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Climatology of the Crop Seasons of India — 2. Wheat

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ABSTRACT. On the basis of the data collected under the All India Co-ordinated Crop Weather Scheme, the normal growth features and the yield of the wheat crop in India are discussed in relation to the climatology of the wheat crop season. The study covers 9 stations with data varying for periods from 13 to 20 years. Information is presented about the chronology and growth attributes of the crop, the average durations of the crop growth periods and the average climatic features of the crop season and their variabilities, separately, for each station and each of the growth periods. It is shown that while the principle of time variation with geographical co-ordinates operate in the sequence of the dates, at different stations, of sowing, flowering and harvesting of the crop, as well as the lengths of the vegetative, reproductive and total crop life periods, only the length of the vegetative period conforms to Hopkins' 'Bioclimatic Law' for North America. There appears to be a negative relationship between the duration of the vegetative growth period and the maximum and minimum temperatures during the same period and also between the height attained by the crop and the maximum temperature during the vegetative growth period.

1. Introduction

Under the All India Co-ordinated Crop Weather Scheme, quantitative observations are being recorded at a network of selected experimental farms, on the growth, yield and the incidence of diseases and pests of rice, wheat, jowar, sugarcane and cotton crops, side by side with the weather experienced by the crops, during their life cycle. Details of the crop and meteorological observations recorded as well as the sampling technique used for recording the observations are given in Agrimet Technical Circular No. 50. The crop weather data recorded each year, at each station, are reviewed in the Annual Reports on Agricultural Meteorology of the India Meteorological Department. The data are also summarised in pictorial crop weather diagrams which are being published in annual volumes beginning with the data for 1957-58. In the first paper of this series, Mallik (1964) has presented and discussed the normal growth features and yield of the rice crop and the climatology of the rice season in India. In this paper, normal growth features and yield of the wheat crop and the climatology of the wheat season in India are presented and discussed as assessed from the data collected so far. All the values in this paper represent the averages based on more than 10 years' data.

2. The crop life-cycle

Unlike rice, wheat is not a hydrophilous (water-loving) crop and is grown during the winter season when there is little rain in India, except in the extreme north of the country. Therefore, the wheat crop is grown mainly with the help of the moisture stored in the soil from the post-monsoon rainfall. However, in the northern parts, the crop receives a little winter rain during the passage of the western disturbances. Also, wherever irrigation facilities are available, the crop is given a few light irrigations which increase the yield, but by far over the greater part of India, wheat is grown without irrigation. The seed is drilled into the fields, directly, germinate and the young seedlings emerge out of the soil surface within about a week's time. Soon after emergence, each plant starts producing a cumber of culms (tillers) and the culm to plant ratio progressively increases to a maximum value (the tillering ratio); thereafter, the plants start growing rapidly in height till the emergence of the ear-heads (flowering) by which time the maximum height is attained. However, although in individual plants the tillering and the elongation phases are quite distinguishable under field conditions because of a certain degree of overlapping of the two phases (some plants start elongating before all plants have completed tillering), the two phases, tillering and elongation, are not sharply defined in the case of the crop. From flowering to harvest, setting and development of the grains and general drying up of the crop take place making the crop ready for harvest. Thus, three distinct periods are noticed in the life-history of the crop, *viz.*, the germination period (from sowing to emergence of the seedlings), the vegetative period, including the tillering and elongation phases (from completion of germination to flowering, *i.e.*, ear-head emergence) and the reproductive period (from flowering to harvest).

