MATERIALS AND METHODS

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Experimental materials

The seeds of Sunflower, variety EC 68415 were obtained from the ICAR, Regional Research Station, Coimbatore, Tamil Nadu.

The seeds of Niger, variety N35 were obtained from Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.

Area of the Experiment

The present investigations were carried out in Summer, Monsoon, and Winter seasons of 1978-'79 and 1979-'80 in the experimental field of the Department of Botany, Maharaja Sayajirao University of Baroda, Baroda.

Climatic Conditions

The climate of Baroda is characterized by a dry and hot summer from March to June, a warm monsoon from July to September which may extend upto October and a dry and mildly cold winter from November to February (Fig. 1). The monsoon which is very irregular arrives by about the last week of June and after some heavy showers in July it may continue till September.

The mean annual rainfall comes to approximately 988 mm

CLIMATIC CONDITIONS IN BARODA
(1969 - 1979)

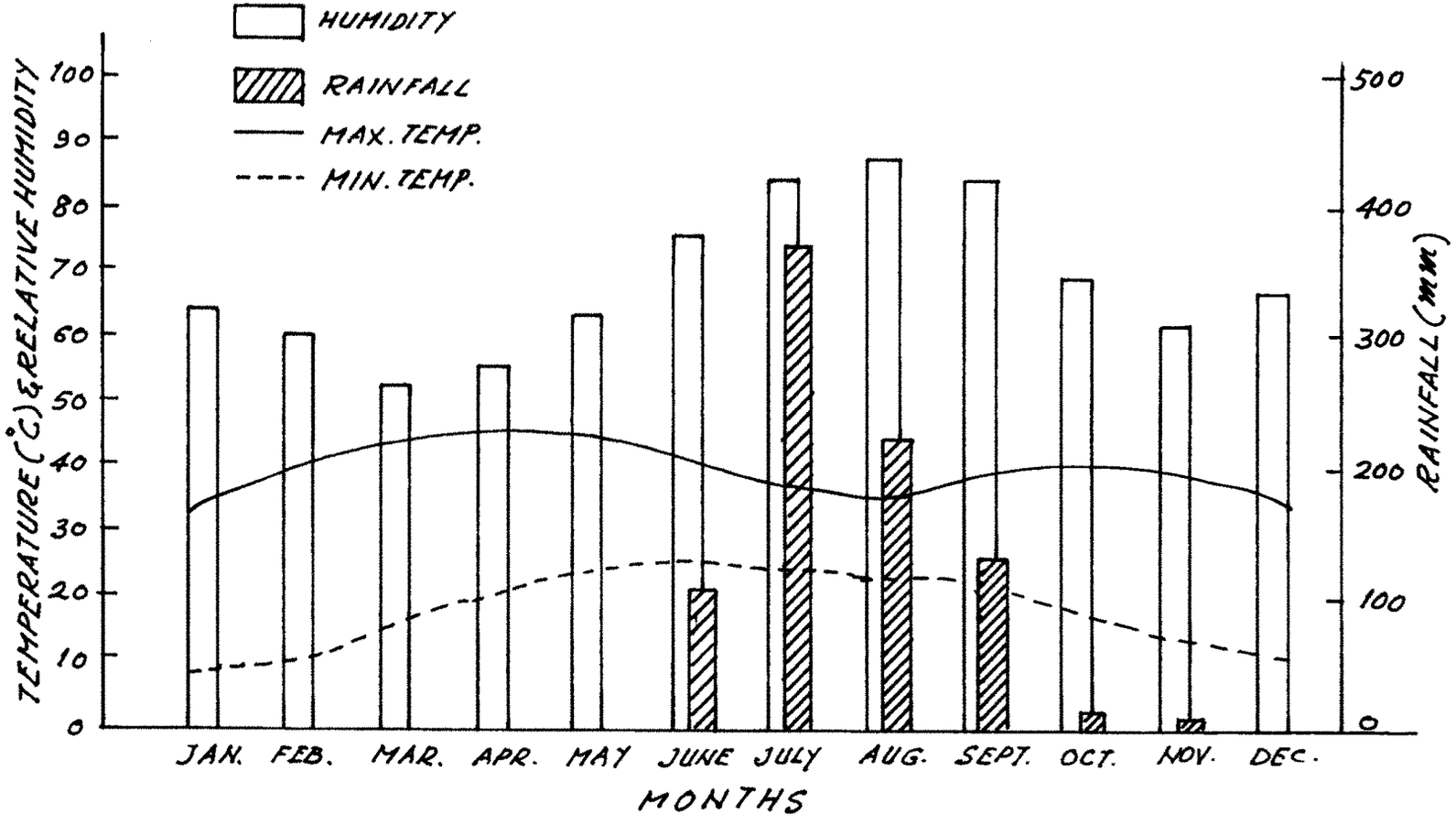

FIG. 1

only. The periodic temperature in Baroda shows great extremes. The temperature during summer (March to June) is high, rising as high as 45.3°C (Mean) during May. The temperature gradually comes down in monsoon, and in the month of November the winter sets in with the maximum (mean) temperature and the minimum (mean) temperature of about 31.6°C and 8.4°C respectively. The relative humidity also shows variations in different seasons. As it can be expected the minimum (about 58.2%) is in the beginning of summer and maximum (approx. 88.2%) during monsoon especially in the month of August. As the climatic factors are known to influence the performance of crops the monthly mean of temperature conditions, rainfall and relative humidity during the course of experiments were collected from Meteorological Observatory of the M. S. University of Baroda and presented in Table 1.

Edaphic Conditions

