SOME ECOLOGICAL PHASES
OF CYNODON DACTYLON (L) PERS. (BERMUDA GRASS)

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INTRODUCTION

Pastures in Eastern Oklahoma are in need of a cover of good forage grass, a perennial grass that will furnish an ample amount of grazing, and one which will withstand long, dry periods without serious damage. A large percentage of the pastures are overgrown with unpalatable annual herbs. Some are little better than exercise lots for the livestock, resulting in serious soil erosion.

Bermuda grass (Cynodon dactylon (L.) Pers.) has been introduced into many pastures in the past decade. This grass has been recognized by many cattlemen as a valuable forage plant. It shows many qualities of a desirable pasture grass, however, very little on the yields, erosion control, root system and drought resisting qualities of this plant has been studied.

The purpose of this study is to investigate some of the characteristics of Bermuda grass that make it valuable as a pasture grass in Oklahoma. A study was made of the root system of seedlings from two weeks to ten weeks of age, to determine its rate, depth, and extensiveness of growth.

The production of the grass was determined and its composition studied by making comparisons with the composition of some other forage plants. These results indicate the value of Bermuda grass as food for livestock.

Some of the drought resisting qualities of the plant are shown in the leaf and stem structure and the osmotic pressure of the plant sap.

The manner and efficiency of propagation are shown by a study of the extensive root system and the production of adventitious roots at the nodes on the stem. Thus the plant is able to establish itself quickly.

CLIMATE

A compilation of data up to 1916 as shown in a Soil Survey of Payne County, 1916, gives the following facts about the climate: The average date for the last killing frost is April 8. The average date for the first killing frost is October 26, giving a normal growing season of 200 days.

The average annual rainfall is 34 inches with most of the precipitation coming in the winter and spring. Low rainfall in the summer months along with high wind velocity, high evaporation rate, and low humidity often results in drought.

Payne county has a mean annual temperature of 59° F., with the mercury going as high as 105° - 108° F. during July and August. The mean temperature of the winter months is 37.8° F. with a temperature as low as -18° F. being recorded.

TEMPERATURE AND RAINFALL

The figures for the daily minimum and maximum temperatures for May and June 1949 were secured from data taken by the Agronomy Department, Oklahoma A. & M. College. Weekly averages of the minimums and maximums are shown in Fig. 1. Also the daily rainfall for the same period was secured and the total for each week recorded.

Most of the precipitation for these two months fell during the two week period of May 15-28, as shown in the chart. The rainfall for the remainder of the period was light.

For the first two weeks the temperature showed a downward trend after which it rose fairly steadily to a maximum day temperature of 92° F.

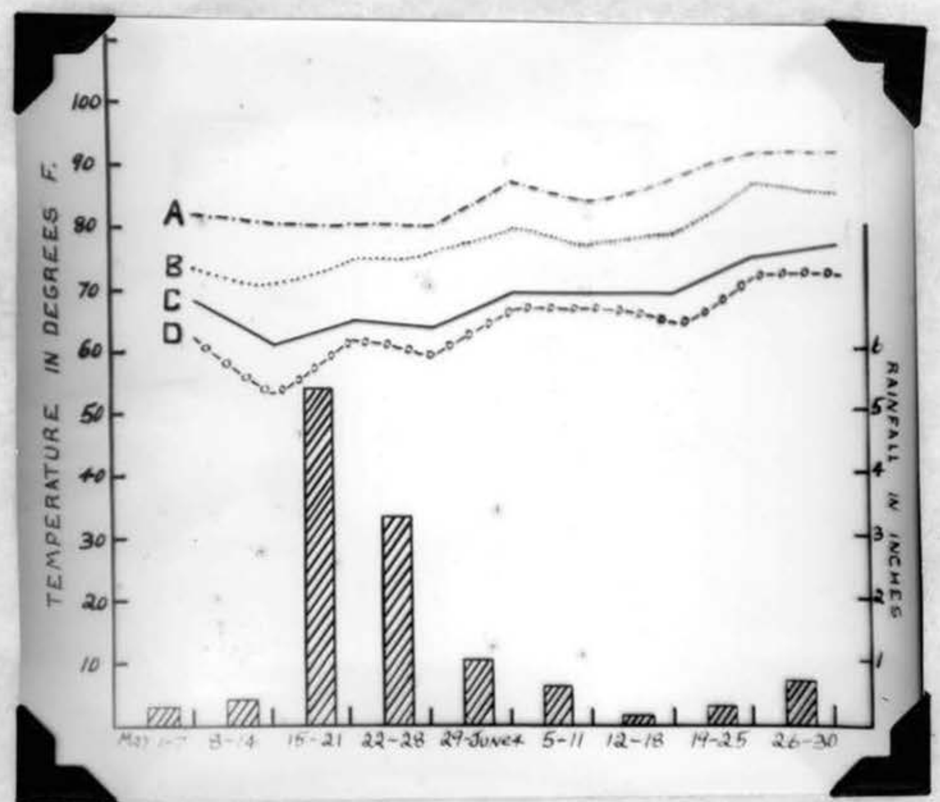

Fig. 1 Weekly averages of the daily minimum and maximum temperatures. A. - Day maximum. B. - Night maximum. C. - Day minimum. D. - Night minimum.

