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Seasonal Influence of Air Temperature on Bare Soil Temperature at Shallow Depths

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Soil temperatures at 7 and 15 cm depths were significantly positively correleted with the maximum and minimum ambient temperatures. However, the studies carried out on sandy loam soil under Delhi climatic conditions during 1969—71 showed different magnitudes of relationships in winter, pre — monsoon and post – monsoon seasons. The changes in soil temperature at 7 cm depth were more pronounced except during pre—monsoon season when soil temperature at 15 cm depth changed more markedly with the change in minimum air temperature. Also increasing maximum air temperature in winter caused decrease in soil temperature at 15 cm till 17°C and beyond this soil temperature increased with increasing ambient temperature as happened in other seasons.

Soil temperature is one of the important components of soil-climate system which affects the seed germination which ultimately decides the crop stand and the yield There are optimum soil temperature values for different crops grown during different seasons. Although, it is possible to measure soil temperature directly air temperature is more commonly and conveniently measured in the climatic characterisation.

The temperature fluctuation of the atmosphere is bound to affect the temperature soil-climate. The degree of such effect will depend on the seasons and soil conditions. By simultaneously measuring atmospheric and soil temperatures an attempt has been made to work out the relationship between them so that the commonly available atmospheric temperature may be used for working out soil temperature. Basu (1968) attempted to compute soil temperature values on the basis of air temperature values in general.

However, in this paper the relation between atmospheric and soil temperature has been studied at the Indian Agricultural Research Institute (I. A. R. I.), New Delhi for three seasons viz. Pre-monsoon (March-May), Post-monsoon (September-November) and winter (December-February). The monsoon period has been omitted for obvious reasons.

MATERIAL AND METHODS

Daily record of soil temperature and air temperature was collected from the meteorological observatory of IARI for three years (1969-71). The soil temperature data were recorded at the above observatory at 7 A. M.

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(minimum epoch) and at 2 P. M. (maximum epoch) for the two depths (7 cm and 15 cm) in a sandy loam soil by using of ordinary soil thermometers (I.M.D. type). The above data were obtained along with the corresponding maximum and minimum ambient temperatures.

A simple correlation was worked out between the above two meteorological factors for above three seasons, at two depths and two times of observations. They were tested for their significance at 5 per cent and 1 per cent levels (Goulden, 1959). Also linear regression equations were worked out for the various combinations for the same (Fig. 1, 2 and 3).

RESULTS AND DISCUSSION

Correlation of soil temperature and air temperature is presented in Table II.

Minimum Air temperature versus soil temperature :

The correlation of coefficent 'r' between minimum ambient temperature and soil temperature (depths 7 cm and 15 cm) observed both morning and evening time was found to range from 0.39 to 1.00. Also this was found to be significant both at 5 per cent and 1 per cent levels except in the case of soil temperature at 15 cm during winter morning and pre-monsoon evening.

The regression equation (Fig. 1, 2 and 3) shows that change in soil temperature at shallow depth (7 cm) with change in the minimum atmospheric temperature is more during winter and post monsoon season as compared to 15 cm depth which is evident from the high slope values of the regression equations. However, during pre-monsoon season the trend is opposite i. e. for a unit increase in the minimum air temperature, there is more increase in soil temperature at 15 cm depth than 7 cm depth.

In general, the soil temperature at 15 cms depth is higher as compared to 7 cms depth irrespective of season expect during winter when there is a decrease of soil temperature at this depth with increase in air temperature beyond 9.5°C.

Minimum air temperature versus soil temperature :

In this case the correlation coefficient 'r' ranged from 0.42 and 1.00. Between maximum ambient temperature and soil temperature and are significant at 5 per cent and 1 per cent levels (Table II).

The regression equations depicted in Fig. 1, 2 and 3. The soil temperature at 15 cm depth is higher during evening hours expect during winter season when there is a decrease in soil temperature with a current increase in ambient temperature beyond 17°C (Fig. 1).

