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EFFECT OF SOIL TEMPERATURE ON SORGHUM EMERGENCE*

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ABSTRACT

Soil temperature strongly influences both percentage germination and time of emergence of sorghum. Ten hybrids were hand planted in the field. Soil surface was irrigated frequently and emerging plants were counted daily. On three treatments, soil temperature was monitored every hour at five depths. Treatments were designed to achieve a range in surface soil temperature. Results of the study indicated an optimum germination temperature of about 23°C and a heat requirement of 67 degree days. The maturity classifications of the hybrids did not show a consistent trend in their heat requirement for emergence.

One of the most variable properties of the soil is its surface temperature. Hide [2] reported daily fluctuations of 31C at Manhattan Kansas. Depending on the transmitting properties of soil and atmosphere, daily fluctuations in surface temperature are lessened in amplitude and increased in phase lag as heat is transmitted deeper in the soil profile [4].

Haberlandt (cited by Bierhuizen [1]) reported cardinal temperatures for the seed germination for many plants. Each plant has a minimum and a maximum temperature at which no seeds will germinate and an optimum temperature at which germination will be greatest. Cardinal temperatures, however, are only approximations because of external conditions, exposure time, and treatment history. Results of germination studies, made at constant temperatures, do not necessarily reflect field germination where

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soil temperature at seed depth may fluctuate widely during the day.

We report the effect of diurnal temperature fluctuations on the emergence of 10 sorghum hybrids.

METHODS AND MATERIALS

The test area was an alluvial silty clay loam approximately 14 km south of Manhattan, Kansas. One hundred seeds of each of 10 sorghum hybrids, chosen for number of days to reach bloom (Table 1), were hand planted at a depth of 2.5 cm about 1.3 cm apart. Each day after the planting, we counted the number of emerging plants. Because soil moisture and surface crusting can significantly affect germination and emergence, we frequently sprinkled the area with water using a perforated lawn hose, providing a very fine mist.

To obtain three thermal regimes, the soil surface was covered with a clear polyethylene (3 mils thick) in one treatment; with a white clay * in another; and was left bare in another. In the experiment, designed as split-plot, each thermal treatment was replicated three times. In each treatment, thermocouples were placed in the soil to measure temperatures at 0 to 2.5-cm, 10-cm, 15-cm, 30-cm, and 60-cm depths. The temperature at the 60-cm depth was the reference for all other depths and reference temperature of the 60-cm depth was an ice-point reference ($\pm$ .01°C). Readings were monitored with a data acquisition system every hour and printed out on a teletype and punched on paper tape.

Plantings were on three dates, to provide a wide temperature range. On May 10, 1973, and May 24, 1973, all three treatments (bare, white clay, and polyethylene) were used; on the third planting (June 7, 1973) only the polyethylene treatment was used.

RESULTS AND DISCUSSION

Figure 1 shows the diurnal trends in soil temperature at various depths during the first planting. As anticipated, the polyethylene-covered plot was the warmest and the white clay (reflectant) was the coolest. Clear polyethylene trasmitted much of the solar radiation and the thermal radiative exchange between the soil and atmosphere was reduced by the droplets of water that condense on the soil side of the polyethylene film. The film reduced the convective and latent heat transfer; therefore, temperatures increased under the film. White clay is highly reflective (albedo = 65 per cent; it reduced the heat load on the soil surface. Figure 2 shows typical

* Peerless kaolin. R. T. Vanderbilt Co., Inc., 230 Park Avenue, New York 10017.

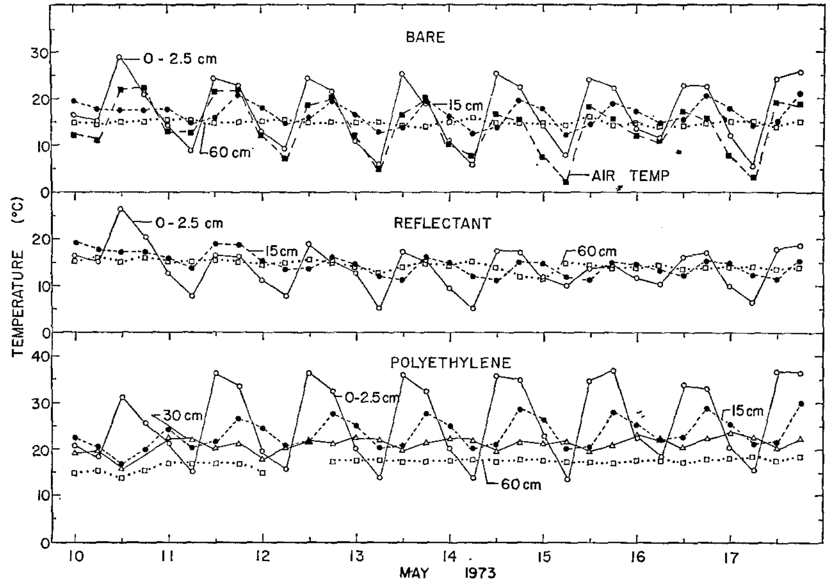

Fig. 1. Trends in temperatures during the first planting.

