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INFLUENCE OF WEATHER VARIABLES ON THE SORGHUM YIELD

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ABSTRACT

A modified form of Fisher's technique has been applied to examine the influence of distribution of weather variables on sorghum yield throughout its life cycle in Surat district, Gujarat. The multiple regression analysis based on 36 years of data (1950-1985) indicated that the weather variables rainfall, maximum and minimum temperatures, relative humidity, and duration of sunshine influence the sorghum yield significantly. The results revealed that the sorghum responds differently to weather variables during different stages of its development. The yield estimates obtained based on the weather variables are discussed.

INTRODUTION

Since a large portion of year to year fluctuation in crop yields is due to weather variables, there have been many efforts to model crop environment relationship and develop operational yield prediction system (Haun 1982). Fisher (1924) developed a technique to examine the influence of meteorological parameters on yield throughout the life cycle of the crop. This technique was further modified and has successfully been applied by Rupkumar (1984) and Huda et al. (1975, 1976) to study the crop weather relationship of rice, maize and sugarcane crops. In this paper therefore, attempts have been made to quantify the crop-weather relationship of sorghum and its yield estimation using weather variables in Surat district of Gujarat.

MATERIAL AND METHODS

The sorghum yield data for Surat district have been obtained from Directorate of Agriculture, Ahmedabad for 36 years i.e. 1950-51 to 1985-86. The Weekly weather data of corresponding periods recorded at Surat have been obtained from Agricultural Meteorology Division of India Meteorological Department, Poona.

Generally sorghum is grown in the district in both kharif and rabi season for either grain or/fodder purpose. In Surat the sorghum varieties grown during kharif season are mainly grain purpose which mature in about 130-140 days.

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Statistical analysis

The total crop life period was divided into 19 weeks i.e. from 25 to 43 standard weeks. The statistical technique used in the present study is similar to those of Runge (1968) adopted from Hendricks and Scholl (1943) which is a modified form of Fisher (1924) teehnique. The multiple regression equation of the following form was developed for each weather variable using least square method and was used to calculate yield response to different weather variables.

$$Y = A_0 + a_1 \sum_{t=1}^{19} (t^0 X) + a_2 \sum_{t=1}^{19} (t^1 X) + a_3 \sum_{t=1}^{19} (t^2 X) + a_4 \sum_{t=1}^{19} (t^3 X) + D.T$$

where Y is the sorghum yield in kg/ha, A_0, a_1, a_2, a_3, a_4, and D are partial regression coefficients. X is weather variable over seven days period, it is the number of each weeks. It is 1 for 25th standard week (June 18-24) and 19 for 43rd standard week October (22-28). To study the influence of presowing rainfall three more weeks before sowing were included in the regression analysis. The time trend (T) in yield was corrected by assigning numeric values 1 for first year 1950 and 36 for the 1985.

RESULTS AND DISCUSSION

Distribution of weather variables during growing season

The 36 years averags values of weather parameters during sorghum growing season are given in Table 1. It is seen from the table that the presowing rainfall was 2.4, 38.2, and 22.7 mm during 22nd, 23rd and 24th standard weeks. During first three weeks after sowing the weekly rainfall was more than 100 mm. Vegetative period experienced weekly rainfall ranging between 50 mm to 100 mm except during 34th week. During maturity period rainfall was low. The temperature was low during vegetative period and it was between 30-35°C during the crop growing period. The minimum temperature decreased from 26.3°C during sowing to 19.9°C during maturity. The morning relative humidity remained above 85% during most of the growing season, whereas the afternoon relative humidity was between 37 to 82% during the season. Duration of bright sunshine decreased from 6.3 hr/day during sowing to 2.7 hr/day during flowering and again increased continuously to 9.7 hr/day during maturity.

Effects of weather variables on the yield of sorghum

Rainfall

The multiple regression equation obtained for rainfall is given as below :

$$Y = 515.65 + 0.6634 \sum_{t=1}^{19} (t^0X) - 0.2312 \sum_{t=1}^{19} (t^1X) + 0.0206 \sum_{t=1}^{19} (t^2X)$$

$$-0.0005 \sum_{t=1}^{19} (t^3X) + 22.85\ T \ (R^2 = 0.7055,\ \text{Sig } 1\%)$$

Table 1. Average values of weather variables during sorghum growing season at Surat.

