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OPTIMUM CROWN DEPTH SOIL TEMPERATURE FOR REPRODUCTIVE DEVELOPMENT OF FOUR WHEAT VARIETIES *

by D. E. SMIKA**

SUMMARY

Number of heads per plant and number of spikelets per head were highly correlated with soil temperature at the crown depth and, when combined, explained 83% to 98% of the variation of these two reproductive components for the four varieties studied. Leaf area per tiller was not influenced by crown depth soil temperature and, therefore, not a factor in affecting the development of the number of heads per plant and the number of spikelets per head. Optimum crown depth soil temperature was near 13°C and 15°C for maximum development of heads per plant and spikelets per head, respectively for the winter varieties. Optimum crown depth soil temperature for maximum spikelet per head development was 12.5°C for Lee and 14.5°C for Crim. For maximum development of heads per plant of the spring varieties, optimum crown depth soil temperature was above 18°C and not obtained in this study. A soil temperature decrease of 1°C below optimum reduced reproductive development.

INTRODUCTION

Soil temperature is known to be an important factor influencing the growth and development of plants [4 5 7 8 9]. During the spring growth period of wheat, mulched field soil may be 6°C cooler than bare soil at the 2.5 cm depth which is the approximate depth of the crown of wheat plants [3 8]. However, research has shown that when mulch does not affect soil temperature the presence of mulch *per se* has no influence on the development of wheat plants. Surface mulch treatments in the field seldom influence soil temperature below 15 cm [8].

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Tiller number and head size originate in the crown of the plant[1 2]; therefore, temperature of soil in contact with the crown should have a more pronounced influence on the development of these two major yield components than soil temperature elsewhere in the root zone. Previous research has shown the influence of root zone soil temperature on tiller and head development [8 9], however optimum crown depth temperature was not considered in these investigations. The objective of the research reported herein was to relate known crown depth soil temperatures to the reproductive development of two winter wheats and two spring wheats to determine the optimum crown depth soil temperature for reproductive development.

METHODS

Wheat (*Triticum aestivum* L.) was grown to heading in water baths thermostatically controlled at temperatures of 7, 13, and 18°C in two greenhouse studies. Two winter varieties ('Wichita' and 'Lancer') and two spring varieties ('Crim' and 'Lee') were used in each study. Plants were grown in plastic-lined steel pots 22.9 cm deep with an inside diameter of 16.5 cm. The pots contained a silt loam soil to a depth of 20 cm that had a bulk density comparable to soil in the field. Each pot contained five plants of a specific variety equally spaced 2.5 cm from the edge of the pot. Each variety was grown with a surface straw mulch equivalent to 6725 kg/ha and without a mulch. Four replications of each residue treatment with each variety were grown at each soil temperature in both studies, except Lee was not grown at 13°C in one study.

Prior to placing the pots in constant temperature water baths the winter varieties were vernalized by growing the plants 54 days in a growth chamber with alternate 12-hour day and night temperatures of 9.5°C and 1.6°C, respectively. Spring wheat seeding was timed so that all varieties were at the same two-leaf growth stage on the same day for placement in the water baths. Before seeding each pot received uniform applications of $Ca(NO_3)_2$, KH_2PO_4, and K_2SO_4 equivalent to 112, 112, and 56 kg/ha of N, P, K, respectively. Water was added to the pots by weight, as needed to wet the total soil volume to near field capacity.

Plants were harvested when heads were completely emerged on three-fourths of all culms. Each plant was cut off at the soil surface and tillers per plant, heads per plant, and leaf area per culm (tiller) were determined. Individual plants were dried at 70°C and weight per head and spikelets per head were determined. Leaf area per tiller was measured with an air-flow planimeter.

Soil temperature was measured at the actual crown depth of the wheat plants and 10 cm below the soil surface with mercury in glass thermometers read daily at 9:00 AM and 3:30 PM. During the two studies actual crown depth soil temperatures of 7.6, 7.9, 8.7, 9.5, 13.4, 14.5, 14.9, 18.0, 18.2, and 18.4°C were obtained. At the 10 cm depth there was no difference between soil temperatures with or without mulch at the respective water bath temperatures. Average daily temperature of the air above the soil surface of all plants was 18°C during both studies. Day length gradually increased from 11 hours and 20 minutes at the time the plants were placed in the water baths to 13 hours and 10 minutes at the time the plants were harvested.

For statistical analysis the reproductive components from the four replications of each mulch treatment were averaged to produce a single value for each crown depth soil temperature per variety. Thus 10 values were obtained for each variety except Lee which had only eight. Using crown depth soil temperatures for each variety and their corresponding reproductive component measurements, correlation coefficients and regression lines for each reproductive component were calculated.

