EFFECTS OF ASPHALT EMULSIONS AND VEGETATIVE MULCHES ON THE VIABILITY OF BERMUDAGRASS SPRIGS

By

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BERMUDAGRASS SPRIGS

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CHAPTER I

INTRODUCTION

It has long been a question as to when and how common bermudagrass (*Cynodon dactylon* (L.) Pers) can be planted in order that it will over-winter. At the present time, the Oklahoma Highway Department stops sprigging or stolonizing operations after the first of August; thus, roadbeds and adjacent slopes prepared after this date generally are allowed to deteriorate by wind and water erosion until these operations can be resumed the following spring. The only protection, if any, these areas receive is an asphalt-hay mixture blown on as a mulch. This mulch is frequently broken down by wind and water, and once more erosion is resumed. Frequently, after one winter these eroded areas have to be completely reworked before stabilization can proceed. This rennovation results in a great loss of time and expense.

The purpose of this study is to determine whether common bermudagrass plantings can successfully be made in the fall and winter through the use of protective asphalt emulsion coatings of sprigs and living vegetative mulches. If this can be achieved then the planting of bermudagrass sprigs can be extended over most of the year and erosion control on the highway can be greatly enhanced.

CHAPTER II

LITERATURE REVIEW

Proper stabilization of highway roadsides and slopes require some kind of a protective soil cover. The main requirements for roadside turf as reported by Jacobs et al. (9), is: rapid establishment to prevent undue erosion, self maintenance, and low growing habits to help ease the rising costs of mowing. This rapid establishment is helped through the use of protective mulches. Mulching helps to improve soil moisture, reduces runoff, and erosion, and will reduce the high daily temperatures and help retard the loss of heat at night. Common bermudagrass, Beavers et al. (6) concluded, has a relatively rapid covering ability and is well adapted to most central and southern areas, but it needs mulch and/or companion species to facilitate its speed of cover and retardation of erosion until it can take over.

There are many types of mulches being used today. Barnett et al. (3) found that whisker dams, which consist of two tons of grain straw per acre embedded or penetrated into the soil surface, provided adequate protection to newly prepared and seeded 2 1/2:1 backslopes when subjected to both 1-year frequency storms, i.e. 1.3 inches of rain in 30 minutes, and the 10-year frequency storms, of 2.7 inches of rain in 60 minutes. He also found that in all cases where AE-5 asphalt emulsion spray was used, the effectiveness of the mulch was decreased when tested by the 10-year frequency storm system. Wheat straw, sawdust, and Turfiber were used by Barkley et al. (2) whereby they moderated the soil temperatures of the seed zone thus improving the germination, emergence, and growth of grass seedlings. The wheat straw and Turfiber treatments appeared to conserve the soil moisture and retard erosion better than the sawdust. Sounders (14) had a situation where the straw mulch could not be used due to the lack of supply and the possibility of a fire hazard, as the road was through an undeveloped wooded area. Instead he used a mixture of equal parts, of AE-5 asphalt and water and achieved fair erosion control, but poor germination due to the unseasonably dry weather.

The loss of plant cover due to winter injury is very important, but also very complex according to Smith (13). Winter injury usually results from exposure to freezing temperatures, alternating temperatures, ice sheets, desiccation, or any combination of these. There appears to be two main theories of actual causes of winter injury in plants: the mechanical and desiccation injury theories. The mechanical injury theory, as explained by Levitt (10) results from the formation of extra cellular ice crystals which along with the contraction of the cell wall subject the protoplasm to stresses and strains resulting in injury. Also, he found that if a plant has a low protoplasm permeability to water, the internal water cannot diffuse from the cell sap to the external ice crystals with sufficient speed to increase the concentration of the cell sap, thus lowering the freezing point. Consequently, intracellular ice crystal formation results in complete destruction of the tissue. Meryman (12) found that injury can occur through dehydration when the external ice crystals withdraw moisture from the internal structure. The plants may survive if the duration of dehydration is not too long. With very low temperatures, the rate of dehydration remains approximately the same, but injury may now result from chemical denaturation.

Beard and Olien (4) and Beard (5) found similar results in which they divided low temperature injury into the equilibrium and non-equilibrium processes. The non-equilibrium process consists of intra-cellular ice crystal formation upon freezing. This explosive growth of ice crystals can cause mechanical disruption of the tissue of the proto-plasm and eventual death. The equilibrium process involves extracellu-lar ice formation in which living protoplasts may or may not be in-jurious. During this process, there is a redistribution of water from within the cells to the extracellular ice crystals because of their low vapor pressure. If this condition continues for a sufficient length of time, frost desiccation of the protoplasm may occur. Upon dehydration, the protoplasm becomes brittle and can be damaged when subjected to extreme tensions during the contraction caused by dehy-dration. In contrast, Levitt (10) showed that the cell sap concentra-tion is only a secondary factor; in that, while as the concentration is increased the actual cell sap freezing temperature drops, but the rate of dehydration remains the same.

It seems logical that partial winter hardiness could be due to difference in cutin thickness. Although this could be true in other species, Ahring and Irving (1) found that there was no apparent dif-ference in the cutin thickness between different varieties of bermuda-grass, even these varieties can withstand different lengths of exposure to freezing temperatures. They found that winter hardiness depended more upon the age of the rhizome rather than inherent conditions such as differential cutin layer thickness. Also, they showed that common bermudagrass could survive an indefinite exposure to temperatures of -22°C, but would not survive more than three days' exposure of -6.6°C, soil temperature. Carroll (7) stated that soil temperatures limited the survival of turfgrass species more than air temperatures.

CHAPTER III

METHODS AND MATERIALS

In August, 1968, an area free from bermudagrass was selected and a program for the evaluation of the winter hardiness of newly planted common bermudagrass sprigs was initiated. This area was located on the Oklahoma State University Agricultural Research Station at Stillwater.

The program was arranged as a 2^3x6 factorial having three replications. This made eight treatments and six planting dates, spaced at monthly intervals. The treatments consisted of AE-5 asphalt emulsion as a sprig covering, living vegetative mulches of German millet (Setaria italica (L.) Beauv.) and hard red winter wheat (Triticum aestivum (L.) em. Thell.) and water. The treatments, along with the planting dates, are listed in Table I. The individual plot size was 0.7 by 0.3 m (2 1/2 ft. by 1 ft.) with a 0.3 m (1 ft.) space between plots and a 1.52 m (5 ft.) space between plots having different planting dates.

The actual planting area in each plot consisted of a furrow 1.18 cm deep by 1.18 cm (3 in. by 3 in.) wide the entire length of the plot. After an initial application of 378.5 liters (100 gals) of water per 170.4 m (500 linear ft.) of row space in every plot, six sprigs, dug and cut just prior to planting, were placed evenly end to end in the furrow. The sprigs were separated by a small (1 in. by 6 in.) stake at each end, to enhance the rating of the individual sprigs. The total

TABLE I

TREATMENTS, PLANTING DATE, PLANTING SEASON, AND NITROGEN CONTENT OF THE BERMUDAGRASS SPRIGS AT PLANTING TIME

Treatments			Planting Date	Planting Season	Percent Nitrogen
No Asphalt	Mulch	Water	Aug. 27, 1968	Summer	1.50
No Asphalt	Mulch	No Water	Sept. 10, 1968	Fall	1.50
Asphalt	Mulch	Water	Oct. 15, 1968	Fall	1.54
Asphalt	Mulch	No Water	Dec. 11, 1968	Winter	1.44
No Asphalt	No Mulch	Water	Jan. 23, 1969	Winter	1.59
No Asphalt	No Mulch	No Water	Mar. 19, 1969	Winter	1.56
Asphalt	No Mulch	Water			
Asphalt	No Mulch	No Water			

length of the individual sprig was not critical; the only requirement being that each sprig contain three nodes. After the sprigs were in place, the asphalt was applied at 3264.7 liters/ha (345 gals/acre) to the respective plots. The furrows were then covered. The August planting was overseeded with German millet at 33.6 kg/ha (30 lbs/acre), while hard red winter wheat at 134.5 kg/ha (120 lbs/acre) was used on all other dates.

The water portion of the treatments was for supplemental purposes throughout the study in order to insure that the available soil moisture would not fall below the permanent wilting point. Prior to the actual field planting, three soil samples were taken and placed in a greenhouse where the moisture content of the soil at the permanent wilting point was determined through the use of hard red winter wheat. The method for the determination of the permanent wilting point and the percent available moisture appear in Appendix Table III. Once these factors were determined, soil samples could be taken throughout the duration of the study and by weighing, drying, and reweighing to determine the percent available moisture, the plots could be kept above the wilting point by the addition of supplemental water.

The treatments were evaluated periodically throughout the program as to the number of nodes per sprig which initiated growth with the final ratings being made on May 6 and 28, 1969.

In August, 1969, another study was started to determine the ability of bermudagrass sprigs treated with different concentrations of asphalt to withstand cold temperatures. This study was made possible through the use of a controlled environment chamber.

The program was arranged as a split plot design with the three temperatures being the main plot. The subplots consisted of six sprigs for each of the 30 treatment-exposure temperatures used. The treatments, exposure periods, and temperatures are listed in Table II.

TABLE II

THE TREATMENTS, EXPOSURE PERIODS, AND TEMPERATURES USED TO EVALUATE THE COLD HARDINESS OF BERMUDAGRASS SPRIGS IN THE LABORATORY

Treatment Number	Treatments		Number of Days of Exposure	Temperatures	
	Parts Asphalt	Parts Water		F°	C°
1	0	0	0	20	-6.67
2	1	0	1	30	-1.11
3	1	1	2	40	4.44
4	1	2	3		
5	1	3	4		
6	1	4	5		

Since only one cold chamber was used, only one temperature range could be run at a time. The sprigs were dug and cut just prior to each day's treatment. Again as in first study, the total length of the sprig was disregarded, with the only requirement being that each one contain three nodes. After the sprigs were cut and labeled, they were treated (respectively) by dipping them into an asphalt and water mixture, then wrapping them in one layer of aluminum foil and then they were placed in the cold chamber. The sprigs requiring the longest exposure period were treated the first day, followed by the others in their respective order with the shortest exposure time going in the last day. At the end of five days, the sprigs were removed, unwrapped and placed in the germinator at 30°C under constant light. At this time, the check treatment, of zero days' exposure, was treated and placed in the germinator with the other treatments. The sprigs were evaluated as to the number of nodes which sprouted at the end of 5, 7, and 14 days.

