SOIL MOISTURE STUDIES WITH FOUR VARIETIES OF BERMUDAGRASS

By

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SOIL MOISTURE STUDIES WITH FOUR VARIETIES

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CHAPTER I

INTRODUCTION

The importance of available soil water in plant growth can be understood from different points of view. Water is essential to all of the complex chemical and physical processes in soil-plant relations. The dynamic relationship of soil moisture and its availability to growing plants involves the physiology of the plant and the soil physical properties.

A knowledge of the range of available water, seasonal periods of moisture stress (when moisture stress begins to reduce yield) and the relationship of continued depletion of water to reduced yield under stress conditions, provides useful information for efficient managemental use of water. Similarly, it would allow management strategies to be devised to improve the likelihood of success in establishing pastures and fodder crops which often are inhibited by lack of moisture.

Crop yield response with restricted soil moisture varies for different crops, and depends on the timing of the deficiency within the growth cycle. Because of the increasing demand for fresh water for domestic and industrial purposes, and because inadequate supplemental water as well as excess water reduces yield, irrigation needs must be carefully determined.

Lack of available soil moisture restricts forage growth in many years. Heavy soil compaction and low soil moisture content cause reduction not only in root proliferation, but also in shoot growth and emergence, which in effect, bring about variations in plant growth, maturity, and yield.

This study was undertaken to obtain information about soil moisture at different depths through a growing season for four bermudagrass (*Cynodon dactylon*) cultivars.

CHAPTER II

LITERATURE REVIEW

Kramer (1955) considered drought a severe deficiency of soil moisture which brings about internal water deficits in plants. The ultimate result is reduced plant growth or death. Price (1975) studied the flux and uptake of soil water within bermudagrass root zones. He concluded that the water uptake pattern changes most rapidly near the soil surface during the first few days after irrigation. Rewetting within the soil profile occurred in late afternoon at depths where upward gradients were present.

Musick *et al*. (1976) made a general statement that fifty percent of the available water can be depleted from the root zone in fine-textured soils before a significant yield reduction occurs. Hagan and Peterson (1953) indicated that for a given soil and climate, the required frequency of irrigation would be directly dependent upon the effective depth of rooting. The consumptive-use rates of soil moisture did not increase with the height of the stand as long as the soil surface was covered. Forde *et al*. (1976) reported that drought tolerance and establishment of seedlings were closely related to their growth rate at higher water potentials, maximum depth of root penetration, and rate of extension of the root system. Nour and Weibel (1978) studied root characteristics among ten sorghum cultivars (*Sorghum bicolor*) known to vary for drought resistance. They reported that the most drought resistant cultivars had heavier root weight, greater root volume, and higher root/shoot ratio. Finally, they commented that root weight would probably be the most indicative and easiest characteristic measurable to determine drought resistance.

Robertson (1952), in his presidential address to the American Society of Agronomy, stated that a knowledge of the critical stage in plant growth when adequate water is necessary, will aid in more efficient use of water. Smith and Stephens (1976) considered soil moisture as the main factor limiting pasture growth during summer. They suggested that soil moisture makes a greater contribution to the variability in pasture growth than does temperature. Smith and Johns (1975) stated that soil moisture levels rise to a maximum in late winter and decline to a minimum in midsummer. Also, they recommended that the safest time for establishing new plant species into temperate pastures is probably early winter. Fodder oats grown in autumn would often be inhibited by a lack of soil moisture, unless preceded by a fallow period to conserve later summer rainfall.

Gubbols (1978) reported that irrigation of buckwheat (Polygonum convolvulus) during flowering and seed development stages resulted in yield increases of 11-26 percent. He noted that the increases in yield were related to increases in the number of seeds. The results agreed with those of Veremeidik (1972). He grew buckwheat in plots at 60 percent of field capacity for the entire growing season. In the second treatment, he grew buckwheat at 60 percent of field capacity until flowering, followed by 30 percent for the remainder of the season. The later treatment reduced the number of seeds per plant by 27 percent. Finally, he stated that management practices which conserve moisture could improve production in a dry season.

Haddock (1949) found that the total amount of irrigation water required to produce sugar beets (*Beta vulgaris*) in Utah may be of less importance than the time when the water is applied. Begg (1959), Johns and Lazenby (1973) noted that soil moisture is usually adequate for pasture growth during winter, but inadequate during summer. During early winter, when evaporative demand is low, soil moisture recharges and reaches a peak by late winter. In addition, they pointed out that during spring and early summer, soil moisture is progressively depleted, reaching a minimum by midsummer.