The soil as an environmental factor (edaphic factor) deserves great attention in an ecological study because plant and soil are strongly influenced by each other. It is known that differences in the quality of soil may affect the different aspects of plants (Daubenmire, 1959). The soils of Gujarat are classified by Shah (1955) into black soils, deep black soils, sandy loam and coastal alluvium. The soil in Baroda is black loamy cotton soil. Soil samples from different

TABLE 1 : CLIMATOLOGICAL DATA OF BARODA
(22°17 55' N 73°15' 8 E)

Month	Mean Temperature 0°C		Total Rain fall (mm)	Mean Relative Humidity (%)
	Maximum	Minimum		
1978				
January	30.35	11.22	0.00	69
February	32.80	16.50	2.52	63
March	35.60	18.40	0.00	61
April	39.90	23.60	0.00	61
May	39.96	26.74	0.00	63
June	35.98	27.39	147.60	77
July	31.54	23.89	434.50	87
August	30.07	25.06	1056.48	88
September	33.68	24.38	59.79	84
October	37.50	21.48	0.0	66
November	34.81	19.51	35.08	72
December	31.79	15.18	0.0	73
1979				
January	30.25	14.39	0.00	72.90
February	31.35	12.81	33.99	68.93
March	35.63	17.33	0.00	58.25
April	40.99	22.91	0.00	60.86
May	40.53	25.69	0.00	60.48
June	41.29	27.85	69.00	72.10
July	33.19	26.23	225.99	85.55
August	32.26	25.32	644.49	89.50
September	35.09	24.60	70.80	83.56
October	36.36	22.39	4.991	74.64
November	33.83	20.22	455.70	76.83
December	31.97	16.13	0.00	79.77

depths upto 25 cm were collected from the experimental site at random and were properly mixed. The soil samples were analysed and their chemical and physical properties were determined as per methods given by Piper (1959). The soil has a water holding capacity ranging from 38% to 53%.

Results of physical analysis (Mixed sample covering the depth of 25 cm)

Size of particles* range in mm

2.0 and above		Gravel	Nil
2.0 -	0.2	Coarse sand	1.1%
0.2 -	0.02	Fine sand	46.5%
0.02 -	0.002	Silt	25.5%
Below	0.002	Clay	26.5%

* Anonymous (1969).

The results of Chemical analysis are given below :

No. of samples	Organic Carbon %	P_2O_5 kg/ha	K_2O kg/ha	pH	Electrical Conductivity
1	0.37	36.20	140	7.25	0.08
2	0.40	31.50	135	7.20	0.11
3	0.34	36.40	142	7.60	0.15
4	0.37	36.00	133.50	7.20	0.12
5	0.30	20.40	115.00	7.60	0.08

The field was ploughed well before each experiment and

the plots were laid out in random block design.