CHAPTER IV

RESULTS AND DISCUSSION

The statistical analyses of both the field and the cold chamber studies show only significant difference between the asphalt and no-asphalt treated sprigs. The results of the winter planting season and treatments interaction in the field study are shown in Figures 1, 2, 3, and 4.

The summer and first fall plantings, August and September, respectfully, sprouted and grew well with all treatments. The untreated sprigs sprouted best. The asphalt treated sprigs did not sprout as well due perhaps to the thick asphalt coating. Despite this good summer and fall growth, the majority of these plants did not overwinter. Within these two planting dates, a total of only one sprout from each of the four nodes out of a possible 432 overwintered, with all four being in the August planting period. Of these sprigs, none were treated with asphalt. The actual number of nodes which survived from each planting are presented in Figure 5.

The four plantings of bermudagrass made in October, December, January, and March, showed no sprouts until the following spring. Within these four plantings, sprouts from two nodes survived from October, two from December, 125 from January and 114 from March. Again as in the first two dates, the sprigs which survived from the October and December plantings were not treated with asphalt. However, from

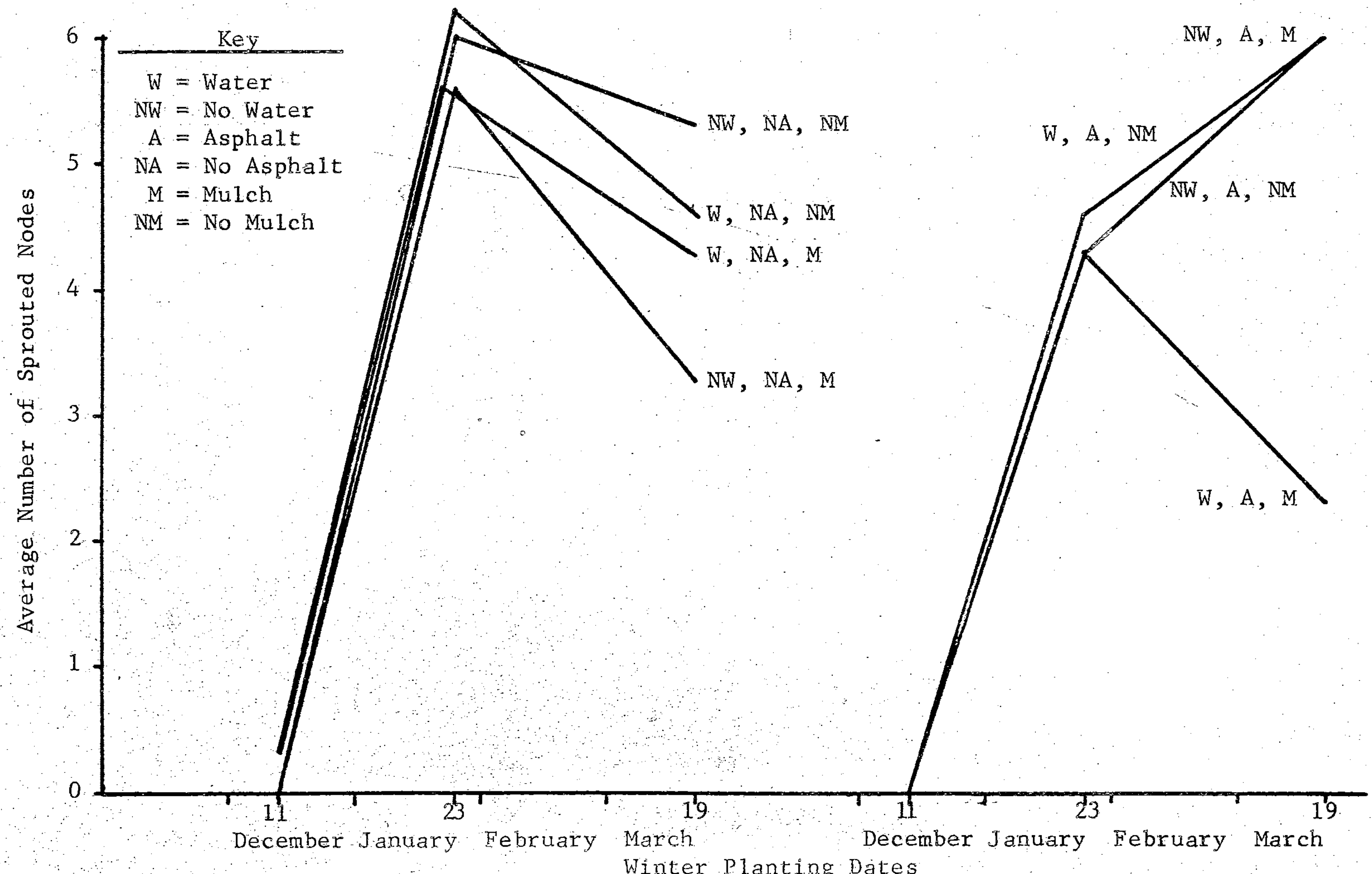

Figure 1. The Average Number of Sprouted Bermudagrass Nodes From the Winter Planting Dates and Treatments of Water, Asphalt, and Mulch

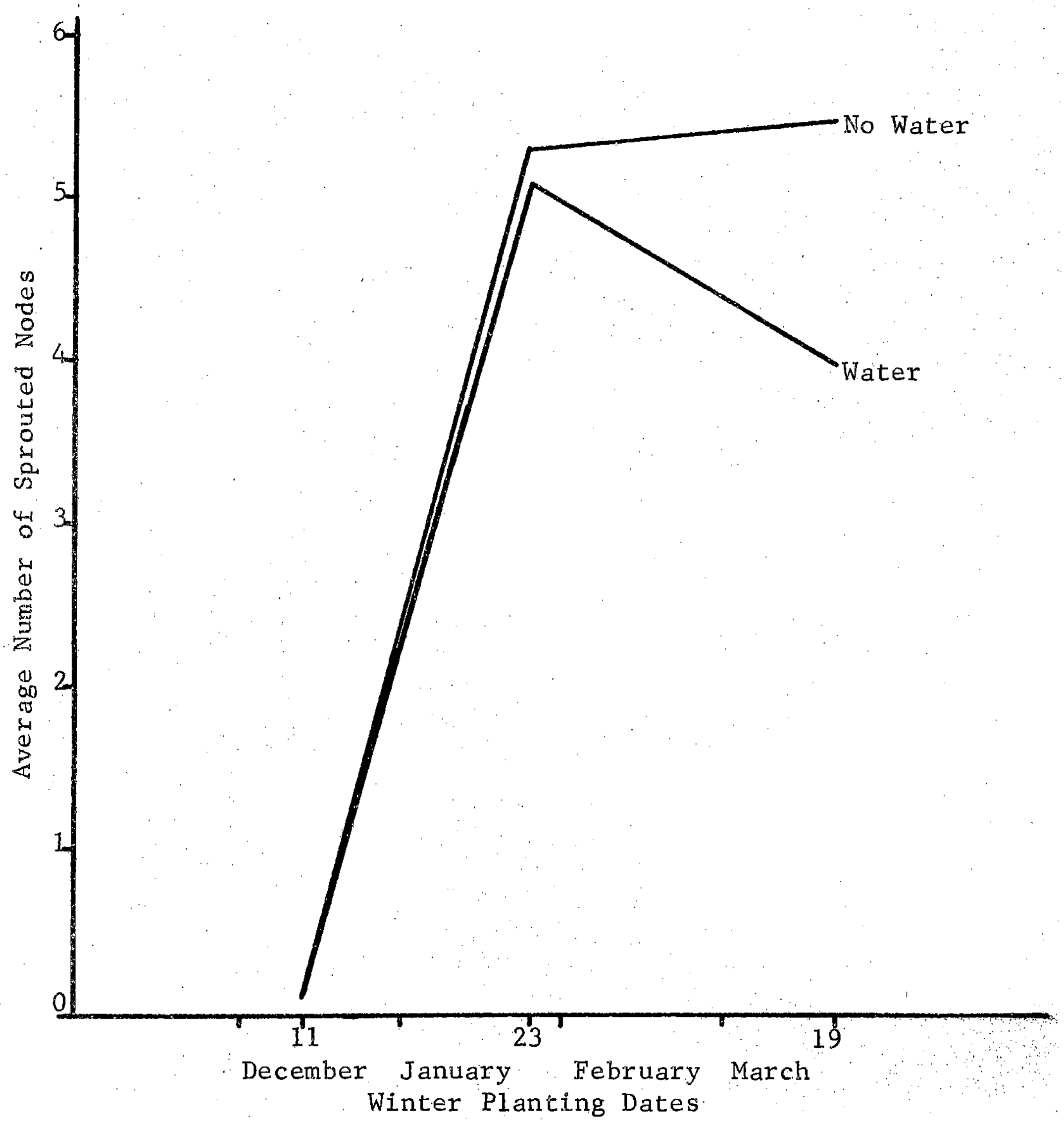

Figure 2. The Average Number of Sprouted Bermudagrass Nodes From the Winter Planting Dates and the Water Treatment