Holford and Doyle (1978) studied the effect of grazed lucerne (*Medicago sativa*) on the moisture status of wheat-growing soil. They concluded that lucerne extracted available soil moisture to a depth of 100 cm (40 inches) within eight months of sowing. Within 18 months, available water was extracted to a depth of 200 cm (80 inches). Furthermore, they stated that wheat extracted water from the soil to a depth of 150 cm (60 inches). Extracted moisture at this depth was less than that extracted by lucerne.

Miller and Duley (1925) found that plant leaf growth responded more readily to changes in soil moisture content than any other part of the plant. Brady *et al*. (1974) stated that the leaf water potential was related to soil-water potential in the root zone and transpiration. They added that leaf-water potential and soil-water potential were in equilibrium at night. Verasan and Ronald (1978) concluded that the soil water content decreased rapidly as the soil-water potential decreased from -3 to -5 bars. Below -15 bars, changes of soil water potential were insignificant. They stated that the soil water content is a function of corn (Zea mays) plant age. As the age of the plant increased, the soil-water potential decreased.

Johns and Lazenby (1973) stated that under irrigation, the sensitivity of water-use to defoliation appeared to be inversely proportional to leaf area index. In contrast, under dry land conditions the availablity of soil water, rather than the interception of solar energy, would be expected to have the most influence on water-use. When soil moisture was limiting growth and water-use, the amount of available water for uptake would control growth and thus leaf area index.

Ashley et al. (1965) studied the effect of nitrogen and irrigation on yield and residual nitrogen recovery by warm-season grasses. They concluded that yield and nitrogen recovery of bermudagrass increased as a result of irrigation during periods of low rainfall. Anslow and Green (1967) suggested that during the growing season, herbage growth from grasses is especially dependent on the provision of moisture and nitrogen in a form which can be absorbed.

Gates (1957) showed that reduced phosphorus concentration in plants subjected to water deficit could result from a decreased mobility of phosphorus in drier soil, or from a reduced uptake by such plants. Williams and Shapter (1955) have suggested that during periods of water deficit, growth of the most rapidly expanding tissue was most depressed. They also found that phosphorus intake by shoots of rye (Secale cereale) was reduced considerably by water deficit.

Freeland (1937) studied the effect of transpiration on the absorption of mineral ions in water culture. He indicated that an increase in transpiration produced an increase in mineral absorption, and the different mineral ions were not changed at the same rate, but varied with species of plants. Using a climatic index of the ratio of precipitation to evaporation equal to 0.5, Roe (1947) concluded that soil moisture should be adequate for pasture growth throughout the year. Veihmeyer et al. (1960) showed that transpiration by perennial rye grass (Lolium perenne) was not affected by decreasing soil water content until the moisture tension in the top 45 cm (18 inches) of the soil profile reached 13-15 bars. Wheeler and Campbell (1969) indicated that high levels of evaporation relative to rainfall during late summer-early autumn may severely limit the growth of sod-seeded winter cereals for winter fodder.

Morton (1966) and Sugawara (1960) pointed out that improvement in seed set could be attributed to lower moisture stress. Moisture stress can cause dessication of flowers, abortion of seed, and prevention of carbohydrate supply to the developing seed. Bokhari (1978) indicated that water and water + nitrogen treated shortgrasses accumulated greater amounts of non-structural carbohydrates than control and nitrogen fertilized plants. He concluded that this was the result of greater biomass production. Vasiliev (1931) studied the effect of drought on the transformation of carbohydrate in wheat. He demonstrated, as the water suply decreased and the water deficit in the tissues increased, the complex carbohydrates break down into simpler forms. An increase in the water content of the plants brought about the reverse process, resulting in a decrease of soluble carbohydrates.

Kramer (1963) emphasized that soil moisture level was a major contributor to plant water stress. Premature closure of stomates due to water stress could reduce photosynthetic activity by interfering with CO_2 movement. The relationship between photosynthesis and water deficit was reviewed by Vaadia _et al_. (1961). They concluded that photosynthesis decreased with increasing water stress when irradiation was not limiting. Baker and Musgrane (1964) reported a decrease in apparent photosynthesis with decreasing soil water potential. It appeared to them that with night solar radiation values, photosynthesis was reduced to near zero before soil water potential reached -2 bars.

Downey (1971) proposed a schematic diagram showing the relationship between relative net photosynthesis and percentage relative turgidity of corn. Net photosynthesis decreased as relative turgidity was decreased. He concluded that the accumulation of photosynthates would be restricted when relative turgidity was below 90 percent. The critical level of relative turgidity of corn leaves corresponded to a leaf water potential of about -1.1 bars.

