THE EFFECT OF DEPTH OF PLANTING AND STORAGE OF WET AND DRY ROOTS ON THE GERMINATION OF FOUR VARIETIES OF FORAGE-TYPE BERMUDAGRASS

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PART I. INTRODUCTION

Bermudagrass is the most important of the introduced pasture grasses for central and eastern Oklahoma and the irrigated sections of the State.

Bermudagrass produces high forage yields and gives excellent response to fertilizer treatments. This grass recovers quickly after heavy grazing and has a very high carrying capacity when properly fertilized and managed. It is adapted to a wide variety of soil types within the State and is used for permanent pasture for livestock, for erosion control, for spillway protection, and for improvement of "worn-out" farm land. Bermudagrass is used in the irrigated areas where the soil salinity has increased to high levels that precludes the production of other agricultural crops.

The improved strains of Bermudagrass must be established by planting sprigs and rhizomes. These methods are expensive and farmers often have difficulty establishing stands.

The purpose of this study was to obtain additional information concerning effects of planting depth and root-storage methods on the germination of Bermudagrass sprigs with four Bermudagrass varieties used in Oklahoma.

REVIEW OF LITERATURE

Fields (8)* reported in 1906 at the Stillwater Station that of all the grasses tried on the Station Farm, Bermudagrass alone had shown the qualities which must be possessed by a pasture grass in Oklahoma.

Craigmiles et al. (4) reports from the Georgia Experiment Station that Coastal Bermudagrass sprigs should be set erect if possible so that a part is deep in the soil with the tip sticking above the surface for best germination. Also, the report shows that a fertilizer ratio of 4:1:2 appears adequate in the Piedmont Region, since Coastal Bermudagrass uses large amounts of nitrogen.

Harper (10) reported that Midland Bermudagrass should not be planted over two inches deep. The best results were obtained between April 1 and June 1. Midland roots failed to produce any plants when they were placed in a horizontal position on cultivated land on the Lone Grove, Oklahoma Experimental Farm in April, 1954, and covered with four, eight, or 12 inches of soil.

Wellhausen (15) stated that best results were obtained in Arkansas by planting Coastal or Midland in a furrow two to three inches deep and adjusting the cultivator to leave the sprig tips exposed.

*Figures in parenthesis refer to literature cited.

Chessmore (3) found the survival of Midland and Coastal was much better at the two-inch depth of planting than the four-inch depth. There was very little emergence at the six-inch depth. He also noted that Midland showed more rapid ground cover than Greenfield on sandy soil at the Lone Grove, Oklahoma Experimental Farm.

Woodle (16) recommended planting Bermuda sprigs on an undisturbed seed-bed the first day after a rain. Coastal should be planted with tips of sprigs above the soil surface for best results and also keep sprigs moist and shaded.

Burton (2) reports that stands of 100 per cent, 58 per cent and 42 per cent were obtained in July when Bermuda sprigs were planted one, two, and three days respectively after a heavy rain.

Harper (11) found that Bermudagrass germinates much better and faster when the sprigs are placed in a perpendicular position with the tip near the surface of the soil, as compared to sprigs placed in a horizontal position.

Elder and Murphy (7) report a three-year average beef production of 914 pounds per acre with Midland Bermudagrass under irrigation at the Stillwater Station. They also show that daily gains of steers decline from April, May, and June to November. The report shows that Midland overseeded with Rye at the Maryland Experiment Station produced 620 pounds of beef per acre, as compared to 410 pounds for Common Bermudagrass. At the Stillwater Station one pound of nitrogen on Common Bermudagrass produced 1.5 pounds of beef over the no-nitrogen pasture.

Elder (6) concludes that for best results, Greenfield Bermudagrass requires a fertile soil, especially high in nitrogen.

Burton (2) showed at the Georgia Experiment Station that Coastal Bermudagrass responds well to applications of nitrogen. Yields were increased from 3,583 pounds of hay per acre on the check-plot to 18,250 pounds of hay from an application of 800 pounds of nitrogen per acre, and the per cent protein was also increased on the same plots from 7.48 per cent to 16.88 per cent. He also stated that sprigs from well-fertilized nurseries give rise to more plants, grow faster, and cover the ground faster than sprigs from an infertile soil. He recommends planting one day after a rain and not over two inches deep.

Elder (5) found that Coastal and Midland made more growth in the fall and did not become dormant as soon as the Common strains. Coastal was not as winter hardy as Midland and most Common strains in Oklahoma. The quality of forage and per cent protein of Bermudagrass is greatly influenced by applications of nitrogen.

Alexander (1) reported from greenhouse studies that treatments of nitrogen from 0, 50, 100, 200, and 400 pounds per acre respectively increased the per cent nitrogen of the roots as follows: Midland from .55, .55, .59, .98, and 1.86; Coastal from .51, .57, .57, .64, and 1.32; Greenfield from .56, .50, .52, 1.01, and 1.79; and Common from .62, .62, .61, 1.05, and 1.79. Alexander also found that nitrogen increased the amount of roots in the soil. The nitrogen treatments had very little effect on per cent phosphorus content of the roots. He found that increased nitrogen decreased the per cent potassium of Bermudagrass roots. Alexander noted that the N, K, and P content of Greenfield forage was higher than the other three varieties and that Midland had the highest per cent of nitrogen utilization of the four varieties.

Simmons (12) reports Midland Bermudagrass fertilized with 300 pounds of actual nitrogen produced 10.8 tons of hay per acre in Pushmataha County. Simmons also reports 524 pounds of beef per acre with Midland Bermudagrass, fertilized with 200 pounds of nitrogen per acre. The per cent protein of Bermudagrass forage was higher in the spring than in the fall on both the fertilized and unfertilized treatments.

Teague (14) found that samples of forage from plots of Greenfield Bermudagrass treated with 0, 50, 100, and 200 pounds of nitrogen per acre and duplications treated with 60 pounds of K_2O were all higher in per cent nitrogen, phosphorous and potassium in May than in October. Teague also found the greatest increase in yield from the K treatment was at the high nitrogen levels.

Harlan, Burton, and Elder (9) concluded that Midland is two to four times as productive as unselected Common Bermudagrasses on medium to high fertility soils. They noted that Midland was no more productive than unselected Common Bermudagrass on low fertility soils. In tests conducted at Stillwater, Oklahoma, Midland produced higher yields of forage than Coastal and Common Bermudagrass. They found the per cent protein to be lower in Midland than in Oklahoma Common Bermudagrass.

EXPERIMENTAL PROCEDURES AND MATERIALS

Four varieties of forage-type Bermudagrass were used in this study: Common, Greenfield, Midland, and Coastal. The Greenfield, Midland, and Coastal roots were obtained from the foundation plots formerly used by the Crop Improvement Association, and the Common was obtained from an adjacent area. These plots are located near Stillwater Creek at the west end of Lake Carl Blackwell. Approximately eight bushels of roots from each of the four varieties which were harvested on June 20, 1962 were used in the study.

Field Studies

The field layout designed to establish the influence of depth of planting on germination consisted of a randomized-block design with three replications. Each plot contained four rows, one each of Common, Greenfield, Midland, and Coastal Bermudagrass. The row spacing was 12 inches with rows being 100 inches long. Plot areas were spaced two feet apart.

The experiment was established on the Agronomy Experiment Station west of Stillwater. The soil on this site is Kirkland silt loam. The Bermudagrass roots were dug on June 20, 1962, and sprigs with three nodes each were cut for planting. Twenty-five three-node sprigs were planted four inches apart in each row. The furrow was opened with a hoe and a gauge was run along a board beside the row to get an accurate measurement of planting depth.

The plots were planted at five different depths: 0", 1", 2", 3", and 4" and made on June 20. There was a one-inch rain the next day, and the plots were sprinkled twice during this study. Counts of sprigs sprouting were made at 10, 16, 23, and 31 days after planting to determine the effect of depth of planting on per cent of sprigs germinating and time required for sprouts to emerge.

Samples of roots were taken at planting time from the four varieties used in the study to determine the effect of per cent moisture and per cent nitrogen on the performance of the sprigs planted. Soil analyses for pH, organic matter, and available phosphorus and potassium were made of soil samples from the fields where the roots were dug.

Laboratory Studies

The laboratory germination study was established to obtain information on the effects of length of storage under wet and dry conditions on the germination of Bermudagrass sprigs. Sprigs used in this study were from the same sample of roots used in the depth of planting study. Four varieties of Bermudagrass roots were used: Common, Greenfield, Midland, and Coastal with approximately eight bushels of roots from each variety. The roots were dug on June 20, 1962, and samples were taken immediately for the first germination test and the first nitrogen and moisture analysis. The roots were then divided into two samples of four bushels for each of the four varieties. One set of samples was stored dry and the other wet. The dry-stored roots were placed on a dry concrete floor and covered with sacks. The wet-stored roots were placed on a sand floor, sprinkled lightly, and then

covered with wet sacks. The wet-stored roots were sprinkled and stirred every two days to keep them in good condition.

Samples were taken from the wet- and dry-stored roots for the germination tests, and the nitrogen and moisture tests were made at 0-, 2-, 4-, 8-, and 16-day intervals after the roots were dug.

Four replications with 25 three-node sprigs in each replication for each variety, stored wet and dry, were placed in the germinator at each interval. The sprigs were rolled in a paper towel with a plastic cover placed around the roll. The four replications were secured with a rubber band and placed on end in the germinator.

Counts were made on sprigs germinated and also total buds germinated. A commercial model daylight germinator was used. The temperature varied between 20 and 30 degrees centigrade.

Three- to four-hundred-gram samples of the wet- and dry-stored roots of each variety were taken at 0-, 2-, 4-, 8-, and 16-day intervals, placed in a paper sack and weighed, then oven dried to determine the moisture content. The root samples were taken at that time for total nitrogen analysis. The Kjeldahl method was used to determine the total per cent nitrogen.

PART II. RESULTS AND DISCUSSION

Field Studies

The field-planting experiment was designed to study the effect of depth of planting on the stand using four varieties of Bermudagrass: Common, Greenfield, Midland, and Coastal. The experiment was originally designed with four replications. However, after three were planted, rain made the soil too wet for planting the fourth replication.

The soil-moisture factor was to be eliminated by irrigation. One inch of rain fell the night after planting, and the plots were sprinkler irrigated the seventh and 14th day after planting. Approximately one and one-half inches of water was applied in each irrigation. Counts were made at 10, 16, 23, and 31 days after planting to study the rate of emergence and per cent sprig germination at the end of the test.

There was a general decrease in the sprig stand from the 0" to the 4" depth of planting, but Common and Greenfield decreased at each depth from 0" to 4". The results with Common are shown in Figure 1. The Coastal and Midland varieties did not decrease uniformly at each depth. Several conditions were noted that may have caused this variation. At the end of the experiment the sprigs were dug to check the accuracy of the germination count and the cause of sprigs failing to germinate. Apparently there was a great deal of damage to the sprigs

and sprouts due to microorganisms. It was also noted that, after rain or sprinkler irrigation, the soil in some areas within the rows seemed to be compact. Diseased roots and poor stands were greater in those areas. Dry crusting of the soil surface did not seem to delay or decrease per cent of sprig germination and emergence.