EXPERIMENTAL RESULTS

For the winter wheat varieties the number of tillers per plant, heads per plant, spikelets per head, and weight per head were all positively related to crown depth soil temperature, significant ($P = .05$), and curvilinear (Fig. 1). Leaf area per tiller of both

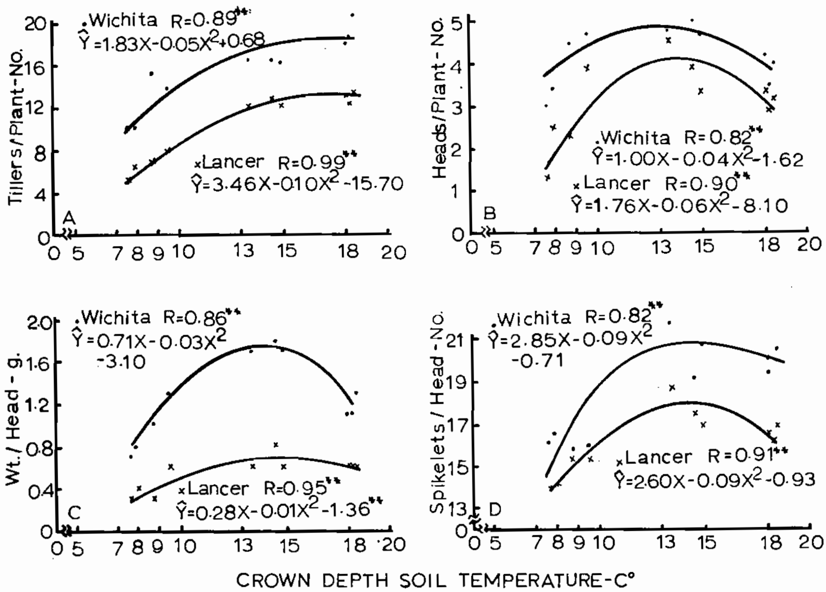

Fig. 1. Relation of reproductive components of two winter wheat varieties to soil temperature at the crown node depth.

TABLE 1

Leaf area (cm^2) per tiller at each crown depth soil temperature for each of the four wheat varieties

Soil temp. °C	Variety			
	Wichita	Lancer	Lee	Crim
7.9	40.9	36.7	32.7	31.2
7.9	41.9	35.3	32.0	27.1
8.7	40.9	36.7	34.6	29.3
9.5	43.1	36.8	31.2	29.9
13.4	42.3	36.2	32.0	30.0
14.5	40.0	36.7	32.7	30.0
14.9	42.3	37.8	31.8	31.1
18.0	39.8	35.8	32.4	31.0
18.2	42.9	35.7	31.8	26.3
18.4	39.0	36.1	34.3	31.2
Avg.	41.3	36.4	32.3	29.7

varieties was not significantly affected by crown depth soil temperature (Table 1). Tillers per plant of both Wichita and Lancer increased with increasing crown depth soil temperatures to approximately 15°C. Temperature increases above 15°C had little affect on tiller number per plant showing that 15°C was the optimum crown depth soil temperatures for both varieties (Fig. 1A). Seventy-one per cent of the differences in number of tillers per plant of Wichita and 98 per cent of the difference in number of tillers per plant of Lancer were explained by differences in crown depth soil temperature.

Number of heads per plant increased with increasing crown depth soil temperature up to 13°C for Wichita and up to 13.8°C for Lancer. Crown depth soil temperatures greater than 13.0 and 13.8°C for Wichita and Lancer, respectively decreased the number of heads per plant; therefore these crown depth soil temperatures were the optimum for development of the greatest number of heads per plant in these two winter wheat varieties (Fig. 1B). Accordingly, 67 per cent of the variation in number of heads per plant for Wichita and 81 per cent of the variation in number of heads per plant of Lancer was explained by the difference in crown depth soil temperature. Weight per head was similar to the pattern of head number per plant except optimum crown depth soil temperature for weight per head was 13.5°C for Wichita and 14.0°C for Lancer (Fig. 1C). The variation in head weight explained by soil temperature at the crown depth was 74 and 90 per cent for Wichita and Lancer, respectively.

Optimum crown depth soil temperature for spikelet number per head was 15.0°C for Wichita and 14.5°C for Lancer (Fig. 1D). Spikelet number per head decreased rapidly when crown depth soil temperature was other than optimum. Crown depth soil temperature difference explained 71 per cent of the variation in number of spikelets per head for Wichita and 83 per cent for Lancer. When soil temperature was correlated with the combined components of heads per plant and spikelets per head, soil temperature explained 83 per cent of the variation in the combined components of Wichita and 96 per cent with Lancer.