At any bulk density, the soil resistance tends to increase with increasing moisture tension. The increase of soil resistance reaches a maximum and then levels off. This phenomenon is more pronounced at the lower densities than at the higher densities. Bilanski and Varma (1976) found that shoot and root growth of corn was influenced by both bulk density and moisture tension. In other words, an interrelationship exists between corn shoot growth and soil resistance; and the lower the moisture tension, the lower the limiting soil resistance. When soil crust strength exceeds the forces exerted by the shoot, the shoot tends to move in a lateral direction, and its axial growth diminishes.

Boyer (1968) stated that entry of water into plant tissue was essential to cell enlargement. Downes (1969) showed that possession of the C_4-pathway by the tropical grasses may result in more economical use of available soil moisture. Bohl (1976) found that toxicity of Biuret was not severe when soil moisture was high and conditions favorable for rapid growth.

CHAPTER III

MATERIALS AND METHODS

The objective of this study was to obtain information concerning moisture status of soil with regard to time, depth, and bermudagrass (Cynodon dactylon) variety.

The experimental design of the pasture study was a randomized block with four varieties and two replications. Each variety contained approximately 3.25 acres (1.3 hectares). The bermudagrass pastures were at the Agraonomy Research Station, Perkins, Oklahoma.

The soil characteristics of experimental plots were considered to be as uniform as possible. The soils are the Dougherty, Konowa, and Teller; all fine sandy loams (Arenic Haplustalfs, Ultic Haplustalfs, and Udic Argistolls). The slope of the experimental area has a range of one to three percent. Soil tests indicated a pH range of 5.7 to 6.5, and a high level of available phosphorus and potassium.

The hybrid bermudagrass varieties of Midland, Oklan, Hardie, and SS-16 (an unreleased experimental strain) were sprigged in 1975. Each pasture was divided into three paddocks using electric fences. Grazing began in 1977 with a rotation period of two to three weeks. Paddocks were mowed in early June of each year to remove cool season annuals.

Application of 150 pounds of actual nitrogen per acre (170 Kg/ha) was made each year as ammonium nitrate in three equal applications in early April, late June, and early August of each year.

In 1978, one metallic tube was installed in two paddocks of each pasture to 60 inches (150 cm) depth. Soil moisture readings were made with a neutron probe (model Chicago-2800). Readings were converted to inches of water by calculation. The equipment was recalibrated before each reading.

The experimental design for the soil moisture study was a four variety by 10 depth by 9 date factorial combination with two replications, and two samples (paddocks). Four varieties, 10 depths (with 6-inch intervals) and nine different dates of reading (June 26, December 19, 1978) were considered as factors, and inches of water as the variable in the experiment.

Statistical analysis was conducted on all factors. Computational analyses were made by the Statistical Analysis System (SAS) at the Oklahoma State University Computer Center.

CHAPTER IV

RESULTS AND DISCUSSION

Table 1 shows the monthly rainfall records from January through December, 1978. Rainfall was above average during the months of February, May, and November. Rainfall for the remainder of the year was less than average.

The results of analysis of variance for soil moisture are presented in Table 2. There were significant differences in moisture content for depths and dates. A strong interaction between varieties and dates, and depths and dates was detected.

Figure 1 demonstrates the state of soil moisture at different depths from June 26 though December, 1978. The highest level of moisture was found near the 24-inch depth; the lowest level of moisture was found near the 12-inch depth. Table 3 indicates that there was no significant difference among 18-, 24-, 30-, and 36-inch depths, but there was a difference between the 24-inch and other depths (P = 0.05). With respect to Figure 1 and Table 3, it appeared that differences among 6-, 12-, 42-, 48-, 54- and 60-inch depths were not significant, and those depths contained less soil moisture than the others.

Figure 2 shows that the highest level of soil water was on June 26, the first sampling date. After June, soil water declined with the lowest level of soil moisture occurring during late August. Table 4 supports Figure 2, and reveals the significant differences in soil

Table 1. Rainfall records, Perkins, 1978.

Month	Amount	Long Term Average	Deviation
		Inches	
Jan.	0.92	1.53	-0.61
Feb.	2.63	1.46	+1.17
Mar.	1.46	2.20	-0.74
Apr.	1.85	3.16	-1.31
May	7.28	5.09	+2.19
June	4.59	4.58	+0.01
July	0.90	3.45	-2.55
Aug.	0.53	3.19	-2.66
Sept.	0.49	3.81	-3.32
Oct.	1.96	3.21	-1.25
Nov.	3.69	1.90	+1.79
Total	26.30	33.58	-7.28

Table 2. Analysis of variance for soil water.

