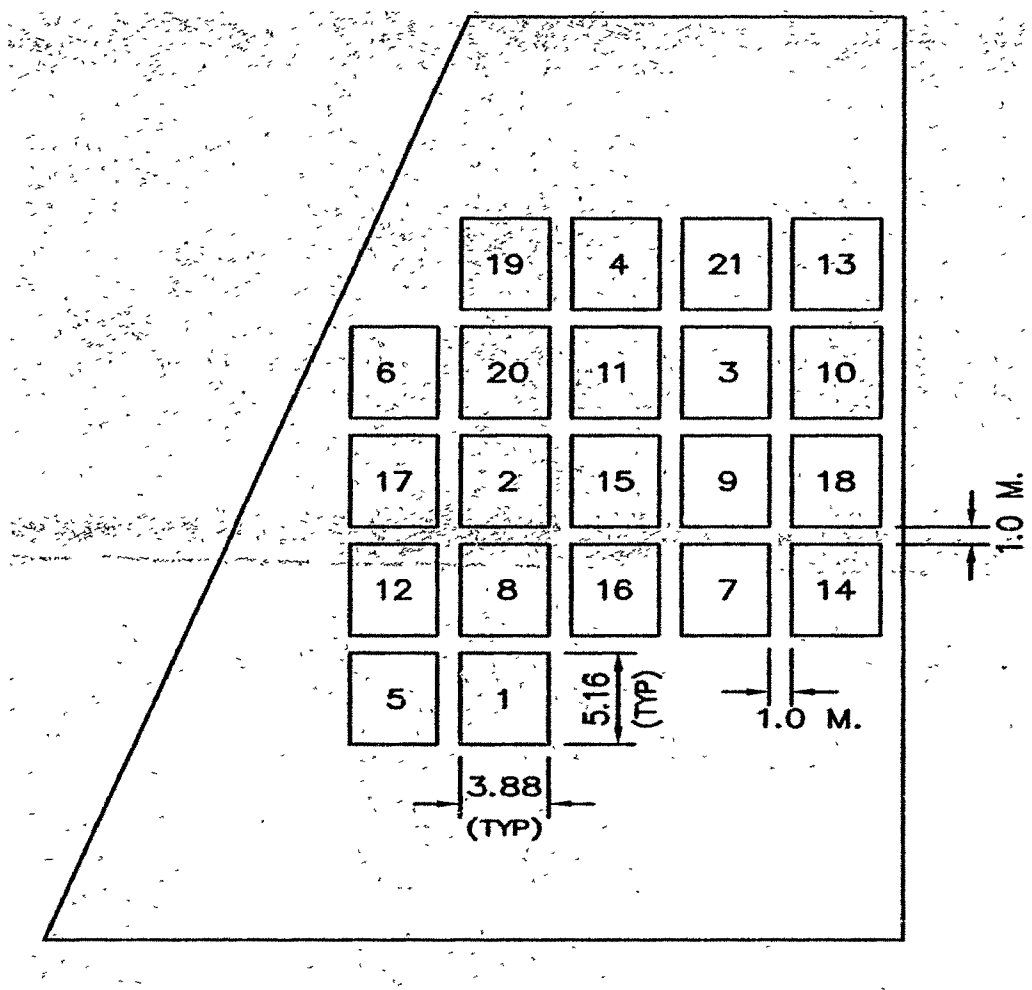

FIG. 4.1 EXPERIMENTAL LAYOUT

Table 4.3 Treatment Plots under Experiment

Plot No.	Irrigation Treatment	Fertilizer Treatment
1.	T1	N1
2.	T2	N1
3.	T3	N1
4.	T4	N1
5.	T5	N1
6.	T6	N1
7.	T7	N1
8.	T1	N2
9.	T2	N2
10.	T3	N2
11.	T4	N2
12.	T5	N2
13.	T6	N2
14.	T7	N2
15.	T1	N3
16.	T2	N3
17.	T3	N3
18.	T4	N3
19.	T5	N3
20.	T6	N3
21.	T7	N3

Table 4.4 Schedule of Experiments

Experiment No.	Crop	Replication (Trial)	Period
1	Wheat	I	November 2002 to March 2003
2	Greengram	I	March 2003 to June 2003
3	Wheat	II	November 2003 to March 2004
4	Greengram	II	March 2004 to June 2004
5	Wheat	III	November 2004 to March 2005
6	Greengram	III	March 2005 to June 2005

4.3 Crop Water Requirement and Irrigation Scheduling for Wheat

The Potential Evapotranspiration (ETo) is worked out by Pan Evaporation method. ETo is calculated by multiplying Kp with Epan. Crop Coefficient (Kc) for various crop growth stages of wheat are worked out from Crop Coefficient Curve (Fig. 4.2) and then Evapotranspiration of Crop (ETc) is calculated by multiplying Kc with ETo as follows.

Crop: Wheat

Variety: GW496, 125 days

Sowing time: 10-25 November

(I) Calculation of Kc_1

Initial ETo: 4.31 mm/day

Irrigation Interval: 20 days

Kc_1 :0.25

(II) Calculation of Kc_3 and Kc_4

RH min : < 20%

Wind Speed: 2-5 m/sec

Kc_3: 1.15 and Kc_4 :0.2

Crop growth stages for Wheat - Central India (November planting) and their corresponding period are mentioned in Table: 4.5.

