Mausam, (1990), **41**, 4, 575-578

632.111 : 633.3

Influence of weather parameters at the crop growth stages on seed yield of soybean

S. JEYARAMAN, S. SUBRAMANIAN and S. R. SREE RANGASWAMY

Centre for Soil and Crop Management Studies, Tamil Nadu Agric. Univ., Coimbatore

(*Received 10 November 1989*)

सार — भारत में सोयाबीन का महत्व बढ़ता जा रहा है। सोयाबीन उगाने के उपयुक्त मौसम का पता लगाने पर विशेषीकृत स्थानों में अधिकतम फसल विभवों का उपयोग करना आवश्यक हो जाता है। तमिलनाडु कृषि विश्वविद्यालय, कोयम्बटूर में, ग्रीष्म और मानसून आर्द्र ऋतु में सोयाबीन बोने के उत्तम समय का पता लगाने के लिए सोयाबीन Var. Co. 1 से फसल बोने के समय पर प्रयोग किया गया। सोयाबीन के बीज के उत्पादन पर क्रान्तिक फसल वृद्धि स्तरों और समूची फसल अवधि के दौरान विद्यमान मौसम प्राचलों के प्रभावों का अध्ययन किया गया। सोयाबीन की फसल की उत्पादन क्षमता को बढ़ाया जा सकता है जबकि 31.2° से 31.6° सें० के अधिकतम तापमान 20.4° से 20.9° सें० के न्यूनतम तापमान, 1274 से 1292 के संचित उष्मा यूनिट मानों में उगाए गए और फसल की समूची अवधि में 383 से 456 घंटों तक तेज धूप मिलें।

ABSTRACT. Soybean is gaining importance in India. Identifying suitable soybean growing seasons necessitates for exploiting maximum yield potential in specific location. A time of sowing experiment with soybean var. Co. 1 was conducted to find the best time of sowing in summer and monsoon wet seasons at Tamil Nadu Agricultural University, Coimbatore. The influence of weather parameters prevailed during critical crop growth stages and whole cropping period on seed yield of soybean was studied. The production potential of soybean crop can be increased when grown in seasons having the maximum tempearture of 31.2 C to 31.6 °C, minimum temperature of 20.4 °C to 20. 9°C, cumulative heat unit values of 1274 to 1292 and total bright sunshine hours of 383 to 456 for the whole cropping period.

1. Introduction

The weather parameters play a major role in determining the crop yield because these strongly influence the physiological expression of genetic potential of the crop. It is well known that the yield from any given crop or variety depends on the extent to which certain optimum conditions of solar radiation, temperature, heat units, etc, are satisfied during different stages of crop growth. Doorenbos and Pruit (1977) differentiated the growth stages of soybean having a duration of 85 days as initial stage (0-15 days), development stage (16-30 days), mid-season growth stage (31-70 days) and late-season stage (71-85 days). The soybean is a short day plant. All varieties flower in less than 30 days after emergence if exposed to day light less than 12 hours (Beard and Knowles 1973). Whigham and Minor (1978) jointly claimed the attainment of light saturation of soybean at 20 klux in green houses and 43 klux in growth chambers but not under field grown soybeans even at 150 klux. Temperatures below 24°C would normally delay flowering by 2 or 3 days for each decrement of 0.5°C or below. Flower initiation was accelerated when mean temperatures increased from 15° to 32°C. Temperatures above 40°C had an adverse effect on the rate of node formation, internodal growth and flower initiation. Heat stress of 40° to 46°C resulted in pod abscission. Temperatures of 18°C or less did not permit pod set. Seed size was the greatest when plants were grown at 27°C and the number of pods per plant was the highest at 30°C. Heat unit concept is the agronomic application of temperature effect on plants based on the idea that plants have a temperature requirement for their growth, development and maturity. Brown (1960) proposed the "soybean development unit" based on temperature which could be used to predict soybean maturity.

The objective of this study is to find the influence of the most important climatic factors, *viz.*, maximum temperature, minimum temperature, heat units and the total bright sunshine hours at critical crop growth stages as well as the whole crop growth period on the seed yield of soybean crop.