The weekly rainfall is shown in the lower part of the graph.

FORAGE PRODUCTION

In order to determine the forage production of Bermuda grass, two Bermuda grass pastures were selected. Four exclosures were erected at random in each pasture. (Fig. 2)

Location of Plots

Pasture no. 1, owned by George Schroeder, is located $2\frac{1}{2}$ miles west of Stillwater on Highway 51. It contains 50 acres with a gently rolling topography. Areas of pure Bermuda grass were scattered over the pasture. It was on one of these, near the southwest corner, that the four exclosures were located. (Fig. 2) In this area the foliage cover was 100%. This pasture was quite heavily grazed by cattle and sheep.

Fig. 2 View of the pasture showing arrangement of exclosures.

Pasture no. 2, owned by Lee Stevens, is located ½ mile west of Stillwater on Highway 51. It contains 5 acres and is quite level over the entire area. The foliage cover of Bermuda grass was 100%. Four exclosures, as shown in Fig. 2, were also placed in this pasture.

Soil Types

The soil in the Schroeder pasture is classed as Reinach silt loam. The Reinach series consists of reddish-brown soils underlain by chocolate-red or salmon-red, lighter textured soils. The Reinach soils occupy terraces along streams which drain the Permian Red Beds.

The Reinach silt loam is a chocolate-brown to dark chocolate-red, friable silt loam, underlain at about 8 to 12 inches by a more compact light chocolate brown silt loam which grades below into yellowish-red to light chocolate-red very fine sandy loam to very fine sand.

In the Stevens pasture the soil is Kirkland loam. The surface soil is typically a brown or dark-brown, mellow loam, varying in depth from 8-15 inches. It usually passes abruptly into a heavy, tenacious, hard clay subsoil.

Soil classifications were given by the Soils Department, Oklahoma A. & M. College.

Materials and Methods

The exclosures used in this study were constructed of one inch material and covered with poultry fencing to keep cattle from grazing any of the grass. The base was 4.5 ft. by 4.5 ft. allowing a margin of 7.5 inches between the base of the exclosure and the meter quadrat, which it enclosed. The center height of the exclosure was 3 ft. (Fig. 2)

Meter quadrats were laid out about seven feet apart with stakes at opposite corners marking the location of each. Four quadrats were laid out in each pasture.

Fig. 3 Clipping the grass.

Early in the spring, before the current year's growth began, all dry grass and foreign material was removed from each quadrat in order to facilitate clipping later.

The first clipping was made on May 18 and the quadrats were clipped at two week intervals thereafter until the final clipping on August 13. The grass was cut to a height of one inch at each clipping to simulate grazing. Hand clippers were used. (Fig. 3) The grass from each quadrat was put in a paper bag; the number of the quadrat and the date were written on the bag. This simplified the taking of data when the grass was weighed later after becoming air dry. Torsion balance scales were used for the weighing. Weights were made to a tenth of a gram.

	Quadrat.	May 18	June 4	June 18	July 2	July 16	July 30	Aug. 13	Total	Averages.	Lbs. Per acre	Tons per acre
Pas-	A	105.5	55.5	61.0	62.5	50.5	58.0	43.0	436.0			
ture	B	70.0	46.9	74.5	61.5	42.0	67.5	50.0	412.4	456.7	4153.2	2.07
1	C	98.7	61.0	82.5	76.5	55.0	78.2	56.5	508.4			
	D	97.9	47.7	69.5	82.0	56.0	66.2	51.0	470.3			
Pas-	A	141.7	30.5	60.5	50.5	44.0	42.5	16.0	385.7			
ture	B	135.0	23.5	43.5	47.0	41.5	34.5	11.0	336.0	363.3	3303.8	1.65
2	C	123.0	19.5	53.5	55.5	47.0	47.0	19.0	364.5			
	D	140.0	27.2	53.0	46.0	42.5	39.5	19.0	367.2			
Total per cutting		911.8	311.8	498.0	481.5	378.5	433.4	265.5				

Table 1. Air dry weight in grams of Bermuda grass clipped at two week intervals.

Results

The average production of the four quadrats in each pasture (Table 1) was as follows: In pasture no. 1 the average production of Bermuda grass was 456.7 grams per square meter, which is equal to 4153.2 pounds per acre. Over two tons of Bermuda grass hay per acre were harvested by August 13.