Table: 4.5 Wheat crop growth stages

Crop growth stages	Days	Trial-I	Trial-II	Trial-III
Initial stage	15	15/11/2002 to 29/11/2002	15/11/2003 to 29/11/2003	15/11/2004 to 29/11/2004
Crop development stage	25	30/11/2002 to 24/12/2002	30/11/2003 to 24/12/2003	30/11/2004 to 24/12/2004
Mid season stage	50	25/12/2002 to 12/02/2003	25/12/2003 to 12/02/2004	25/12/2004 to 12/02/2005
Late season stage	30	13/02/2003 to 14/03/2003	13/02/2004 to 13/03/2004	13/02/2005 to 14/03/2005

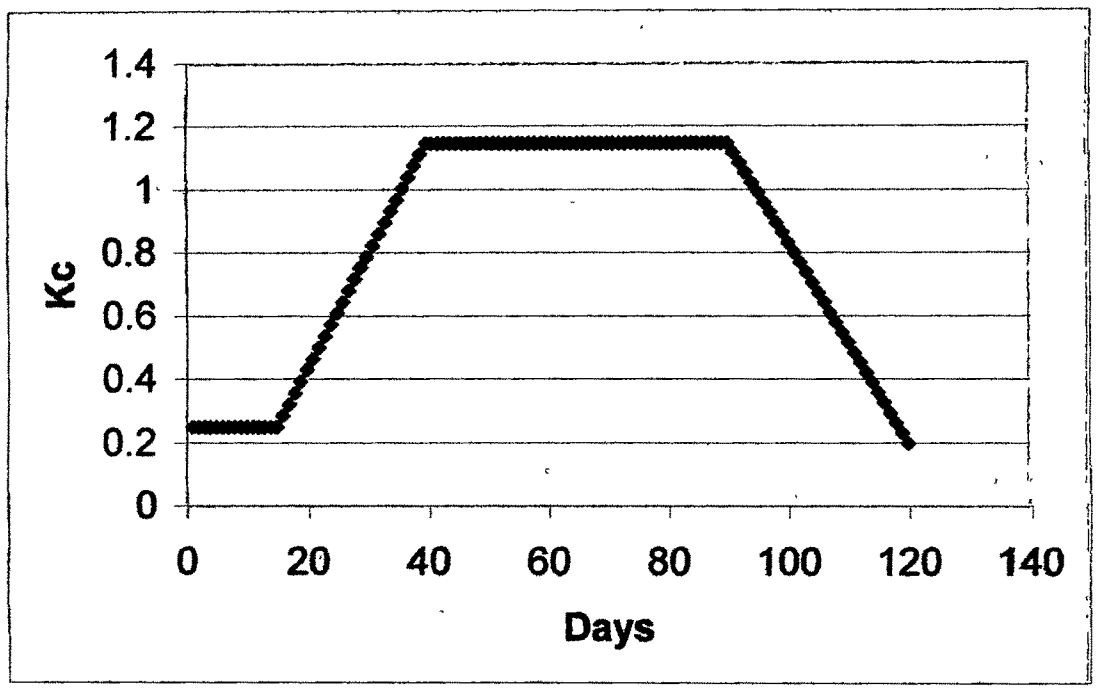

Fig. 4.2 Crop Coefficient (Kc) Curve for Wheat

(III) Calculation of Pan Evaporation Coefficient (Kp):

Location of Pan: Fallow area

Windward side distance of dry fallow: 10 m

Wind speed: Moderate

RH mean : 40-70%

Kp: 0.65

$$\text{Gross Irrigation Depth (GID)} = \frac{\text{Net Irrigation Depth (NID) X 100}}{\text{Water application efficiency (Ea)}}$$

Gross Irrigation Depth (GID) is calculated by considering water application efficiency (Ea)=80% in above equation.

Table 4.6 refers to Irrigation Scheduling for Wheat Crop.

Table 4.6 Irrigation Scheduling for Wheat Crop

Month	Day	Pan Evap^{n} (Epan) mm	Pan Coeff. (Kp)	Crop Coeff. (Kc)	Crop Evapo Transpi. (ETc) mm/day	Cumu. Crop Evapo Transpi. (ETc) mm	NID (mm)	GID (mm)
Nov	15	4.31	0.65	0.25	0.70	0.70		
Nov	16	4.31	0.65	0.25	0.70	1.40		
Nov	17	4.31	0.65	0.25	0.70	2.10		
Nov	18	4.31	0.65	0.25	0.70	2.80		
Nov	19	4.31	0.65	0.25	0.70	3.50		
Nov	20	4.31	0.65	0.25	0.70	4.20		
Nov	21	4.31	0.65	0.25	0.70	4.90		
Nov	22	4.31	0.65	0.25	0.70	5.60		
Nov	23	4.31	0.65	0.25	0.70	6.30		
Nov	24	4.31	0.65	0.25	0.70	7.00		
Nov	25	4.31	0.65	0.25	0.70	7.70		
Nov	26	4.31	0.65	0.25	0.70	8.40		
Nov	27	4.31	0.65	0.25	0.70	9.10		
Nov	28	4.31	0.65	0.25	0.70	9.81		
Nov	29	4.31	0.65	0.25	0.70	10.51		
Nov	30	4.31	0.65	0.2860	0.80	11.31		
Dec	1	3.64	0.65	0.3220	0.76	12.07		
Dec	2	3.64	0.65	0.3580	0.85	12.92		
Dec	3	3.64	0.65	0.3940	0.93	13.85		
Dec	4	3.64	0.65	0.4300	1.02	14.87		
Dec	5	3.64	0.65	0.4660	1.10	15.97	14.87	18.59
Dec	6	3.64	0.65	0.5020	1.19	17.16		
Dec	7	3.64	0.65	0.5380	1.27	18.43		
Dec	8	3.64	0.65	0.5740	1.36	19.79		
Dec	9	3.64	0.65	0.6100	1.44	21.23		