Standard week	Rain fall (mm)	Temperature (°C)		Relative humidity (%)		Sunshine* duration (hrs/day)
		Maximnm	Minimum	Morning	Afternoon	
25	78.7	33.4	26.3	85.0	71.7	6.3
26	108.1	32.2	25.9	87.0	76.4	4.9
27	113.8	31.7	25.9	88.8	77.9	4.0
28	100.5	31.1	25.3	88.0	78.4	4.1
29	89.8	31.0	25.2	89.0	78.0	3.8
30	80.2	30.9	25.2	88.4	78.8	3.9
31	73.6	30.3	25.1	89.8	81.2	2.7
32	97.4	30.1	25.0	89.3	81.6	3.0
33	54.8	30.4	24.8	88.6	77.7	3.8
34	30.8	31.0	24.8	88.0	73 6	4.7
35	56.8	30.9	24.5	87.5	73.1	4.7
36	62.8	30.9	24.2	87.5	72.1	4.7
37	31.0	31.4	24.0	88.2	68.6	6.3
38	22.9	32.7	23.7	86.9	63.0	7.5
39	38.3	33.4	23.9	86.5	61.1	7.3
40	13.4	34.2	23.3	85.7	55.3	8.6
41	9.8	34.5	22.6	83.6	49.5	9.0
42	2.4	35.4	21.2	76.6	40.8	9.5
43	1.7	35.0	19.9	72.1	37.2	9.7

*average of 30 years (1950 - 1979).

The response curve obtained for 25 mm of additional rainfall from above equation is shown in figure 1A. It is seen that the rainfall before sowing is very much helpful in increasing the sorghum yield. After, emergence the average rainfall is more than 80 mm which seems to be sufficient for the crop and an increase of 25 mm rainfall over average may cause reduction of 3.5 kg/ha in yield during 29 week (July 16-22). However, during flowering and maturity periods the rainfall has beneficial effect.

Maximum temperature

The multiple regression equation obtained for maximum temperature is given as

$$Y=2017.59+25.1336 \sum_{t=1}^{19} (t^0X)-9.3995 \sum_{t=1}^{19} (t^1X)+0.8693 \sum_{t=1}^{19} (t^2X)$$

$$-0.0246 \sum_{t=1}^{19} (t^3X)+21.99\ T \quad (R^2=0.7026,\ \text{Sig. } 1\%)$$

The response curve for maximum temperature derived from above equation by increasing the weekly maximum temprature by 1 °C is shown in Figure 1B. The above average maximum temprature during emergence and early growth period was beneficial to sorghum crop. However, during vegetative and maturity periods the average maximum temperature of 30 to 35 ^{0}C seems to be adequate for sorghum crop and further increase over this may cause adverse effect on its yield.

Minimum temperature

The multiple regression equation obtained for minimum temperaturs is given as

$$Y=465.65+31.9861 \sum_{t=1}^{19} (t^0X)-8.7315 \sum_{t=1}^{19} (t^1X)+0.6621 \sum_{t=1}^{19} (t^2X)$$

$$-0.0164 \sum_{t=1}^{19} (t^3X)+24.13\ T\ (R^2=0.7016\ \text{Sig. } 1\%)$$

The reponse curve for minimum temperature is sown in Figure 1C. The sorghum yield response to minimum temperature is similar to that of maximum temperature. During emergence and early growth period the night temprature should be more than average in order to harvest good yield. The average minimum temperature during subsequent periods of crop life seems to be sufficient for the crop and any increase over this may adversely affect the crop yield.

Morning relative humidity

The multiple regression equation obtained for morning relative humidity is given as :

$$Y=652.25-4.2485 \sum_{t=1}^{19} (t^0x) + 0.2317 \sum_{t=1}^{19} (t^1x) + 0.0747 \sum_{t=1}^{19} (t^2x)$$

$$-0.0042 \sum_{t=1}^{19} (t^3x) + 21.81\ T\ (R^2 = 0.6981,\ \text{Sig } 1\%)$$

The response curve for morning relative humidity is shown in Figure 1D. Above average morning relative humidity during emergence and early growth periods was unfavourable to sorghum. However, during vegetative and flowering periods an increase of 5% of morning relative humidity over average may cause an increase of the order of 11.3 kg/ha in sorghum yield. At the time of harvest the higher humidity is undesirable as this may adversely affect the quality of the produce.

Afternoon relative humidity

The multiple regression equation obtained for afternoon relative humidity is given as :

$$Y=236.42-6.3099 \sum_{t=1}^{19} (t^0x) + 2.0179 \sum_{t=1}^{19} (t^1x) - 0.1453 \sum_{t=1}^{19} (t^2x)$$

$$-0.0027 \sum_{t=1}^{19} (t^3x) + 22.80\ T\ (R^2 = 0.7339,\ \text{Sig } 1\%)$$

The response curve obtained from above equation for 5% more than average afternoon relative humidity is shown in Figure 1E. The sorghum response to afternoon relative humidity is similar to that of morning relative humidity. During most of the vegetative and flowering periods (July 16 to September 30) the afternoon relative humidity had beneficial effect on the crop. However, during maturity period the afternoon relative humidity has detrimental effect on the yield.