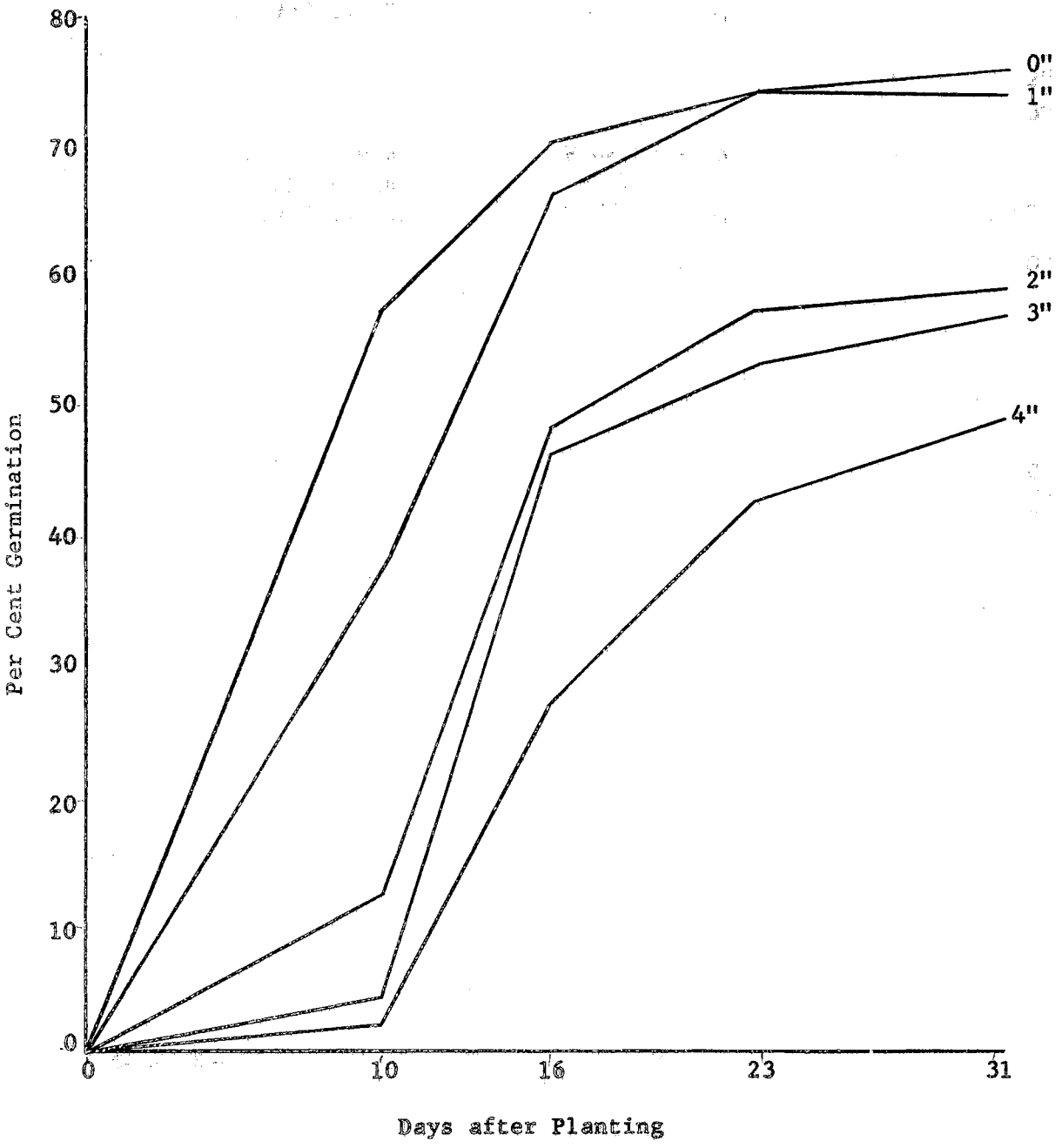
There was a direct relationship between the length of time from planting to emergence and the decrease in stand. A comparison of the effect of planting depth on the per cent germination of the four varieties of Bermudagrass is shown in Figure 2 and also in Table I.

Common Bermudagrass was much more vigorous and had a higher rate of germination at all depths of planting than the other varieties except Coastal at 0" depth. Greenfield had less vigor, lower germination, and was slower emerging than Common. This difference may be explained by plant nutrient reserves of the sprigs as indicated in the difference in nitrogen content. Total nitrogen content of sprigs of the four varieties is given in Table VII. Nitrogen content of the Common roots was 1.16 per cent N., compared to .28 per cent N. in the Greenfield. The Midland sprigs tested .26 per cent nitrogen, compared to .35 per cent for Coastal. Midland had less vigor and the lowest average per cent germination of the four varieties. Coastal appears to be affected by depth of planting more than the other varieties, dropping from 76 per cent at 0" to 14.66 per cent germination at 4" depth. Results from the different treatments by variety are shown in Tables III, IV, V, and VI and are summarized in Table I and Figure 2.

The history of the fields where the roots were dug and results of the soil tests shown in Table II may explain the difference in

FIGURE 1

EFFECT OF DEPTH OF PLANTING ON RATE OF EMERGENCE OF COMMON BERMUDAGRASS, KIRKLAND SILT LOAM JUNE 20, 1962 TO JULY 21, 1962, STILLWATER, OKLAHOMA



vigor and nitrogen content of the sprigs planted.

The Coastal, Midland, and Greenfield roots were from fields that were formerly used for a nursery for harvesting Bermudagrass roots. The fields had been mowed, and no fertilizer or lime had been applied for several years. The soil test was low to very low in organic matter. The Bermudagrass had depleted the nitrogen the year before, and there was very little rain through May of 1962, prior to digging the roots. The Common variety came from an area that had not been mowed and had more cover on the ground. The soil test showed a higher fertility level, and there was more growth on the grass at the time of digging the sprigs. The soil used in this field experiment was Kirkland silt loam. A description of the soil is presented in Publication P-315 (13).

Germination and Laboratory Studies

The results reported in the germination and laboratory studies deal primarily with the effect of wet and dry storage and length of storage of four varieties of Bermudagrass on germination. The moisture and nitrogen content of the roots were related to results from the germination tests.

Sprig Germination and Moisture Studies

Results of the sprig germination tests and moisture content of the four varieties of Bermudagrass roots are given in Tables VIII, IX, X, and XI. The total bud germination count was made with the sprig germination count and is also presented in those tables, the results being summarized in Figures 3 through 14.

FIGURE 2

PER CENT GERMINATION OF COMMON, GREENFIELD, MIDLAND, AND COASTAL BERMUDAGRASS SPRIGS 31 DAYS AFTER PLANTING AT VARIOUS DEPTHS, KIRKLAND SILT LOAM, JULY 21, 1962, STILLWATER, OKLAHOMA

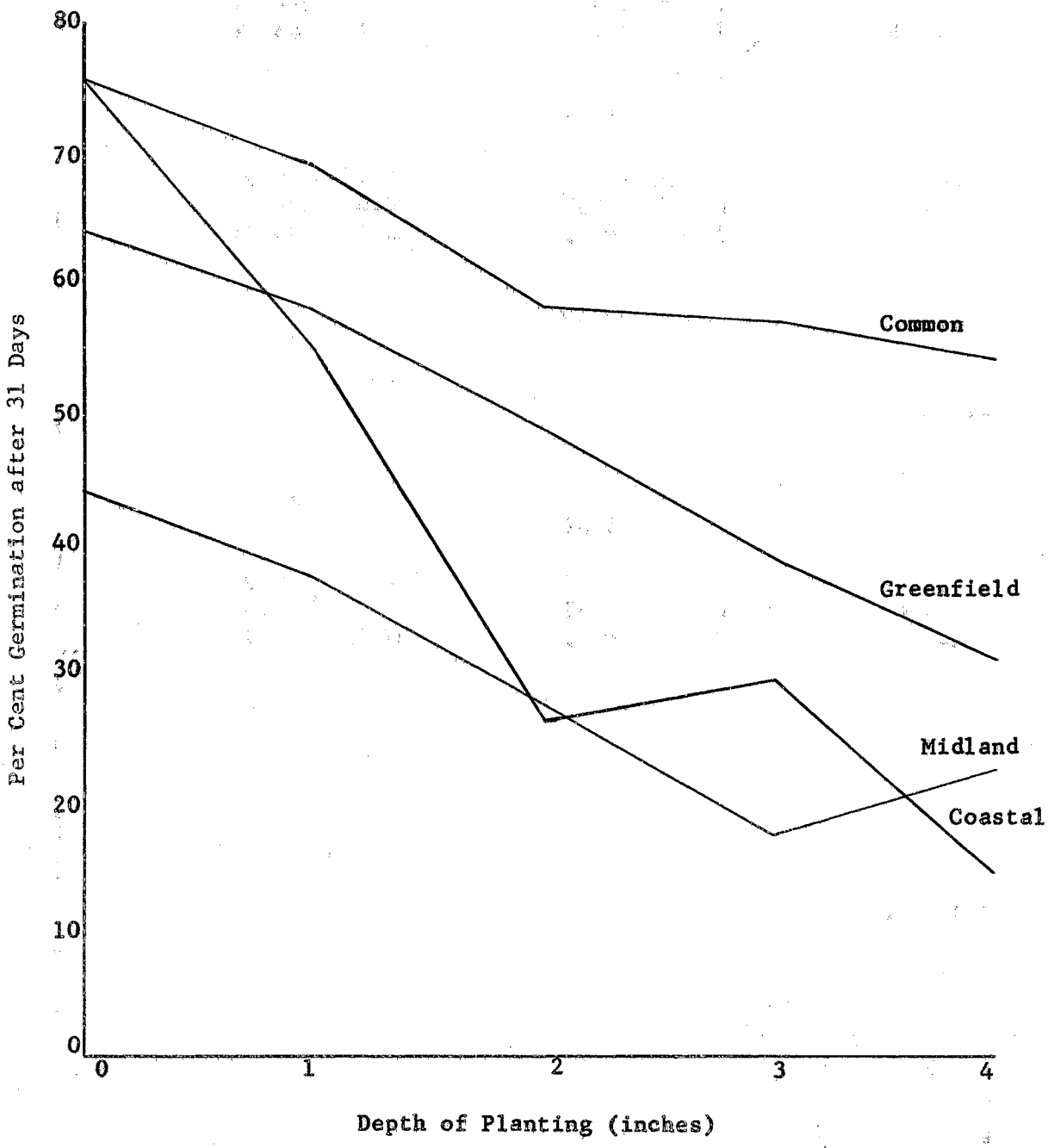


TABLE I

EFFECTS OF DEPTH OF PLANTING ON PER CENT OF SPRIGS SPROUTING DURING A THIRTY-ONE-DAY PERIOD AFTER PLANTING OF FOUR BERMUDAGRASS VARIETIES ON KIRKLAND SILT LOAM AT THE AGRONOMY FARM, STILLWATER, OKLAHOMA, JUNE 20, 1962

Days After Planting	COMMON Per Cent	GREENFIELD Per Cent	MIDLAND Per Cent	COASTAL Per Cent
0" Depth				
10	57.33	9.33	20.00	32.00
16	70.66	56.00	36.00	56.00
23	74.66	61.33	41.33	74.66
31	76.00	64.00	44.00	76.00
1" Depth				
10	37.33	1.33	13.33	12.00
16	66.66	33.33	33.33	49.33
23	74.66	53.33	34.66	49.33
31	74.66	58.66	37.33	56.00
2" Depth				
10	12.00	1.33	1.33	2.66
16	48.00	17.33	18.66	17.33
23	57.33	42.66	24.00	23.33
31	58.66	49.33	26.66	25.33
3" Depth				
10	4.00	0.00	2.66	2.66
16	46.66	10.66	8.00	17.33
23	53.33	33.33	14.66	24.00
31	57.33	38.66	17.33	29.33
4" Depth				
10	1.33	1.33	1.33	1.33
16	26.66	14.66	2.66	1.33
23	42.66	29.33	20.00	9.33
31	49.33	30.66	22.66	14.66

Twenty-five sprigs were planted in each of three replications. See Tables III, IV, V, and VI for details of germinating sprigs by variety and depth.