Month	Day	Epan (mm)	Kp	Kc	ETc (mm/day)	ETc Cumulative (mm)	NID (mm)	GID (mm)
Dec	10	3.64	0.65	0.6460	1.53	22.76		
Dec	11	3.64	0.65	0.6820	1.61	24.37		
Dec	12	3.64	0.65	0.7180	1.70	26.07		
Dec	13	3.64	0.65	0.7540	1.78	27.85		
Dec	14	3.64	0.65	0.7900	1.87	29.72		
Dec	15	3.64	0.65	0.8260	1.95	31.68		
Dec	16	3.64	0.65	0.8620	2.04	33.72		
Dec	17	3.64	0.65	0.8980	2.12	35.84		
Dec	18	3.64	0.65	0.9340	2.21	38.05		
Dec	19	3.64	0.65	0.9700	2.30	40.35	20.98	26.23
Dec	20	3.64	0.65	1.0060	2.38	42.73		
Dec	21	3.64	0.65	1.0420	2.47	45.19		
Dec	22	3.64	0.65	1.0780	2.55	47.74		
Dec	23	3.64	0.65	1.1140	2.64	50.38		
Dec	24	3.64	0.65	1.1500	2.72	53.10		
Dec	25	3.64	0.65	1.15	2.72	55.82		
Dec	26	3.64	0.65	1.15	2.72	55.82		
Dec	27	3.64	0.65	1.15	2.72	58.54		
Dec	28	3.64	0.65	1.15	2.72	61.26		
Dec	29	3.64	0.65	1.15	2.72	63.98	25.42	31.78
Dec	30	3.64	0.65	1.15	2.72	66.70		
Dec	31	3.64	0.65	1.15	2.72	69.43		
Jan	1	3.62	0.65	1.15	2.72	72.15		
Jan	2	3.62	0.65	1.15	2.71	74.85		
Jan	3	3.62	0.65	1.15	2.71	77.56		
Jan	4	3.62	0.65	1.15	2.71	80.26		
Jan	5	3.62	0.65	1.15	2.71	82.97		

Month	Day	Epan (mm)	Kp	Kc	ETc (mm/day)	ETc Cumulative (mm)	NID (mm)	GID (mm)
Jan	6	3.62	0.65	1.15	2.71	88.38		
Jan	7	3.62	0.65	1.15	2.71	91.09	27.12	33.90
Jan	8	3.62	0.65	1.15	2.71	93.79		
Jan	9	3.62	0.65	1.15	2.71	96.50		
Jan	10	3.62	0.65	1.15	2.71	99.21		
Jan	11	3.62	0.65	1.15	2.71	101.91		
Jan	12	3.62	0.65	1.15	2.71	104.62		
Jan	13	3.62	0.65	1.15	2.71	107.32		
Jan	14	3.62	0.65	1.15	2.71	110.03		
Jan	15	3.62	0.65	1.15	2.71	112.74		
Jan	16	3.62	0.65	1.15	2.71	115.44		
Jan	17	3.62	0.65	1.15	2.71	118.15	27.06	33.83
Jan	18	3.62	0.65	1.15	2.71	120.85		
Jan	19	3.62	0.65	1.15	2.71	123.56		
Jan	20	3.62	0.65	1.15	2.71	126.27		
Jan	21	3.62	0.65	1.15	2.71	128.97		
Jan	22	3.62	0.65	1.15	2.71	131.68		
Jan	23	3.62	0.65	1.15	2.71	134.38		
Jan	24	3.62	0.65	1.15	2.71	137.09		
Jan	25	3.62	0.65	1.15	2.71	139.79		
Jan	26	3.62	0.65	1.15	2.71	142.50		
Jan	27	3.62	0.65	1.15	2.71	145.21	27.06	33.83
Jan	28	3.62	0.65	1.15	2.71	147.91		
Jan	29	3.62	0.65	1.15	2.71	150.62		
Jan	30	3.62	0.65	1.15	2.71	153.32		
Jan	31	3.62	0.65	1.15	2.71	156.03		
Feb	1	4.58	0.65	1.15	3.42	159.45		

Month	Day	Epan (mm)	Kp	Kc	ETc (mm/day)	ETc Cumulative (mm)	NID (mm)	GID (mm)
Feb	2	4.58	0.65	1.15	3.42	162.88		
Feb	3	4.58	0.65	1.15	3.42	166.30		
Feb	4	4.58	0.65	1.15	3.42	169.72		
Feb	5	4.58	0.65	1.15	3.42	173.15		
Feb	6	4.58	0.65	1.15	3.42	176.57	30.65	38.31
Feb	7	4.58	0.65	1.15	3.42	180		
Feb	8	4.58	0.65	1.15	3.42	183.42		
Feb	9	4.58	0.65	1.15	3.42	186.84		
Feb	10	4.58	0.65	1.15	3.42	190.27		
Feb	11	4.58	0.65	1.15	3.42	193.69		
Feb	12	4.58	0.65	1.15	3.42	197.11		
Feb	13	4.58	0.65	1.12	3.33	200.44		
Feb	14	4.58	0.65	1.09	3.24	203.68		
Feb	15	4.58	0.65	1.06	3.14	206.82		
Feb	16	4.58	0.65	1.02	3.05	209.86	33.67	42.09
Feb	17	4.58	0.65	0.99	2.95	212.82		
Feb	18	4.58	0.65	0.96	2.86	215.67		
Feb	19	4.58	0.65	0.93	2.76	218.44		
Feb	20	4.58	0.65	0.90	2.67	221.11		
Feb	21	4.58	0.65	0.87	2.58	223.68		
Feb	22	4.58	0.65	0.83	2.48	226.16		
Feb	23	4.58	0.65	0.80	2.39	228.55		
Feb	24	4.58	0.65	0.77	2.29	230.84		
Feb	25	4.58	0.65	0.74	2.20	233.04		
Feb	26	4.58	0.65	0.71	2.10	235.14	26.22	32.78
Feb	27	4.58	0.65	0.68	2.01	237.15		