Spring wheat varieties reacted somewhat differently to crown depth soil temperature increases than did winter wheats (Fig. 2) but all relationships were positive. Relationship to crown depth soil temperature was curvilinear for spikelets per head and tillers per plant for both varieties and for weight per head for Crim. Heads

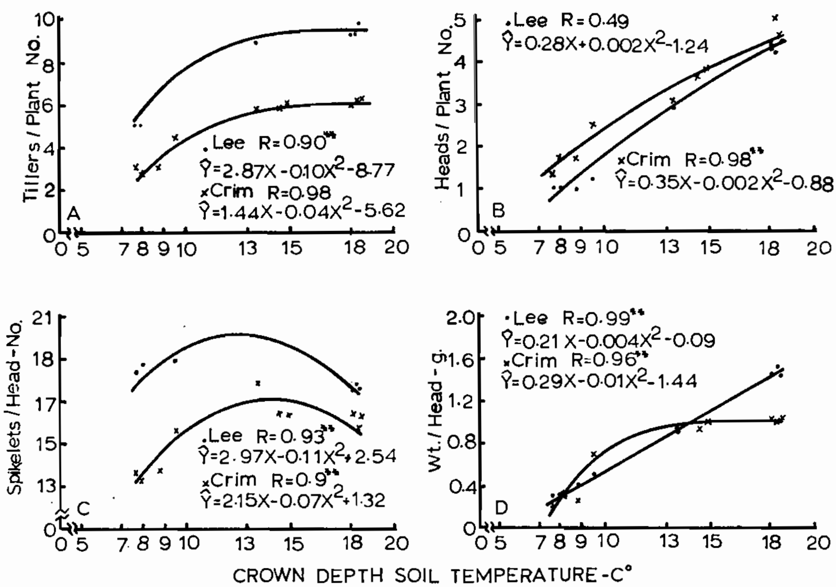

Fig. 2. Relation of reproductive components of two spring wheat varieties to soil temperature at the crown node depth.

per plant of both varieties and weight per head of Crim increased linearly with increasing crown depth soil temperatures (Fig. 2) but leaf area per tiller was not significantly influenced by crown depth soil temperature (Table 1). Tillers per plant of both Lee and Crim increased with each increase in crown depth soil temperature to 15°C and remained constant with temperature increases above 15°C (Fig. 2A). Therefore, optimum crown depth soil temperature was 15°C for both varieties. Crown depth soil temperature explained 81 per cent of the variation in number of tillers of Lee and 96 per cent for Crim. Number of heads per plant (Fig. 2B) of Crim and Lee had an average linear increase per degree of 0.3 and 0.4, respectively. The optimum crown depth soil temperature for head number per plant of these varieties was not obtained in these studies. Crown depth soil temperature explained 96 per cent of the variation in number of heads per plant for Crim and 98 per cent of the variation for Lee.

Optimum crown depth soil temperature for development of spikelets per head was 12.5°C for Lee and 14.5°C for Crim (Fig. 2C). This 2°C temperature difference was not explained in these studies but does point out the importance of variety selection to fit soil temperature conditions. Crown depth soil temperature explained 86 per cent of the difference in spikelets per head of Lee and 83 per cent for Crim.

Weight per head of Lee increased linearly an average of 0.12 g per degree between 7.8 and 18.4°C (Fig. 2D) with optimum crown depth soil temperature not obtained in these studies. For Crim, optimum crown depth soil temperatures for maximum weight per head was near 14.5°C (Fig. 2D). Crown depth soil temperature differences explained 98 per cent of the differences in weight per head for Lee and 92 per cent for Crim. By combining heads per plant and spikelets per head for correlation with crown depth soil temperature, 98 per cent of the variation in these two components for both varieties was associated with crown depth soil temperature.

DISCUSSION

Wheat yield reductions associated with mulched soil have been recorded and attributed to many factors [10]. However, previous work has shown that when mulched and bare soils have identical soil temperatures at the crown depth of the plant, mulch as such does not influence the reproductive development of wheat [8]. Mulch will influence soil temperature as shown in these studies, even where the pots were in controlled temperature water baths but with the soil surface exposed to ambient greenhouse temperatures. The number of heads per plant and the number of spikelets per head are the two most important reproductive components influencing final wheat grain yield. Soil temperature differences at the crown depth of the plant explained from 83 to 98 per cent of the difference in the development of these two reproduction components. Leaf area per tiller within each of the varieties studied was not influenced by crown depth soil temperature. Therefore each head and the spikelets per head of a particular variety had the same leaf manufacturing capacity regardless of crown depth soil temperature. Where air temperature has been reported to control the growth habit of wheat [6]; in these studies soil temperature at the crown depth of the plant was shown to have a major role in controlling the development of number of heads per plant and the number of spikelets per head. Information was not obtained in these studies to determine whether there is a simultaneous reduction in number of spikelets per head and heads per plant or which one occurs first when crown depth soil temperature is not optimum for their development. However, a reduction in spikelets per head and/or heads per plant would result in a grain yield reduction. If fertilizer had been limiting in this study, reductions in reproductive development might have been greater because fertilization has been shown to mitigate the adverse effects of soil temperature on plant growth and reproductive development [1 7].

Soil temperature differences of 1°C between bare and mulched soils have been recorded in the field in years when small yield reductions with mulch have been obtained. Larger differences in soil temperature between bare and mulch field soils have also been recorded in years when large yield reductions have been obtained [9]. Results from this study show that soil temperature differences at the crown depth of wheat plants directly influence reproductive development of the plants which, in turn, directly influence grain yields and can explain the yield reductions obtained with mulch in some years.

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