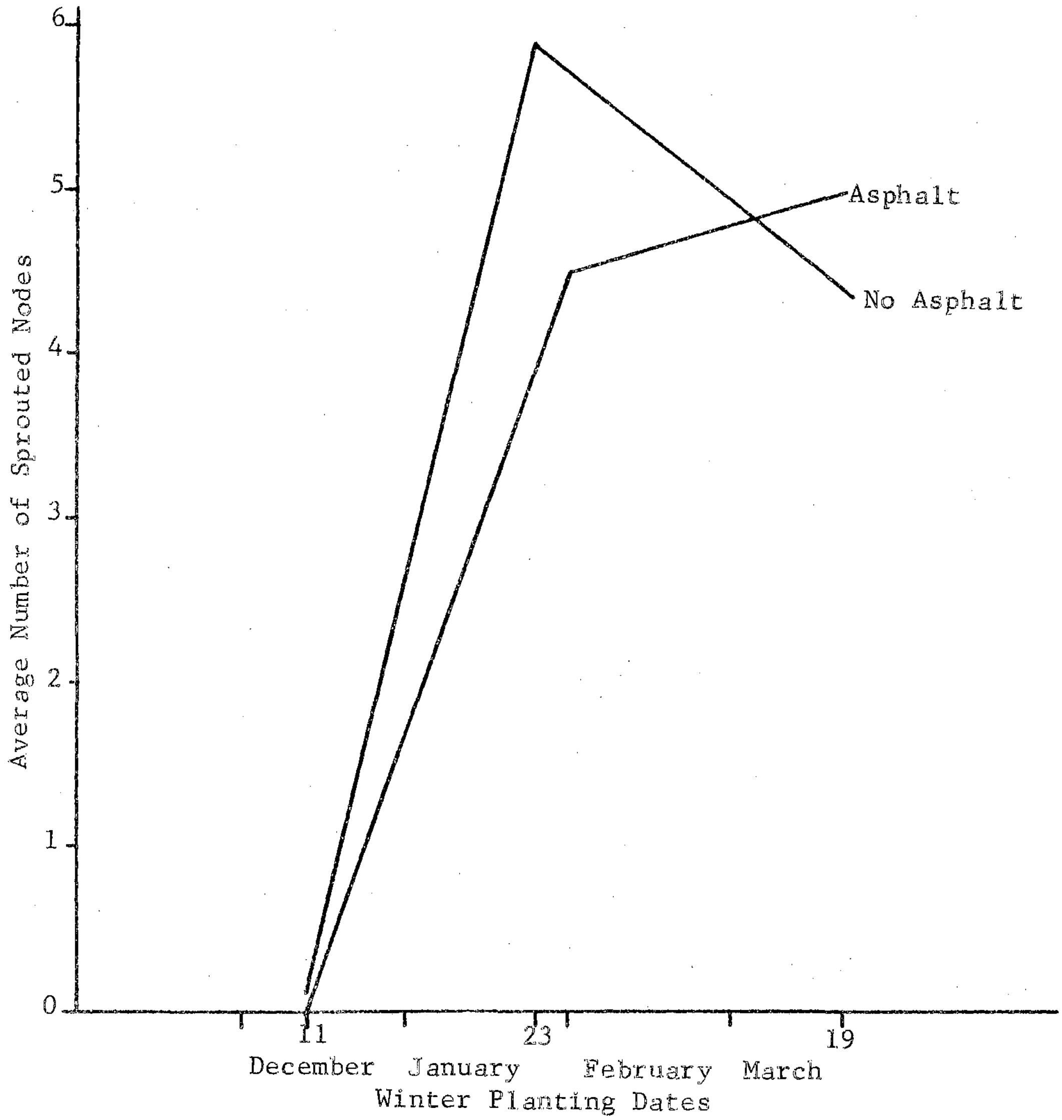

Figure 3. The Average Number of Sprouted Bermudagrass Nodes From the Winter Planting Dates and the Asphalt Treatment

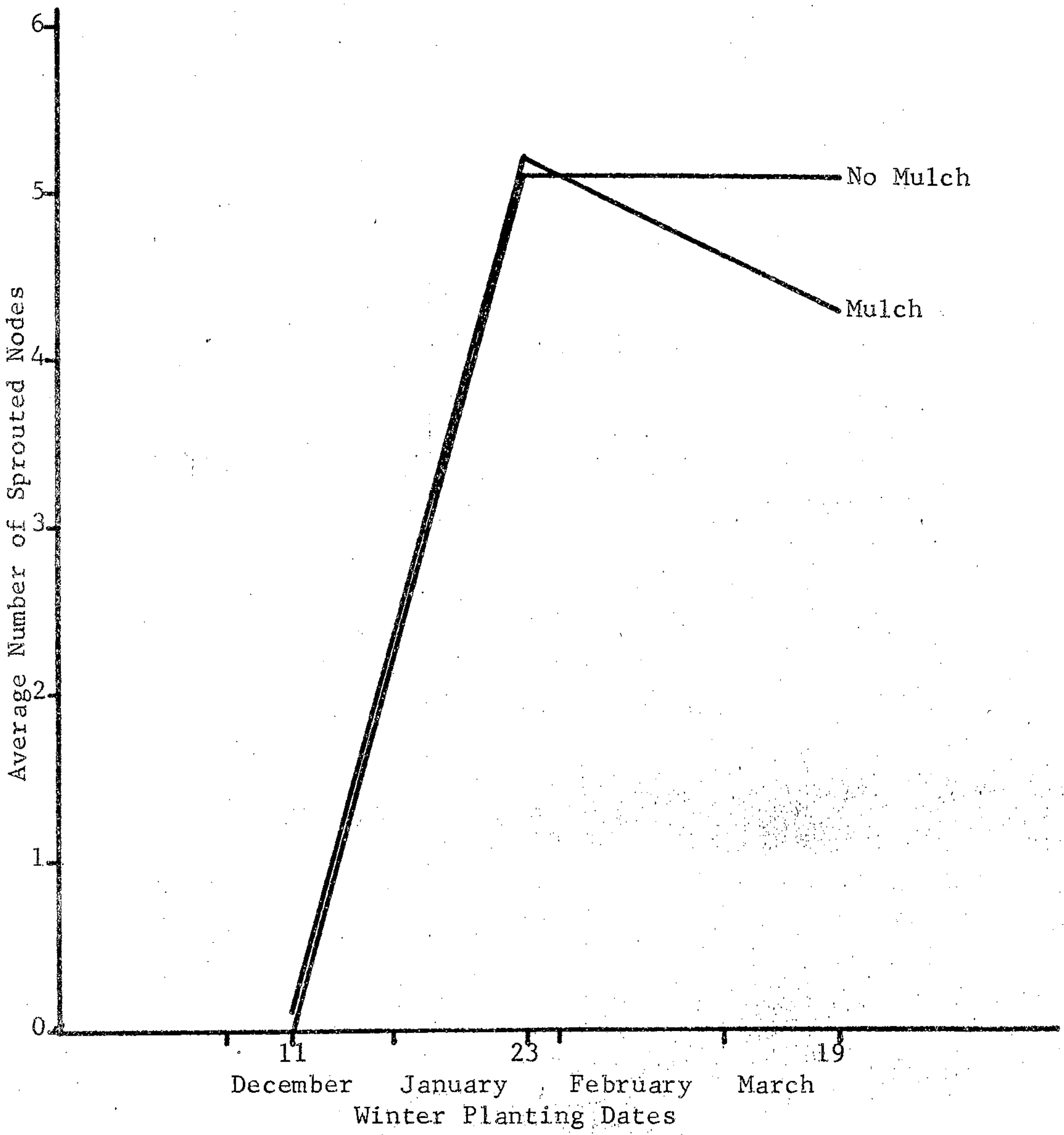

Figure 4. The Average Number of Sprouted Bermudagrass Nodes From the Winter Planting Dates and the Mulch Treatment

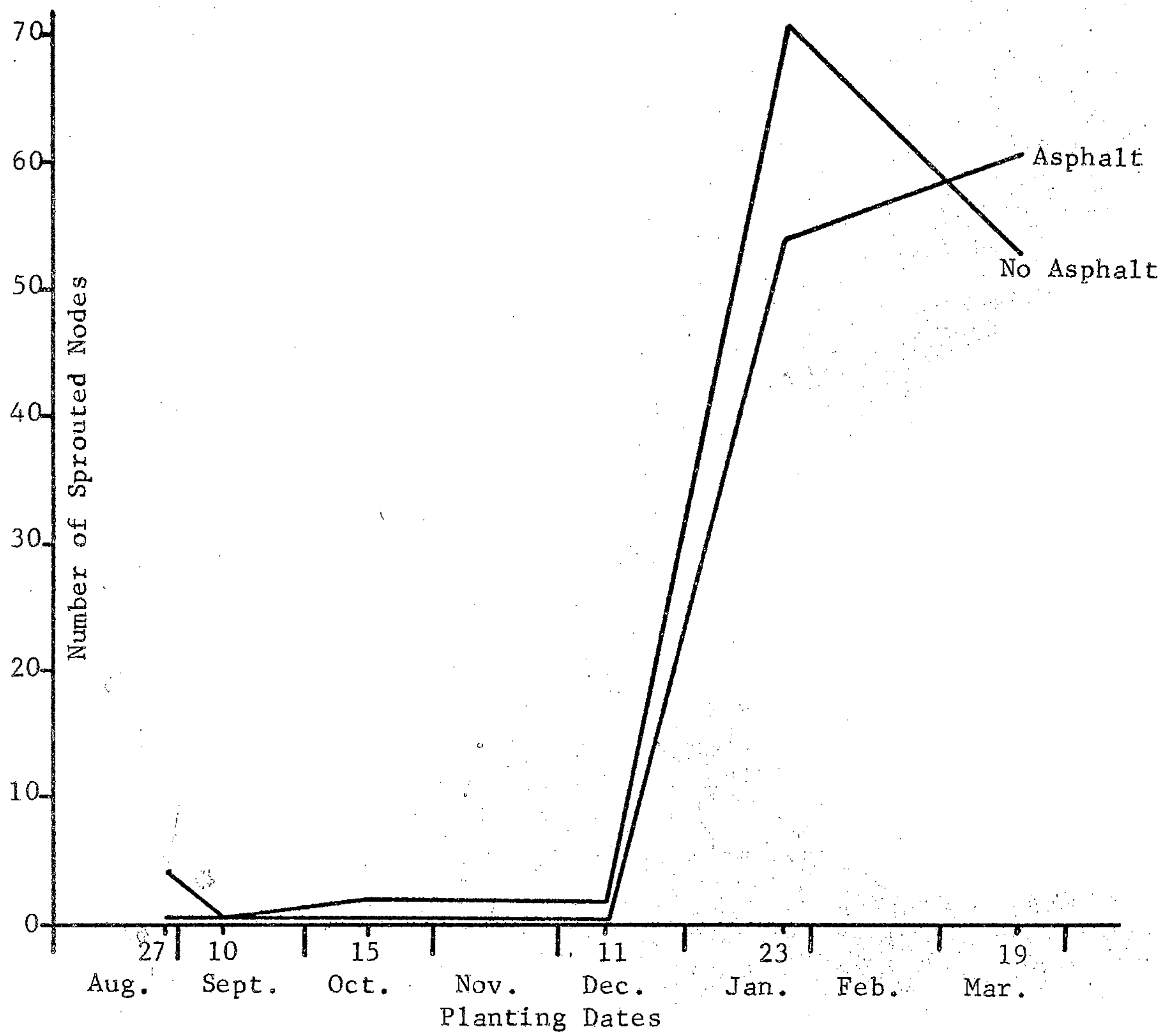

Figure 5. The Total Number of Common Bermudagrass Nodes Which Had Sprouted as of the May 28 Evaluation Date

the January planting 53 treated and 71 non-treated nodes survived whereas 60 treated and 54 non-treated nodes survived from the March planting.