Month	Day	Epan (mm)	Kp	Kc	ETc (mm/day)	ETc Cumulative (mm)	NID (mm)	GID (mm)
Feb	28	4.58	0.65	0.64	1.92	239.07		
Mar	1	5.98	0.65	0.61	2.38	241.45		
Mar	2	5.98	0.65	0.58	2.25	243.70		
Mar	3	5.98	0.65	0.55	2.13	245.83		
Mar	4	5.98	0.65	0.52	2.01	247.84		
Mar	5	5.98	0.65	0.49	1.89	249.73		
Mar	6	5.98	0.65	0.45	1.76	251.49		
Mar	7	5.98	0.65	0.42	1.64	253.13		
Mar	8	5.98	0.65	0.39	1.52	254.64		
Mar	9	5.98	0.65	0.36	1.39	256.04		
Mar	10	5.98	0.65	0.33	1.27	257.31		
Mar	11	5.98	0.65	0.30	1.15	258.45		
Mar	12	5.98	0.65	0.26	1.02	259.48		
Mar	13	5.98	0.65	0.23	0.90	260.38		
Mar	14	5.98	0.65	0.20	0.78	261.15		

Table 4.7 shows schedule for blending of irrigations for wheat.

Table 4.7 Schedule for Blending of Irrigations for Wheat

Plot No.	Irrigation								
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
1	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage
2	Sewage	Sewage	Ground	Sewage	Sewage	Ground	Sewage	Sewage	Ground
3	Ground	Ground	Sewage	Ground	Ground	Sewage	Ground	Ground	Sewage
4	Ground	Ground	Ground	Ground	Ground	Ground	Ground	Ground	Ground
5	Sewage	Sewage	Surface	Sewage	Sewage	Surface	Sewage	Sewage	Surface
6	Surface	Surface	Sewage	Surface	Surface	Sewage	Surface	Surface	Sewage
7	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
8	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage
9	Sewage	Sewage	Ground	Sewage	Sewage	Ground	Sewage	Sewage	Ground
10	Ground	Ground	Sewage	Ground	Ground	Sewage	Ground	Ground	Sewage
11	Ground	Ground	Ground	Ground	Ground	Ground	Ground	Ground	Ground
12	Sewage	Sewage	Surface	Sewage	Sewage	Surface	Sewage	Sewage	Surface
13	Surface	Surface	Sewage	Surface	Surface	Sewage	Surface	Surface	Sewage
14	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
15	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage
16	Sewage	Sewage	Ground	Sewage	Sewage	Ground	Sewage	Sewage	Ground
17	Ground	Ground	Sewage	Ground	Ground	Sewage	Ground	Ground	Sewage
18	Ground	Ground	Ground	Ground	Ground	Ground	Ground	Ground	Ground
19	Sewage	Sewage	Surface	Sewage	Sewage	Surface	Sewage	Sewage	Surface
20	Surface	Surface	Sewage	Surface	Surface	Sewage	Surface	Surface	Sewage
21	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface

The volume of water (Sewage, groundwater and surface water) applied to each treatment plot during each successive irrigation for wheat crop is shown in Table 4.8 to Table 4.16. Volume of irrigation water is worked out by multiplying GID with treatment-plot area of 20.02 m^2.

Table 4.8 First Irrigation for Wheat

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	373	0	0
2.	373	0	0
3.	0	373	0
4.	0	373	0
5.	373	0	0
6.	0	0	373
7.	0	0	373
8.	373	0	0
9.	373	0	0
10.	0	373	0
11.	0	373	0
12.	373	0	0
13.	0	0	373
14.	0	0	373
15.	373	0	0
16.	373	0	0
17.	0	373	0
18.	0	373	0
19.	373	0	0
20.	0	0	373
21.	0	0	373

Table 4.9 Second Irrigation for Wheat

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	525	0	0
2.	525	0	0
3.	0	525	0
4.	0	525	0
5.	525	0	0
6.	0	0	525
7.	0	0	525
8.	525	0	0
9.	525	0	0
10.	0	525	0
11.	0	525	0
12.	525	0	0
13.	0	0	525
14.	0	0	525
15.	525	0	0
16.	525	0	0
17.	0	525	0
18.	0	525	0
19.	525	0	0
20.	0	0	525
21.	0	0	525

Table 4.10 Third Irrigation for Wheat

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	637	0	0
2.	0	637	0
3.	637	0	0
4.	0	637	0
5.	0	0	637
6.	637	0	0
7.	0	0	637
8.	637	0	0
9.	0	637	0
10.	637	0	0
11.	0	637	0
12.	0	0	637
13.	637	0	0
14.	0	0	637
15.	637	0	0
16.	0	637	0
17.	637	0	0
18.	0	637	0
19.	0	0	637
20.	637	0	0
21.	0	0	637

Table 4:11 Fourth Irrigation for Wheat

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	679	0	0
2.	679	0	0
3.	0	679	0
4.	0	679	0
5.	679	0	0
6.	0	0	679
7.	0	0	679
8.	679	0	0
9.	679	0	0
10.	0	679	0
11.	0	679	0
12.	679	0	0
13.	0	0	679
14.	0	0	679
15.	679	0	0
16.	679	0	0
17.	0	679	0
18.	0	679	0
19.	679	0	0
20.	0	0	679
21.	0	0	679

Table 4.12 Fifth Irrigation for Wheat

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	678	0	0
2.	678	0	0
3.	0	678	0
4.	0	678	0
5.	678	0	0
6.	0	0	678
7.	0	0	678
8.	678	0	0
9.	678	0	0
10.	0	678	0
11.	0	678	0
12.	678	0	0
13.	0	0	678
14.	0	0	678
15.	678	0	0
16.	678	0	0
17.	0	678	0
18.	0	678	0
19.	678	0	0
20.	0	0	678
21.	0	0	678