There were four treatments and each treatment was replicated six times. The following are the details of the plots :

Length of individual plot - 3 M

Breadth of individual plot - 2.4 M

Total net area of individual plot - 7.2 sq. M.

Distance between plots - 0.5 M.

Total number of plots - 24 (Sunflower) + 24 (Niger) = 48

Treatments

Farm yard manure normally used in the conventional farming methods and mineral fertilizers (NPK) were used for the treatments as per the details shown below :

Treatment	N P K (18:27:9)	Urea (N 46%)	MP (KCl) (K 58-60%)	Farm Yard Manure*
T_1	222 kg/ha	108 kg/ha	66 kg/ha	10 tonnes
T_2	222 kg/ha	108	66 kg/ha	00
T_3	0	0	0	10 tonnes
T_4	0	0	0	0

* (Approximate N, P, K Content per tonne is 5.17 kg, 1.996 kg and 5.67 kg respectively) (Firman , 1953).

The full amount of farm yard manure (FYM) and that of

NPK Mixture (18:27:9) and Muriate of Potash (KCl) were applied to the respective plots as a basal dose, three days before sowing. The remaining dose of the mineral fertilizer i.e. Urea was applied after one month of sowing in order to give N, P and K at the rate of 90 kg, 60 kg and 60 kg respectively per hectare (as recommended by the Chief Agronomist, G.S.F.C., Baroda). A pre-sowing irrigation was given uniformly on the same day when fertilizers were added. The plot surface was then carefully levelled spreading the fertilizers evenly.

Sowing :

The seeds were sown at a depth of about 4 cm in the case of Sunflower and at a depth of about 3 cm in the case of Niger, in rows by dibbling method, each hole receiving only 3 seeds. The distance between two rows and plants was maintained at 60 cm and 20 cm respectively. Each plot contained five rows. After fifteen days seedlings were thinned retaining only one at each spot. Thus 12 plants in a row and sixty per plot were maintained.

Irrigation :

On every 15th day the plots were uniformly irrigated.

Weeding :

Two weedings, one on the 20th day and the other on the

40th day after sowing were done.

Field Operation :

Datewise details of the field operation are given in Table 1A to 1F.

Sampling methods :

The samples of plants were collected for the productivity studies on every 15th day after sowing till the final harvest employing short term harvest method (Hughes and Freeman, 1967). At each sampling three plants were collected at random from each plot. The plants on the marginal rows were avoided. The middle six plots in the central row were left undisturbed for the studies on yield characteristics.

The monolith method (Pandey et al., 1968) was employed to dig out the plants in order to avoid any marked loss of roots.Soil particles adhering to the roots were carefully removed by washing in water. Excess moisture was blotted off and further observations were made.

In the laboratory the data were collected and classified under three headings as given below :

I. Morphological characteristics

a) Length of the main root

b) Length of the shoot

TABLE 1 A : SUMMER - I

Sr. No.	Details of Field Operation	Date
1.	Ploughing the field - Soil Samples collection	25-1-'78
2.	Preparation of plots	28-1-'78
3.	Irrigation, fertilizer application	9-2-'78
4.	Sowing	11-2-'78
5.	Harvest, thinning, irrigation	26-2-'78
6.	Weeding (i)	3-3-'78
7.	Application of second dose of fertilizer	11-3-'78
8.	Harvest, irrigation	13-3-'78
9.	Weeding (ii)	23-3-'78
10.	Harvest, irrigation	28-3-'78
11.	Harvest, irrigation	2-4-'78
12.	Harvest, irrigation	27-4-'78
13.	Harvest, irrigation	12-5-'78
14.	Harvest	27-5-'78

TABLE 1 B : SUMMER - II

Sr. No.	Details of Field Operation	Date
1.	Ploughing the field - Soil Sample Collection	20-1-'79
2.	Preparation of plots	27-1-'79
3.	Irrigation, fertilizer application	12-2-'79
4.	Sowing	14-2-'79
5.	Harvest, Thinning, Irrigation	1-3-'79
6.	Weeding (i)	6-3-'79
7.	Application of second dose of fertilizer	14-3-'79
8.	Harvest, Irrigation	26-3-'79
9.	Weeding (ii)	31-3-'79
10.	Harvest, Irrigation	4-4-'79
11.	Harvest, Irrigation	15-4-'79
12.	Harvest, Irrigation	30-4-'79
13.	Harvest	15-5-'79