2. Materials and methods

A time of sowing experiment was conducted in red loamy soil under irrigated condition during the year 1982 with soybean var. Co. 1 with a duration of 85 days at the Pulse Breeding Station, Tamil Nadu Agricultural University, Coimbatore. It is located at 11°N latitude and 77°E longitude at an altitude of 426 metres above mean sea level. The average annual rainfall is 640 mm distributed in about 50 rainy days with its peak in October. The highest mean relative humidity is 76 per cent and the lowest mean relative humidity is 58 per cent

TABLE 1

Maximum, minimum and mean values of weather parameters and seed yield at critical growth stages and whole growth period of soybean crop

Character/Stage of crop	Max. temp. (°C)	Min. temp. (°C)	Cumulative heat units	Total bright sunshine hours		Seed yield (kg/ha)
Initial seedling stage	(0-15 DAS)					
(*i*) Maximum	35.7	22.3	242.1	166.5	(11.1)	—
(*ii*) Minimum	30.8	16.8	201.5	61.5	(4.1)	—
(*iii*) Mean	33.7	20.5	228.4	127.0	(8.5)	—
Crop development stage	(16-30 DAS)					
(*i*) Maximum	38.0	23.1	242.1	160.5	(10.7)	—
(*ii*) Minimum	30.5	17.3	208.5	46.5	(3.1)	—
(*iii*) Mean	33.8	21.0	231.2	114.8	(7.7)	—
Mid season growth stage	(31-70 DAS)					
(*i*) Maximum	35.2	22.1	642.7	424.0	(10.6)	—
(*ii*) Minimum	30.3	19.8	587.9	156.0	(3.9)	—
(*iii*) Mean	32.9	21.2	565.2	272.0	(6.8)	—
Late season growth stage	(71-85 DAS)					
(*i*) Maximum	35.1	22.3	242.2	135.0	(9.0)	—
(*ii*) Minimum	30.3	18.9	217.3	51.0	(3.4)	—
(*iii*) Mean	32.5	20.9	230.5	95.3	(6.4)	—
Whole crop growth period	(0-85 DAS)					
(*i*) Maximum	35.0	21.8	1348.2	859.0	(10.1)	867
(*ii*) Minimum	31.2	19.3	1264.8	383.5	(4.5)	111
(*iii*) Mean	33.2	20.9	1308.6	609.1	(7.2)	395

with a grand mean of 67 per cent. The maximum temperature ranges from 28.4° to 35.1°C with a mean of 31.4°C and the minimum temperature ranges between 18.4° and 23.2°C with a mean of 21.2°C. Heat units have been computed using the formula suggested by Major *et al.* (1975) :

$$\sum_{i=1}^{n}\left[\frac{(X_i^H + X_i^L)}{2}\right] - 10$$

where,

X_i^H = Maximum temperature in °C for day;

X_i^L = Minimum temperature in °C for day;

n = Number of days thermal units were accumulated;

10 = 10°C is the base temperature for soybean.

Multiple regression equations have been worked out involving the seed yield of soybean (Y), mean maximum (X_1) and minimum temperatures (X_2), heat units (X_3) and total bright sunshine hours (X_4) for each critical crop growth stages as well as whole crop growth petiod.

3. Results and discussion

The weather parameters, *viz.*, maximum and minimum temperatures, cumulative heat units and total bright sunshine hours prevailed during whole crop growth period and at critical growth stages of soybean crop is presented in Table 1. The correlation and regression of seed yield and weather parameters during critical crop growth stages and whole cropping period is presented in Table 2.

3.1. *Initial seedling stage*

The mean values of maximum temperature, minimum temperature, cumulative heat units and total bright sunshine hours during the initial seedling growth stage of soybean crop were 33.7°C, 20.5°C, 228.4 units and 127.0 hours respectively. Heat units had strong positive relationship with maximum temperature (r=0.9941) but negative towards the total bright sunshine hours (r= −0.7475) during the initial seedling growth stage of soybean crop. The weather parameters, *viz.*, maximum and minimum temperatures, heat units and the total bright sunshine hours whether positive or negative had no significant influence on the seed yield of soybean. However, 82.8 per cent of yield was contributed by the combined effect of the above weather parameters studied