After the October planting, the only treatment which could influence the results was the asphalt coating of the sprigs. Prior to and including the October planting date, the millet and wheat produced very adequate mulch covers; while after this date, the environmental conditions were such that the wheat did not germinate, thus the last four plantings had no vegetative mulch. Originally some plots in this study were designed to receive supplemental watering when necessary; however, the soil moisture was at such a high level throughout the entire program, that this was not necessary. Sprouts from the untreated bermudagrass sprigs withstood the cold temperatures from the January planting better than the treated ones as shown in Figures 1 and 3, while in the March planting the asphalt treated sprigs sprouted better than the untreated ones. This benefit in the March planting might be attributed to the asphalt coating that sealed the sprigs and helped to prevent internal moisture loss, thus keeping them from drying out. Upon freezing, as from the September to January plantings, this retention of internal moisture perhaps causes the cells to swell and burst, thus destroying the sprig. The untreated sprigs, however, apparently lost enough moisture that the freezing temperatures did not rupture the plant cells. Thus the untreated sprigs were able to endure the cold temperature of December, January, and February better than those that were treated. The asphaltic coating providing possibly additional moisture retention appeared to be of value during the March planting as the treated sprigs excelled in the number of sprouts over the untreated ones.

The results of the cold chamber study were very similar to the field study. The untreated and lower asphalt concentration treated sprigs survived the cold temperatures as well if not better than the asphalt treated sprigs as shown in Figures 6, 7, and 8. All of the sprigs exposed to the 4.44 (40°F) and -1.11 (30°F) °C temperatures survived equally well, as expected; while the viability of those exposed to the -6.67 (20°F) °C dropped very sharply from an average of 197 to 5 out of a possible 216 sprigs. This sharp drop in viability perhaps can be attributed to the same factor as in the field study in that the untreated sprigs partially dried out and survived while the treated ones ruptured internally and died upon excessive exposure to freezing temperatures.

The cold chamber study showed that bermudagrass sprigs, having all the treatments studied, can withstand at least five days of continuous exposure to -1.11°C and up to two days at -6.67°C. Appendix Table IV, compiled from Figures 9 through 16 shows the days on which the high and low air temperatures at Stillwater, Oklahoma, dropped below -1.11 and -6.67°C during the period from August 1, 1968, through March 31, 1969. Throughout this eight month period, the air temperatures dropped below -6.67°C more than one continuous day only once, December 30 through the 31st, and below -1.11°C only three times, January 3 through the 4th, January 23 through the 24th, and March 8 through the 9th. At no time during this eight month period did the temperature remain below -1.11 or -6.67° for more than two consecutive days. According to Fluker (8), the soil acts as a buffer to rapid changes in temperature, but at a soil

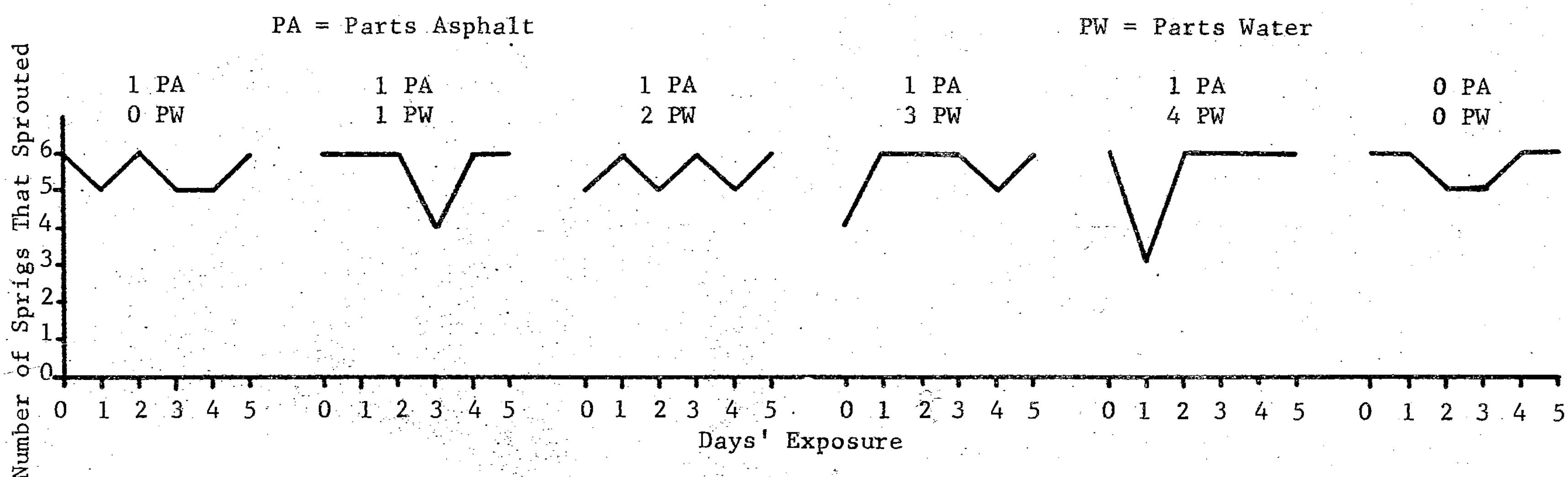

Figure 6. The Total Number of Bermudagrass Sprigs per Replication Which Sprouted Under the Various Asphalt Treatments and Days' Exposure to a Constant Temperature of 4.44°C (40°F)

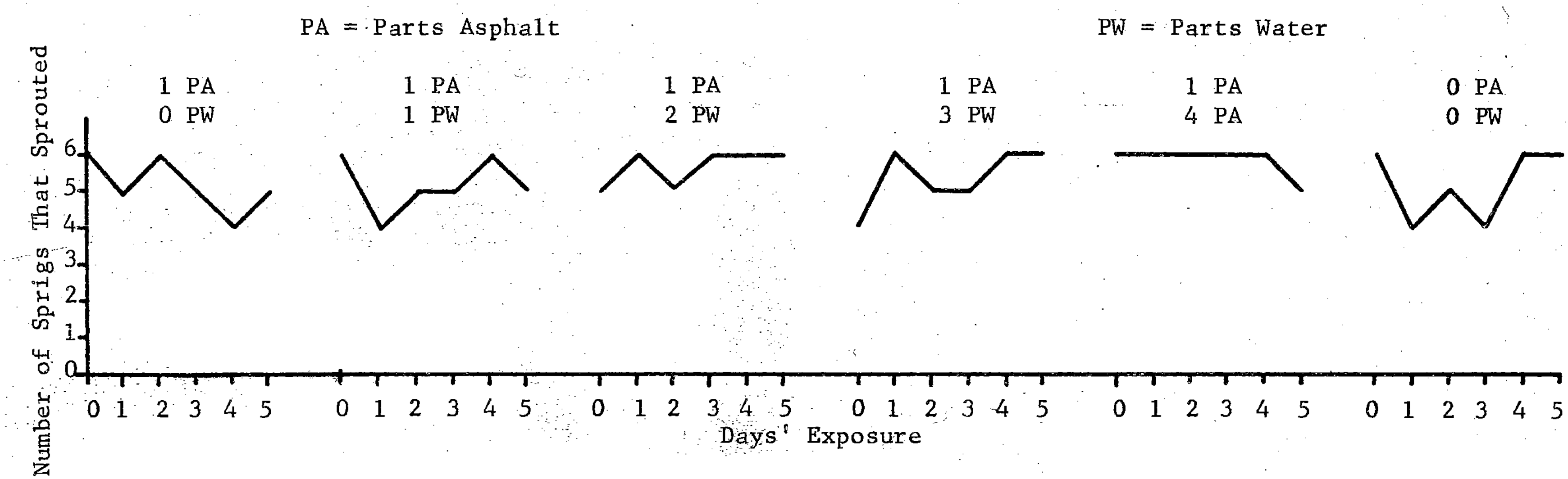

Figure 7. The Total Number of Bermudagrass Sprigs per Replication Which Sprouted Under the Various Asphalt Treatments and Days' Exposure to a Constant Temperature of -1.11°C (30°F)

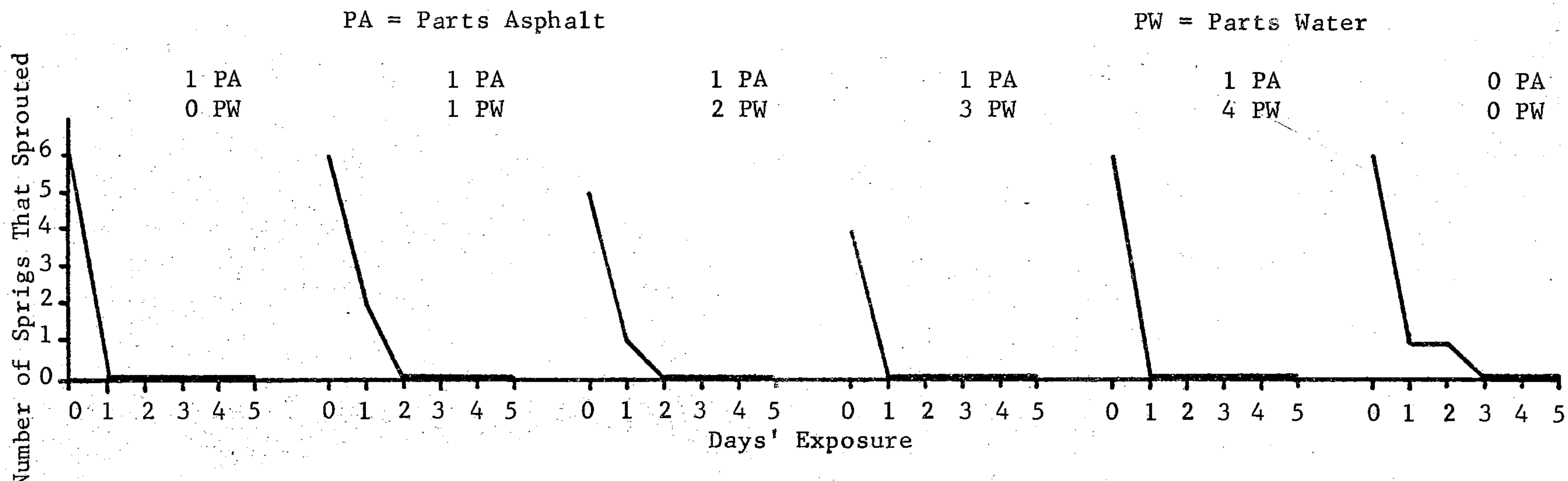

Figure 8. The Total Number of Bermudagrass Sprigs per Replication Which Sprouted Under the Various Asphalt Treatments and Days' Exposure to a Constant Temperature of -6.67°C (20°F)