Table 4.13 Sixth Irrigation for Wheat

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	678	0	0
2.	0	678	0
3.	678	0	0
4.	0	678	0
5.	0	0	678
6.	678	0	0
7.	0	0	678
8.	678	0	0
9.	0	678	0
10.	678	0	0
11.	0	678	0
12.	0	0	678
13.	678	0	0
14.	0	0	678
15.	678	0	0
16.	0	678	0
17.	678	0	0
18.	0	678	0
19.	0	0	678
20.	678	0	0
21.	0	0	678

Table 4.14 Seventh Irrigation for Wheat

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	767	0	0
2.	767	0	0
3.	0	767	0
4.	0	767	0
5.	767	0	0
6.	0	0	767
7.	0	0	767
8.	767	0	0
9.	767	0	0
10.	0	767	0
11.	0	767	0
12.	767	0	0
13.	0	0	767
14.	0	0	767
15.	767	0	0
16.	767	0	0
17.	0	767	0
18.	0	767	0
19.	767	0	0
20.	0	0	767
21.	0	0	767

Table 4.15 Eight Irrigation for Wheat

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	843	0	0
2.	843	0	0
3.	0	843	0
4.	0	843	0
5.	843	0	0
6.	0	0	843
7.	0	0	843
8.	843	0	0
9.	843	0	0
10.	0	843	0
11.	0	843	0
12.	843	0	0
13.	0	0	843
14.	0	0	843
15.	843	0	0
16.	843	0	0
17.	0	843	0
18.	0	843	0
19.	843	0	0
20.	0	0	843
21.	0	0	843

Table 4.16 Ninth Irrigation for Wheat

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	657	0	0
2.	0	657	0
3.	657	0	0
4.	0	657	0
5.	0	0	657
6.	657	0	0
7.	0	0	657
8.	657	0	0
9.	0	657	0
10.	657	0	0
11.	0	657	0
12.	0	0	657
13.	657	0	0
14.	0	0	657
15.	657	0	0
16.	0	657	0
17.	657	0	0
18.	0	657	0
19.	0	0	657
20.	657	0	0
21.	0	0	657

4.4 Crop Water Requirement and Irrigation Scheduling for Greengram

The Potential Evapotranspiration (ETo) is worked out by Pan Evaporation method. ETo is calculated by multiplying Kp with Epan. Crop Coefficient (Kc) for various crop growth stages of greengram are worked out from Crop Coefficient Curve (Fig. 4.3) and then Evapotranspiration of Crop (ETc) is calculated by multiplying Kc with ETo as follows.

Crop: Greengram

Variety: Gujarat Moong-4, 65 days

Sowing time: March

(I) Calculation of Kc_1

Initial ETo : 6.08 mm/day

Irrigation Interval: 10 days

Kc_1: 0.30

(II) Calculation of Kc_3 and Kc_4

RH min : < 20%

Wind Speed : 2-5 m/sec

Kc_3 : 1.15 and Kc_4 : 0.25

Crop growth stages for Greengram and their corresponding period are mentioned in Table: 4.17.

Table: 4.17 Greengram Crop Growth Stages

Crop growth stages	Days	Trial-I	Trial -II	Trial -III
Initial stage	15	30/03/2003 to 13/04/2003	30/03/2004 to 13/04/2004	30/03/2005 to 13/04/2005
Crop development stage	20	14/04/2003 to 03/05/2003	14/04/2004 to 03/05/2004	14/04/2004 to 03/05/2005
Mid season stage	20	04/05/2003 to 22/05/2003	04/05/2004 to 22/05/2004	04/05/2005 to 22/05/2005
Late season stage	10	23/05/2003 to 02/06/2003	23/05/2004 to 02/06/2004	23/05/2005 to 02/06/2005

(III) Calculation of Kp:

Location of Pan: Fallow area

Windward side distance of dry fallow: 10 m

Wind speed: Moderate

RH mean : 40-70%

Kp: 0.65

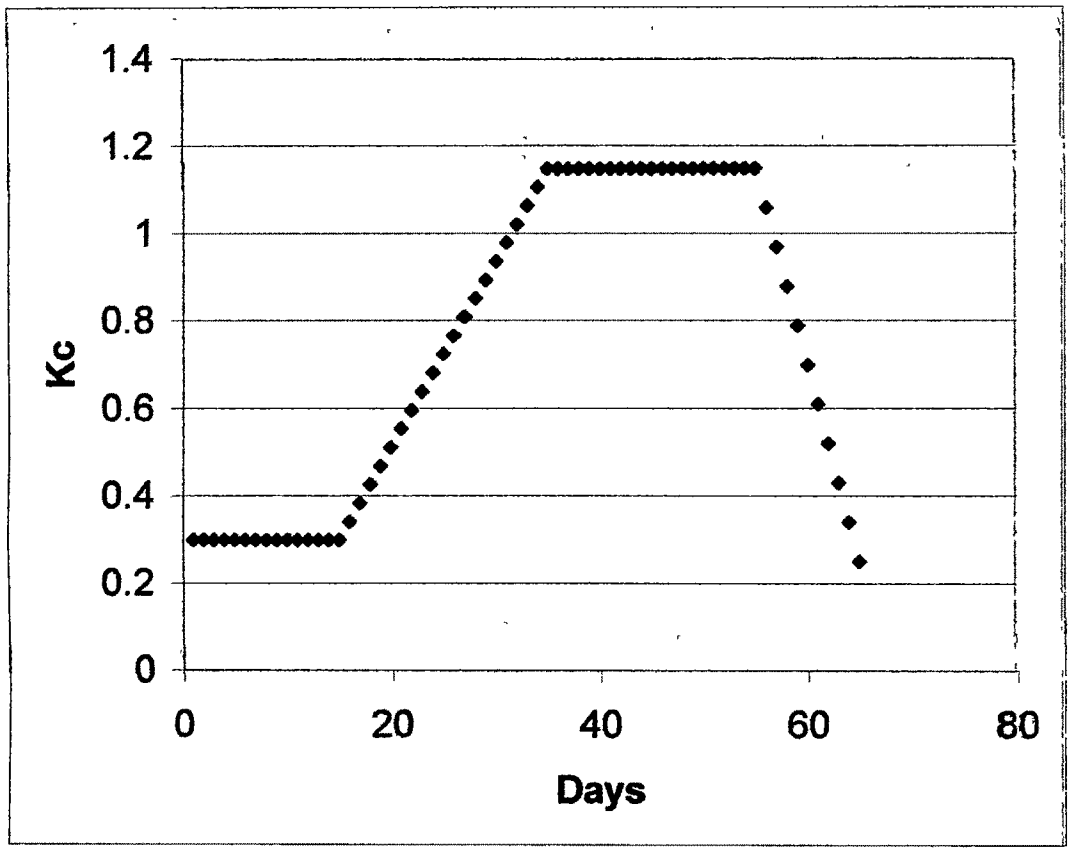

Fig. 4.3 Crop Coefficient (Kc)Curve for Greengram

$$\text{Gross Irrigation Depth (GID)} = \frac{\text{Net Irrigation Depth (NID) X 100}}{\text{Water application efficiency (Ea)}}$$

Gross Irrigation Depth (GID) is calculated by considering water application efficiency (Ea)=80% in above equation.

Table 4.18 refers to Irrigation scheduling for greengram crop.

Table 4.18 Irrigation Scheduling for Greengram Crop

Month	Day	Pan Evap^{n} (Epan) mm	Pan Coeff. (Kp)	Crop Coeff. (Kc)	Crop Evapo Transpi. (ETc) mm/day	Cumu. Crop Evapo Transpi. (ETc) mm	NID (mm)	GID (mm)
March	30	6.08	0.65	0.3	1.19	1.19		
March	31	6.08	0.65	0.3	1.19	2.37		
April	1	7.7	0.65	0.3	1.50	3.87		
April	2	7.7	0.65	0.3	1.50	5.37		
April	3	7.7	0.65	0.3	1.50	6.88		
April	4	7.7	0.65	0.3	1.50	8.38		
April	5	7.7	0.65	0.3	1.50	9.88		
April	6	7.7	0.65	0.3	1.50	11.38		
April	7	7.7	0.65	0.3	1.50	12.88		
April	8	7.7	0.65	0.3	1.50	14.38	12.88	16.10
April	9	7.7	0.65	0.3	1.50	15.88		
April	10	7.7	0.65	0.3	1.50	17.39		
April	11	7.7	0.65	0.3	1.50	18.89		
April	12	7.7	0.65	0.3	1.50	20.39		
April	13	7.7	0.65	0.3	1.50	21.89		
April	14	7.7	0.65	0.34	1.70	23.59		
April	15	7.7	0.65	0.38	1.91	25.50		
April	16	7.7	0.65	0.42	2.11	27.61		
April	17	7.7	0.65	0.46	2.31	29.92		
April	18	7.7	0.65	0.5	2.51	32.44	17.04	21.30
April	19	7.7	0.65	0.54	2.72	35.15		
April	20	7.7	0.65	0.58	2.92	38.07		
April	21	7.7	0.65	0.62	3.12	41.20		
April	22	7.7	0.65	0.66	3.32	44.52		
April	23	7.7	0.65	0.7	3.53	48.05		

Month	Day	Epan (mm)	Kp	Kc	ETc (mm/day)	ETc Cumulative (mm)	NID (mm)	GID (mm)
April	24	7.7	0.65	0.75	3.73	51.78		
April	25	7.7	0.65	0.79	3.93	55.71		
April	26	7.7	0.65	0.83	4.14	59.85		
April	27	7.7	0.65	0.87	4.34	64.18		
April	28	7.7	0.65	0.91	4.54	68.72	34.26	42.83
April	29	7.7	0.65	0.95	4.74	73.47		
April	30	7.7	0.65	0.99	4.95	78.41		
May	1	8.67	0.65	1.03	5.80	84.21		
May	2	8.67	0.65	1.07	6.02	90.23		
May	3	8.67	0.65	1.11	6.25	96.49		
May	4	8.67	0.65	1.15	6.48	102.97		
May	5	8.67	0.65	1.15	6.48	109.45		
May	6	8.67	0.65	1.15	6.48	115.93		
May	7	8.67	0.65	1.15	6.48	122.41		
May	8	8.67	0.65	1.15	6.48	128.89	58.23	72.79
May	9	8.67	0.65	1.15	6.48	135.37		
May	10	8.67	0.65	1.15	6.48	141.85		
May	11	8.67	0.65	1.15	6.48	148.33		
May	12	8.67	0.65	1.15	6.48	154.81		
May	13	8.67	0.65	1.15	6.48	161.29		
May	14	8.67	0.65	1.15	6.48	167.77		
May	15	8.67	0.65	1.15	6.48	174.26		
May	16	8.67	0.65	1.15	6.48	180.74		
May	17	8.67	0.65	1.15	6.48	187.22		
May	18	8.67	0.65	1.15	6.48	193.70	64.81	81.01
May	19	8.67	0.65	1.15	6.48	200.18		

Month	Day	Epan (mm)	Kp	Kc	ETc (mm/day)	ETc Cumulative (mm)	NID (mm)	GID (mm)
May	20	8.67	0.65	1.15	6.48	206.66		
May	21	8.67	0.65	1.15	6.48	213.14		
May	22	8.67	0.65	1.15	6.48	219.62		
May	23	8.67	0.65	1.07	6.02	225.64		
May	24	8.67	0.65	0.99	5.56	231.20		
May	25	8.67	0.65	0.9	5.10	236.30		
May	26	8.67	0.65	0.82	4.64	240.93		
May	27	8.67	0.65	0.74	4.18	245.11		
May	28	8.67	0.65	0.66	3.71	248.82	57.89	72.36
May	29	8.67	0.65	0.58	3.25	252.08		
May	30	8.67	0.65	0.5	2.79	254.87		
May	31	8.67	0.65	0.41	2.33	257.20		
June	1	7.37	0.65	0.33	1.59	258.79		
June	2	7.37	0.65	0.25	1.20	259.99		

Table 4.19 shows schedule for blending of irrigations for green gram.