Pasture no. 2 had an average production of 363.3 grams. This amounts to 3303.8 pounds of Bermuda grass hay per acre (slightly over a ton and a half of hay).

Fig. 4 shows one of the plots just prior to being cut. The grass was carefully cut and put in a paper sack for air drying, prior to its being weighed.

Fig. 4 Quadrat of Bermuda grass before clipping.

In making a comparison of the composition of green Bermuda grass with other green pasture plants (Table 2), it was found that Bermuda grass ranks high in both digestible protein and in total digestible nutrients. (Morrison 1945) Some of the legumes are higher in digestible proteins, but none are higher in total digestible nutrients. Even on some of the poorer soils a comparatively high production of nutrients can be harvested.

Green Roughages	Dig. Protein(%)	Total dig. nutrients(%)
Alfalfa, green, all analyses	3.4	14.7
Bermuda grass	2.8	25.0
Blue grass, Ky., all analyses	2.4	18.6
Clover, red, all analyses	2.6	15.4
Grama grass	2.0	20.6
Lespedeza, annual	5.0	20.9
Rye grass, perennial	1.4	15.5
Sudan grass, all analyses	1.4	17.7

Table 2. Analysis of some green roughages as given in F.B. Morrison's "Feeds and Feeding", twentieth edition 1945.

SURFACE FOUR INCHES OF ROOTS IN SOD

The roots near the surface of the soil aid the plant to utilize small amounts of rainfall. This feature, along with depth of roots, enables a plant to withstand relatively long periods of drought and to recover with a light rainfall. These surface roots are also valuable as a soil binder. Information regarding the amount of roots of Bermuda grass in the surface soil is not available, therefore it was decided to include this problem in my research.

Method Used

A stout box one meter long, by one-half meter wide, and ten centimeters deep (i.e. 39 3/8 by 19 5/8 by 4 inches) was made of planed pine lumber about one inch thick. A frame was made with outside dimensions of one meter by one-half meter.

The grass tops and other refuse were removed from the area to be dug. The frame was placed on the sod and the area marked off by spading around the outside of the frame. An area of soil completely surrounding the plot to be studied was removed to a depth of 2 to 3 feet. This left a pillar of soil topped by the sod. The frame was removed and the box was placed top down to enclose the desired roots. The pillar of soil was dug to a V shape at the bottom so that the whole mass could be inverted, leaving the box holding the roots and soil. The soil was cut off even with the top of the box and boards nailed across to hold the sod in place while it was being moved to the greenhouse for washing. Fig. 5 shows the 4 inches of soil with the roots ready for washing.

Washing Soil From the Roots

The box was placed on a frame with a 30 degree slope. A spray was used to begin the washing. This had little effect upon the soil as it was so firmly held by the mass of roots. After the soil was well soaked more water pressure

Fig. 5 Bermuda grass roots
in the surface 4 inches of
soil ready for washing.

Fig. 6 Roots after soil
has been washed away.

was applied to hasten the removal of the soil. This washing continued for eight hours. During the night the box of sod was placed in a large pan and covered with water, thus permitting soaking of the soil. The washing was resumed the following day, being continued for 12 hours, at the end of which the soil was washed out. This gave a total of 20 hours required to free the roots of all soil. It can be seen that this mass of roots in the top 4 inches of soil has remarkable soil holding qualities. (Fig. 6) This along with the abundance of top growth, which breaks the force of the rainfall, reduces erosion to a negligible amount. Kramer and Weaver (1937) state that in Brome grass tops reduce erosion by 7 times.

Determining Weight and Volume

The roots were air dried, then weighed on a torsion balance scale. The weight of the ½ square meter of roots in the surface four inches was 721 grams, which is equal to 13076.25 pounds per acre or 6.53 tons. Kramer and Weaver (1937) found the following: for Brome grass 4001.4 pounds or 2 tons per acre, for Bluegrass 4892.6 pounds or 2.44 tons per acre.

The volume of the roots was determined by water displacement as described by Kramer and Weaver (1937). The volume amounted to 1.2 liters, which is equal to 9900 liters in the surface four inches of soil over an acre. This is 2.4% of the soil.

GROWTH OF SEEDLINGS IN THE GREENHOUSE

The growth habits of a plant can best be studied by observing the development of the plant from seed. Such studies will show the rate of growth of both tops and roots as well as the total growth of the plant. With this in mind, Bermuda grass seeds were planted in the greenhouse on January 27, 1949.

Fig. 7 Soil boxes showing the removable side.

Materials and Methods

Bermuda grass seeds were planted about 2 inches apart in two tall wooden boxes. The boxes were 10 inches square and 30 inches deep with a removable side. (Fig. 7) The boxes were packed with sterile soil. Each spot where a seed was planted was marked in order that the germination of each seed could be determined. The seeds germinated quite readily.