3. Average crop and average season

Data for periods of 2 to 19 years, varying from station to station, have become available. In this

TABLE 1

Stations and data

Station	Co-ordinates			No. of years for which data are utilised
	Lat. (N)	Long. (E)	Alt. (m)	
(1)	(2)	(3)	(4)	(5)
Dharwar	15°26′	75°06′	677	19
Parbhani	19°16′	76°47′	408	20
Niphad (Nasik)	20°06′	74°07′	549	19
Jalgaon	21°03′	75°34′	201	18
Nagpur	21°09′	79°22′	320	18
Labhandi (Raipur)	21°16′	81°36′	290	17
Powerkhera (Hoshangabad)	22°44′	77°42′	299	15
Chinsurah (Calcutta)	22°52′	88°24′	9	17
Delhi	28°04′	77°10′	229	13

TABLE 3

Geographical criteria for the sequence of dates and lengths of periods

Event	Number of days by which the date is delayed or the period is prolonged		
	Per deg. Lat.(N)	Per deg. Long.(E)	Per 100m altitude
(1)	(2)	(3)	(4)
Date of sowing	1·3	2·5	1
Date of flowering	7·0	5·0	1
Date of harvesting	6·0	2·5	3
Length of vegetative period*	4·0	0·8	3
Length of reproductive period	4·9	0·6	1
Length of total crop life period	6·0	0·8	1

*Criteria same as Hopkins

TABLE 2

Chronology of the crop life-history

Station	Average dates of			Duration of crop growth periods			
	Sowing	Flowering	Harvesting	Germination (days)	Vegetative (weeks)	Reproductive (weeks)	Total crop life (weeks)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dharwar	23 Oct (9)	12 Dec (9)	29 Jan (10)	9 (28)	6 (10)	7 (13)	14 (7)
Parbhani	13 Oct (9)	8 Dec (9)	9 Feb (10)	7 (16)	7 (15)	9 (20)	17 (8)
Niphad	26 Oct (7)	22 Dec (6)	24 Feb (8)	9 (31)	7 (6)	9 (13)	17 (6)
Jalgaon	24 Oct (6)	15 Dec (7)	9 Feb (7)	9 (19)	6 (7)	8 (9)	15 (6)
Nagpur	30 Oct (7)	29 Dec (9)	25 Feb (8)	8 (15)	7 (8)	8 (14)	17 (6)
Labhandi	13 Nov (12)	14 Jan (13)	22 Mar (12)	11 (22)	7 (8)	10 (22)	18 (8)
Powerkhera	1 Nov (7)	2 Jan (4)	13 Mar (11)	11 (16)	7 (8)	10 (16)	18 (8)
Chinsurah	15 Dec (6)	21 Feb (6)	2 Apr (6)	13 (22)	8 (11)	6 (15)	16 (4)
Delhi	12 Nov (8)	10 Feb (10)	11 Apr (6)	9 (21)	12 (6)	9 (15)	21 (6)

Note — Figures within brackets represent standard deviation for dates and coefficient of variability percentage for periods

paper, the average crop and the average season at such of the stations where data for more than 10 years have been collected, are presented and discussed. The stations, their geographical co-ordinates and the number of years for which data are available are given in Table 1.

On the basis of districtwise information from the whole of India, the wheat zone of our country was demarcated in an earlier communication (India met. Dep. 1957). It will be seen that all the stations (Table 1) lie within the wheat zone except Chinsurah. This is because even though it is possible to grow wheat at Chinsurah during winter, a second crop of rice can also be grown there during the same season. Therefore, rice being the staple food of the local population, it gets preference and normally wheat is not grown in this area.

Taking into account the lengths of the period for which data are available as shown in Table 1, the average values presented and discussed in this paper may be considered to represent 'provisional normals' for all practical purposes.

(*A*) *Average crop*

At each of the crop weather stations (Table 1), two varieties of the wheat crop are under observations, one of which is N.P. 4, so that this is a variety common for all the stations. Therefore, to eliminate varietal differences, the crop features dealt with refer to the variety N.P. 4 only.

The chronology of the crop life history together with the year to year variabilities is given in Table 2. The values in Table 2 give some idea of the average wheat crop season at the respective stations.

(*i*) *Dates of sowing, flowering and harvesting*

It would appear from Table 2 that in a very general way, the sowing, flowering and harvesting are delayed and the length of the vegetative and reproductive periods increase northwards and eastwards. This aspect is considered in greater detail later in this paper.

The year-to-year variabilities of the dates of sowing, flowering and harvesting are more or less of the same order of magnitude, except at Powerkhera where the variabilities of the three dates are markedly different, flowering date being the least variable and harvesting date the most. The variability of all the three dates are somewhat higher at Labhandi than that at the other stations.