TABLE II

ANALYSIS OF SOIL SAMPLES FROM VARIETY PLOTS WHERE BERMUDAGRASS ROOTS WERE HARVESTED FOR THE PLANTING AND GERMINATION TESTS, LAKE CARL BLACKWELL AREA, STILLWATER, OKLAHOMA

Variety Plot	Organic Matter Per Cent	P_2O_5 Pounds per Acre	K_2O Pounds per Acre	pH Acidity
Coastal	1.35 Very Low	19 Low	145 Medium	4.9 Very Strong
Common	2.1 Low	90+ Very High	315 Very High	6.3 Slight
Greenfield	1.5 Low	46 High	91 Low	4.4 Strong
Midland	1.2 Very Low	46 High	248 High	5.5 Moderate

FIGURE 3

PER CENT GERMINATION AND MOISTURE CONTENT OF COMMON BERMUDAGRASS SPRIGS DURING SIXTEEN DAYS WET STORAGE

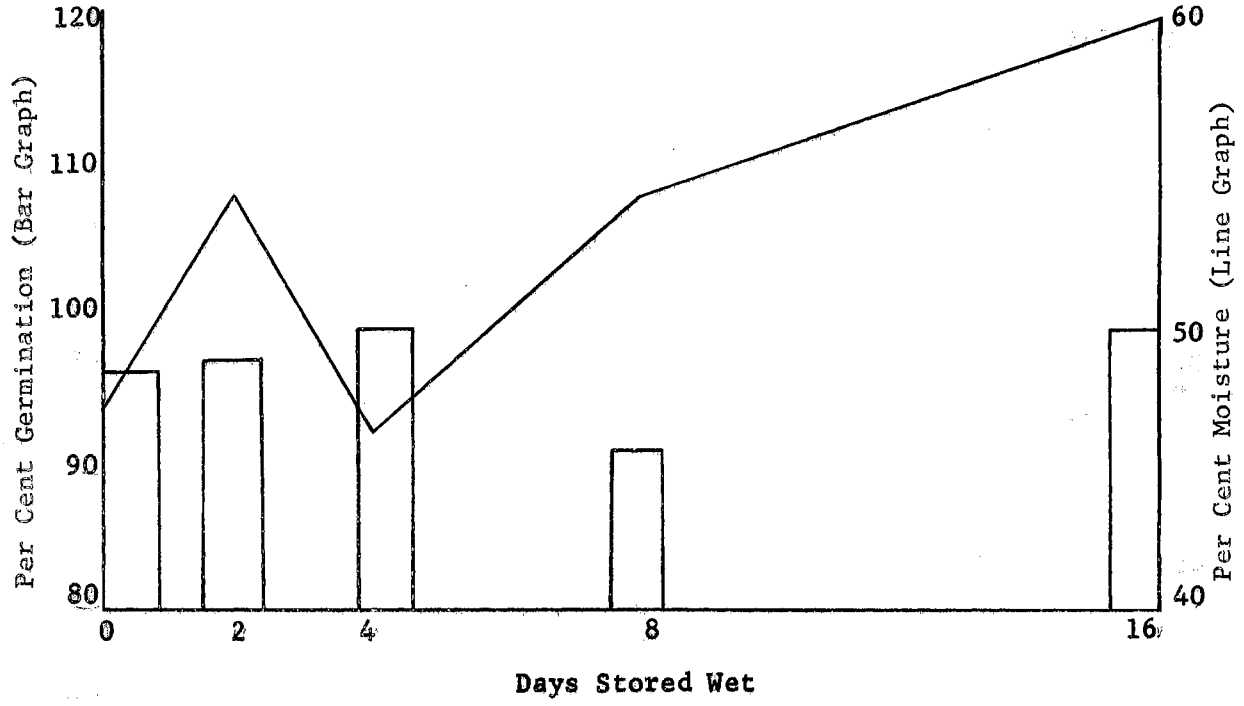


FIGURE 4

PER CENT GERMINATION AND MOISTURE CONTENT OF COMMON BERMUDAGRASS SPRIGS DURING SIXTEEN DAYS DRY STORAGE

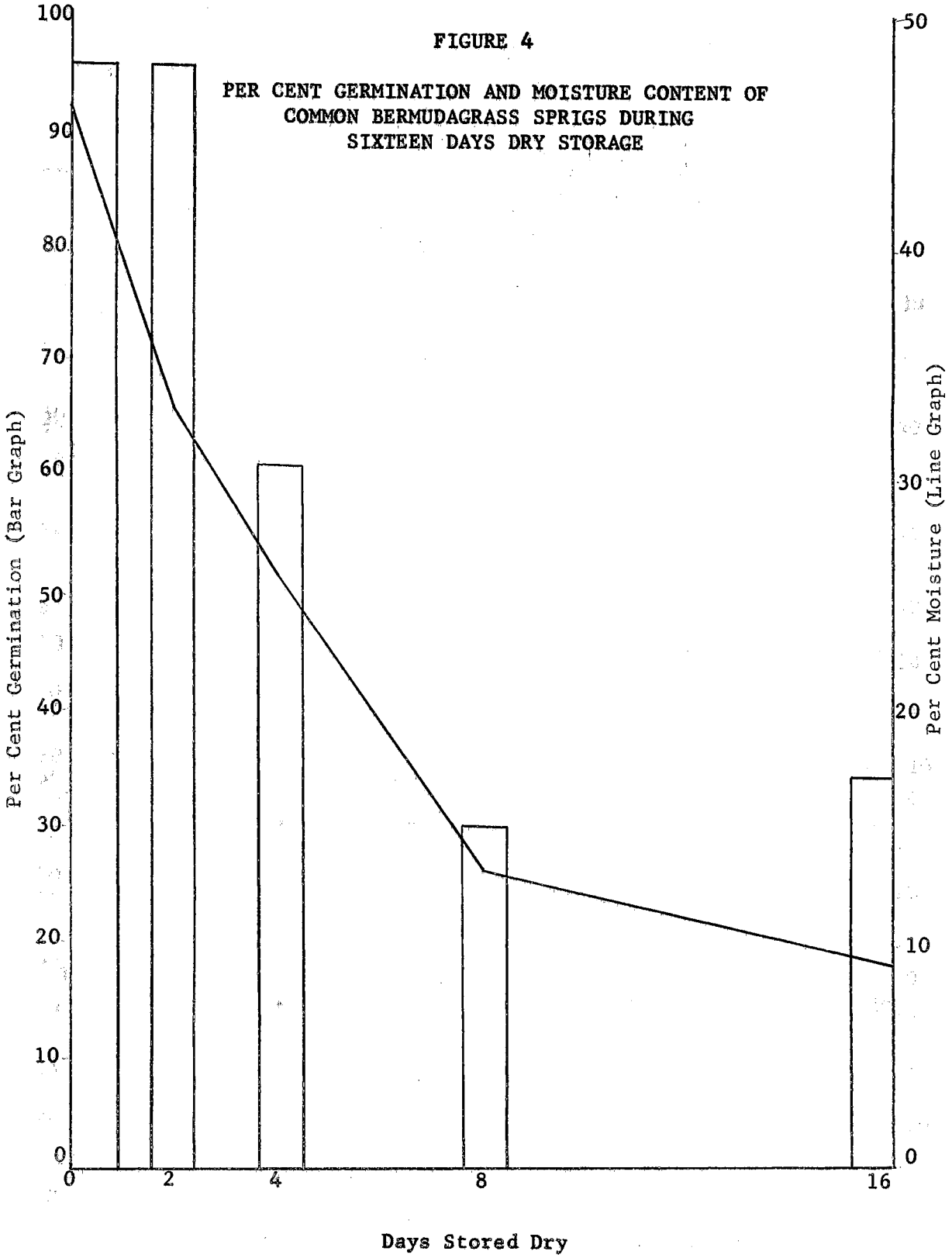