Table 4.19 Schedule for Blending of Irrigations for Green gram

Plot No.	Irrigation					
	1st	2nd	3rd	4th	5th	6th
1	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage
2	Sewage	Sewage	Ground	Sewage	Sewage	Ground
3	Ground	Ground	Sewage	Ground	Ground	Sewage
4	Ground	Ground	Ground	Ground	Ground	Ground
5	Sewage	Sewage	Surface	Sewage	Sewage	Surface
6	Surface	Surface	Sewage	Surface	Surface	Sewage
7	Surface	Surface	Surface	Surface	Surface	Surface
8	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage
9	Sewage	Sewage	Ground	Sewage	Sewage	Ground
10	Ground	Ground	Sewage	Ground	Ground	Sewage
11	Ground	Ground	Ground	Ground	Ground	Ground
12	Sewage	Sewage	Surface	Sewage	Sewage	Surface
13	Surface	Surface	Sewage	Surface	Surface	Sewage
14	Surface	Surface	Surface	Surface	Surface	Surface
15	Sewage	Sewage	Sewage	Sewage	Sewage	Sewage
16	Sewage	Sewage	Ground	Sewage	Sewage	Ground
17	Ground	Ground	Sewage	Ground	Ground	Sewage
18	Ground	Ground	Ground	Ground	Ground	Ground
19	Sewage	Sewage	Surface	Sewage	Sewage	Surface
20	Surface	Surface	Sewage	Surface	Surface	Sewage
21	Surface	Surface	Surface	Surface	Surface	Surface

The volume of water (Sewage, groundwater and surface water) applied during each successive irrigation for Greengram crop is worked out by multiplying gross irrigation depth with plot area and given in Table 4.20 to Table 4.25. Volume of irrigation water is worked out by multiplying GID with treatment-plot area of 20.02 m^2.

Table 4.20 First Irrigation for Greengram

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	323	0	0
2.	323	0	0
3.	0	323	0
4.	0	323	0
5.	323	0	0
6.	0	0	323
7.	0	0	323
8.	323	0	0
9.	323	0	0
10.	0	323	0
11.	0	323	0
12.	323	0	0
13.	0	0	323
14.	0	0	323
15.	323	0	0
16.	323	0	0
17.	0	323	0
18.	0	323	0
19.	323	0	0
20.	0	0	323
21.	0	0	323

Table 4.21 Second Irrigation for Greengram

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	427	0	0
2.	427	0	0
3.	0	427	0
4.	0	427	0
5.	427	0	0
6.	0	0	427
7.	0	0	427
8.	427	0	0
9.	427	0	0
10.	0	427	0
11.	0	427	0
12.	427	0	0
13.	0	0	427
14.	0	0	427
15.	427	0	0
16.	427	0	0
17.	0	427	0
18.	0	427	0
19.	427	0	0
20.	0	0	427
21.	0	0	427

Table 4.22 Third Irrigation for Greengram

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	858	0	0
2.	0	858	0
3.	858	0	0
4.	0	858	0
5.	0	0	858
6.	858	0	0
7.	0	0	858
8.	858	0	0
9.	0	858	0
10.	858	0	0
11.	0	858	0
12.	0	0	858
13.	858	0	0
14.	0	0	858
15.	858	0	0
16.	0	858	0
17.	858	0	0
18.	0	858	0
19.	0	0	858
20.	858	0	0
21.	0	0	858

Table 4.23 Fourth Irrigation for Greengram

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	1458	0	0
2.	1458	0	0
3.	0	1458	0
4.	0	1458	0
5.	1458	0	0
6.	0	0	1458
7.	0	0	1458
8.	1458	0	0
9.	1458	0	0
10.	0	1458	0
11.	0	1458	0
12.	1458	0	0
13.	0	0	1458
14.	0	0	1458
15.	1458	0	0
16.	1458	0	0
17.	0	1458	0
18.	0	1458	0
19.	1458	0	0
20.	0	0	1458
21.	0	0	1458

Table 4.24 Fifth Irrigation for Greengram

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	1622	0	0
2.	1622	0	0
3.	0	1622	0
4.	0	1622	0
5.	1622	0	0
6.	0	0	1622
7.	0	0	1622
8.	1622	0	0
9.	1622	0	0
10.	0	1622	0
11.	0	1622	0
12.	1622	0	0
13.	0	0	1622
14.	0	0	1622
15.	1622	0	0
16.	1622	0	0
17.	0	1622	0
18.	0	1622	0
19.	1622	0	0
20.	0	0	1622
21.	0	0	1622

Table 4.25 Sixth Irrigation for Greengram

Plot No.	Volume of water applied in litres		
	Sewage Water	Ground Water	Surface Water
1.	1449	0	0
2.	0	1449	0
3.	1449	0	0
4.	0	1449	0
5.	0	0	1449
6.	1449	0	0
7.	0	0	1449
8.	1449	0	0
9.	0	1449	0
10.	1449	0	0
11.	0	1449	0
12.	0	0	1449
13.	1449	0	0
14.	0	0	1449
15.	1449	0	0
16.	0	1449	0
17.	1449	0	0
18.	0	1449	0
19.	0	0	1449
20.	1449	0	0
21.	0	0	1449

4.5

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Fig. 4.4 Trickling Filter at Sewage Treatment Plant, Jaspur, Gandhinagar