(*ii*) *The lengths of crop growth periods*

It will be seen from Table 2 that the germination period at all the stations except at Labhandi and Powerkhera (11 days) and Chinsurah (12 days), is about a week. The great variation in the length of the vegetative period (interval from sowing to flowering), from station to station show that the flowering of the wheat crop in India is not 'time bound', but is 'season bound'. Delhi with a rather long vegetative period, stands in a class by itself. The reproductive periods are of a little longer duration than the vegetative periods except at Chinsurah where the vegetative period is a little longer and at Delhi where it is considerably so.

Considering all the stations together, the year-to-year variabilities in the lengths of the period are in the order of Germination period > Reproductive period > Vegetative period > Total crop life period. Considering all the growth periods together, the year-to-year variability is high at Dharwar, Parbhani, Niphad, Labhandi and Chinsurah, lesser at Powerkhera and Delhi and least at Jalgaon and Nagpur stations.

On the basis of the total length of the crop life period, the wheat season in the different parts of India can be broadly divided into three classes. In the northwestern parts, as represented by Delhi, the season is longer than 20 weeks, while in the extreme south, as represented by Dharwar, the season is shorter than 15 weeks. In the rest of the wheat zone, as represented by the remaining stations, the season varies between the above two limits.

(*iii*) *Phenology of the crop*

According to the 'Bioclimatic Law' of Hopkins (1918), other conditions being equal, the time variation of a periodical natural phenomenon in North America is at the average rate of 4 days to each degree of latitude, 5 degrees of longitude and 400 feet of altitude. The sequence of the dates of sowing, flowering and harvesting as well as the lengths of the reproductive and total crop life periods at different stations, presented in Table 2, does not conform to the above criteria of Hopkins.

Only the lengths of the vegetative periods (flowering to harvest) appear to give a near fit to Hopkins' criteria. Many different criteria were tried to fit the data in Table 2 to the principle of the 'Bioclimatic Law'. The criteria which give the best fit are given in Table 3. The actual and the estimated values according to the 'best fit' criteria are shown in Figs. 1(a) and 1(b). It will be seen from Figs. 1(a) and 1(b) that even in the case of the best fits, there are some gross misfits. These are : date of sowing — Parbhani and Chinsurah; date of flowering — Dharwar; length of reproductive period — Chinsurah and Delhi and length of total crop life period — Chinsurah.