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TABLE II Correlation coefficient 'r' values between atmosphere and soil temperature

Season	Minimum air temperature and soil temperature				Maximum air temperature and soil temperature			
	7 cm depth		15 cm depth		7 cm depth		15 cm depth	
	morning	evening	morning	evening	morning	evening	morning	evening
Winter (Dec. Jan & Feb)	+1.0**	+0.63**	+0.43*	+0.83**	+0.59**	+0.82**	+0.99*	+0.42**
Pre-monsoon (March. April & May)	+0.98**	+0.90**	+0.80**	+0.39*	+0.95**	+0.95**	+0.89**	+0.85**
Post-monsoon (Sept., Oct. & Nov.)	+0.98**	+0.79**	+0.96**	+0.94**	+0.88**	+1.0**	+0.98**	+0.97*

** Significant at 1% level
* Significant at 5% level

TABLE I Ambient and soil temperature

1969

Standard week No.	Temperature °C		Soil temperatures °C				Temperature °C	
			7 cm		15 cm			
	Min.	Max	7 hrs	14 hrs	7 hrs	14 hrs	Min	Max
1	5.5	19.8	8.7	20.1	—	—	5.7	22.6
2	6.9	20.8	10.1	20.7	—	—	4.2	21.1
3	2.9	20.5	7.0	21.1	—	—	9.1	21.2
4	6.5	23.3	9.4	22.7	—	—	8.1	18.7
5	5.6	21.9	8.8	22.5	—	—	5.3	17.2
6	3.9	22.0	8.0	22.9	—	—	3.8	20.6
7	11.7	24.8	13.5	25.4	—	—	6.8	24.6
8	8.6	25.6	12.6	26.6	—	—	11.6	21.4
9	10.3	22.1	15.2	30.9	—	—	11.5	22.6
10	12.1	31.5	16.7	33.0	—	—	12.2	26.4
11	15.2	34.9	19.4	35.8	—	—	13.4	27.8
12	15.8	30.5	18.8	32.0	—	—	12.7	27.8
13	14.8	33.9	19.7	35.3	—	—	13 7	33.2
14	19.4	35.6	22.0	35.6	—	—	14.8	34.0
15	22.3	37.8	25.4	39.2	—	—	18.9	37.7
16	20.7	37.4	25.2	39.2	—	—	19.2	37.5
17	18.6	37 7	23.9	40.4	—	—	23.0	41.5
18	18.6	32.5	23.0	36.3	—	—	22.0	41.3
19	25.2	39.0	28.1	41.9	—	—	22.9	40.6
20	21.2	37.4	25.7	41.1	—	—	26.4	44.0
21	24.1	42.1	29.5	45.0	—	—	24.1	35.7
22	28.6	41.5	31.2	43.2	—	—	26.2	38.0
23	26.5	41.4	29.8	42.4	—	—	23.9	34.5
24	27.8	41.7	31.8	41.6	—	—	26.8	26.4
25	29.3	41.9	31.2	41.7	—	—	29.2	40.9
26	38.6	26.7	29.7	41.0	—	—	26.7	35.4
27	27.8	38.3	32.1	43.3	—	—	26.3	34.1
28	26.8	34.9	30.8	37.9	—	—	26.9	35.0
29	26.1	33.3	28.1	35.1	—	—	28.0	38.1
30	25.1	32.6	27.5	32.1	—	—	27.4	37.9
31	27.6	34.7	29.3	38.2	—	—	25.5	33.6
32	25.0	31.2	27.6	33 4	—	—	25.7	32.0
33	25.9	32.1	27.7	35.5	—	—	25.7	31.6
34	24.1	33.9	26.7	38.1	—	—	26.1	33.7
35	26.1	37.1	29.4	40.4	—	—	25.8	33.0
36	25.5	34.5	29.3	37.3	—	—	25.1	33.7
37	25.0	30.7	26.3	31.6	—	—	23.9	33.4
38	22.6	31.0	24.2	31.7	—	—	24.5	34.1
39	20.6	33 0	22.0	33.3	24.9	27.8	23.1	33.3
40	19.0	33 9	22.6	37.2	25.5	29.6	21.2	33.8
41	20.2	33.8	23.4	36.5	26.2	30.0	18.1	33.5
42	16.6	33.7	21.5	34.6	24.9	28.7	15.8	35.2
43	19.5	33.2	22.3	34.6	25.2	28.7	15.1	33.8
44	15.9	33.2	20.6	33.2	24.2	27.0	12.0	319.
45	15.3	31.3	19.9	31.5	23.5	26.2	11.5	30.5
46	12.1	28.6	17.0	29.1	21.3	23.9	10.4	28.6
47	9.2	27.8	14.1	26.8	18.7	21.3	7.6	26.1
48	5.1	24.4	10.4	23.1	15.6	17.9	4.8	23.8
49	6.6	24.2	10.5	22.4	14.8	17.2	5.7	24.4
50	5.8	23.4	9.9	21.6	14.7	16.5	6.7	24.4
51	4.1	23.4	8.4	20.6	13.0	15.1	5.7	22.3
52	4.1	22.3	8.0	20.2	12.3	14.6	4.2	22.2