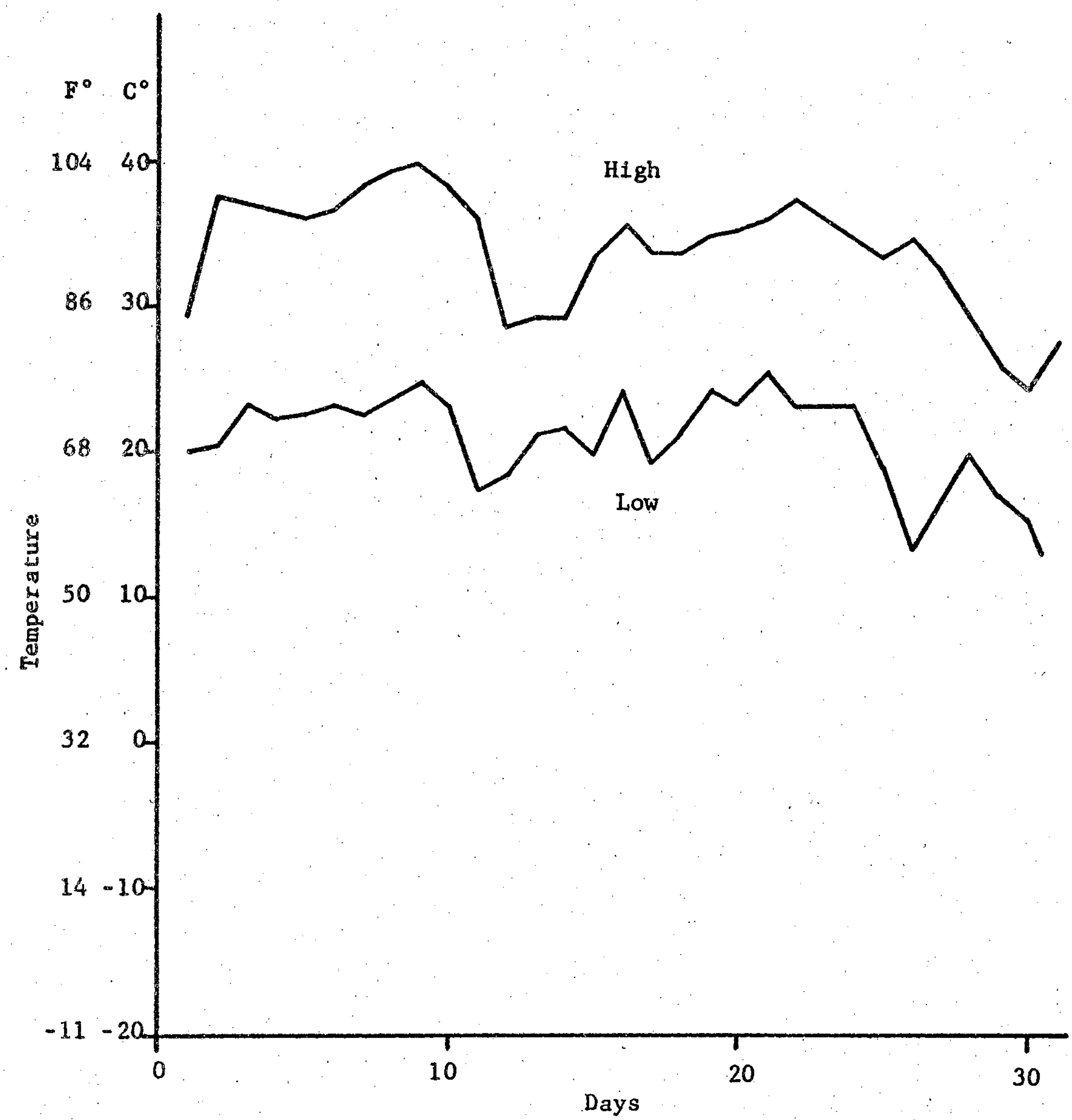

Figure 9. The Daily Maximum and Minimum Air Temperatures for the Month of August, 1968.

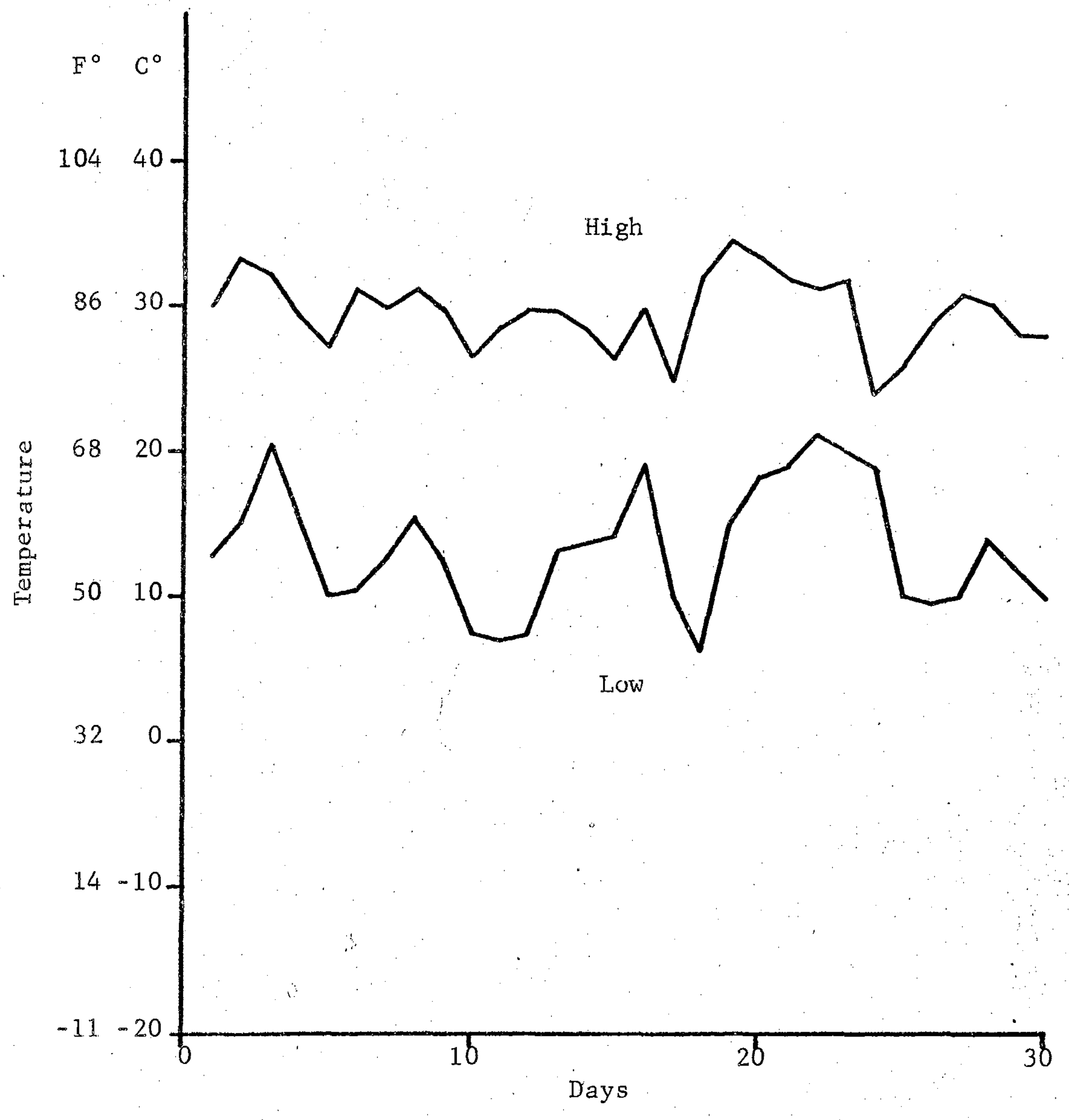

Figure 10. The Daily Maximum and Minimum Air Temperatures for the Month of September, 1968