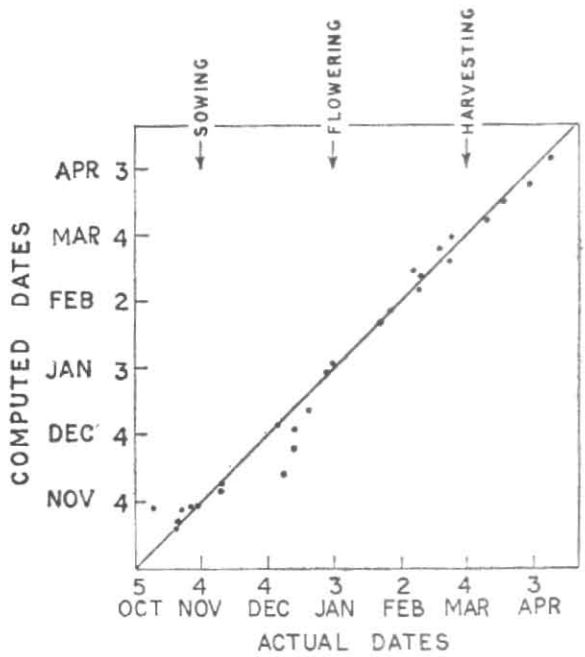

Fig. 1(a). Dates of Epochs

TABLE 4

Crop growth features

Station	Germination percentage	Tillering ratio (Highest value of culm to plant ratio)	Height attained (cm)	Yield grain (kg/hect.)
(1)	(2)	(3)	(4)	(5)
Dharwar	64 (36)	3·8 (24)	47 (13)	810 (40)
Parbhani	68 (22)	3·1 (27)	42 (17)	759 (39)
Niphad	70 (27)	2·9 (19)	41 (17)	485 (39)
Jalgaon	52 (41)	2·7 (18)	45 (17)	691 (43)
Nagpur	61 (43)	2·9 (11)	52 (23)	949 (30)
Labhandi	33 (57)	1·8 (28)	46 (16)	486 (36)
Powerkhera	40 (27)	1·4 (17)	35 (10)	330 (52)
Chinsurah	32 (57)	5·3 (31)	57 (15)	606 (46)
Delhi	65 (31)	3·5 (12)	88 (11)	1280 (32)

Note—Figures within brackets represent coefficient of variability

It would thus appear that while the principle of time variation with the geographical co-ordinates underlying Hopkins' 'Bioclimatic Law' does operate, the phenology of the wheat crop in India does not strictly conform to Hopkins' 'Bioclimatic Law' for North America.

(*iv*) *Vegetative growth*

The three vegetative growth features covered in this paper are germination percentage, tillering ratio (maximum number of culms per plant) and the height attained by the crop. The values of these three growth features at the different stations are presented in Table 4.

The values in Table 4 provide some idea about the normals of the growth attributes and their year-to-year variabilities, in the different parts of India. It will be seen from Table 4 that, considering the three growth features together, Delhi stands out as the station with the best and least variable vegetative growth, while Powerkhera and Labhandi are at the other extreme with poor and highly variable vegetative growth, the rest of the stations being somewhat intermediate between the above two stations. Considering the variabilities of the growth features for all the stations taken together, germination percentage appears to be much more variable than tillering and height, height being slightly less variable than tillering.

(*v*) *Yield*

The yield values in Table 4 (col. 5) show that on the basis of the yield of grain, the stations can be grouped under three categories. Out of the 9 stations, only at one, *i.e.*, Delhi, the yield is more than 1000 kg per hectare; at 5 other stations, *viz.*, Dharwar, Parbhani, Jalgaon, Nagpur and Chinsurah, the yield lies between 1000 to 500 kg per hectare; at the remaining 3 stations, *viz.*, Niphad, Labhandi and Powerkhera, the yield is less than 500 kg per hectare. Considering the variabilities, the yield is least variable at Nagpur and Delhi and highly variable at Powerkhera and Chinsurah, the other stations being intermediate in this respect. Considering all the stations together, the yield appears to be the most variable of all the crop growth features being slightly more variable than even the germination percentage. Amongst the stations covered in this paper, Delhi stands in a class by itself with high and steady yield and is thus by far the most suitable area for the wheat crop.

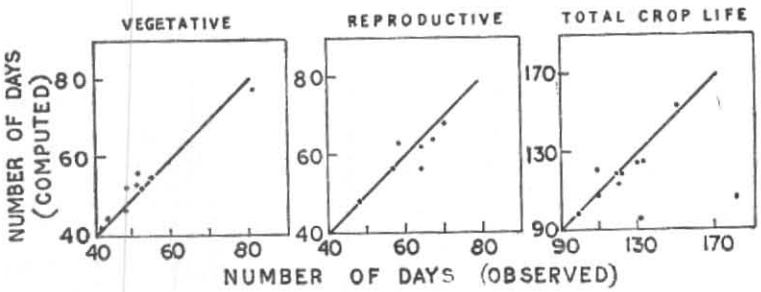

Fig. 1(b). Lengths of periods

From the values given in Table 4, it appears that in a general way, higher yields are associated with higher values of tillering and more so with height. The height as well as the product of tillering ratio and height, for each station, is plotted against the corresponding yield values in Fig. 2. It will be seen from Fig. 2 that there is definite indication of a direct quantitative relationship. Therefore, the tillering ratio and the height of the crop are important factors to be taken into account in any attempt to forecast the yield of the wheat crop in India.

The average yield for all the stations taken together comes out about 710 kg per hectare. As given in a recent publication (Bharat Krishak Samaj 1964), the yield of wheat for India as a whole is 730 kg per hectare. It would appear, therefore, that the stations under consideration comprise a not too unrepresentive a sample for the wheat crop in India.