Duration of sunshine

The multiple regression equation obtained for sunshine duration is given as :

$$Y = 366.14 + 20.6140 \sum_{t=1}^{19} (t^0x) - 6.4527 \sum_{t=1}^{19} (t^1x) + 04604 \sum_{t=1}^{19} (t^2x)$$

$$-0.0085 \sum_{T=1}^{19} (t^3x) + 28.12\, T \; (R^2 = 0.4408, \text{Sig } 1\%)$$

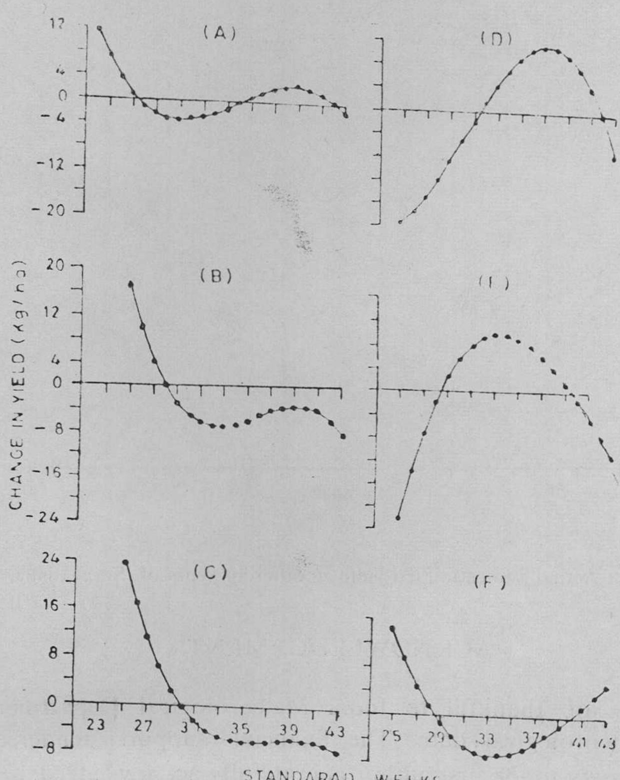

Figure 1. Effect of above - average values of weather variables on sorghum yield during the crop season.

A. 25 mm above-average rainfall; B. 1°C above average maximum temperature; C. 1°C above average minimum temperature; D. 5% above average morning relative humidity; E. 5% above average afternoon relative humidity; and F. 1 hrs/day above average sunshine duration.

Figure 1 F shows the response curve for duration of sunshine. Above average duration of sunshine during 25th to 28th standard weeks (June 18 to July 15) affects favourably the yield. During vegetative period the detrimental effect has been observed. However, during maturity period the higher sunshine duration may enhance the maturation process resulting in good yeild of sorghum. Among all weather variables as discussed earlier and derived agroclimatic variables (Pandey and Gupta 1989), the afternoon relative humidity explain the maximum yield variation ($R^2=0.734$) in sorghum yield at Surat district. Therefore, the regression equation obtained by afternoon relative humidity can be used for estimating the sorghum yield for different years in the district. The estimated yield alongwith the actual yield are shown in Figure 2. It may be seen that the actual and estimated yields are in good agreement. The estimated yields are generally within 20% of actual yield.

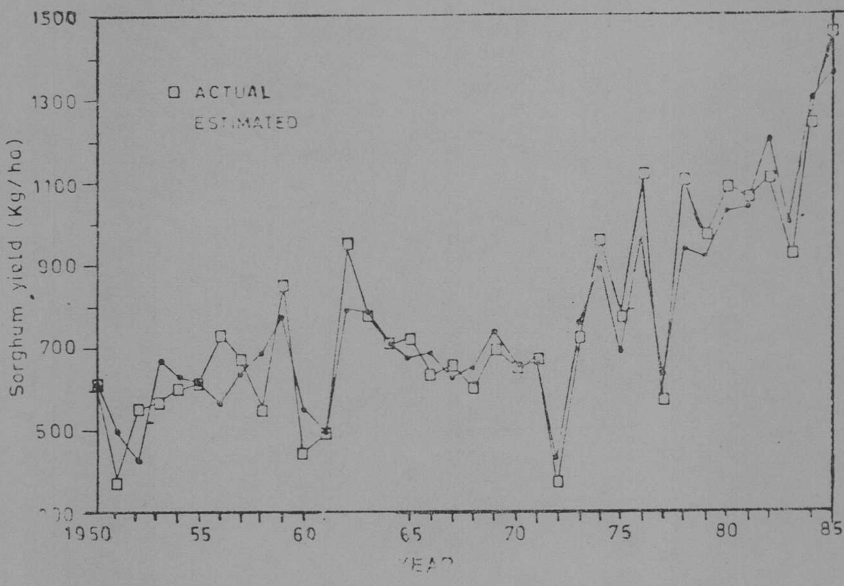

Figure 2. Actual and estimated yield in different years of Surat district.

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