FIGURE 5

PER CENT GERMINATION AND MOISTURE CONTENT OF GREENFIELD BERMUDAGRASS SPRIGS DURING SIXTEEN DAYS WET STORAGE

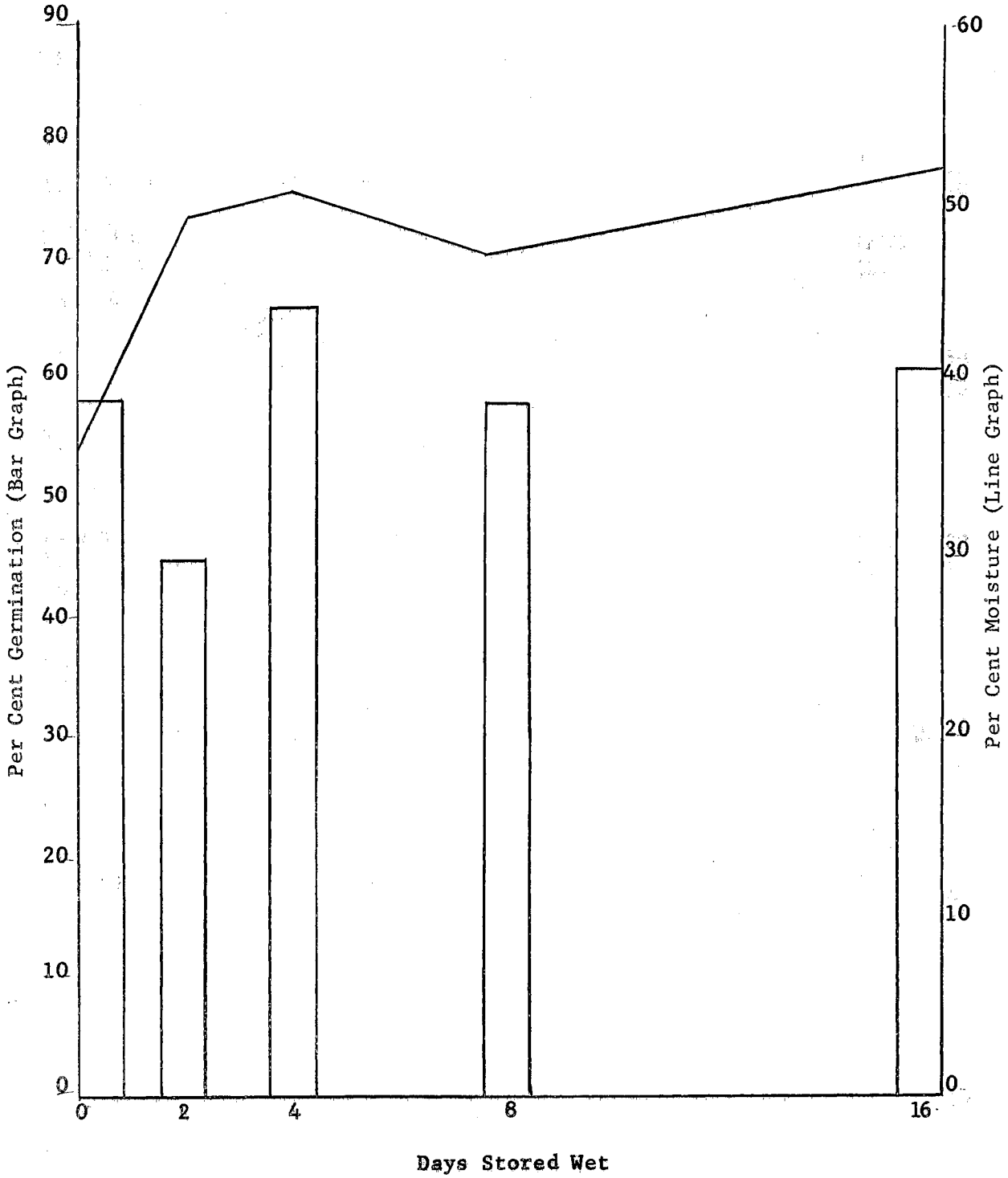


FIGURE 6

PER CENT GERMINATION AND MOISTURE CONTENT OF GREENFIELD BERMUDAGRASS SPRIGS DURING SIXTEEN DAYS DRY STORAGE

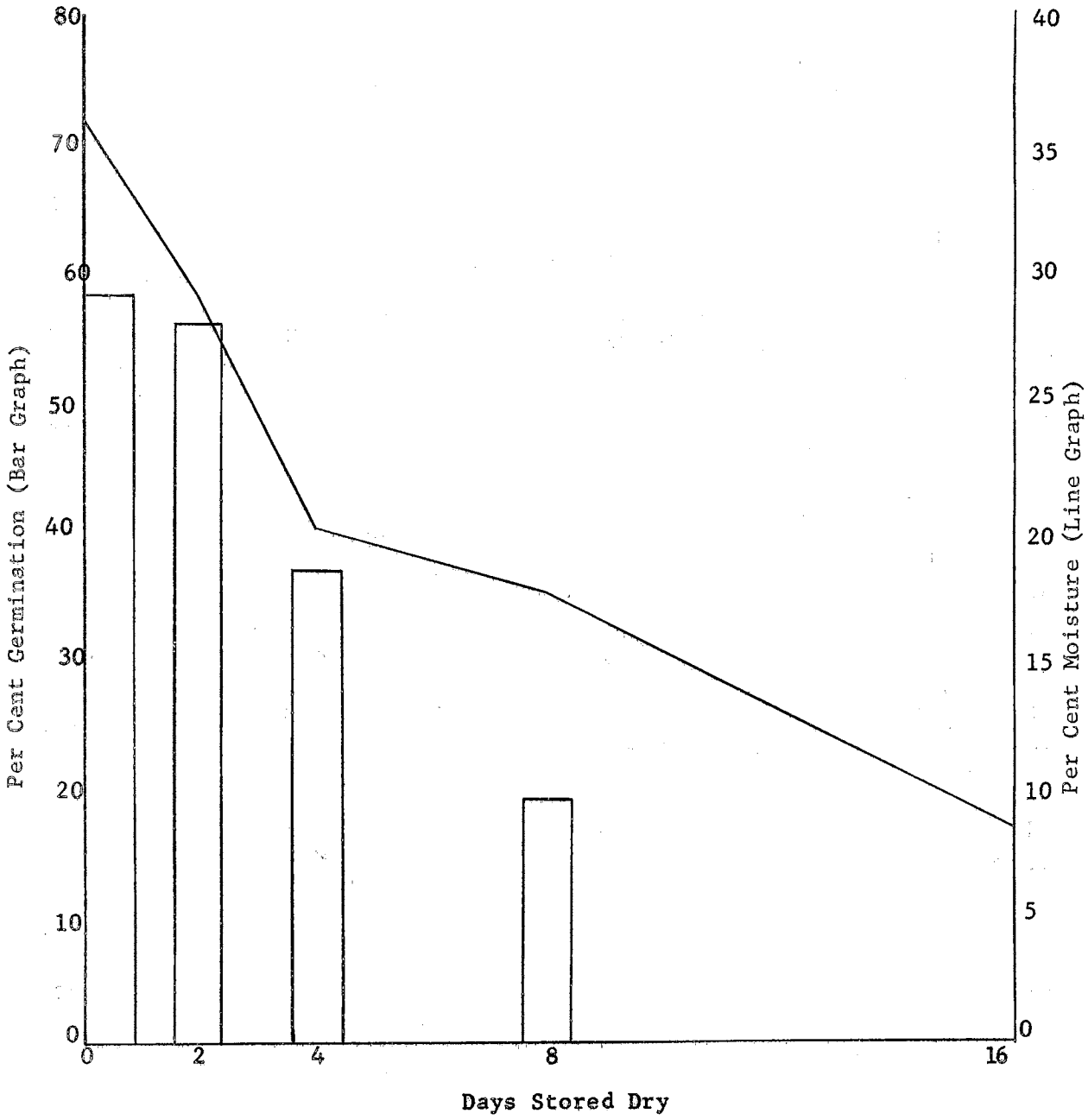


FIGURE 7

PER CENT GERMINATION AND MOISTURE CONTENT OF MIDLAND BERMUDAGRASS SPRIGS DURING SIXTEEN DAYS WET STORAGE

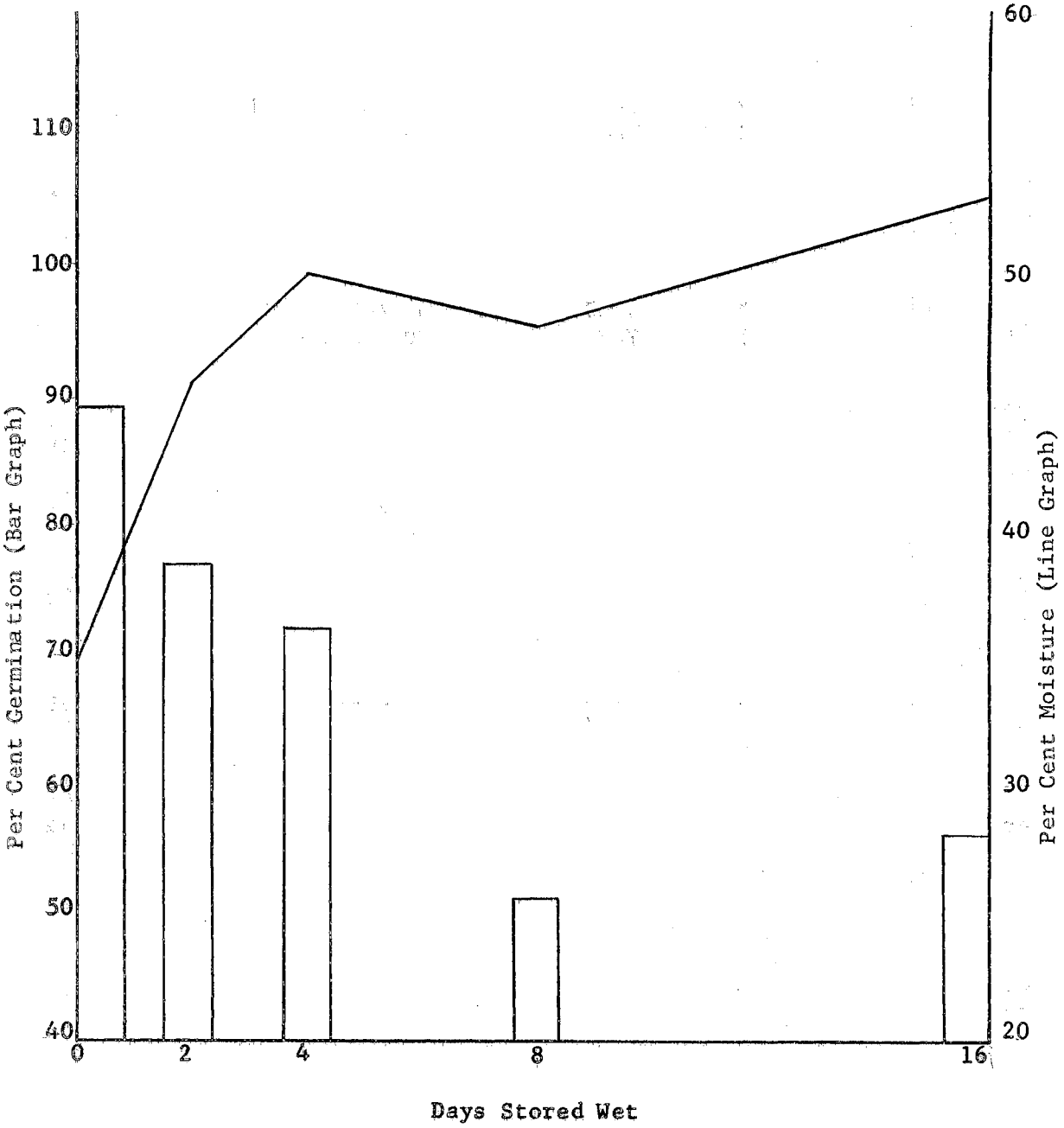


FIGURE 8

PER CENT GERMINATION AND MOISTURE CONTENT OF MIDLAND BERMUDAGRASS SPRIGS DURING SIXTEEN DAYS DRY STORAGE

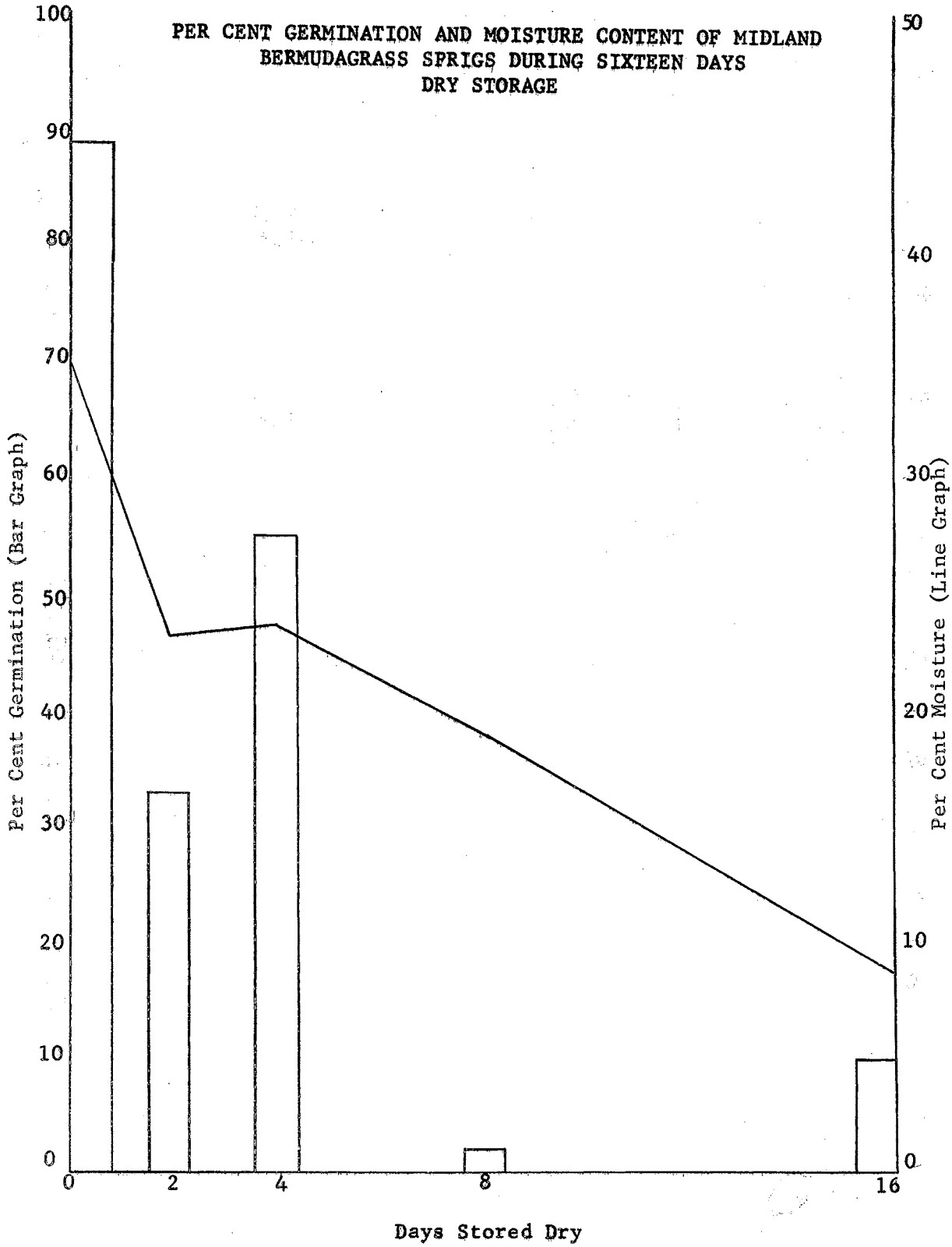


FIGURE 9

PER CENT GERMINATION AND MOISTURE CONTENT OF COASTAL BERMUDAGRASS SPRIGS DURING SIXTEEN DAYS WET STORAGE