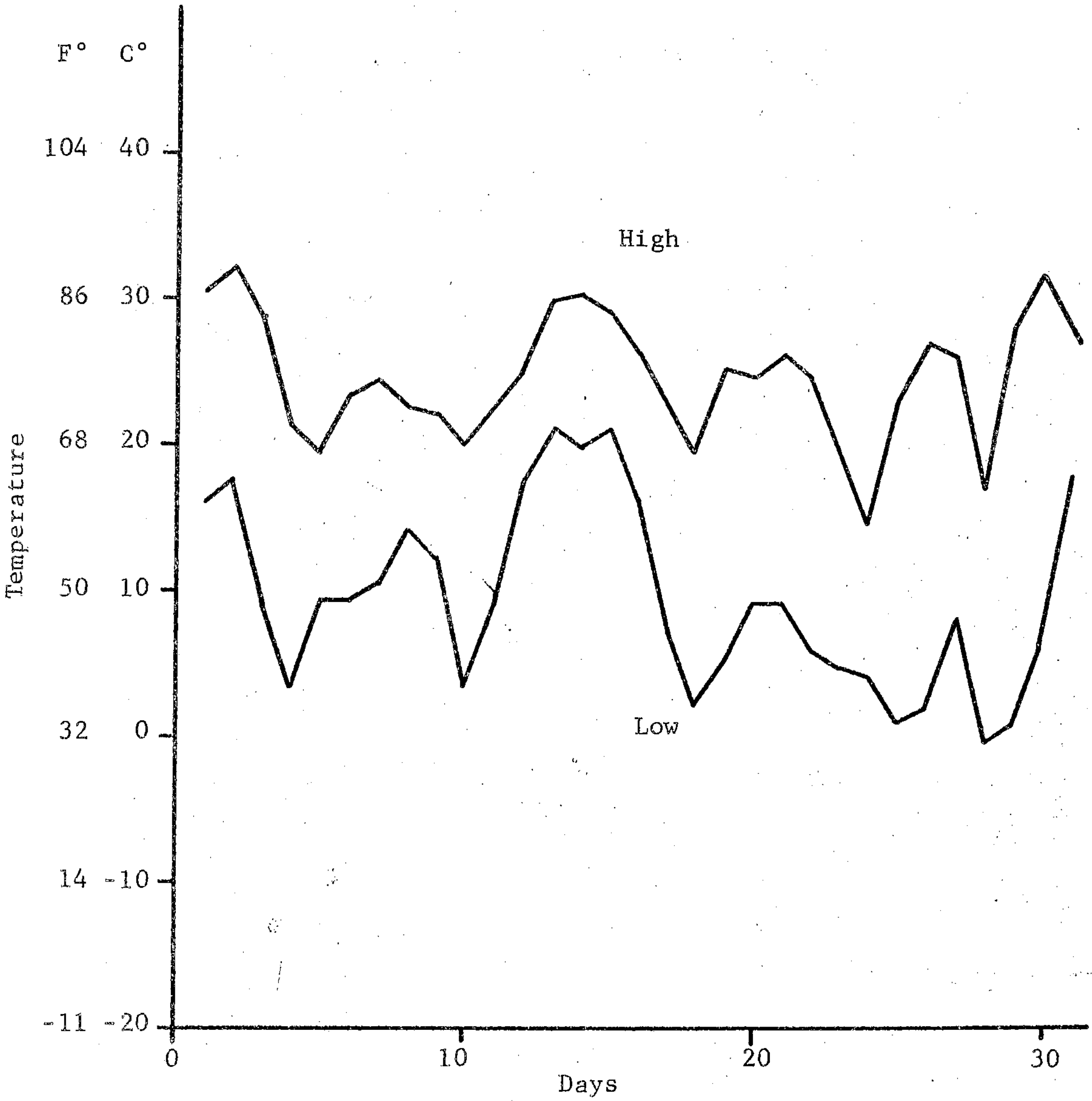

Figure 11. The Daily Maximum and Minimum Air Temperatures for the Month of October, 1968

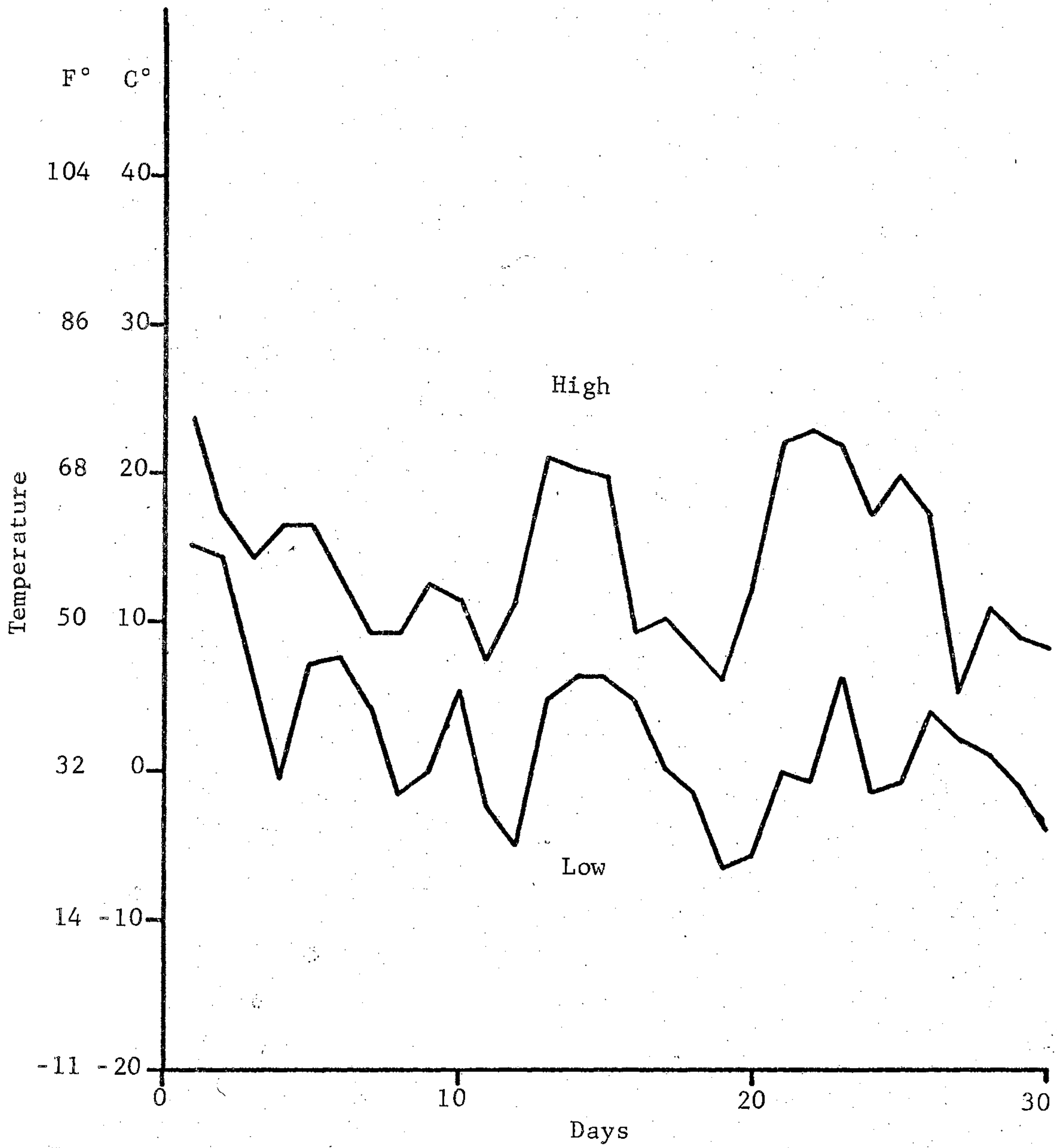

Figure 12. The Daily Maximum and Minimum Air Temperature for the Month of November, 1968

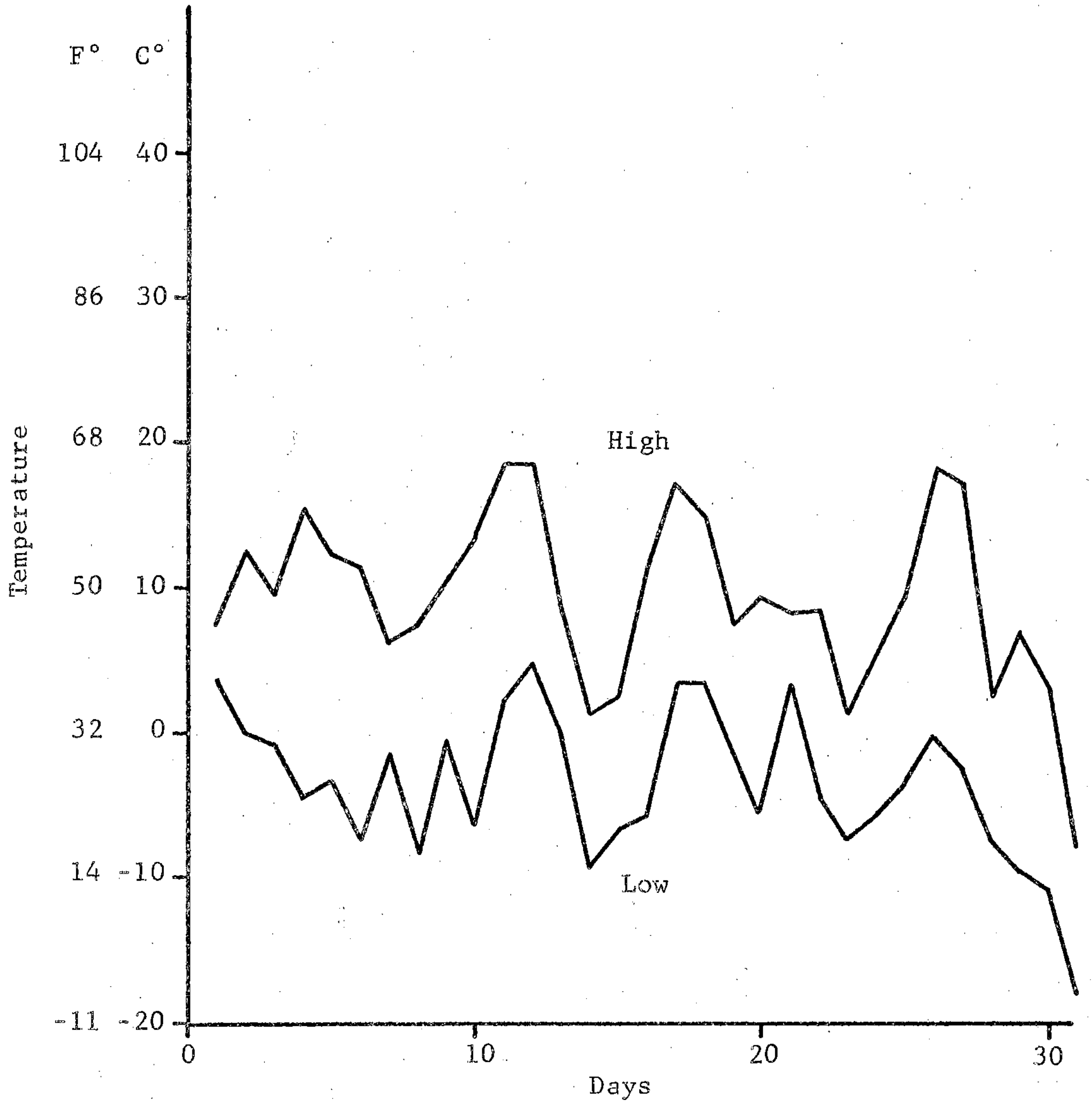

Figure 13. The Daily Maximum and Minimum Air Temperatures for the Month of December, 1968