TABLE 2

Correlation and regression of seed yield of soybean and weather parameters

	X_1	X_2	X_3	X_4	Partial regression coefficients	SEb_i	t	R_2
(a) Initial growth stage								
					a=6008.15			
Y	—0.7379	+0.2182	+0.2875	+0.6738	b_1=122.73	SEb_1=89.33	t_1=1.3738^{NS}	
X_1		+0.0438	+0.9941**	—0.4996	b_2=488.33	SEb_2=269.86	t_2=1.8095^{NS}	
X_2			-0.0273	—0.4488	b_3= —88.34	SEb_3=39.14	t_3=—2.0777^{NS}	0.82801*
X_3				—0.7475*	b_4= —9.24	SEb_4= 3.48	t_4= —2.4538^{NS}	(F=7.22)
(b) Crop development stage								
					a=9421.62			
Y	—0.5409	+0.2844	+0.2362	+0.8565*	b_1=—329.28	SEb_1=101.05	t_1= —3.2585*	
X_1		—0.1709	+0.9463**	—0.1886	b_2=344.15	SEb_2=135.67	t_2=2.5366*	0.71136
X_2			—0.2215	—0.1919	b_3= —29.08	SEb_3=16.90	t_3= —1.7204^{NS}	(F=3.69)
X_3				—0.3234	b_4=13.88	SEb_4=5.0704	t_4=2.7367*	NS
(c) Mid season stage								
					a=9636.64			
Y	—0.4664	+0.6189	+0.7253	+0.9197**	b_1=104.41	SEb_1=154.90	t_1 =0.6740^{NS}	
X_1		—0.5643	+0.9857**	+0.3982	b_2=169.66	SEb_2=1036.17	t_2 =1.0323^{NS}	0.4751
X_2			—0.6075	+0.5220	b_3= —56.80	SEb_3=47.24	t_3=1.2023^{NS}	(F=1.3)
X_3				—0.3820	b_4= —3.88	SEb_4=2.31	t_4=0.1674^{NS}	NS
(d) Late season stage								
					a=6839.58			
Y	—0.0151	+0.5277	+0.6971	+0.8372*	b_1= —184.04	SEb_1=164.10	t_1= —1.1215^{NS}	
X_1		—0.4762	+0.9710**	+0.5396	b_2=289.68	SEb_2=482.70	t_2=6.0014**	0.6017 (F=2.34)
X_2			—0.4156	+0.2584	b_3= —33.49	SEb_3=71.02	t_3=4.7165*	NS
X_3				+0.4015	b_4=12.67	SEb_4=6.0292	t_4=2.1018 ^{S}	
(e) Whole crop growth period of soybean crop								
					a=12689.60			
Y	—0.5610	—0.3506	—0.5555	—0.3640	b_1= —293.36	SEb_1=434.43	t_1= —0.67527	
X_1		+0.1649	+0.5337	+0.8890**	b_2=651.51	SEb_2=657.14	t_2=0.99143	0.49056
X_2			+0.9074**	—0.2920	b_3= —13.64	SEb_3=14.1793	t_3=—0.96180	(F=1.414)
X_3				+0.1080	b_4=2.78	SEb_4=3.7305	t_4=0.74613	NS

3.2. *Crop development stage*

The mean maximum temperature ranged from 30.5° to 38.0°C with a mean of 33.8°C while the minimum temperature ranged from 17.3° to 23.1°C with a mean of 21.0°C during the crop development growth stage of soybean crop. The mean total bright sunshine hours and cumulative heat units were 114.8 hours and 231.2 units respectively, during crop development stage.

Positive relationship existed between seed yield and total bright sunshine hours (r=0.8565) and maximum temperature with heat units (r=0.9463) during crop development stage. The minimum temperature and the total bright sunshine hours prevailed during crop development stage increased the seed yield whereas the maximum temperature decreased the seed yield of soybean crop. However, the heat units at crop development stage had no effect on seed yield. The variation in seed yield brought by these factors was 71.1 per cent.

3.3. *Mid-season stage*

The values mean maximum and minimum temperatures, cumulative heat units and total bright sunshine hours during mid-season growth stage were 32.9°C, 21.2°C, 565.2 units and 272 hours, respectively.