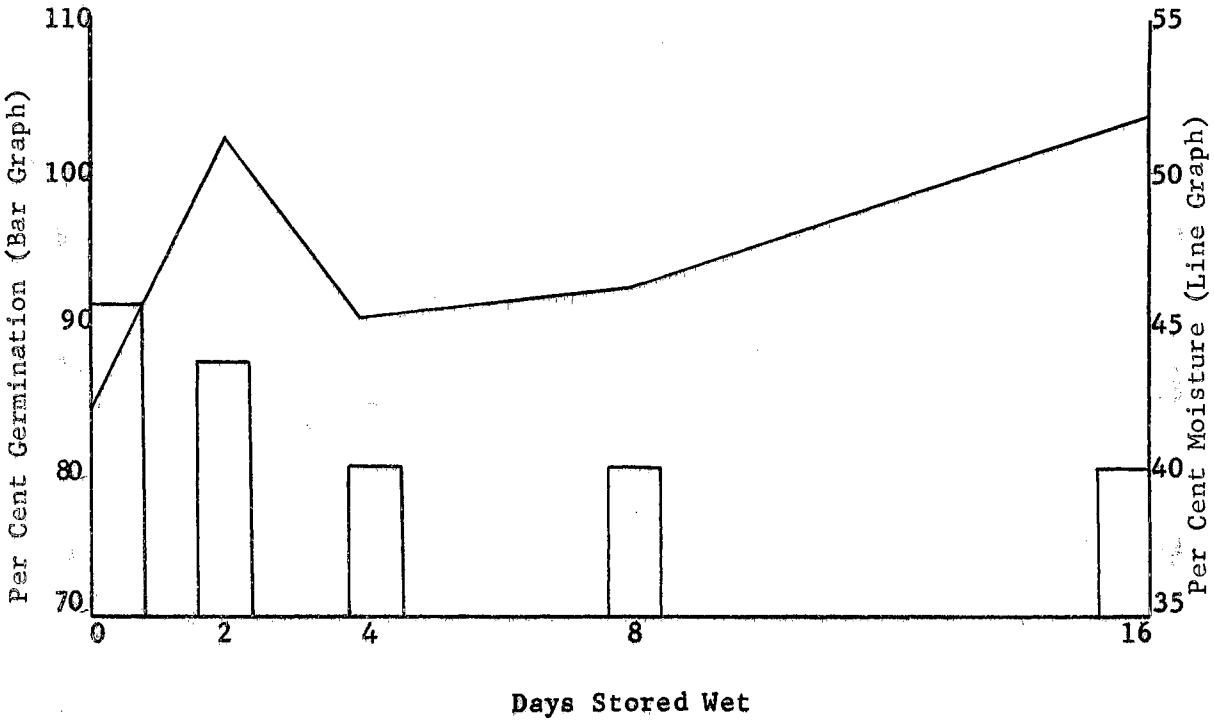


FIGURE 10

PER CENT GERMINATION AND MOISTURE CONTENT OF COASTAL BERMUDAGRASS SPRIGS DURING SIXTEEN DAYS DRY STORAGE

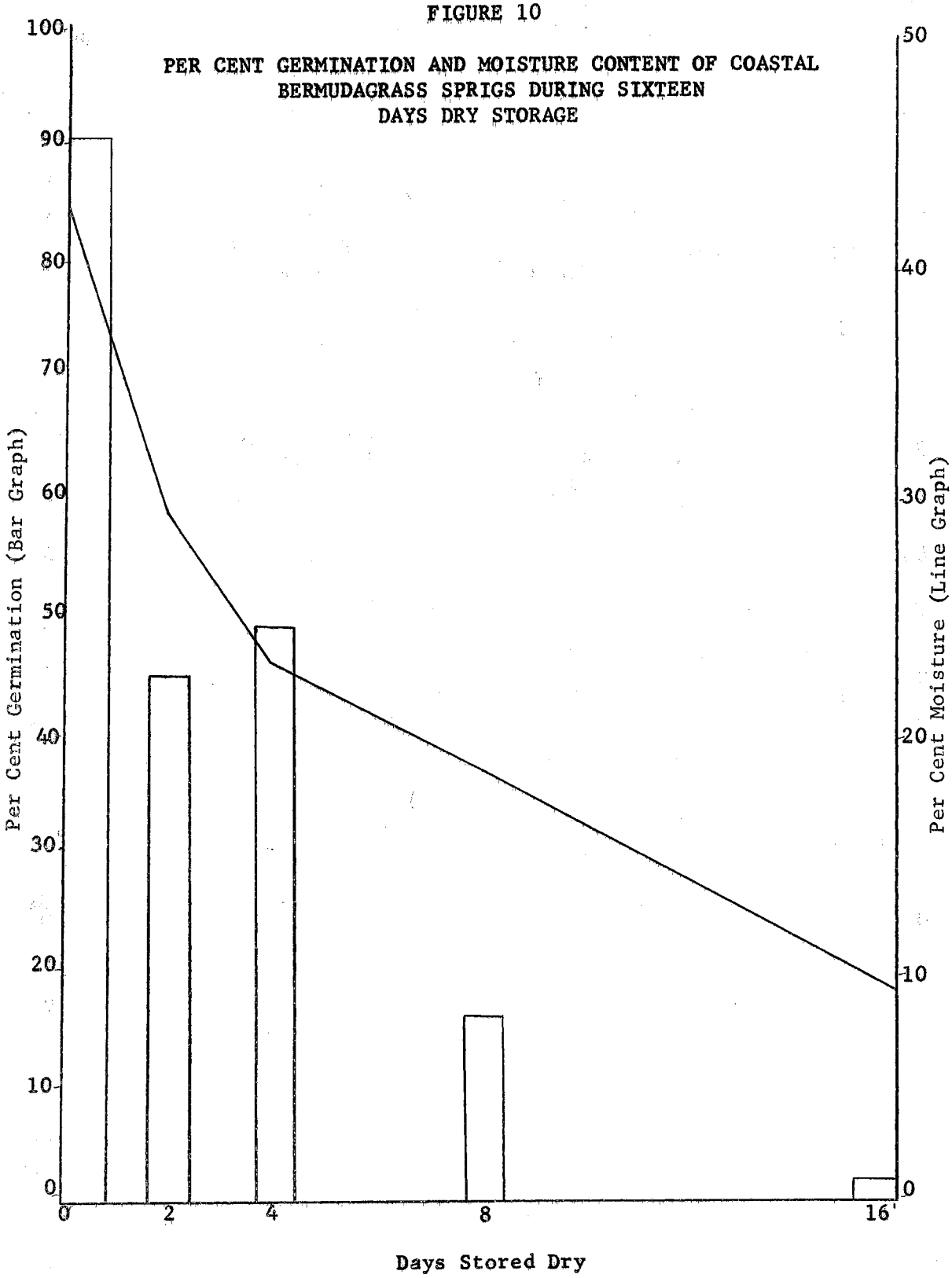


FIGURE 11

EFFECTS OF WET AND DRY STORAGE ON BUD GERMINATION OF COMMON BERMUDAGRASS SPRIGS, ONE HUNDRED THREE-NODE, SIX-BUD SPRIGS WERE PLACED IN GERMINATION AT 0-, 2-, 4-, 8-, AND 16-DAY INTERVALS AFTER STORAGE JUNE 20, 1962 TO JULY 6, 1962, STILLWATER, OKLAHOMA

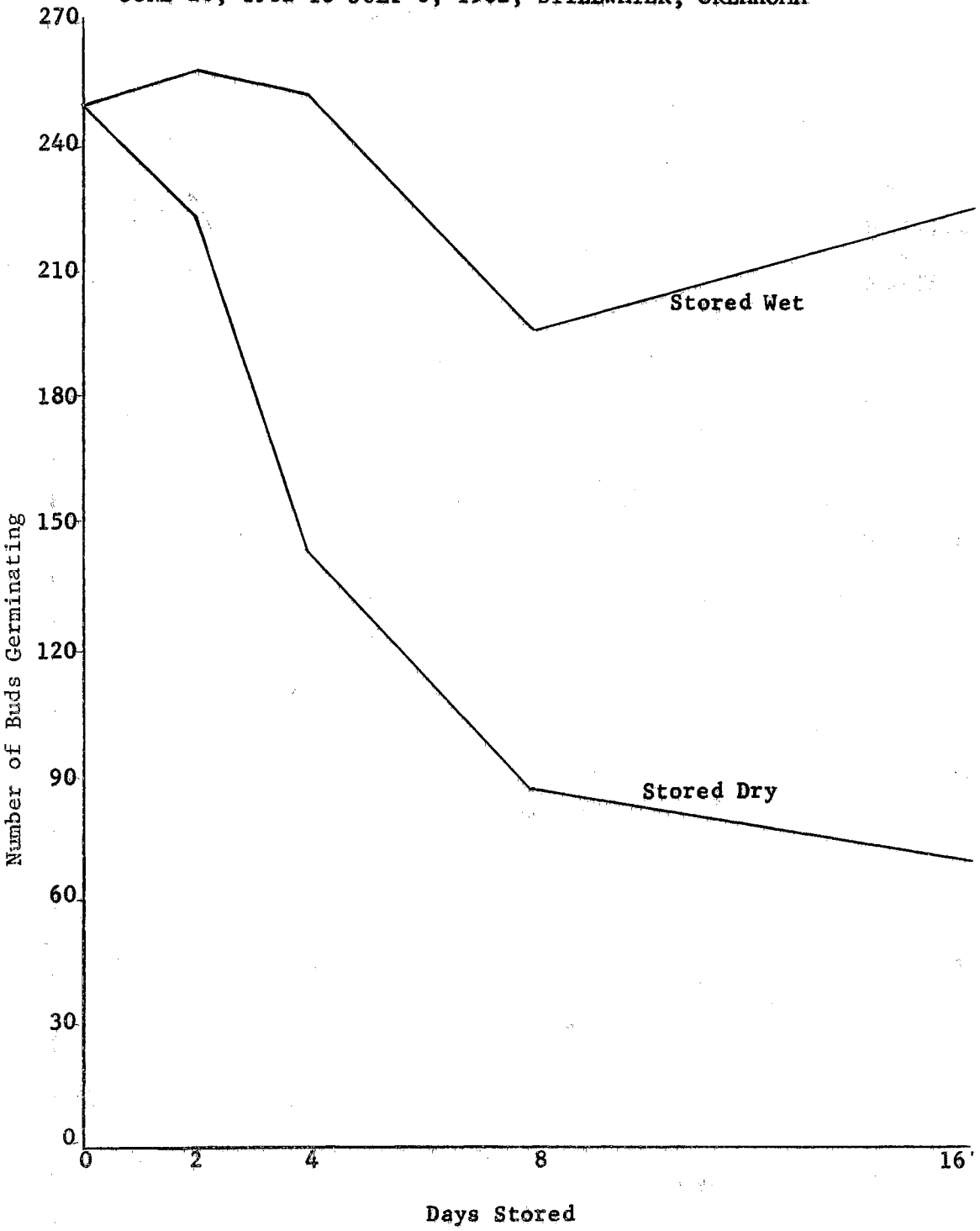


FIGURE 12

EFFECTS OF WET AND DRY STORAGE ON BUD GERMINATION OF GREENFIELD BERMUDA-GRASS SPRIGS, ONE HUNDRED THREE-NODE, SIX-BUD SPRIGS WERE PLACED IN GERMINATION AT 0-, 2-, 4-, 8-, AND 16-DAY INTERVALS AFTER STORAGE JUNE 20, 1962 TO JULY 6, 1962, STILLWATER, OKLAHOMA