After two weeks four plants were removed and drawn. The side of the box was removed and the soil carefully dug away with an ice pick so the entire root system could be removed. The side of the box was then replaced and the soil put back in the box. Measurements were made of the tops and roots and sketches were made of the entire plants. (Fig. 8)

Measurement of Plants at Different Stages of Growth

On January 27, 1949 twenty-eight Bermuda grass seeds were planted in each of two boxes. The seeds were very small and tedious to handle. When watering

Fig. 8 Development of Bermuda grass from seeds. A - two weeks after planting. B - four weeks after planting.

the plants, extreme care had to be exercised to prevent washing the seeds from their places.

Of the 56 seeds planted 75.8% or 44 seeds germinated. At two, four, six, and ten weeks after the seeds were planted 4, 5, 3, and 3 plants respectively were removed, measurements taken of tops and roots, and drawings made of the entire plants. The averages of the respective measurements were taken (Table 3)

No. weeks after planting	Length in millimeters Roots	Tops
2 weeks	38	30
4 weeks	92	160
6 weeks	166	321
10 weeks	683	750

Table 3. Rate of growth of seedlings from 2 to 10 weeks.

At the end of the two week period the roots had grown to a depth of 38 mm. with very few secondary roots. Only one plant showed evidence of an adventitious root. At the end of 4 weeks the roots had almost tripled in length while the tops were more than 5 times as long. The root system at this period was made up mainly of adventitious roots. By the end of ten weeks the roots had grown to a length of 683 mm.

Fig. 9 Bermuda grass seedling 6 weeks after planting.

Fig. 10 Bermuda grass roots at ten weeks.

Fig. 11 Roots of Bermuda grass at 21 weeks.

Twenty-nine plants were left in the boxes and allowed to grow until July 3, 1949, 21 weeks after planting. A side was removed from each box and by use of a hose all the soil was washed carefully from the roots. (Fig. 10) After roots and tops had become air dry, the tops were cut from the roots. (Fig. 11 and Fig. 12) The tops and roots were then weighed on torsion balance scales. (See Table 4)

Fig. 12 Hay from 29 Bermuda grass plants at 21 weeks of age.

A container was completely filled with water and placed in another container. The roots were wet thoroughly, the excess water squeezed out, and the water on the surface of the roots taken off with a blotter. The roots were immersed in the water causing some water to overflow into the lower container. This over-flow water was measured, which gave the volume of the roots as shown in Table 4.

No. weeks after planting.	Air dry weight in grams Roots	Tops	Volume in c.c. Roots
21 weeks	119.2	802	292

Table 4. Weight of roots and tops, and volume of roots at 21 weeks.

Results

In the first two weeks growth, the roots exceeded the top growth. The primary roots were practically the only ones in evidence at this time, with only one plant showing development of an adventitious root. After four weeks of growth the tops began to show greater development than the roots, until the final observation when the tops weighed almost eight times that of the roots. When the roots were removed at the end of 21 weeks, they had reached the bottom of the box, where the ends were spread out and netted.

Fig. 13 Roots of a single plant of Bermuda grass at 21 weeks.

VEGETATIVE METHODS OF REPRODUCTION

In addition to reproduction by seed Bermuda grass can reproduce from runners and from underground stems, the former being the method by which it establishes a thick sod in the summer. Wherever a node, on the stem, comes in contact with the moist soil, adventitious roots develop, a new shoot will begin to grow, and a new plant will be established. (Fig. 14) In Bermuda grass this method of reproduction is so rapid that in a single season one plant can completely cover an area of several square feet. (Fig. 15)