of I. A. R. I., Delhi Farm

1970						1971			
Soil temperatures °C				Temperature °C		Soil temperatures °C			
7 cm		15 cm		Min	Max	7 cm		15 cm	
7 hrs	14 hrs	7 hrs	14 hrs			7 hrs	14 hrs	7 hrs	14 hrs
8.9	20.6	13.3	15.3	3.1	21.8	5.9	20.7	11.2	13.7
8.5	19.4	12.4	14.3	3.0	21.7	5.7	19.9	10.9	13.1
11.9	20.6	14.6	16.0	5.2	21.1	8.0	20.0	12.0	14.1
9.3	18.6	12.7	14.6	5.6	16.0	8.8	18.6	12.0	13.9
6.3	17.1	10.4	12.8	2.7	18.3	3.9	20.1	8.9	13.0
5.7	23.1	10.9	14.1	8.0	23.3	10.3	25.0	13.5	16.8
9.4	25.1	13.9	16.9	7.8	24.7	10.6	26.3	14.3	18.1
13.2	22.9	15.3	17.6	12.0	26.1	14.7	29.0	16.0	21.2
12.7	23.8	15.8	18.4	10.7	22.4	13.1	25.3	16.2	19.4
13.6	28.4	17.0	20.5	8.5	24.6	12.5	30.0	16.8	21.4
15.3	31.5	18.3	22.1	10.9	30.5	15.9	33.8	19.5	34.3
16.3	33.4	19.7	24.1	14.4	33.9	18.6	36.9	22.5	27.7
18.7	36.1	22.7	26.9	14.3	34.9	—	—	23.7	28.3
18.8	37.5	23.4	27.7	18.6	37.5	—	—	26.3	30.8
23.6	39.5	26.3	30.5	19.7	37.9	—	—	27.9	30.9
23.8	40.7	27.1	31.2	20.0	32.7	—	—	26.8	30.1
26.4	42.3	29.2	32.8	21.8	37.3	—	—	29.2	33.3
26.3	43.2	29.2	33.4	21.9	39.9	—	—	30.0	34.3
27.3	44.4	30.5	34.5	24.2	37.7	—	—	30.1	33.5
30.1	45.7	32.1	35.5	22.1	35.2	—	—	28.6	32.6
27.9	42.0	30.1	32.8	24.7	34.9	—	—	28.1	32.7
29.6	42.9	32.2	35.5	26.0	36.7	—	—	31.5	35.3
26.7	38.5	28.8	32.8	27.3	37.8	—	—	32.4	35.2
30.7	44.4	32.3	36.9	29.0	39.4	—	—	33.6	36.6
32.5	44.6	33.8	37.4	26.5	36.4	—	—	31.7	34.5
29.3	36.6	31.2	33.2	26.5	33.9	—	—	30.9	34.4
29.4	31.2	30.8	31.3	24.7	33.3	—	—	28.9	31.5
28.2	37.6	29.7	32.6	26.6	35.3	—	—	30.9	33.7
31.4	42.4	33.1	36.5	24.9	32.9	—	—	28.8	31.3
30.7	42.5	32.5	35.8	25.5	32.2	—	—	29.1	31.9
28.7	36.1	31.0	33.0	25.2	30.7	—	—	28.7	30.2
27.6	32.8	28.4	30.2	25.3	30.0	—	—	27.8	29.2
27.3	36.5	28.2	31.2	25.1	31.2	—	—	27.0	28.8
28.5	38.2	30.0	33.0	25.5	32.7	—	—	28.0	30.4
27.4	38.9	28.6	31.9	25.2	32.3	—	—	28.3	31.3
28.0	41.4	29.7	34.4	24.2	30.3	—	—	27.0	29.2
26.4	34.6	28.2	31.0	22.4	32.5	—	—	25.4	28.5
26.8	40.6	29.1	33.1	19.7	35.4	—	—	25.9	30.7
26.9	38.5	28.5	32.4	22.1	34.8	—	—	27.4	30.7
25.8	39.5	27.9	32.2	18.9	34.5	—	—	25.1	29.8
23.4	39.7	26.9	31.1	17.8	35.3	—	—	25.0	29.0
21.8	38.9	26.0	30.2	18.2	27.6	—	—	22.6	25.6
20.0	36.2	24.4	28.1	13.9	30.2	—	—	21.1	25.3
17.4	33.8	22.2	25.9	13.8	29.1	—	—	20.5	24.2
16.2	31.5	20.9	24.7	8.0	28.0	—	—	18.0	21.5
14.8	29.7	18.6	22.7	9.9	28.7	—	—	18.1	21.3
11.7	26.8	17.1	20.4	9.1	27.6	—	—	17.4	20.6
9.4	24.9	15.1	18.0	8.6	25.8	—	—	17.2	20.1
9.2	24.2	14.6	17.1	5.9	24.7	—	—	—	—
9.5	23.9	14.5	17.0	6.0	23.0	—	—	—	—
9.3	22.5	14.0	16.5	7.1	20.9	—	—	—	—
7.3	21.3	12.5	14.9	3.8	21.7	—	—	—	—