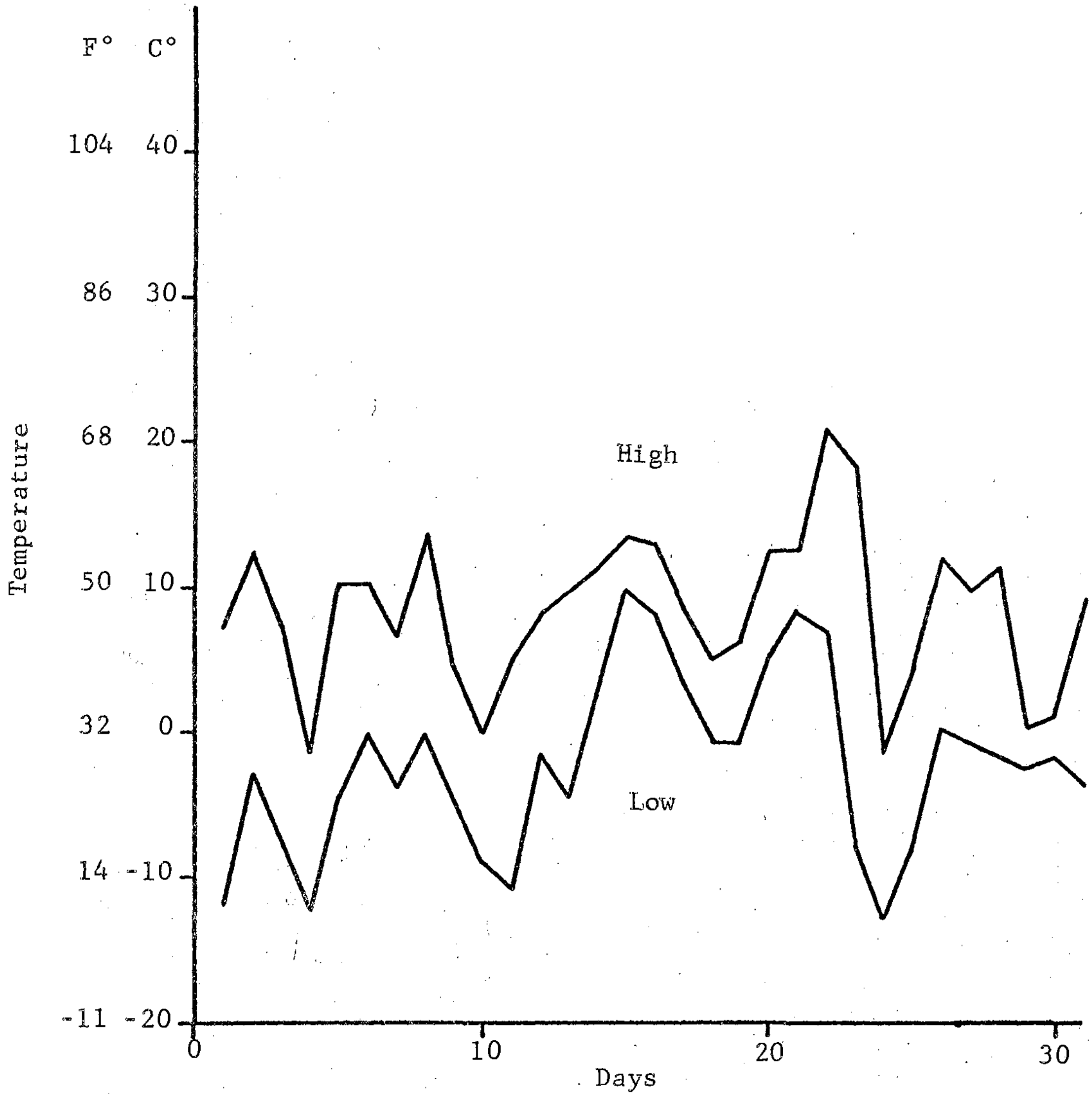

Figure 14. The Daily Maximum and Minimum Air Temperatures for the Month of January, 1969

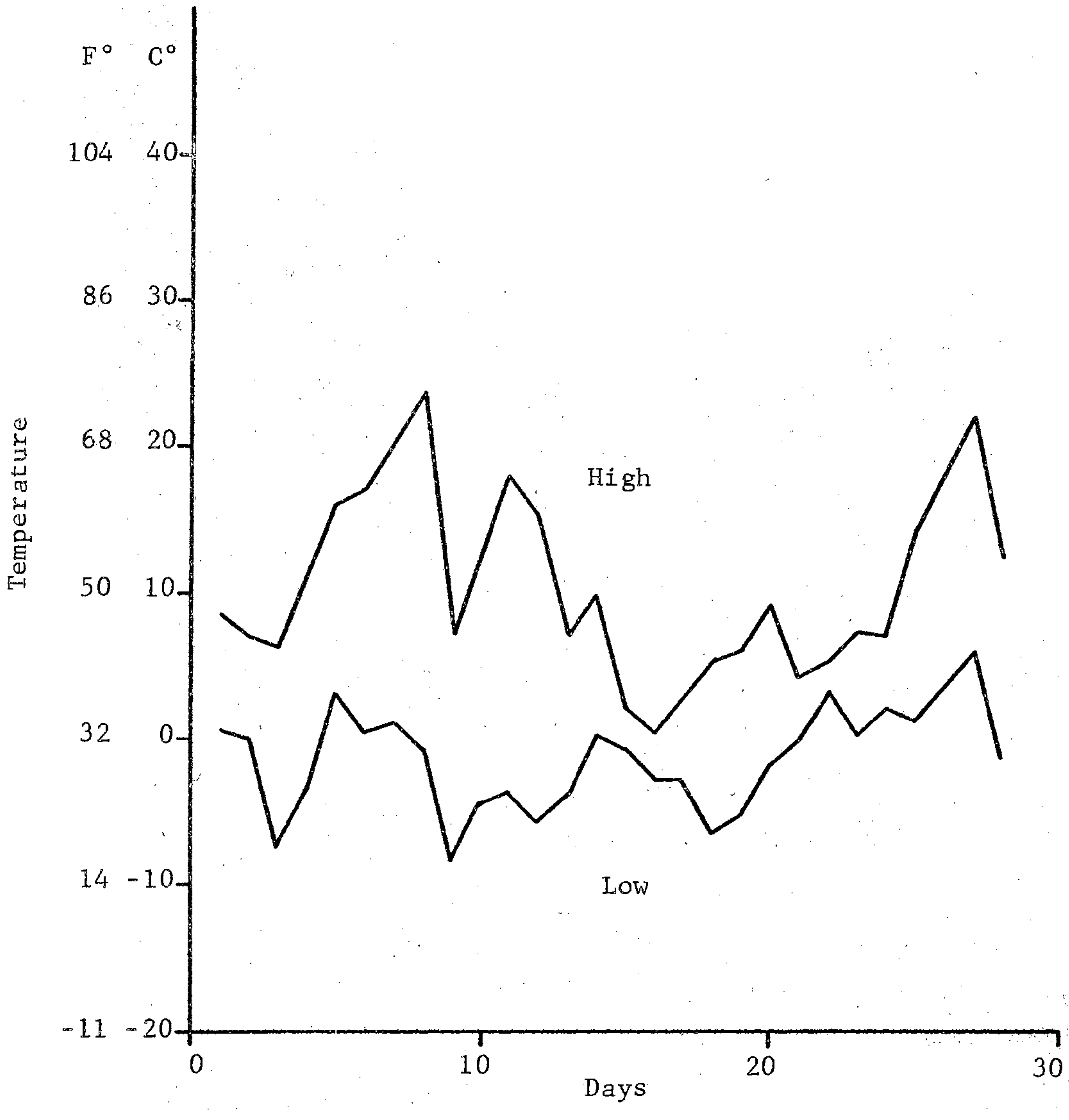

Figure 15. The Daily Maximum and Minimum Air Temperatures for the Month of February, 1969

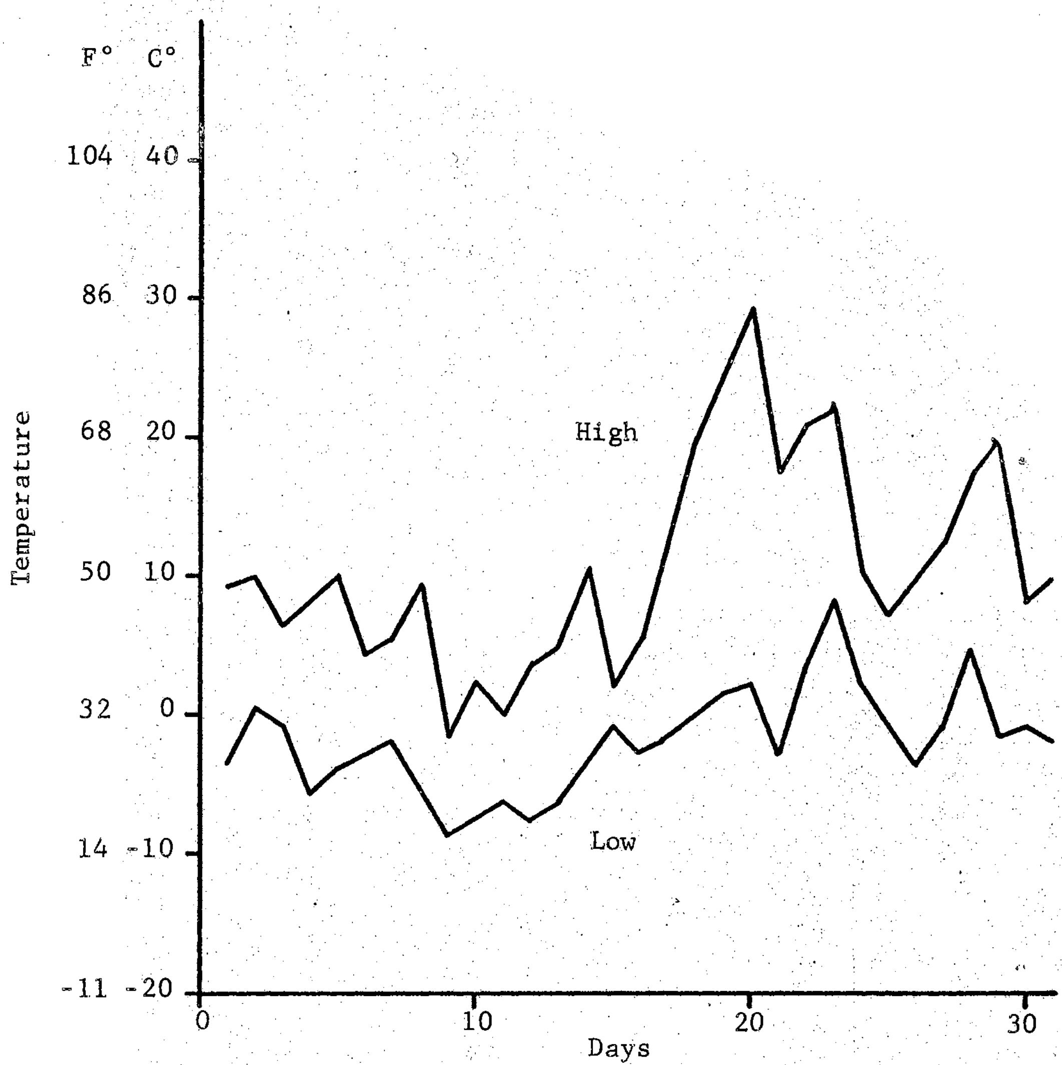

Figure 16. The Daily Maximum and Minimum Air Temperatures for the Month of March, 1969

depth of three inches or less the soil temperatures would be very close to the air temperatures listed. Prior to the January plantings the temperature fell to a level below that of -6.67°C. Based on the laboratory study this could have been enough to destroy all but the hardiest sprigs. After that date the temperature never fell below -1.1°C for more than two days. Since the January and March plantings were not exposed to the extreme cold temperatures as the previous plantings, therefore all treatments had fairly good germination and growth.