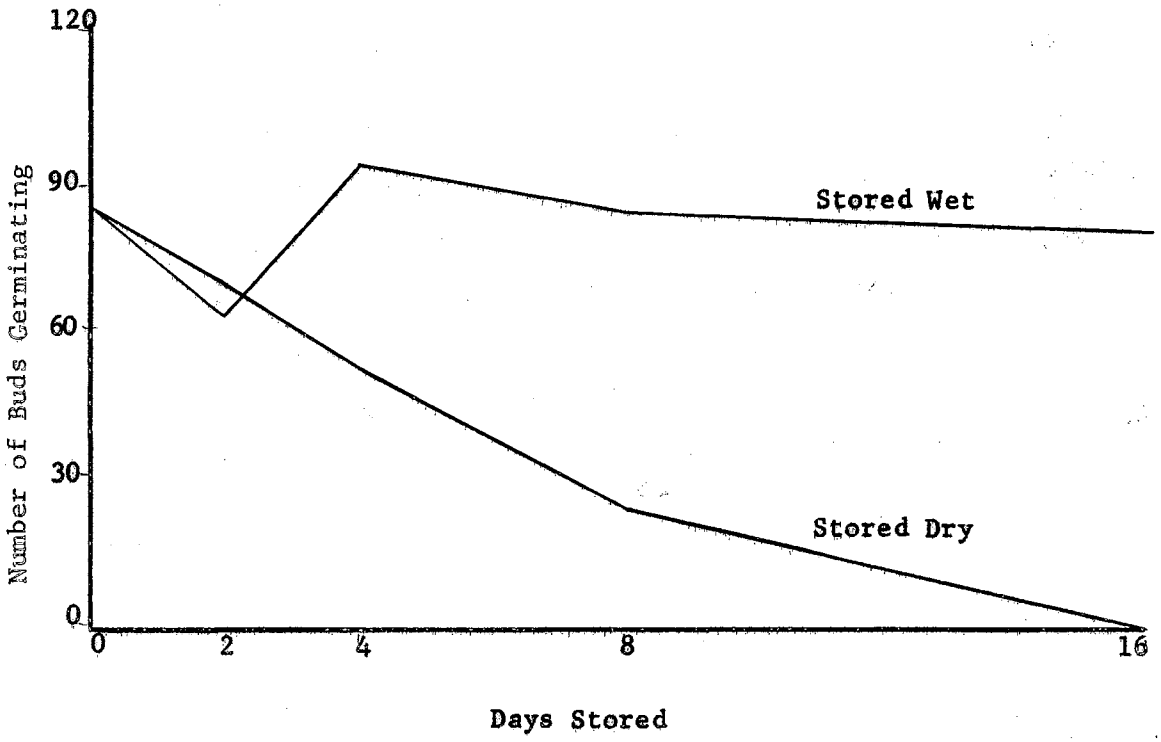


FIGURE 13

EFFECTS OF WET AND DRY STORAGE ON BUD GERMINATION OF MIDLAND BERMUDA-GRASS SPRIGS, ONE HUNDRED THREE-NODE, SIX-BUD SPRIGS WERE PLACED IN GERMINATION AT 0-, 2-, 4-, 8-, AND 16-DAY INTERVALS AFTER STORAGE, JUNE 20, 1962 TO JULY 6, 1962, STILLWATER, OKLAHOMA

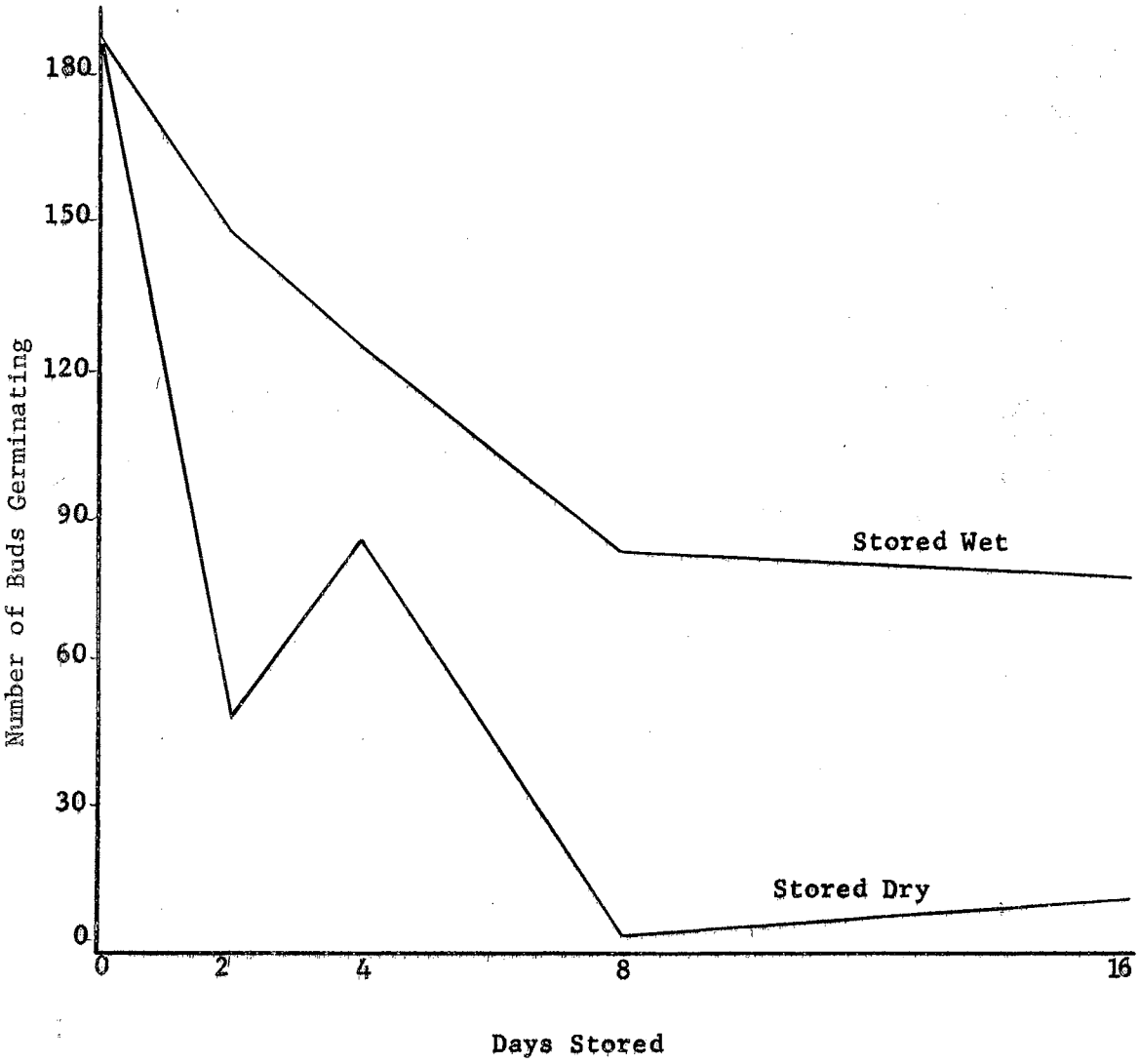
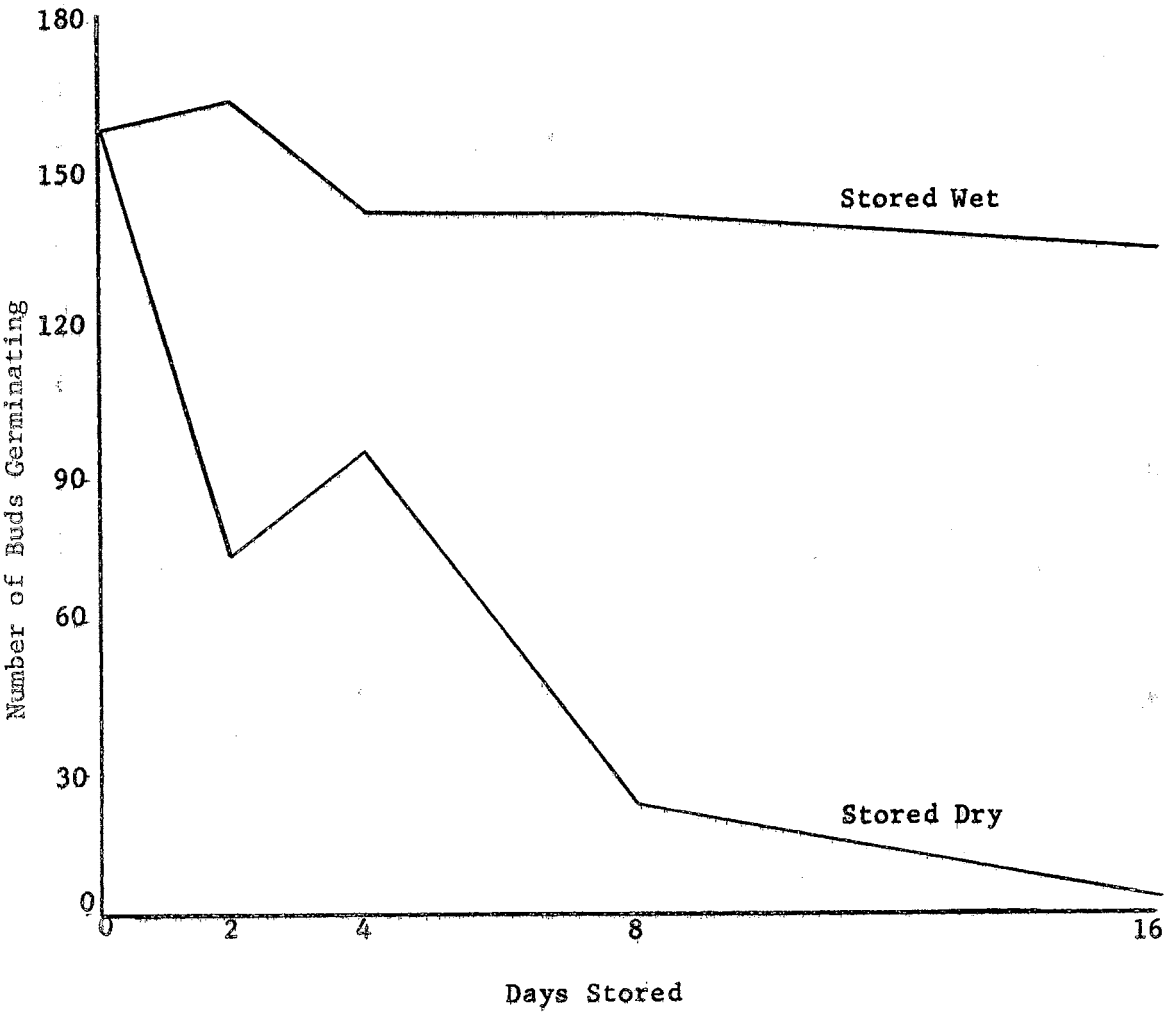


FIGURE 14

EFFECTS OF WET AND DRY STORAGE ON BUD GERMINATION OF COASTAL BERMUDA-GRASS SPRIGS, ONE HUNDRED THREE-NODE, SIX-BUD SPRIGS WERE PLACED IN GERMINATION AT 0-, 2-, 4-, 8-, AND 16-DAY INTERVALS AFTER STORAGE, JUNE 20, 1962 TO JULY 6, 1962, STILLWATER, OKLAHOMA



Wet-Storage Roots

The results of this study show that the moisture content of the roots in all varieties increased with wet storage over the 16-day storage period, as shown in Figures 3, 5, 7, and 9. This was due to absorption of moisture the first few days. After five days the sprigs began to sprout and grow, which increased water absorption and the moisture content. The Coastal and Midland germinated sooner than the Common and Greenfield while in storage. The Greenfield was lower in moisture at 0 days than the other varieties. It was noted that there was slight increase in the per cent sprig germination in the Common and Greenfield over the 16-day storage period, as shown in Tables VIII and IX.

There was a decrease in the per cent sprig germination of both Midland and Coastal over the 16-day storage period, as shown in Tables X and XI. The greatest decrease was in Midland. This may be due to the fact that Coastal and Midland break dormancy sooner than the Common varieties. The Common and Greenfield had a greater number of roots, and they were shorter between nodes and were hard and firm compared to Coastal and Midland. It was noted that at the eighth and 16th-day periods a large per cent of the roots had sprouted on all varieties except the Greenfield, which was more dormant.

Nitrogen Analysis

Three hundred- to 400-gram samples of roots were taken at 0-, 2-, 4-, 8-, and 16-day intervals from both wet and dry storage to determine per cent nitrogen, Table VII. The per cent nitrogen was very low

in the Coastal, Midland, and Greenfield samples in both wet and dry storage. The Common was higher in all samples. The per cent nitrogen averaged from the wet samples was: Coastal, .38 per cent, Midland, .36 per cent; Greenfield, .33 per cent; and Common, 1.31 per cent. There was an increase in per cent nitrogen over the first samples during the 16-day period. The wet-stored roots were higher in nitrogen than the dry-stored roots in all varieties.

The dormancy and lower germination of Greenfield, as compared to Common, may be due to a difference in plant food reserves in the roots as indicated by the difference in the nitrogen content of the roots, Tables VII, VIII, and IX.