The yield per acre in India is the lowest in the world. The figure for other countries are much higher, *e.g.*, Japan 2740, U.S.A. 1610, Australia 1130 and Pakistan 820 kg per hectare. However, if the yield for the stations Niphad, Labhandi and Powerkhera is not taken into account, the average yield for the other crop weather stations comes out as 850 kg per hectare. It would appear, therefore, that in the areas of India represented by Niphad, Powerkhera and Labhandi stations, it is unprofitable to grow wheat so that, in these regions, there is scope for the introduction of some other winter crop, more profitable than wheat.

(*B*) *Average season*

The whole crop season can be conveniently divided into 3 periods, *viz.*, germination period (from sowing to the emergence of the seedlings), vegetative period (from emergence of seedlings to flowering) and reproductive period (from flowering to harvest). The durations of these three periods have been presented and discussed earlier in this paper. The climatology of the three crop growth seasons is presented in the following section.

4. Climatology of the crop periods

The meteorological factors covered in this paper are rainfall, rainy days (days with rainfall of 2·5 mm or more), sunshine and maximum and minimum temperatures. The average weekly values, based on the number of years' data available (col. 5 of Table 1), for each of the weeks, from sowing to harvest, together with their coefficients of variability were computed. The normal weekly values (average of weekly values of all the years) of the meteorological elements for the whole of the crop season in respect of Delhi are depicted in Fig. 3 as a crop climatogram. The crop climatogram shows at a glance the march of climatological factors, week by week, from sowing to harvest of the wheat crop at Delhi.

It will be seen from Fig. 3 that the crop is sown after the season has started cooling down. The flowering takes place soon after the temperatures start rising after having reached the lowest values. The harvesting is done before the season gets too hot. Thus the vegetative growth period is one of continuous falling temperatures while the reproductive period is one of a continuously rising temperatures. The same pattern holds good for all the other stations, except Chinsurah. At Chinsurah, because of excessive soil moisture, the sowing is delayed till the season has reached almost the coldest stage so that the whole crop period at Chinsurah is one of continuous rise of temperatures.

For the sake of brevity, only the average of the weekly values of the elements as well as the coefficients of variability at each of the stations and for the three crop growth periods are presented in Tables 5, 6 and 7 for the germination, vegetative and reproductive periods respectively. In these tables, the values for rainfall and rainy days represent the averages of the yearly values for the period as a whole while those for the other elements represent the averages of the mean daily values for each of the weeks of the period.