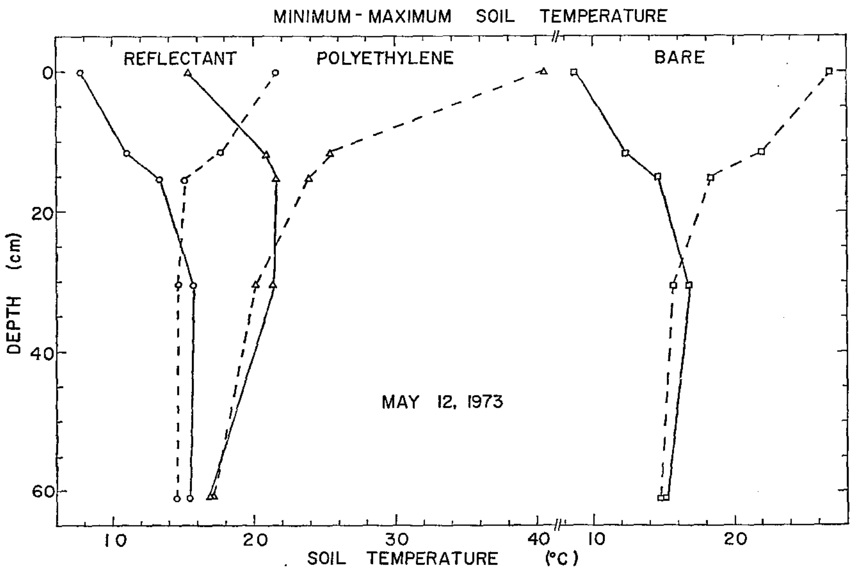

Fig. 2. Tautochrones of maximum and minimum surface soil temperature for the three treatments.

tautochrones of maximum and minimum surface-soil temperatures for each treatment. Compared with the bare soil, the polyethylene treatment produced a 13°C higher maximum and a 4°C higher minimum surface temperature and the reflectant treatment had a 5°C maximum and a 0.5°C cooler minimum surface temperature.

Figure 3 shows the average percentage germination of the 10 hybrids as function of days after the first planting. Though percentage germination was nearly equal for the polyethylene and the bare treatments, time for maximum germination was 4 days shorter for the polyethylene. The average laboratory germination for all hybrids was 88 per cent (Table 1), but that for field planting was 75 per cent.

Soil temperature (ST) at 0-to-seed depth was averaged from planting to 50 per cent emergence. A curve fitted to the pooled data of percentage germination and ST for all three planting dates showed an optimum germination temperature of 23.3°C, which is slightly lower than the 25°C optimum germination temperature found in the laboratory by Sinh and Dhaliwal[3].

The heat unit (S) is assumed to be constant for a particular

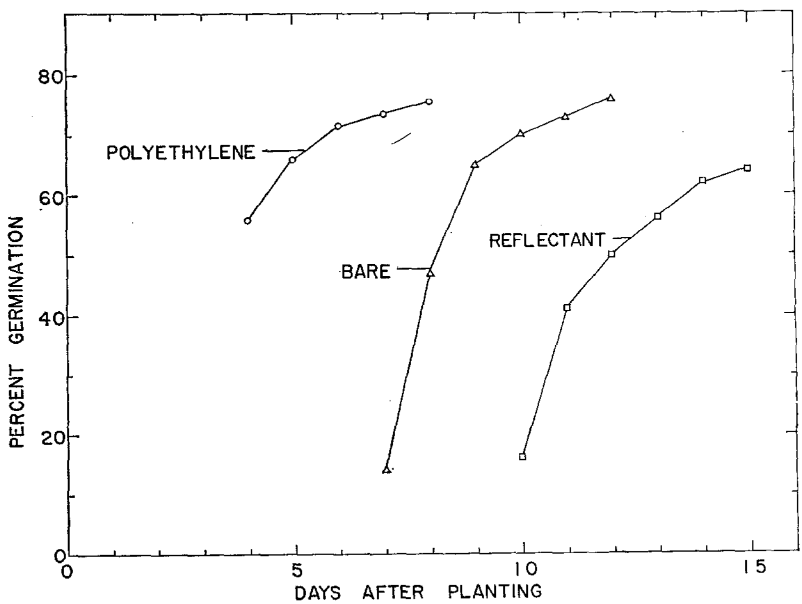

Fig. 3. Percentage germination as a function of days after the first planting.