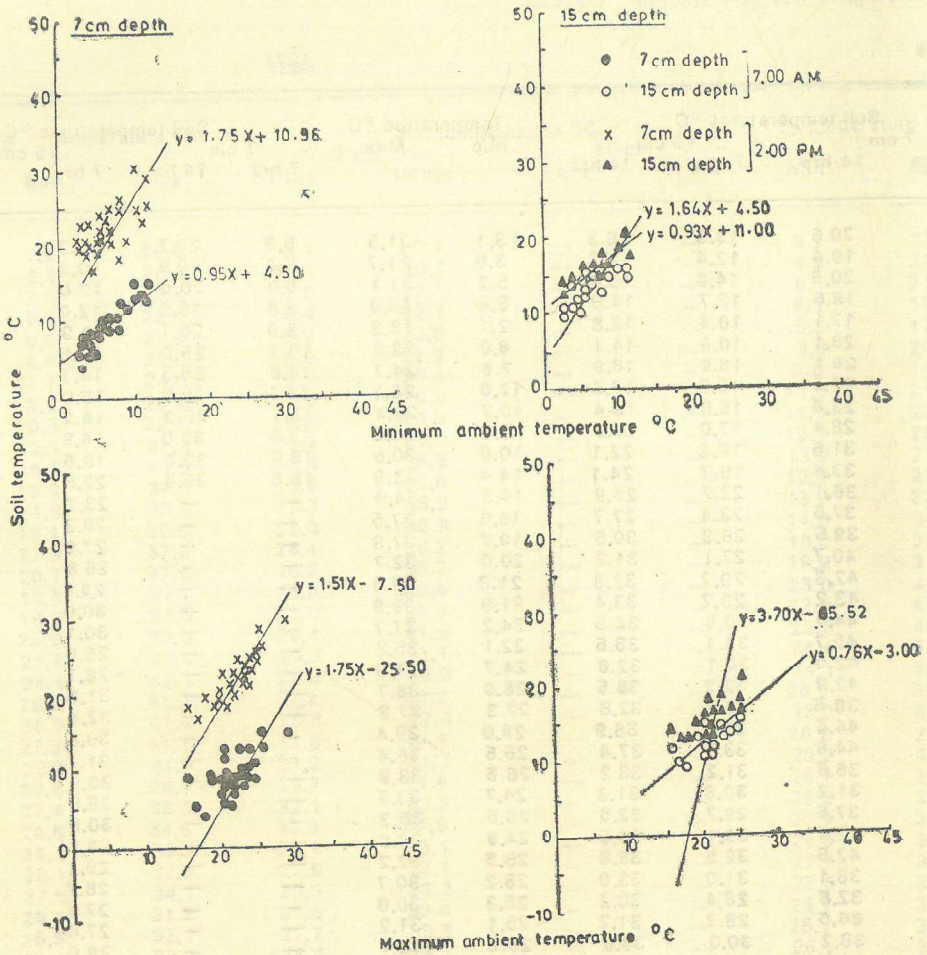

Fig.1. RELATIONSHIP BETWEEN SOIL TEMPERATURE AND AMBIENT TEMPERATURE IN WINTER SEASON

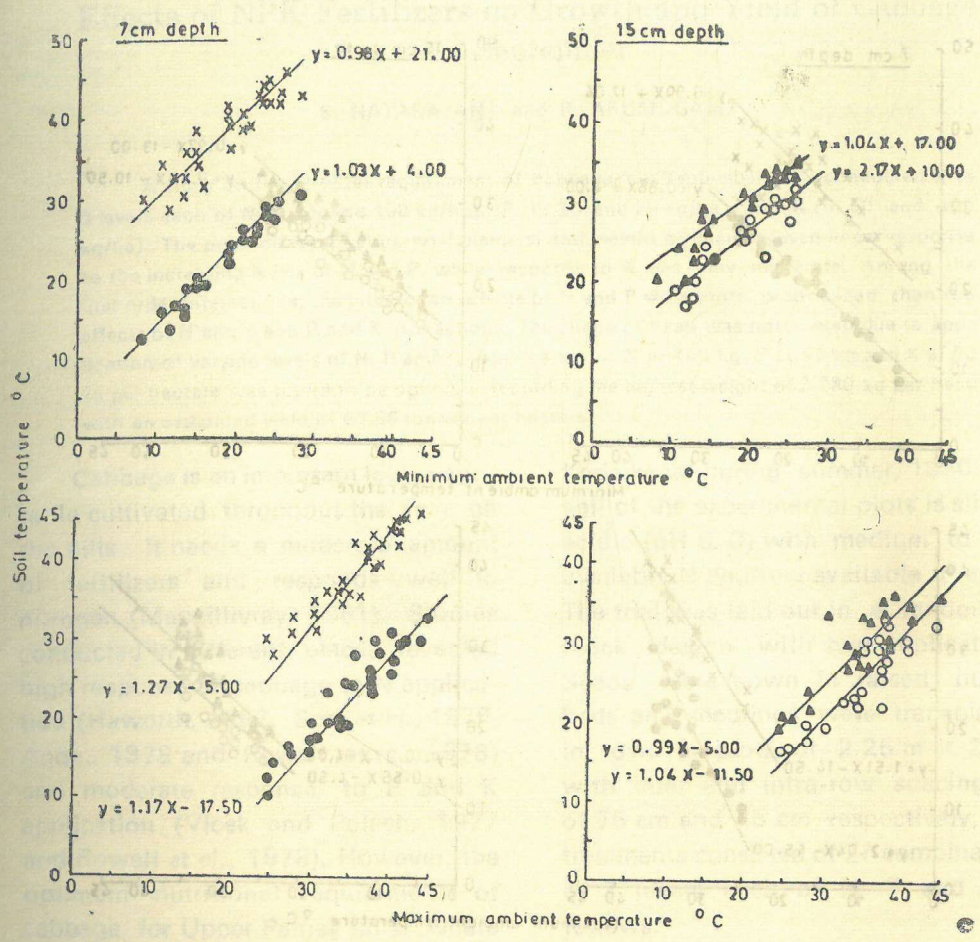