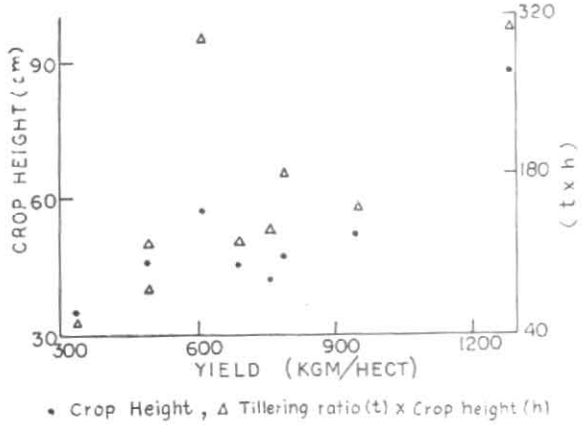

Fig. 2. Yield of grain and tillering and height of crop

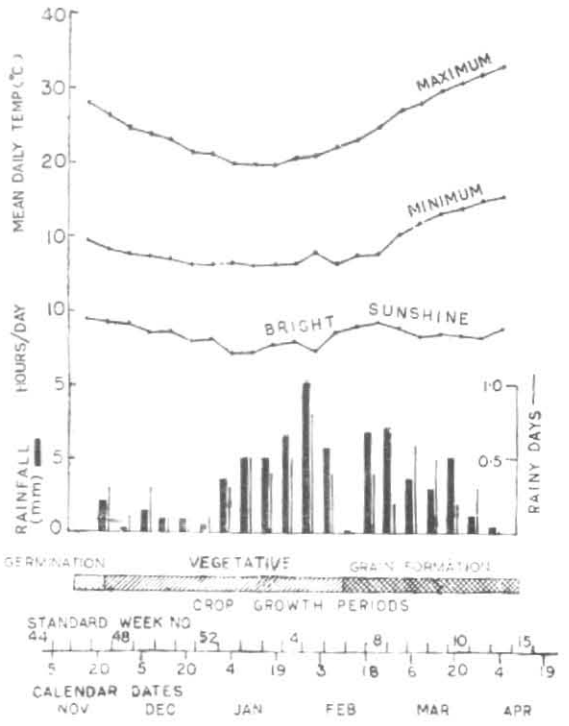

Fig. 3. Crop climogram — Wheat
Delhi (28°04′N, 77°10′E, 13 metres)

The values given in Tables 5, 6 and 7 provide some idea of the variation in the climatological conditions under which the wheat crop is raised in the plains of India.

The coefficients of variability in Tables 5, 6 and 7 show that the year-to-year variablity of the weekly values is very high for rainfall and the rainy days. This is because wheat is grown during the non-rainy part of the year when rainfall is an exception rather than the rule. Of the other three elments, *viz.*, sunshine and maximum and minimum temperatures, the variability of the maximum temperature is the least, that of minimum temperature slightly more while sunshine is more variable than temperatures.

The highest and the lowest values of each of the meteorological elements, experienced at each of the stations, in any week during the period covered in this paper (col. 5 of Table 1), are given in Tables 8 and 9 for the vegetative and reproductive periods respectively. Considering the lengths of the period covered, chances are that the values in Tables 8 and 9 set the limits of climatic conditions, over a weekly period, likely to be experienced by the wheat crop in the different areas of India, as represented by the stations.

Indications of crop climate relationships, based on the average values presented in this paper were sought with the help of scatter diagrams. However, only the following indications could be seen —

(*i*) The length of the vegetative period is negatively related to the average values of mean daily maximum and minimum temperatures during the vegetative period, as shown by Fig. 4.

(*ii*) The height attained by the crop is negatively related to the average value of mean daily maximum temperature during the vegetative period as shown by Fig. 5.

It appears, therefore, that of all the different aspects of the growth of the wheat crop the length of the vegetative period and the height of the crop are the most weather sensitive. Further, the negative relationships in the above cases suggest that at all the stations covered in this paper, the temperature conditions during the wheat season are higher than the optimum for the wheat crop; that is to say, where the temperatures are lower, the vegetative growth period of the crop are likely to be longer and the crop height greater.

TABLE 5

Climatology — Germination period

Climatic element	Dharwar	Parbhani	Niphad	Jalgaon	Nagpur	Labhandi	Power-khera	Chinsurah	Delhi
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rainfall (mm)	23 (100)	2 (287)	3 (260)	0	5 (300)	0	0	0	0
Rainy days	0·9 (105)	0·4 (125)	0·2 (270)	0	0·3 (210)	0	0	0	0
Mean daily bright sunshine (hrs)	7·3 (40)	9·3 (21)	9·9 (12)	9·6 (15)	8·0 (21)	8·8 (9)	10·3 (9)	9·5 (8)	9·5 (7)
Mean daily maximum temperature (°C)	30·1 (4)	32·5 (3)	31·8 (2)	33·9 (3)	30·4 (3)	28·5 (3)	30·8 (5)	26·3 (2)	27·1 (3)
Mean daily minimum temperature (°C)	18·4 (4)	18·5 (5)	14·5 (10)	17·5 (9)	15·8 (8)	14·8 (7)	12·3 (10)	9·8 (7)	9·3 (6)