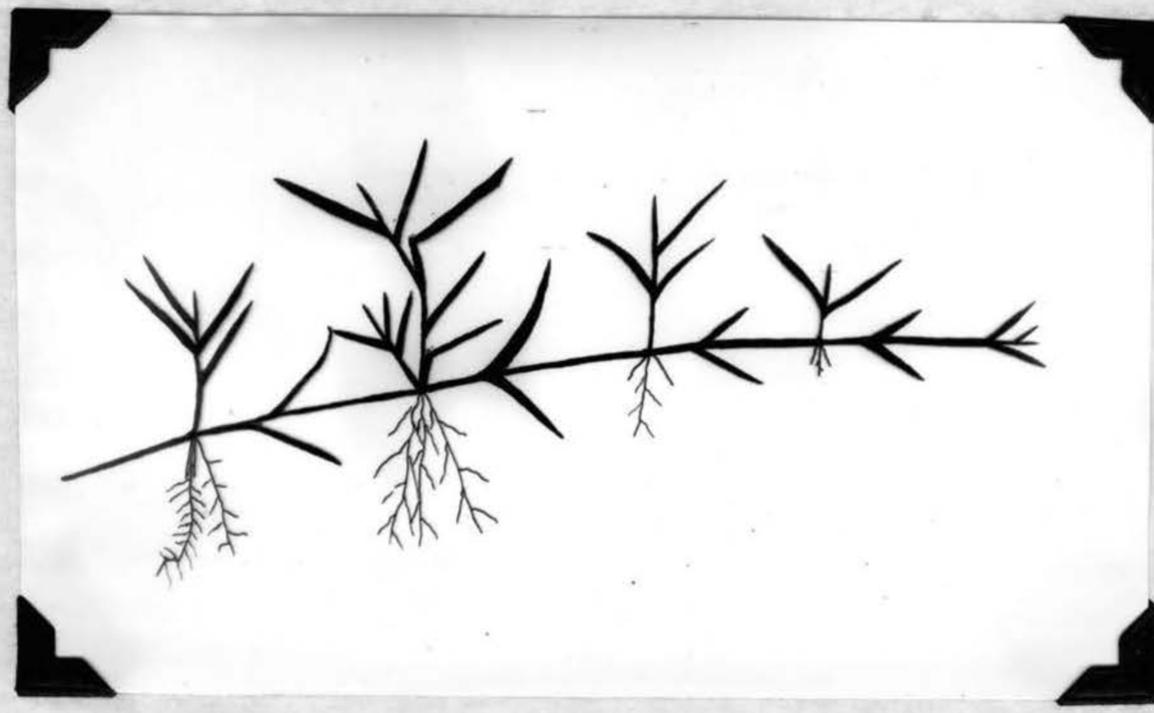

Fig. 14 A runner of Bermuda grass showing roots and shoots growing at the nodes.

In Oklahoma and in other areas near the northern limit of the growth of Bermuda grass (Fig. 16) the vegetative method is the most desirable in establishing a pasture. The vegetatively propagated plant will withstand a severe winter much better than a plant grown from seed. Even though Oklahoma enjoys relatively mild winters, temperatures as low as -18° F. have been recorded.

In temperatures as low as this Bermuda grass grown from seed is likely to succumb.

Fig. 15 A single plant of Bermuda grass showing runners spreading out in all directions.

Fig. 16 Distribution of all species of Bermuda grass in the United States. The upper line indicates its northern limit, but the grass is of most value for pasture in the lower, shaded area.

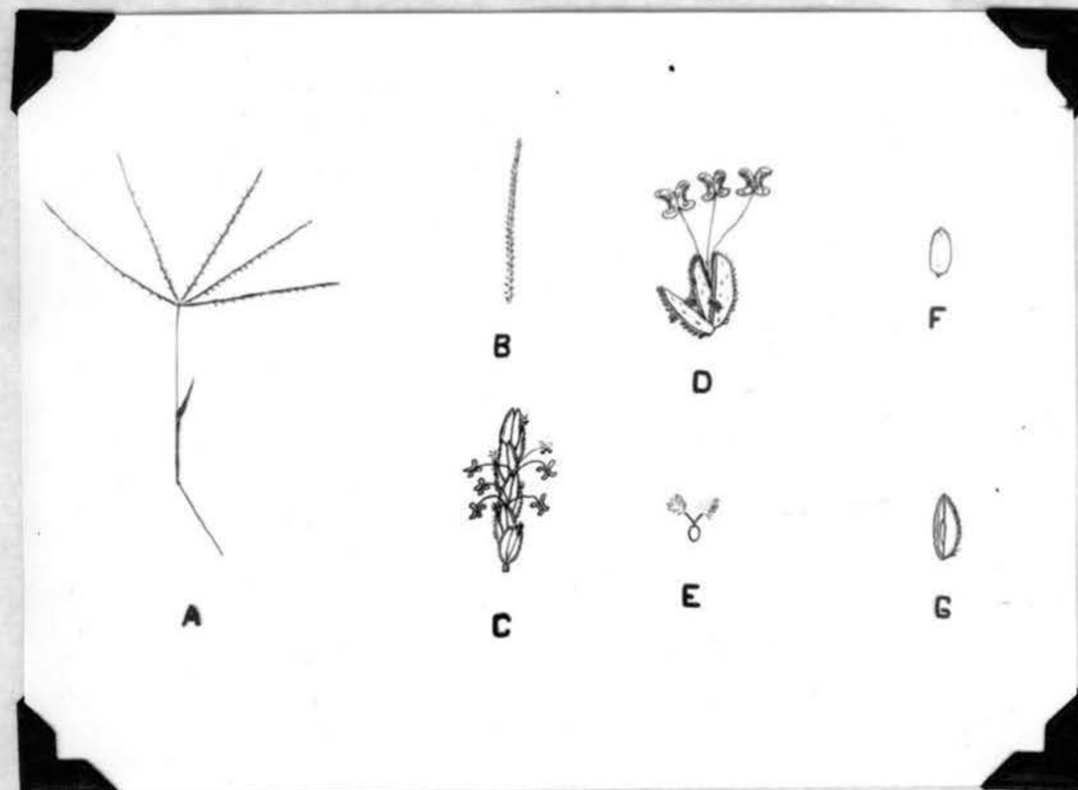

Fig. 17 The inflorescence of Bermuda grass. A – Complete inflorescence. B – A single spike. C – Enlarged portion of a spike showing the arrangement of the spikelets. D – A single spikelet. E – Pistil showing the plumose stigmas. F.– A naked seed. G – Seed with husk.