TABLE 1 C : MONSOON - I

Sr. No.	Details of Field Operation	Date
1.	Ploughing the field - Collection of Soil Samples	5-7-'78
2.	Plot preparation	6-7-'78
3.	Application of fertilizer (No irrigation as there was rain)	-
4.	Sowing	8-7-'78
5.	Harvest, Thinning (No irrigation as there was rain)	23-7-'78
6.	Weeding (i)	28-7-'78
7.	Harvest, Irrigation	7-8-'78
8.	Application of second dose of fertilizer	8-8-'78
9.	Weeding (ii)	17-8-'78
10.	Harvest (No irrigation as there was rain)	22-8-'78
11.	Harvest, Irrigation	7-9-'78
12.	Harvest, Irrigation	22-9-'78
13.	Harvest, Irrigation	7-10-'78
14.	Harvest, (Final of Sunflower) Niger irrigated	22-10-'78
15.	Harvest (Niger)	6-11-'78

TABLE 1 D : MONSOON - II

Sr. No.	Details of Field Operation	Date
1.	Ploughing the field	25-6-'79
2.	Soil Sample Collection	26-6-'79
3.	Preparation of Plots	28-6-'79
4.	Irrigation - application of fertilizers	31-6-'79
5.	Sowing	1-7-'79
6.	Harvest, thinning (no irrigation as there was rain)	16-7-'79
7.	Weeding (i)	21-7-'79
8.	Harvest (no irrigation)	31-7-'79
9.	Application of second dose of fertilizers	1-8-'79
10.	Weeding (ii)	10-8-'79
11.	Harvest (no irrigation)	15-8-'79
12.	Harvest, Irrigation	27-8-'79
13.	Harvest, Irrigation	14-9-'79
14.	Harvest, Irrigation	29-9-'79
15.	Harvest, (no irrigation)	14-10-'79
16.	Harvest	29-10-'79.

TABLE 1 E : WINTER - I

Sr. No.	Details of Field Operations	Date
1.	Ploughing the field - Soil Sample Collection	25-10-'79
2.	Preparation of plots	5-11-'79
3.	Irrigation, fertilizer application	10-11-'79
4.	Sowing	12-11-'79
5.	Harvest, thinning, irrigation	27-11-'79
6.	Weeding (i)	7-12-'79
7.	Harvest, Irrigation, Application of second dose of fertilizers.	12-12-'79
8.	Weeding (ii)	22-12-'79
9.	Harvest, Irrigation	27-12-'79
10.	Harvest, Irrigation	11-1-'80
11.	Harvest, Irrigation	26-1-'80
12.	Harvest, Irrigation	10-2-'80
13.	Harvest	25-2-'80

TABLE 1 F : WINTER - II

Sr. No.	Details of Field Operation	Date
1.	Ploughing the field - Soil Sample Collection	2-11-'79
2.	Plot preparation	8-11-'79
3.	Irrigation - fertilizer application	13-11-'79
4.	Sowing	16-11-'79
5.	Harvest, thinning - irrigation	1-12-'79
6.	Weeding (i)	6-12-'79
7.	Harvest, Irrigation, Application of Second dose of fertilizers.	16-12-'79
8.	Weeding (ii)	26-12-'79
9.	Harvest, Irrigation	31-12-'79
10.	Harvest, Irrigation	15-1-'80
11.	Harvest, Irrigation	30-1-'80
12.	Harvest, Irrigation	14-2-'80
13.	Harvest	1-3-'80

c) Root/shoot length ratio

d) Total number of leaves

e) Leaf area.

The area of each leaf was determined planimetrically after marking outlines of all leaves on a plain sheet of paper and the total leaf area per plant was tabulated and is expressed as cm^2.

II. Functional behaviour :

(a) Total biomass - $g.plant^{-1}$:

The samples of plants were separated into root, stem, leaf and head and were oven dried at 80°C till a constant weight was obtained. Then each part was separately weighed and the biomass determined.

(b) Root/Shoot weight ratio :

The root/shoot weight ratio was calculated by dividing the weight of the root by that of the shoot (Monk, 1966).