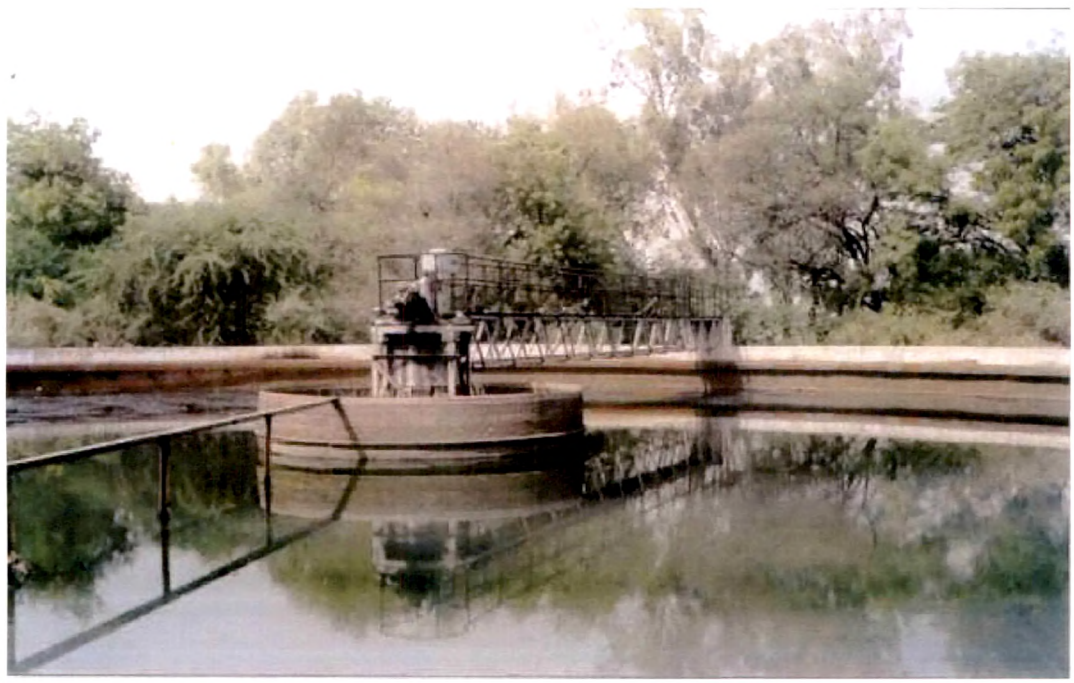

Fig. 4.5 Secondary Settling Tank at Sewage Treatment Plant, Jaspur, Gandhinagar

Fig. 4.6 Narmada Main Canal – Source of Surface Water for Irrigation

Fig. 4.7 Experimental Site

Fig. 4.8 Experimental Site – Another View

Fig. 4.9 Head Unit

Fig. 4.10 Layout of Plots under Experiment

Fig. 4.11 Wheat Growth after Complete Germination

Fig. 4.12 Observing Experiment under Wheat Cultivation

Fig. 4.13 Wheat at End of Mid Season Stage

Fig. 4.14 Observing Wheat Growth at Beginning of Maturity Stage

Fig. 4.15 Wheat at Complete Maturity Stage

Fig. 4.16 Green gram at End of Crop Development Stage

Fig. 4.17 Green gram at Mid Season Stage

Fig. 4.18 Green gram at Maturity Stage

Fig. 4.19 Green gram at Maturity Stage – Another View

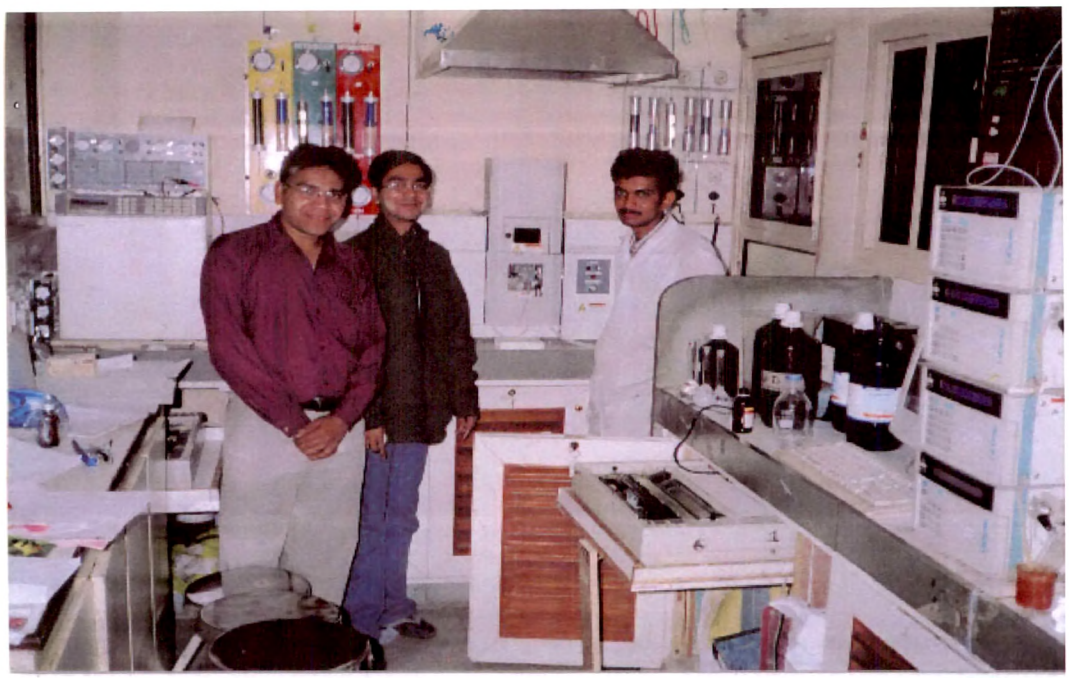

Fig. 4.20 Heavy Metal Detection by Atomic Absorption Spectrophotometer

Fig. 4.21 Prof. G. S. Parthasarathy – A Source of Valuable Guidance