FLORAL PARTS

The inflorescence of Bermuda grass consists of 3-6 slender, secund, digitate spikes from the apex of a branch. (Fig. 17-A) Spikelets (Fig. 17-D) are one-flowered with the rachilla extending behind the palea.

STRUCTURE OF LEAF, STEM, AND ROOT

The leaf of Bermuda grass is 4-6 inches long, varying with the variety. It is narrow, entire, and acuminate at the apex. It has many inconspicuous, parallel veins, extending the length of the leaf. (Fig. 18-A) Along the upper edge of the leaf, between the veins are large parenchyma cells which enable the leaf to curl (Fig. 18-B) and thereby reduce transpiration when dry weather occurs.

Strengthening tissue is located within the veins. The spaces between the veins are filled with parenchyma cells.

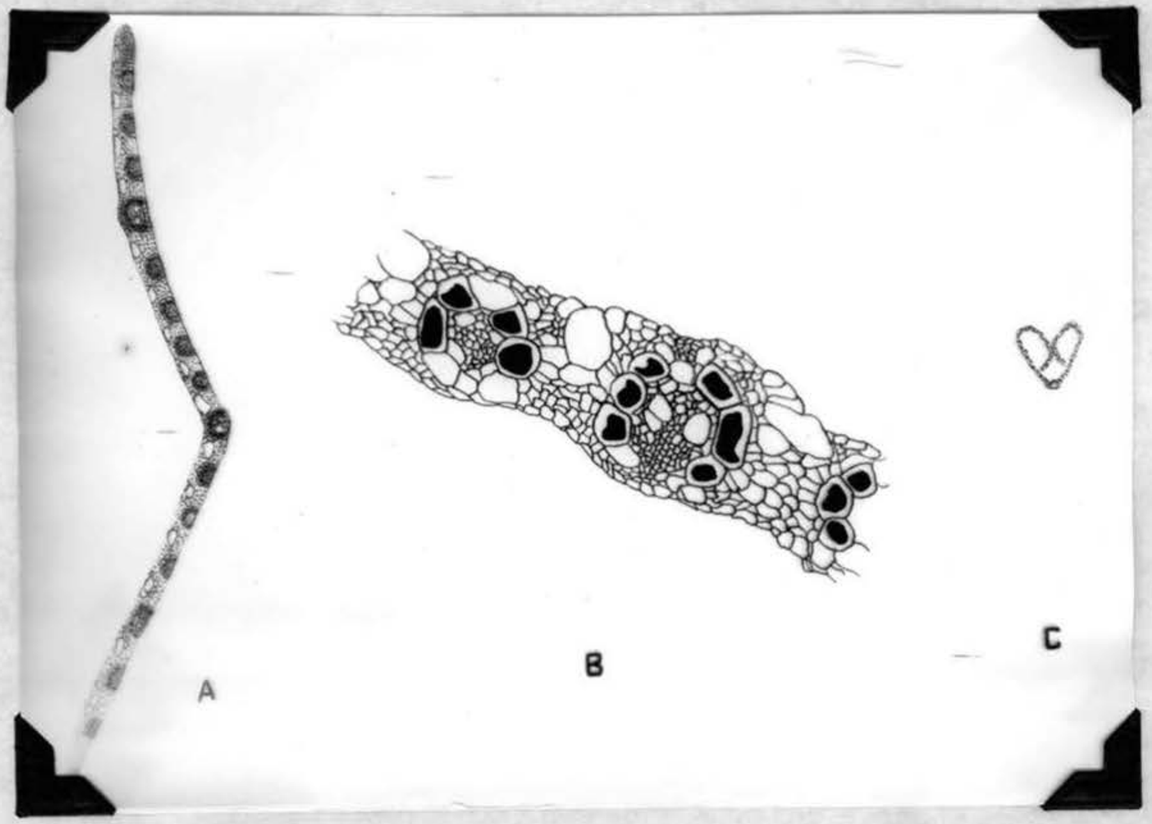

Fig. 18 A - Cross-section of leaf of Bermuda grass, showing the arrangement of the veins. B - Enlarged portion of leaf, showing the large cells between the veins. C - Section of curled leaf.