Fig. 2. RELATIONSHIP BETWEEN SOIL TEMPERATURE AND AMBIENT TEMPERATURE IN PRE-MONSOON SEASON

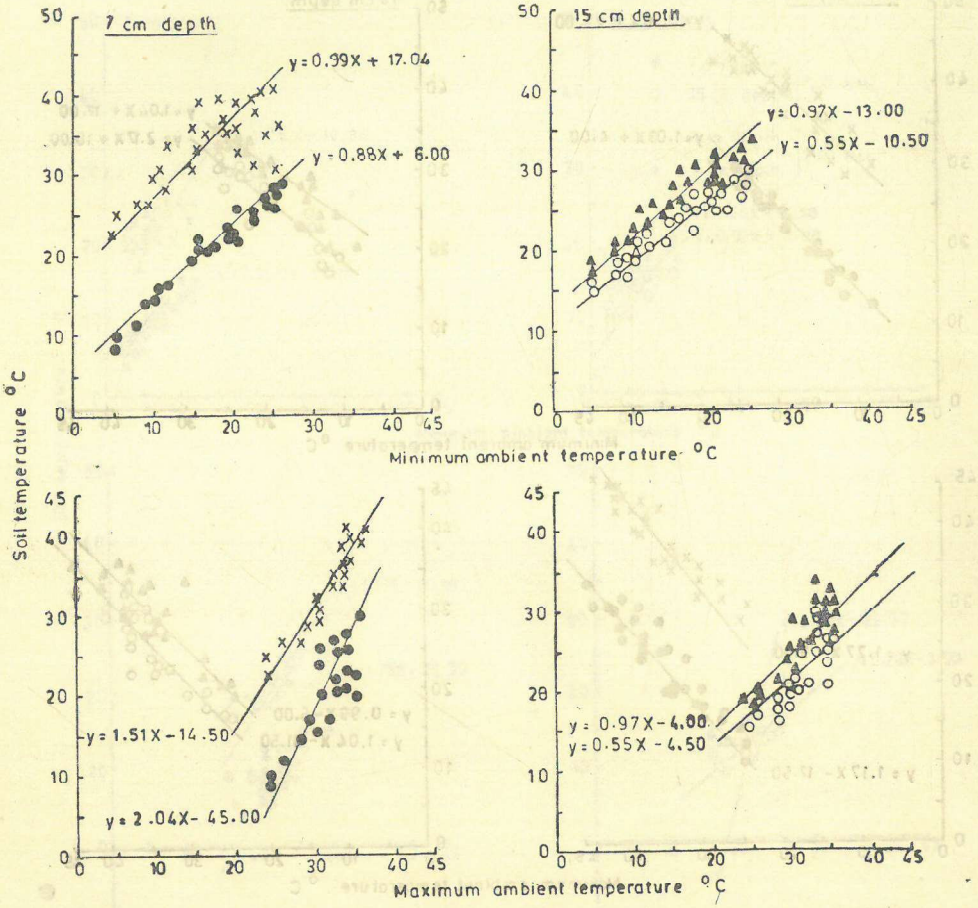

Fig.3. Relationship between soil temperature and ambient temperature in post-monsoon season

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