There was positive correlation between maximum temperature and seed yield (r=0.9197) but it could not contribute to seed yield in combination with other weather parameters studied during mid-season stage. Maximum temperature had positive relationship with heat

TABLE 3

Seed yield, maximum and minimum temperatures, heat units and total bright sunshine hours for different time of sowing of soybean

Season	Seed yield (kg/ha)	Maximum temperature (°C)	Minimum temperature (°C)	Cumulative heat units	Total sunshine hours
3 Feb	356	34.0	19.3	1264.3	859.0
16 Feb	378	34.8	20.2	1297.9	848.0
3 Mar	289	34.8	21.0	1332.3	809.5
16 Mar	222	35.0	21.8	1343.5	721.0
1 Apr	333	33.8	21.8	1348.2	619.5
16 Apr	344	33.8	21.6	1339.8	577.0
4 May	178	32.8	21.4	1325.0	500.5
15 May	111	32.1	21.1	1309.5	434.5
1 Jun	778	31.2	20.9	1292.1	383.5
16 Jun	867	31.6	20.4	1274.3	456.0
1 Jul	489	31.6	20.2	1267.7	500.5
Mean	395	33.2	20.9	1308.6	609.1

units (r=0.9857). All the four weather parameters studied, *viz.*, maximum temperature, minimum temperature, cumulative heat units and total bright sunshine hours, whether positive or negative during mid-season growth stage had no significant influence on seed yield of soybean.

3.4. *Late season growth stage*

The mean maximum temperature during late season growth stage of soybean ranged from 30.3° to 35.1°C with a mean of 32.5°C whereas the minimum temperature ranged from 19.8° to 22.1°C with a mean of 21.2°C. The mean cumulative heat units and total bright sunshine hours during late season stage were 230.5 and 95.3, respectively.

The maximum temperature had positive correlation (r=0.9710) with heat units. Although the total bright sunshine hours during late season stage had positive correlation (r=0.8372) with seed yield individually, it could not contribute to seed yield in combination with other weather parameters. While the minimum temperatures prevailed during late season stage of crop growth positively contributed to the seed yield, the heat unit had negatively influenced the seed yield of soybean crop. The negative contribution of heat units to seed yield was mainly due to the maximum temperatures prevailed during the late season stage.

3.5. *Whole crop growth period*

The values mean maximum and minimum temperatures, cumulative heat units and total bright sunshine hours prevailed during the whole growth period of soybean crop were 33.2°C, 20.9°C, 1308.6 units and 609.1 hours, respectively.

The maximum temperature had positive correlation with the total bright sunshine hours (r=0.8890) while the minimum temperature with heat units (r=0.9074) during the whole growth period of soybean crop.

The regression coefficient values for maximum temperature (b= —293.36) and heat units (b= —13.64) showed their negative influence on seed yield whereas minimum temperature (b=651.51) and total bright sunshine hours (b=2.78) showed positive contribution towards the seed yield of soybean crop. The minimum temperature and total bright sunshine hours seem to favour the final seed yield of soybean.

The seed yield, maximum temperature, minimum temperature, heat units and total bright sunshine hours for different dates of sowing are furnished in Table 3.

The maximum temperature, the minimum temperature, cumulative heat units value and total bright sunshine hours with a range of 31.2° to 31.6°C, 20.4° to 20.9°C, 1274 to 1292 units and 383 to 456 hours prevailed during the whole cropping period favoured the seed yield of soybean under tropical conditions. The increase in seed yield is attributed to the favourable weather factors mentioned above for higher flower production, seed size, number of pods per plant and this corraborates the findings of Whigham and Minor (1978).

4. Conclusion

The production potential of soybean crop can be increased when grown seasons having the maximum temperature of 31.2° to 31.6°C, minimum temperature of 20.4° to 20.9°C, cumulative heat unit values of 1274 to 1292 and total bright sunshine hours of 383 to 456 for the whole cropping period. Thus soybean crop can be successfully grown wherever the above climatic condition prevails under tropical condition.

References

All India Coordinated Research Project on soybean, Annual Report 1982-83, School of Genetics, Tamil Nadu Agricultural University, Coimbatore.

Beard, B.H. and Knowles, P.F. (eds.), 1973, *Soybean Research in California*, Calif. Agr. Exp. Sta. Bull., 862.

Brown, D.M., 1960, 'Soybean ecology I. Development temperature relationships from controlled environment studies', *Agron. J.*, **52**, 493-496.

Doorenbos, J. and Pruit, W.O., 1977, Crop Water requirements, FAO Irrigation and Drainage paper 24, FAO, Rome, pp. 21-63.

Major, D.J., Johnson, D.R. and Luedders, V.D., 1975, 'Evaluation of eleven thermal unit methods for predicting soybean development', *Crop Sci.*, **15**, 172-174.

Whigham, D.K. and Minor, H.C., 1978, Agronomic characteristics and environmental stress, In A.G. Normal (ed.) Soybean Physiology, Agronomy and Utilization, Academic Press, Inc., New York, pp. 77-118.