CHAPTER V

SUMMARY AND CONCLUSIONS

In August of 1968 a study of the winter hardiness of newly planted bermudagrass sprigs (Cynodon dactylon (L.) Pers) was initiated. The treatments consisted of all possible combinations of AE-5 asphalt emulsion, water, and living vegetative mulches of German millet (Setaria italica (L.) Beauv.) and wheat (Triticum aestivum (L.) em. Thell.). These experiments were started on monthly intervals beginning in August, 1968, and proceeding through March, 1969, with the exceptions of November and February. A similar study was started in the laboratory in August, 1969, to determine the actual cold temperatures which freshly harvested common bermudagrass sprigs could endure. The treatments of this study consisted of AE-5 asphalt emulsions diluted with different volumes of water, and different exposure periods to the constant temperatures of 20, 30, and 40°F.

The data and the statistical analyses from both studies indicate that common bermudagrass sprigs cannot endure more than two days' constant exposure to 20°F or below. The mulches used (German millet and wheat) and the sprig coating (AE-5 asphalt emulsion) did not enhance the cold hardiness of newly planted sprigs. Even though some of the untreated sprigs did sprout and grow, there was not enough to make it feasible to try to establish bermudagrass after August and prior to January with the mulching and sprig coating systems used in this study.

From these data it can be concluded the common bermudagrass sprigs can be successfully planted and established after January 1.

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APPENDIX

TABLE III

THE MATHEMATICAL PROCEDURE USED FOR DETERMINING THE PERCENT MOISTURE OF A SOIL SAMPLE FROM THE FIELD STUDY TO DETERMINE THE OVERWINTERING ABILITY OF NEWLY PLANTED SPRIGS

Formulas:

X/A = The percent available moisture

Y/B = The percent unavailable moisture

where:

X = available moisture, weight in grams

Y = unavailable moisture, weight in grams

A = weight of the soil sample at field capacity

B = weight of the soil sample at the permanent wilting point

When a soil sample is taken from the field, weighed, dried, and reweighed the percent soil moisture must be above 7.8 percent.

TABLE IV

THE DATES IN WHICH THE DAILY MAXIMUM AND MINIMUM TEMPERATURES FELL BELOW A -1.11°C (30°F) AT THE AGRONOMY RESEARCH STATION IN STILLWATER, OKLAHOMA

Day	November				December				January				February				March			
	High		Low		High		Low		High		Low		High		Low		High		Low	
	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F
1											-11.7	11.0							- 3.3	26.0
2											- 2.7	27.0								
3											- 7.2	19.0			- 7.2	19.0				
4							- 4.4	24.0	- 1.6	29.0	-12.2	10.0			- 3.3	26.0			- 5.5	22.0
5							- 3.3	26.0			- 4.4	24.0							- 3.8	25.0
6							- 7.2	19.0												
7							- 1.6	29.0			- 3.8	25.0							- 1.6	29.0
8			- 1.1	30.0			- 8.3	17.0											- 5.0	23.0
9											- 4.4	24.0			- 8.3	17.0	- 1.1	30.0	- 8.8	16.0
10							- 6.1	21.0			- 8.8	16.0			- 4.4	24.0			- 7.7	18.0
11			- 2.7	28.0							-10.6	13.0			- 3.8	25.0			- 6.1	21.0
12			- 5.0	23.0							- 1.1	30.0			- 5.6	22.0			- 7.7	18.0
13											- 4.4	24.0			- 3.8	25.0			- 6.1	21.0
14							- 9.4	15.0											- 3.3	26.0
15							- 6.6	20.0												
16							- 5.6	22.0							- 2.7	27.0			- 2.7	27.0
17															- 2.7	27.0			- 1.6	29.0
18															- 6.1	21.0				
19			- 6.1	21.0											- 5.0	23.0				
20			- 5.5	22.0			- 5.6	22.0							- 1.6	29.0				
21																			- 2.7	27.0
22							- 4.4	24.0												
23							- 7.2	19.0			- 7.7	18.0								
24			- 1.1	30.0			- 5.5	22.0	- 1.1	30.0	-12.8	9.0								
25							- 3.2	26.0			- 7.7	18.0								
26																				
27							- 2.2	28.0												
28							- 7.2	19.0			- 1.1	30.0			- 1.1	30.0				
29							- 9.4	15.0			- 2.2	28.0							- 1.1	30.0
30			- 3.8	25.0			-10.6	13.0			- 1.6	29.0								
31					- 7.7	18.0	-18.0	- 1.0			- 3.3	26.0							- 1.6	29.0

TABLE V

THE AVERAGE NUMBER OF SPROUTED NODES PER THREE REPLICATIONS FROM WINTER PLANTING DATES AND THE TREATMENTS: WATER, ASPHALT, AND MULCH

	Treatments*			
Planting Dates	Water	Asphalt	Mulch	Average
December 11	1	1	1	0.00
December 11	1	1	2	0.00
December 11	1	2	1	0.00
December 11	1	2	2	0.00
December 11	2	1	1	0.33
December 11	2	1	2	0.33
December 11	2	2	1	0.00
December 11	2	2	2	0.00
January 23	1	1	1	6.00
January 23	1	1	2	5.66
January 23	1	2	1	4.33
January 23	1	2	2	4.66
January 23	2	1	1	6.33
January 23	2	1	2	5.66
January 23	2	2	1	4.66
January 23	2	2	2	4.33
March 19	1	1	1	5.33
March 19	1	1	2	3.33
March 19	1	2	1	6.00
March 19	1	2	2	6.00
March 19	2	1	1	4.66
March 19	2	1	2	4.33
March 19	2	2	1	6.00
March 19	2	2	2	2.33

*The number 1 under the treatments signifies that no water, asphalt or mulch was applied whereas, the number 2 indicates they were used.

TABLE VI

THE AVERAGE NUMBER OF SPROUTED NODES PER THREE REPLICATIONS FROM WINTER PLANTING DATES AND THE WATER TREATMENT

	Treatment*	
Planting Dates	Water	Average
December 11	1	0.00
December 11	2	0.16
January 23	1	5.16
January 23	2	5.25
March 19	1	5.16
March 19	2	4.33

*The number 1 under the treatment of water signifies that no water was applied whereas, the number 2 indicates that water was applied.

TABLE VII

THE AVERAGE NUMBER OF SPROUTED NODES PER THREE REPLICATIONS FROM WINTER PLANTING DATES AND THE ASPHALT TREATMENT

	Treatment*	
Planting Dates	Asphalt	Average
December 11	1	0.16
December 11	2	0.00
January 23	1	5.91
January 23	2	4.50
March 19	1	4.41
March 19	2	5.08

*The number 1 under the treatment of asphalt signifies that no asphalt was applied whereas, the number 2 indicates that asphalt was applied.

TABLE VIII

THE AVERAGE NUMBER OF SPROUTED NODES PER THREE REPLICATIONS FROM WINTER PLANTING DATES AND THE MULCH TREATMENT

Planting Dates	Treatment* Mulch	Average
December 11	1	0.08
December 11	2	0.08
January 23	1	5.33
January 23	2	5.08
March 19	1	5.50
March 19	2	4.00

*The number 1 under the treatment of mulch signifies that no mulch was applied whereas, the number 2 indicates that mulch was applied.

TABLE IX

THE TOTAL NUMBER OF COMMON BERMUDAGRASS NODES PER PLANTING DATE WHICH INITIATED GROWTH AS DETERMINED ON MAY 28, 1969

Planting Dates	Total Nodes Sprouted	Number of Sprouted Nodes per Treatment	
		Asphalt	No Asphalt
August 27	4	0	4
September 10	0	0	0
October 15	2	0	2
December 11	2	0	2
January 23	125	53	72
March 19	114	60	54

TABLE X

THE TOTAL NUMBER OF BERMUDAGRASS SPRIGS WHICH SPROUTED UNDER THE VARIOUS ASPHALT TREATMENTS AND DAYS' EXPOSURE TO A CONSTANT TEMPERATURE OF 4.44°C

Asphalt Concentration		Total Number of Sprouted Sprigs per Exposure Period in Days*					
Parts Asphalt	Parts Water	0	1	2	3	4	5
1	0	6	5	6	5	5	6
1	1	6	6	6	4	6	6
1	2	5	6	5	6	5	6
1	3	4	6	6	6	5	6
1	4	6	3	6	6	6	6
0	0	6	5	5	6	6	6

*These are totals of six replications.

TABLE XI

THE TOTAL NUMBER OF BERMUDAGRASS SPRIGS WHICH SPROUTED UNDER THE VARIOUS ASPHALT TREATMENTS AND DAYS' EXPOSURE TO A CONSTANT TEMPERATURE OF A -1.11°C

Asphalt Concentration		Total Number of Sprouted Sprigs per Exposure Period in Days*					
Parts Asphalt	Parts Water	0	1	2	3	4	5
1	0	6	5	6	5	4	5
1	1	6	4	5	5	6	5
1	2	5	6	5	6	6	6
1	3	4	6	5	5	6	6
1	4	6	6	6	6	6	5
0	0	6	3	5	4	6	6

*These are totals of six replications.

TABLE XII

THE TOTAL NUMBER OF BERMUDAGRASS SPRIGS WHICH SPROUTED UNDER THE VARIOUS ASPHALT TREATMENTS AND DAYS' EXPOSURE TO A CONSTANT TEMPERATURE OF A -6.67°C

Asphalt Concentration		Total Number of Sprouted Sprigs per Exposure Period in Days*					
Parts Asphalt	Parts Water	0	1	2	3	4	5
1	0	6	0	0	0	0	0
1	1	6	2	0	0	0	0
1	2	5	1	0	0	0	0
1	3	4	0	0	0	0	0
1	4	6	0	0	0	0	0
0	0	6	1	1	0	0	0

*These are totals of six replications.

VITA

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Master of Science

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