TABLE 1

Ten sorghum hybrids laboratory germination percentages and maturity classification*

Maturity group	Lab. germ. % **	Average days from planting to bloom at 6 test locations, 1971–72
Early		
(NB 505)***	92	63
(RS 506)	89	63
Medium early		
(DeKalb C-42a)	86	66
(RS 610)	88	66
Medium		
(RS 628)	92	69
(Pioneer 846)	84	70
Medium late		
(Asgrow Dorado)	86	73
(RS 671)	92	73
Late		
(T-E 77-A)	86	77
(RS 702)	87	79

* Mr. Ted Walters provided the seed and laboratory germination tests.
** Average from duplicate 50-seed samples germinated in petri dishes at 26.7 C in April 1973.
*** Brand and hybrid.

growth stage. A linear relationship between ST and the reciprocal value of number of days to emergence (t) provides a method of calculating S (the slope) and ST_{min} (intercept) from

$$ST = S/t + ST_{min}. \quad (1)$$

Figure 4 shows a typical plot of one maturity group (two hybrids). Table 2 shows the values of S, ST_{min}, and correlation coefficient for different maturity groups. There did not appear to be a trend in heat units or minimum emergence temperatures for the different maturity groups. The pooled data for all varieties gave S = 69.4 degree days. ST_{min} = 9.9°C and a correlation coefficient of 0.986.

Sorghum hybrids sampled from different maturity groups did

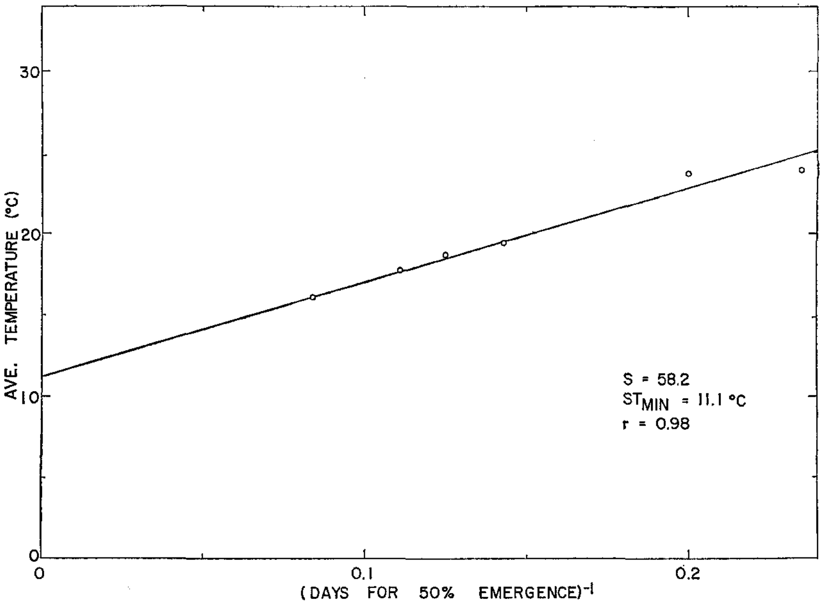

Fig. 4. Typical data for the calculation of the heat unit (S) minimum soil temperature (ST_{min}), and correlation coefficient (r).

TABLE 2

Heat unit (degree days), minimum emergence temperature, and correlation coefficient for sorghum maturity groups

Maturity group	S (degree day)	ST_{min} (C)	Correlation coefficient r
Early	66.3	10.3	.985
Medium early	58.2	11.1	.980
Medium	68.1	9.8	.991
Medium late	72.9	8.8	.996
Late	69.1	9.6	.993

not show a trend in their requirement for emergence. We found that for emergence, sorghum required a heat unit of about 64 degree days and an optimum soil temperature of about 23°C at seed depth. At the optimum soil temperature the percentage field emergence was 81 per cent, about 7 per cent lower than laboratory germination.

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