The stem of Bermuda grass has a small pith cavity surrounded by a large area of parenchyma cells. (Fig. 19-A) It is within the parenchyma that the vascular bundles are scattered, with the outermost bundles being arranged in a more or less irregular ring near a narrow band of sclerenchyma fibers. Immediately beneath the epidermal cells is a strip of chlorenchyma tissue.

The stele of the root of Bermuda grass is relatively large, having a large xylem area with several short radiating arms. (Fig. 19-B) It is between these arms that the phloem is located. Surrounding the stele is a wide band of cortical parenchyma. The hypodermis is very narrow, lying beneath the epidermis.

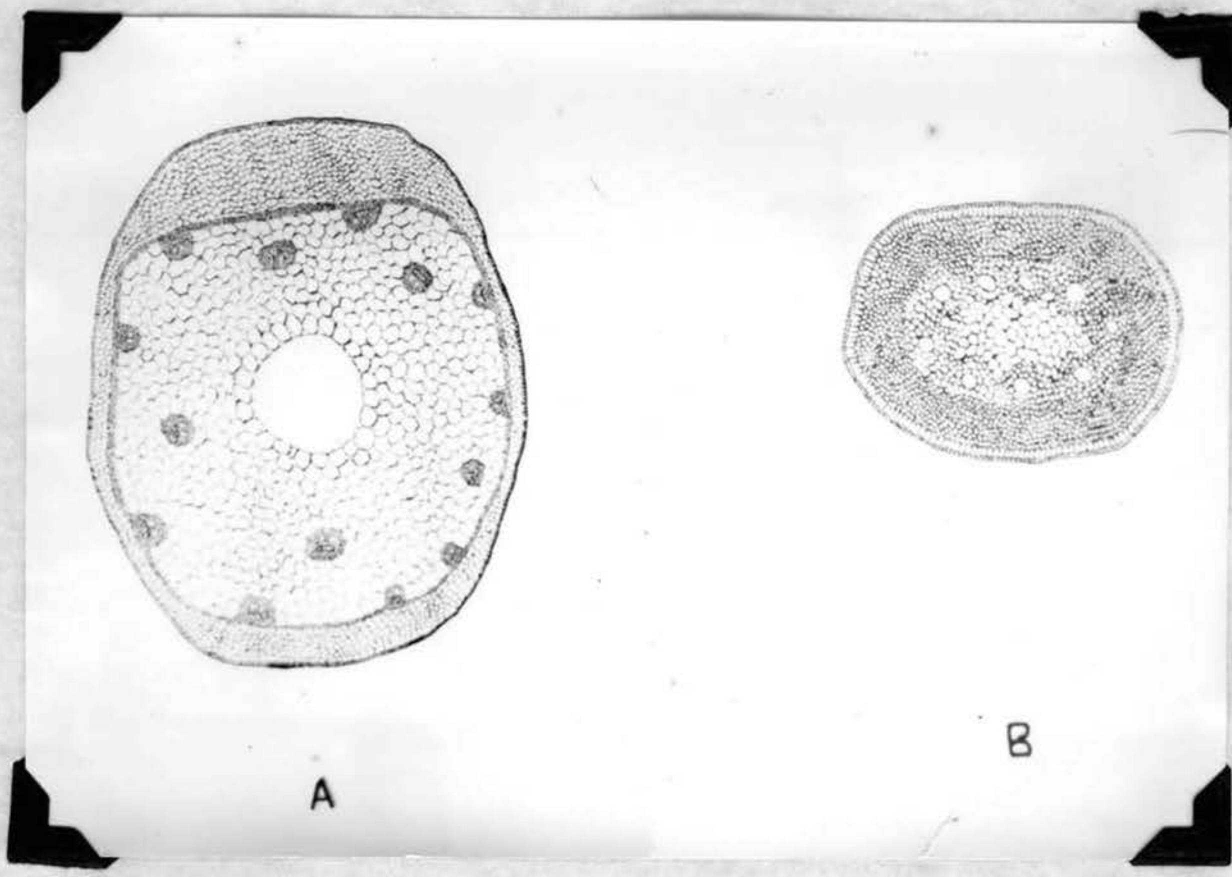

Fig. 19 A - Cross-section of stem of Bermuda grass. B - Cross-section of the root.

OSMOTIC PRESSURE OF PLANT SAP

The osmotic pressure of the plant sap is an indication of the concentration of the solutes in the cell solutions. The higher the osmotic pressure the greater the concentration of solutes. The concentration of the solutes in the plant sap affect its ability to withstand drought. The osmotic pressure of the plant sap of Bermuda grass was determined at two different periods during the summer, June 7 and July 15, 1949.