(c) Chlorophyll content :

Leaf discs were cut out from stacks of green leaves of different ages with a leaf disc cutter. Chlorophyll was extracted from 0.25 g of fresh leaf discs as per standard methods (Arnon, 1949) in acetone (80%). The optical density

of the extract was determined using a Spekol Colorimeter at 663 and 645 m u in a 1 cm cell using the specific absorption coefficients given by Mackinney (1941). The chlorophyll content on a fresh weight basis was computed by the following equations as modified by Maclachlan and Zalik (1963).

1. Chlorophyll a (mg/g)

$$= \frac{12.3\ D\ 663 - 0.86\ D\ 645}{d \times 1000 \times W} \times V$$

2. Chlorophyll b (mg/g)

$$= \frac{19.3\ D\ 645 - 3.6\ D\ 663}{d \times 1000 \times W} \times V$$

Where

D = optical density

V = volume of the extract in ml

d = length of the light path in cm

W = Fresh weight of the material in grams.

The values of the equations 1 and 2 were summed and the amount of total chlorophyll in unit fresh weight of leaf was calculated (mg/g).

(d) Head diameter

In the final harvest the heads from three out of six plants in the central row which were left undisturbed were collected. The diameter of the heads of Sunflower and the

number of heads per plant of Niger were determined.

(e) Number of seeds per head :

The number of seeds per head was calculated directly counting the same.

(f) Weight of seeds per plant :

The seeds were properly sun dried and the weight of the seeds per plant was determined.

(g) Weight of 1000 seeds :

Weight of 1000 seeds was determined and recorded as a test weight. Per treatment 12 samples of seeds at random were separately drawn from the lot of seeds from each plot, oven dried and the weight recorded.

(h) Seed output per hectare :

The seed output per hectare was computed from the weight of the seeds per plant.

(i) Seed Oil Content :

Representative samples of seeds at random were drawn from the lot of seeds from each plot, oven dried at 60°C for 24 hrs and the oil was extracted using standard methods (AOAC, 1970) using Petroleum ether by means of Soxhlet apparatus. The seed oil content in relation to the total weight of the seeds in per cent was calculated.

(J) Oil output/hectare - was computed on the basis of seed oil content.

(k) Harvest Index (HI) :

HI was worked out on the proportion of the economic yield (seeds) to the total biomass yield.

III. Growth Analysis :

The growth of the plant was analysed on the basis of the data collected on every 15th day, in the following parameters.

(a) Net Primary Productivity (NPP) (Leith, 1962 & 1965).

NPP was calculated using the formula

$g.plant^{-1}.\ day^{-1}$

formula : $$\frac{W_2 - W_1}{t_2 - t_1}$$

(b) The Relative Growth Rate (RGR) $(g.g^{-1}.\ day^{-1})$

was computed by the formula :

$$\frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$ (Briggs, Kidd and West, 1920).

(c) Net Assimilation Rate (NAR)

Net assimilation rate $(mg.cm^{2}.\ day^{-1})$ has worked out as :

$$\frac{W_2 - W_1}{A_2 - A_1} \times \frac{\ln A_2 - \ln A_1}{t_2 - t_1}$$ (Briggs, Kidd and West, 1920; Gregory, 1926; William, 1946; Coombe, 1960).

(d) Leaf Area Ratio (LAR) ($cm^2 . g^{-1}$)

was computed by :

Formula : $\frac{A}{WL} \times \frac{WL}{W}$ (Gregory, 1926).

(e) Leaf Area Index (LAI) (Leaf area : ground area)

was calculated as : $\frac{LA}{GA}$ (Watson, 1947, 1952).

Where W_1 = Initial dry weight

W_2 = Final dry weight

A_1 = Initial leaf area

A_2 = Final leaf area

WL = Dry weight of leaf.

W = Total dry weight of the plant

A = Leaf Area (Total)

GA = Ground area

t_1 = Time of initial observation

t_2 = Time of final observation.

Statistical analysis :

The two years data were pooled and statistically analysed for the following :

1. Test of Significance between different treatments.
2. Test of Significance between different seasons.
3. Analysis of Variance.
4. Correlation between vegetative biomass and reproductive biomass (seeds).

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