Note — Figures within brackets represent the coefficient of variability

TABLE 6

Climatology — Vegetative period

Climatic element	Dharwar	Parbhani	Niphad	Jalgaon	Nagpur	Labhandi	Power-khera	Chinsurah	Delhi
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rainfall (mm)	74 (66)	54 (126)	29 (151)	29 (157)	30 (176)	7 (179)	20 (213)	31 (110)	38 (57)
Rainy days	5·0 (105)	2·7 (195)	2·5 (221)	1·5 (229)	1·5 (264)	1·0 (265)	1·1 (323)	2·4 (171)	2·6 (90)
Mean daily bright sunshine (hrs)	8·2 (24)	9·2 (18)	10·0 (11)	9·8 (13)	8·7 (16)	9·1 (9)	9·7 (12)	9·1 (10)	8·2 (17)
Mean daily maximum temperature (°C)	29·3 (3)	30·7 (3)	29·2 (3)	31·2 (3)	29·1 (3)	27·6 (3)	28·8 (4)	26·3 (4)	22·2 (5)
Mean daily minimum temperature (°C)	15·7 (7)	14·8 (10)	11·5 (11)	15·2 (10)	13·1 (8)	12·0 (7)	10·9 (9)	10·4 (8)	7·0 (8)

Note— Figures within brackets represent the coefficient of variability

TABLE 7

Climatology — Reproductive period

Climatic element	Dharwar	Parbhani	Niphad	Jalgaon	Nagpur	Labhandi	Power-khera	Chinsurah	Delhi
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rainfall (mm)	8 (254)	4 (239)	4 (280)	11 (137)	26 (130)	26 (116)	19 (101)	32 (89)	25 (116)
Rainy days	0·4 (381)	0·5 (352)	0·4 (426)	0·9 (195)	2·2 (193)	2·5 (187)	2·0 (161)	2·5 (143)	1·0 (181)
Mean daily bright sunshine (hrs)	9·6 (10)	10·1 (7)	10·3 (7)	9·8 (10)	8·8 (15)	9·1 (10)	9·8 (8)	9·2 (11)	8·7 (13)
Mean daily maximum temperature (°C)	29·3 (2)	30·1 (2)	30·2 (3)	30·7 (3)	29·3 (3)	31·2 (4)	29·6 (4)	34·4 (3)	28·8 (4)
Mean daily minimum temperature (°C)	12·9 (6)	12.1 (9)	9·2 (8)	12·9 (9)	12·8 (8)	14·9 (6)	11·3 (8)	17·9 (7)	11·9 (8)

Note — Figures within brackets represent coefficients of variability

TABLE 8

Climatology (Vegetative period) — Highest and lowest values for a week

Climatic element	Dharwar	Parbhani	Niphad	Jalgaon	Nagpur	Labhandi	Power-khera	Chinsurah	Delhi
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rainfall (mm)	98	203	64	86	102	41	103	86	59
Rainy days (number)	5	4	5	4	4	2	5	4	4
Mean daily bright sunshine (hrs)	10·9 3·2	11·0 2·9	11·0 4·4	10·8 3·7	10·3 2·4	10·2 6·1	11·1 3·5	10·4 5·3	10·0 2·4
Mean daily maximum temperature (°C)	32·1 27·2	25·0 27·7	33·6 25·9	25·9 27·4	32·9 24·4	31·2 24·1	33·6 22·7	32·7 21·6	29·7 14·2
Mean daily minimum temperature (°C)	21·1 8·9	21·8 7·2	20·6 4·2	24·1 8·1	21·8 7·6	17·5 8·7	17·4 5·6	17·1 5·0	12·9 1·8

TABLE 9

Climatology (Reproductive period) — Highest and lowest values for a week

Climatic element	Dharwar	Parbhani	Niphad	Jalgaon	Nagpur	Labhandi	Power-khera	Chinsurah	Delhi
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rainfall (mm)*	46	30	38	31	66	70	42	69	64
Rainy days (number)*	3	2	2	3	4	2	4	4	3
Mean daily bright sunshine (hrs)	10·6 5·1	11·0 5·2	11·2 5·2	10·7 4·5	10·7 3·6	10·2 5·6	11·0 4·2	10·6 6·1	10·5 5·0
Mean daily maximum temperature (°C)	31·7 26·4	33·6 26·2	25·9 26·8	34·5 26·1	36·0 24·5	39·1 25·2	38·8 23·4	38·7 27·8	37·1 19·8
Mean daily minimum temperature (°C)	16·5 7·5	18·1 5·2	14·6 4·4	17·8 8·3	18·8 6·2	21·4 7·7	17·3 4·5	24·7 9·6	17·1 3·4