Procedure

The samples of Bermuda grass were cut three inches from the tip of the plant between the hours of 12 O'clock noon and 1 O'clock p.m. The grass tissues were frozen and allowed to remain so for 24 hours (a plan used similarly by Dr. Marsh (1940) of Nebraska, as described in "Water Content and Osmotic

Pressure of Certain Prairie Plants in Relation to Environment"). The tissues were then thawed and the sap expressed under a pressure of 12,000 pounds. The

Fig. 20 Beckman thermometer set up for determining osmotic pressure.

sap was kept on ice until it was used. Twenty c.c. of the sap was taken and the osmotic pressure determined by use of the Beckman thermometer. (Fig. 20) This method involves the determination of the freezing point of the sap (depression in degrees below the freezing point of distilled water).

Results

When using the Beckman thermometer to determine the freezing point of plant saps, the freezing point of water must first be determined. Before making the first osmotic pressure test on Bermuda grass sap, the freezing point of distilled water was found to be 3.06 on the Beckman thermometer. Using the formula

$\Delta = \delta - \frac{\delta u}{80}$ as a correction factor for supercooling where:

Δ = true depression below the freezing point of water.
δ = the apparent depression below the freezing point of water.
μ = the supercooling.

and using the formula, osmotic pressure = $\frac{\Delta \times 24}{1.86}$, it was found that the osmotic pressure of Bermuda grass sap was 12.7 atmospheres.

Using the same method for the second test, the osmotic pressure was found to be 11 atmospheres. Dr. Marsh (1940) found the osmotic pressure of *Andropogon furcatus* to be 12.8 and for *Poa pratensis* to be 8.8 atmospheres.

DISCUSSION

In Payne County, Oklahoma, the location of this study, Bermuda grass is near its northern limit of growth. However, Eastern Oklahoma lies within the area suitable for its best production.

Rainfall in this area was quite uneven during the summer months of 1949. In one period there was an excessive amount, while at another time and for a fairly long period there was very light rainfall. The root system of Bermuda grass is adaptable to this type of precipitation. The depth of roots (35 inches in ten weeks) enables it to survive relatively long dry periods, while with the extensive root system in the surface soil it is able to utilize a light rainfall and to make a quick recovery.

In Oklahoma, where soil erosion is an important consideration in the use of the land, these roots in the surface soil are valuable in binding the soil and in aiding to prevent erosion, as indicated by requiring 20 hours to wash 4 inches of soil from the roots. The character of the foliage growth in making a mat of cover over the soil breaks up the rain-drops and slows down the water runoff to a point where erosion is practically nil.

The primary interest that a farmer has in a pasture grass is the amount of food material it will furnish to grazing animals. The high production (as shown in Table 1) and the high nutrient content (as shown in Table 2) make Bermuda grass valuable as a pasture grass. Animals show a liking for this grass in its early stages of growth, but, they will eat very little of it as it nears maturity. A palatable stand of grass may be maintained by heavier grazing or frequent mowing. Probably most Bermuda grass pastures are undergrazed. The clipped quadrats maintained a cover of tender grass free from tough stems.

The cellular construction of the leaf of Bermuda grass has an interesting feature in the large parenchyma cells located near the upper side between the many vascular bundles. During dry, hot weather these cells enable the leaf to curl thereby reducing transpiration and the resultant loss of water. This adds to the drought resisting qualities of the plant.

The ease of propagation from vegetative parts and the rapid growth made by Bermuda grass readily establishes a cover of foliage over bare areas.

In this experiment it was necessary to have a well prepared seedbed, as the seeds were easily washed away if the seedbed was too loose. Also, depth of planting was important, as a cover of more than a quarter of an inch of soil prevented germination. Plants are easily washed away in the seedling stages thus making propagation from seed more difficult than vegetative propagation.

SUMMARY

Some unknown characters of *Cynodon dactylon* (L.) Pers. were studied in an attempt to determine its value as a pasture grass, and to reveal its drought resisting and erosion control qualities.

Evidence gathered from clipping quadrats in two pastures near Stillwater, shows Bermuda grass to have a good yield of forage. The average production of the 8 areas in the two pastures was 3728.5 pounds per acre. A comparison of the composition of green Bermuda grass with some other green roughages, shows it to rank high both in digestible protein and in total digestible nutrients.

Bermuda grass has an unusual ability to hold soil. A study of the roots

in the surface four inches of soil brought to light some interesting qualities. Twenty hours were required to completely wash the 4 inches of soil from the roots of $\frac{1}{2}$ square meter of sod.

The development of Bermuda grass was studied by observing plants grown from seeds planted in the greenhouse. Growth was rapid and extensive. At the end of 8 weeks the roots grew to a depth of nearly 6 inches, while the tops grew over 12 inches. The habit of the grass in reproducing from runners and underground stems makes it possible to quickly establish a thick sod over a pasture.

Large parenchyma cells located in the leaf enables it to curl and thereby aids the plant to withstand dry periods. An osmotic pressure of 12 atmospheres also aids in drought resistance.

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