Soil Analysis of Fields

The soil analyses are of samples from the fields where the roots were dug. Results are given in Table II. The over-all fertility level of the Common field is higher than the other three. The nitrogen level is highest in the common field and was also higher in the roots. There was more ground cover on the Common field and more growth on the grass, which indicated a better moisture condition for Common. There was a shorter growth on the Coastal, Midland, and Greenfield plots. The preceding month of May had been extremely dry. The plants on these three plots indicated a shortage of nitrogen as compared to the Common Bermudagrass.

Bud Germination of Wet-Stored Roots

The number of buds germinating was studied in this test, Tables VII, IX, X, and XI and Figures 11, 12, 13, and 14. There were twenty-five three-node sprigs in each replication and four replications in each germination test at 0-, 2-, 4-, 8-, and 16-day intervals. There are two buds at each node, making 600 buds in each four replications of 100 sprigs. There was much variation in the number of buds germinating within the varieties and at the different intervals from 0 to 16 days storage. Common had the highest number of buds germinating. The highest number of buds germinating from any 100-sprig sample was 258 buds from the sample of two-day storage wet. The sprigs germinating had from one to six buds. Many of them germinated from three to four buds.

Greenfield had the lowest average bud germination in the wet storage; the highest number was a 93-bud count from the four-day storage sample. The number of buds per sprig ranged from one to three, and in no case did over three buds germinate per sprig. Coastal and Midland buds germinated from one to five buds per sprig. The highest number for a 100-sprig sample was Coastal with 164 buds in the two-day wet storage and Midland with 189 buds in the 0-day wet storage. There was a decline in number of buds germinating from 0 to 16 days wet storage in all four varieties. The greatest decline was in Midland, which decreased from 189 to 78. The comparison of germination of wet and dry storage is shown in Figures 11, 12, 13, and 14.

Dry-Storage Roots

Samples were taken at 0-, 2-, 4-, 8-, and 16-day intervals for checking the per cent moisture and nitrogen. A test was made on sprig and bud germination the same as the wet-stored roots.

Sprig Germination and Moisture Studies

The results of the sprig germination and moisture studies are given for the four varieties of Bermudagrass in Tables VIII, IX, X, and XI. The correlation between the moisture per cent and the sprig germination is given in Figures 4, 6, 8, and 10. The moisture content declined in all varieties at a rapid rate. During the 16-day storage, Common was reduced from 47.2 per cent to 9.09 per cent; Greenfield, 36.7 per cent to 8.33 per cent; Midland, 35 per cent to 8.9 per cent; and Coastal from 42.6 per cent to 9.2 per cent. The germination of sprigs was reduced with dry storage and was closely related to the decline in moisture content. Common germination dropped from 96 per cent to 34 per cent, Figure 4. There was no decrease in germination until after two days of dry storage. There was a four per cent increase from the eight-day to the 16-day sample. This variation was apparently due to mold and disease in the eight- and 16-day samples.

Greenfield germination declined from 58 per cent to 0 per cent over the 16-day period. Greenfield showed the same slow germination or dormancy as in the other tests. Midland declined rapidly at two days storage from 89 per cent to 33 per cent, then up to 55 per cent, then dropped to two per cent, and back to 10 per cent.

Coastal followed about the same pattern as Midland with an increase from two to four days storage of nine per cent. This variation may have been due to variation in sampling and moisture and also mold growth on the samples. It was noted that there was a large increase in mold and disease after two days stored dry. The mold was very severe at eight and 16 days storage and apparently damaged the roots and killed some of the buds. The buds on all samples were badly damaged by mold and disease and were very weak after eight days storage. Some of the nodes developed small roots, but no buds developed. Others had small bud germination with no root development.

Bud Germination of Dry-Stored Roots

A comparison of the number of buds germinating from the wet- and dry stored roots is given for the four varieties of Bermudagrass in Figures 11, 12, 13, and 14. The decline in germination of buds follow the same pattern as the sprig germination. The number of buds per sprig that germinate is reduced rapidly by dry storage when compared to the wet-stored roots. The number of buds germinating on the Common from the eight- to 16-day storage declined even though sprig germination increased.

SUMMARY AND CONCLUSIONS

The objectives of this study were to obtain information on the effect of depth of planting on Bermudagrass stands and to study the effect of wet and dry storage on the germination of Bermudagrass sprigs.

Common, Greenfield, Midland, and Coastal were used in the experiment for both the field planting and the germinating tests. Plantings were made at depths of 0, 1, 2, 3, and 4 inches on Kirkland silt loam soil at the Stillwater Agronomy Experiment Station.

The germination tests were made from the wet- and dry-stored roots, and the per cent nitrogen was determined over a 16-day period at 0-, 2-, 4-, 8-, and 16-day intervals.

The following conclusions were based on results and statistical analyses on the data obtained from these experiments:

Field Planting Studies

1. The highest per cent germination of all varieties was at the 0-inch depth with the sprigs in a vertical position.
2. The 0- and 1-inch depth of planting were superior to the 3- and 4-inch depth in total germination of sprigs in all varieties.
3. The Common strain of Bermudagrass used in the experiment had a higher per cent germination at all depths of planting than the other three strains, except it was equaled at the 0-inch depth by Coastal with 76 per cent germination.

4. Greenfield was slower in emerging and had lower germination at all depths than Common. The nitrogen content of the Common sprigs was 1.16 per cent as compared to .28 per cent for Greenfield. This could have contributed to the difference in germination and vigor.

5. Midland had the lowest average per cent germination of all varieties. Midland had a higher per cent germination than Coastal at the four-inch depth with 17 per cent as compared to 11 per cent for Coastal.

6. The per cent nitrogen content was very low in Greenfield, Midland, and Coastal, as compared to Common. The per cent nitrogen content for Common, Greenfield, Midland, and Coastal was 1.6, .28, .26, and .35, respectively. A soil test of the fields where roots were harvested showed a higher fertility level for Common than the other varieties.

7. The Common and Greenfield, which are both Common strains, germinated much better at the three-inch and four-inch depths of planting than the Midland and Coastal varieties.

8. It was noted that in a part of the plots where the soil remained wet and packed for two days after the rain which fell the day after planting, germination was reduced. Dry crusting of the soil did not seem to prevent emergence or damage the sprigs.

9. In general, the shallow-planted sprigs produced more vigorous plants and covered the ground more rapidly. The Greenfield planted at the three- and four-inch depths produced very weak plants.

10. The deeper plants delayed emergence and seemed to increase sprig damage by microorganisms. Soil that remained wet above the sprigs for two days after the rain seemed to contribute to sprig decay.

11. There was a wide variation in the growth of individual plants within the different rows of all four varieties.

Germination and Lab Studies

1. Dry storage of roots reduced germination in the four varieties of Bermudagrass.

2. Dry storage, in general, reduced the per cent moisture content of the sprigs throughout the 16-day period.

3. A rapid increase in mold growth was observed after two days dry storage in all varieties. This condition increased through the 16-day period.

4. Dry storage reduced the vigor of sprouts and retarded germination.

5. Dry storage reduced the number of buds germinating on the sprigs.

6. The per cent nitrogen content was slightly lower in the dry-stored roots than in the wet storage.

7. The decrease in moisture content of the roots in dry storage appears to be a major factor in the reduction in germination.

8. The germination and emergence under field conditions probably would be much less than the germinating test indicates because of reduced vigor and poor condition of the dry-stored sprigs.

9. The wet-stored roots maintained a higher per cent germination throughout the 16-day storage period than the dry-stored roots.

10. There was very little change in per cent germination of the Common, Greenfield, and Coastal throughout the 16 days wet storage. Midland was reduced from 89 per cent to 56 per cent.

11. Greenfield appeared to be more dormant than the other varieties. It required 14 days in the germinator to germinate fresh harvested roots of Greenfield as compared to eight to nine days for the other three varieties.

12. After eight days stored wet all varieties started sprouting except Greenfield.

13. There was less mold in the wet-stored roots as compared to dry storage, and the sprigs were in much better condition.

14. The per cent moisture increased in the wet-stored roots.

15. The results in the germinator would probably be higher than per cent germination in the field because many of the sprigs had sprouts that would be damaged in planting.

16. A major factor in successful storage of Bermudagrass roots is to maintain the moisture content.

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APPENDIX

TABLE III

EFFECT OF PLANTING DEPTH ON GERMINATION OF THREE-NODE SPRIGS OF COMMON BERMUDAGRASS ON KIRKLAND SILT LOAM JUNE 20 TO JULY 21, 1962

Depth Inches	June 30-62 Replications I	II	III	Total	Ave.	Per Cent Germ.	Depth Inches	July 6-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	16	13	14	43	14.3	57.33	0	18	16	19	53	17.66	70.66
1	10	12	6	28	9.3	37.33	1	13	19	18	50	16.66	66.66
2	3	0	6	9	3.0	12.00	2	9	9	18	36	12.00	48.00
3	1	1	1	3	1.0	4.00	3	13	12	10	35	11.50	46.66
4	1	0	0	1	.33	1.33	4	7	9	4	20	6.66	26.66
	31	26	27	84				60	65	69	194		

Treatment F= 2.0 (n.s.)

Treatment F= 5.3*

Depth Inches	July 13-62 Replications I	II	III	Total	Ave.	Per Cent Germ.	Depth Inches	July 21-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	19	17	20	56	18.66	74.66	0	19	17	21	57	19.00	76.00
1	14	23	19	56	18.66	74.66	1	14	23	19	56	18.66	74.66
2	12	12	19	43	14.33	57.33	2	12	12	20	44	14.66	58.66
3	16	11	13	40	13.33	53.33	3	17	13	13	43	14.33	57.33
4	12	9	11	32	10.66	42.66	4	12	13	12	37	12.33	49.33
	73	72	82	227				74	78	85	237		

Treatment F = 3.5 (n.s.)

Treatment F= 2.3 (n.s.)

Figures are the number of sprigs germinating of 25 sprigs planted of each replication at each depth on the dates indicated.

n.s. = Not statistically significant
* = Statistically significant at the 5 per cent level

TABLE IV

EFFECT OF PLANTING DEPTH ON GERMINATION OF THREE-NODE SPRIGS OF GREENFIELD BERMUDAGRASS ON KIRKLAND SILT LOAM JUNE 20 TO JULY 21, 1962

Depth Inches	June 30-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	1	3	3	7	2.33	9.33
1	0	1	0	1	.33	1.33
2	0	0	1	1	.33	1.33
3	0	0	0	0	.0	.00
4	1	0	0	1	.33	1.33
	2	4	4	10		

Treatment F = 4.6 (n.s.)

Depth Inches	July 6-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	9	14	19	42	14.00	56.00
1	7	9	9	25	8.33	33.33
2	2	5	6	13	4.33	17.33
3	2	1	5	8	2.66	10.66
4	7	0	4	11	3.66	14.66
	27	29	43	99		

Treatment F = 8.1*

Depth Inches	July 13-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	12	18	16	46	15.33	61.33
1	12	13	15	40	13.33	53.33
2	5	12	15	32	10.66	42.66
3	9	5	11	25	8.33	33.33
4	10	2	10	22	7.33	29.33
	48	50	67	165		

Treatment F = 2.8 (n.s.)

Depth Inches	July 21-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	12	18	18	48	16.00	64.00
1	13	15	16	44	14.66	58.66
2	18	13	16	47	15.66	62.66
3	11	7	11	29	9.66	38.66
4	10	2	11	23	7.66	30.66
	64	55	72	191		

Treatment F = 4.8*

Figures are the number of sprigs germinating of 25 sprigs planted of each replication at each depth on the dates indicated.

n.s. = Not statistically significant
* = Statistically significant at the 5 per cent level

TABLE V

EFFECT OF PLANTING DEPTH ON GERMINATION OF THREE-NODE SPRIGS OF MIDLAND BERMUDAGRASS ON KIRKLAND SILT LOAM JUNE 20 TO JULY 21, 1962

Depth Inches	June 30-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	1	1	13	15	5.00	20.00
1	0	2	8	10	3.33	13.33
2	0	0	1	1	.33	1.33
3	0	0	2	2	.66	2.66
4	0	0	1	1	.33	1.33
	1	3	25	29		

Treatment F = 2.01 (n.s.)