*Lowest value in all cases is 0, hence not given

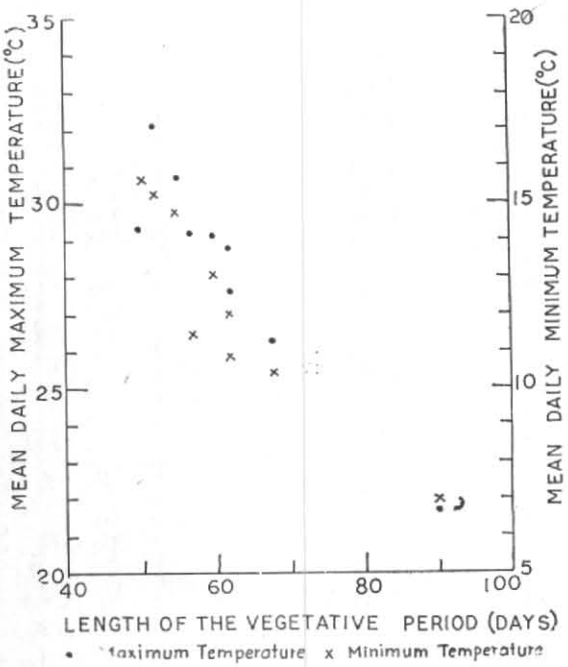

Fig. 4. Length of the vegetative period and temperatures during the period

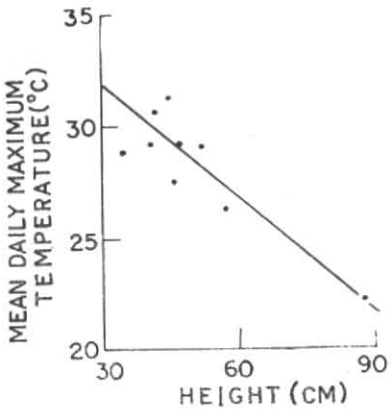

Fig. 5. Crop height and maximum temperature during the vegetative period

Crop growth is an integration of complex soil-plant-climate interactions. In this paper, soil factors have not been taken into account. Hence the absence of indications about linear crop climate relationship is not surprising. In fact, it is gratifying to find indications of such a relationship in the above few instances.

5. Summary and conclusion

In this contribution, crop and weather data being collected under the Co-ordinated Crop Weather Scheme are presented in terms of the average. The progress of the climatological elements, week by week, during the crop season is shown as a crop climatogram (Fig. 3). Information is presented about the average wheat crop and average climatic features of the crop season together with their variabilities from year-to-year, as asssessed from the crop weather data collected so far. It has been shown that —

(*i*) There are indications that the sequence of the dates of sowing, flowering and harvesting as well as the lengths of the vegetative, reproductive and total crop life periods obey the principle of time variation with geographical co-ordinates. However, only the length of the vegetative period at the different stations conform to Hopkins' 'Bioclimatic Law' for North America.

(*ii*) The yield at Chinsurah (Calcutta) where wheat is normally not grown is quite good as compared to the yield in the wheat areas of Peninsular India.

(*iii*) In the areas represented by the stations Niphad (Nasik), Powerkhera (Hoshangabad) and Labhandi (Raipur), where wheat is extensively grown, the yield is so poor that it may be profitable to replace, if possible, the wheat crop of this area by some other suitable alternative rabi crop.

(*iv*) Amongst the stations considered, Delhi stands out in a class by itself with a long vegetative growth period, very good crop height and heavy and steady yield.

(*v*) The data appear to indicate negative relationships between the length of the vegetative growth period and maximum and minimum temperatures during the same period and also between the height of the crop and the maximum temperature during the vegetative growth period.

6. Acknowledgement

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