Depth Inches	July 6-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	5	6	16	27	9.00	36.00
1	0	7	18	25	8.33	33.33
2	3	0	11	14	4.66	18.66
3	0	1	5	6	2.00	8.00
4	2	0	4	6	2.00	8.00
	10	14	54	78		

Treatment F = 3.09 (n.s.)

Depth Inches	July 13-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	5	10	16	31	10.33	41.33
1	1	7	18	26	8.66	34.66
2	3	1	14	18	6.00	24.00
3	2	4	5	11	3.66	14.66
4	6	1	8	15	5.00	20.00
	17	23	61	101		

Treatment F = 1.5 (n.s.)

Depth Inches	July 21-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	6	10	17	33	11.00	44.00
1	1	9	18	28	9.33	37.33
2	4	1	15	20	6.66	26.66
3	3	4	6	13	4.33	17.33
4	6	2	9	17	5.66	22.66
	20	26	65	111		

Treatment F = 1.7 (n.s.)

Figures are the number of sprigs germinating of 25 sprigs planted of each replication at each depth on the dates indicated.

n.s. = Not statistically significant

TABLE VI

EFFECT OF PLANTING DEPTH ON GERMINATION OF THREE-NODE SPRIGS OF COASTAL BERMUDAGRASS ON KIRKLAND SILT LOAM JUNE 20 TO JULY 21, 1962

Depth Inches	June 30-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	4	11	9	24	8.00	32.00
1	3	1	5	9	3.00	12.00
2	0	1	1	2	.66	2.66
3	1	1	0	2	.66	2.66
4	1	0	0	1	.33	1.33
	9	14	15	38		

Treatment F = 12.1**

Depth Inches	July 6-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	9	15	18	42	14.00	56.00
1	10	9	18	37	12.33	49.33
2	2	3	8	13	4.33	17.33
3	7	4	2	13	4.33	17.33
4	1	0	0	1	.33	1.33
	29	31	46	106		

Treatment F = 5.3*

Depth Inches	July 13-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	15	20	21	56	18.66	74.00
1	14	9	14	37	12.33	49.33
2	2	3	11	16	5.33	21.33
3	8	5	5	18	6.00	24.00
4	2	1	4	7	2.33	9.33
	41	38	55	134		

Treatment F = 16.0*

Depth Inches	July 21-62 Replications I	II	III	Total	Ave.	Per Cent Germ.
0	15	20	22	57	19.00	76.00
1	15	11	16	42	14.00	56.00
2	2	5	12	19	6.33	25.33
3	9	7	6	22	7.33	29.33
4	3	2	6	11	3.66	14.66
	44	45	62	151		

Treatment F = 14.8**

Figures are the number of sprigs germinating of 25 sprigs planted of each replication at each depth on the dates indicated.

* = Statistically significant at the 5 per cent level
** = Statistically significant at the 1 per cent level

TABLE VII

PER CENT NITROGEN CONTENT OF MIDLAND, GREENFIELD, COASTAL, AND COMMON BERMUDAGRASS SPRIGS MAINTAINED UNDER WET AND DRY CONDITIONS FOR SIXTEEN DAYS, STILLWATER, OKLAHOMA, JUNE 20, 1962 TO JULY 6, 1962

Days Storage	COASTAL		MIDLAND		GREENFIELD		COMMON	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
0	.35		.26		.28		1.16	
2	.43	.28	.43	.23	.40	.31	1.26	1.13
4	.41	.40	.34	.25	.30	.30	1.45	1.15
8	.34	.41	.39	.26	.38	.32	1.38	1.36
16	.34	.31	.38	.32	.29	.26	1.33	1.40
Average	.38	.35	.36	.265	.33	.297	1.31	1.26

TABLE VIII

EFFECT OF WET AND DRY STORAGE ON MOISTURE CONTENT, PER CENT SPRIG GERMINATION, AND TOTAL BUDS GROWING ON ONE HUNDRED THREE-NODE SPRIGS OF COMMON BERMUDAGRASS

Days Stored Wet	Sprigs Replications I	II	III	IV	Per Cent	Per Cent H_2O	Days Stored Dry	Sprigs Replications I	II	III	IV	Per Cent	Per Cent H_2O
0	24	25	23	24	96	47.2	0	24	25	23	24	96	47.20
2	24	25	25	23	97	54.2	2	25	23	24	24	96	33.65
4	25	24	25	25	99	45.6	4	16	15	15	15	61	25.60
8	23	20	24	24	91	54.0	8	8	9	5	8	30	13.66
16	25	25	25	24	99	61.6	16	13	5	8	8	34	9.09
	121	119	122	120				86	77	75	79		

Treatment F = 2.1 (n.s.)

Treatment F = 92.0**

Days Stored Wet	Bud Count Replications I	II	III	IV	Total	Per Cent H_2O	Days Stored Dry	Bud Count Replications I	II	III	IV	Total	Per Cent H_2O
0	77	75	48	49	249	47.2	0	77	75	48	49	249	47.20
2	64	66	61	67	258	54.2	2	64	50	55	53	222	33.65
4	62	64	67	60	253	45.6	4	34	33	32	43	142	25.60
8	56	40	52	47	195	54.0	8	18	28	16	24	86	13.66
16	55	51	63	55	224	61.6	16	31	10	14	13	68	9.09
	314	296	291	278				224	196	165	182		

Treatment F = 2.3 (n.s.)

Treatment F = 20.8**

n.s. = Not statistically significant
** = Statistically significant at the 1 per cent level

TABLE IX

EFFECT OF WET AND DRY STORAGE ON MOISTURE CONTENT, PER CENT SPRIG GERMINATION, AND TOTAL BUDS GROWING ON ONE HUNDRED THREE-NODE SPRIGS OF GREENFIELD BERMUDAGRASS

Days Stored Wet	Sprigs Replications I	II	III	IV	Per Cent	Per Cent H_2O	Days Stored Dry	Sprigs Replications I	II	III	IV	Per Cent	Per Cent H_2O
0	14	15	17	12	58	36.7	0	14	15	17	12	58	36.7
2	11	10	13	11	45	49.7	2	17	13	14	12	56	29.3
4	18	14	18	16	66	50.77	4	11	10	9	7	37	20.3
8	18	14	12	14	58	47.00	8	6	3	7	3	19	17.37
16	17	14	17	13	61	52.45	16	0	0	0	0	0	8.33
	78	67	77	66				48	41	47	34		

Treatment F = 5.0* Treatment F = 76.0**

Days Stored Wet	Bud Count Replications I	II	III	IV	Total	Per Cent H_2O	Days Stored Dry	Bud Count Replications I	II	III	IV	Total	Per Cent H_2O
0	19	21	26	17	83	36.7	0	19	21	26	17	83	36.7
2	14	13	22	14	63	49.7	2	19	17	19	13	68	29.3
4	21	20	24	28	93	50.77	4	13	14	14	11	52	20.3
8	24	16	22	20	82	47.00	8	8	3	9	3	23	17.37
16	22	18	21	19	80	52.45	16	0	0	0	0	0	8.33
	100	88	115	98				59	55	68	44		

Treatment F = 3.2 (n.s.) Treatment F = 141.**

n.s. = Not statistically significant
* = Statistically significant at the 5 per cent level
** = Statistically significant at the 1 per cent level

TABLE X

EFFECT OF WET AND DRY STORAGE ON MOISTURE CONTENT, PER CENT SPRIG GERMINATION AND TOTAL BUDS GROWING ON ONE HUNDRED THREE-NODE SPRIGS OF MIDLAND BERMUDAGRASS

Days Stored Wet	Sprigs Replications I	II	III	IV	Per Cent	Per Cent H_2O	Days Stored Dry	Sprigs Replications I	II	III	IV	Per Cent	Per Cent H_2O
0	23	21	23	22	89	35.00	0	23	21	23	22	89	35.00
2	17	20	21	19	77	45.83	2	15	7	6	5	33	22.9
4	18	18	21	15	72	49.77	4	16	14	12	13	55	23.75
8	12	13	12	14	51	47.8	8	2	0	0	0	2	19.69
16	15	17	9	15	56	52.9	16	4	2	2	2	10	8.9
	85	89	86	85				60	44	43	42		

Treatment F = 8.7** Treatment F = 104**

Days Stored Wet	Bud Count Replications I	II	III	IV	Total	Per Cent H_2O	Days Stored Dry	Bud Count Replications I	II	III	IV	Total	Per Cent H_2O
0	50	46	51	42	189	35.00	0	50	46	51	42	189	35.00
2	34	36	41	38	149	45.83	2	24	8	8	9	49	22.9
4	29	28	41	29	127	49.77	4	23	21	20	22	86	23.75
8	23	16	19	25	83	47.8	8	2	0	0	0	2	19.69
16	21	25	14	18	78	52.9	16	5	3	2	3	13	8.9
	157	151	166	152				104	78	81	76		

Treatment F = 2.7 (n.s.) Treatment F = 116**

n.s. = Not statistically significant
** = Statistically significant at the 1 per cent level

TABLE XI

EFFECT OF WET AND DRY STORAGE ON MOISTURE CONTENT, PER CENT SPRIG GERMINATION, AND TOTAL BUDS GROWING ON ONE HUNDRED THREE-NODE SPRIGS OF COASTAL BERMUDAGRASS

Days Stored Wet	Sprigs Replications I	II	III	IV	Per Cent	Per Cent H_2O	Days Stored Dry	Sprigs Replications I	II	III	IV	Per Cent	Per Cent H_2O
0	24	22	23	22	91	42.6	0	24	22	23	22	91	42.6
2	22	25	20	20	87	51.22	2	14	11	12	8	45	29.64
4	20	18	22	20	80	45.1	4	14	10	17	13	54	22.9
8	21	17	21	21	80	46.4	8	6	1	4	5	16	18.3
16	19	20	19	22	80	52.2	16	2	0	0	0	2	9.2
	106	102	105	105				60	44	56	48		

Treatment F = 1.8 (n.s.)

Treatment F = 101.**

Days Stored Wet	Bud Count Replications I	II	III	IV	Total	Per Cent H_2O	Days Stored Dry	Bud Count Replications I	II	III	IV	Total	Per Cent H_2O
0	27	38	43	39	157	42.6	0	37	38	43	39	157	42.6
2	41	51	38	34	164	51.22	2	23	17	22	9	71	29.64
4	39	26	40	35	140	45.1	4	23	25	30	16	94	22.9
8	42	26	35	38	141	46.4	8	9	1	6	6	22	18.3
16	34	33	33	33	133	52.2	16	3	0	0	0	3	9.2
	193	174	189	179				95	81	101	70		

Treatment F = 1.3 (n.s.)

Treatment F = 6.6**

n.s.= Not statistically significant
**= Statistically significant at the 1 per cent level

VITA

Richard Ellison Chiles

Candidate for the Degree of

Master of Science

Thesis: THE EFFECT OF DEPTH OF PLANTING AND STORAGE OF WET AND DRY ROOTS ON THE GERMINATION OF FOUR VARIETIES OF FORAGE-TYPE BERMUDAGRASS

Major Field: Agronomy (Field Crops)

Biographical:

Personal data: Born November 20, 1907 at Billings, Oklahoma, the son of W. R. and Blanch Chiles.

Education: Attended elementary and three years high school at Woodland Rural School in Osage County, Oklahoma; graduated from Fairfax High School, Fairfax, Oklahoma in 1929. Undergraduate work at Oklahoma A. & M. College, with a major in Animal Husbandry, from 1929 to 1933; graduate study completed at Oklahoma State University in 1963.

Experience: Reared on a farm in Osage County; County Agricultural Agent, Murray County, 1933 to 1947; Director of Oklahoma State Parks, 1947 to 1951; Agricultural Extension Livestock Marketing Specialist, 1951 to 1953; Agricultural Extension Pasture Specialist, 1953 to 1963, Oklahoma State University.

Date of Final Examination: 1963