Source	df	Mean Square	F
Rep.	1	2.43	1.39
Var.	3	1.53	0.87
Rep.*Var.	3	1.75	
Sample	8	0.47	0.27
Depth	9	2.69	7.01**
Var.*Depth	27	0.68	1.78
Depth*Sample	72	0.38	0.98
Rep.*Depth+Rep.*Var.*Depth	36	0.38	
Date	8	9.35	572.40**
Var.*Date	24	0.05	3.11**
Depth*Date	72	0.65	39.95**
Var.*Depth*Date	216	0.01	0.85
Rep.*Date+Rep.*Date*Var./Depth	320	0.02	
Date*Sample	64	0.03	1.96**
Depth*Date*Sample	576	0.01	0.62
Corrected Total	1439	0.17	

**Significant at P = 0.01.

*Significant at P = 0.05.

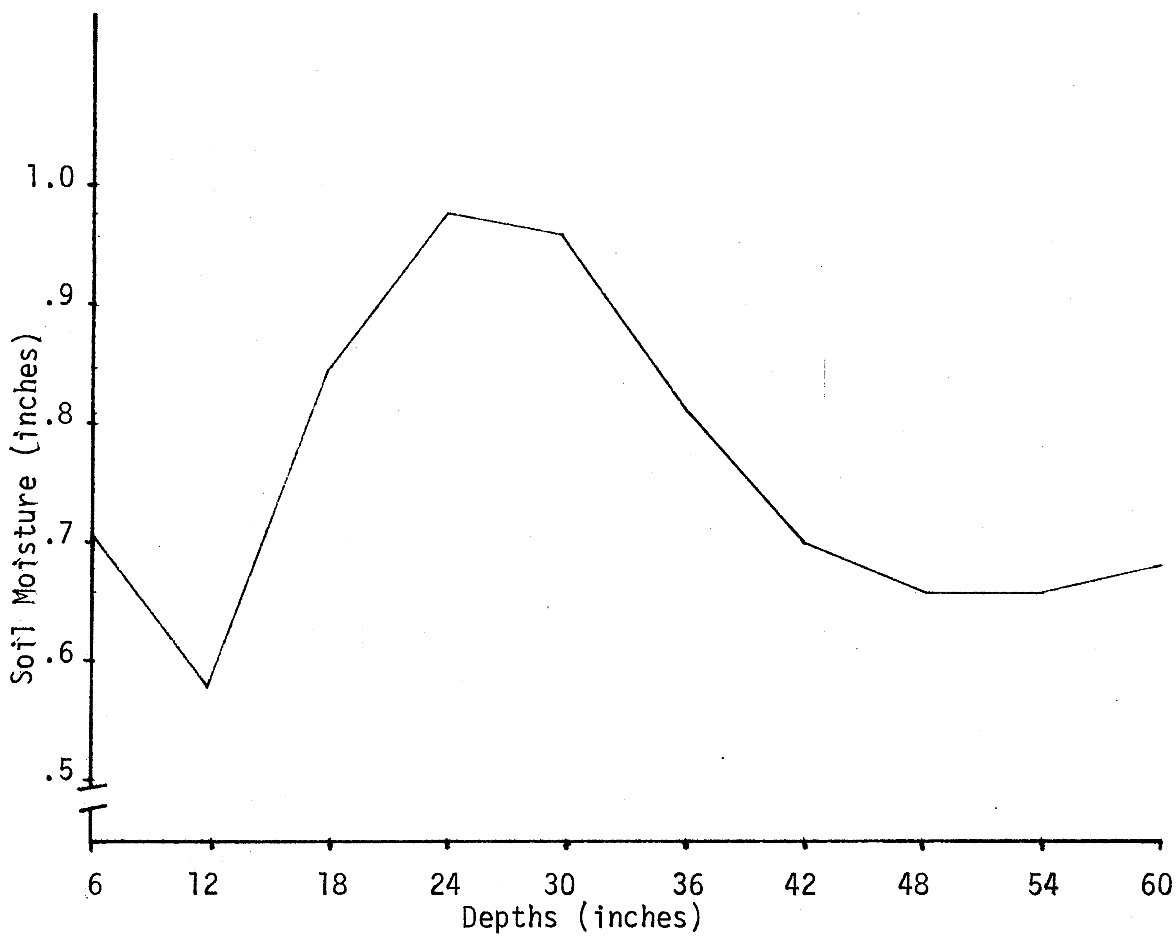

Figure 1. Seasonal average soil moisture at different depths in inches of water per six-inch depth.

Table 3. Seasonal average of soil moisture at different depths from bermudagrass pasture, 1978.

Soil Depth (inches)	Soil Water[1] (inches)					
24	0.98	a				
30	0.96	a	b			
18	0.85	a	b	c		
36	0.81		b	c	d	
06	0.71			c	d	e
42	0170			c	d	e
60	0.68				d	e
48	0.66				d	e
54	0.66				d	e
12	0.58					e

[1]Means followed by the same letters are not different, Duncan's Multiple Range Test with P = 0.05.

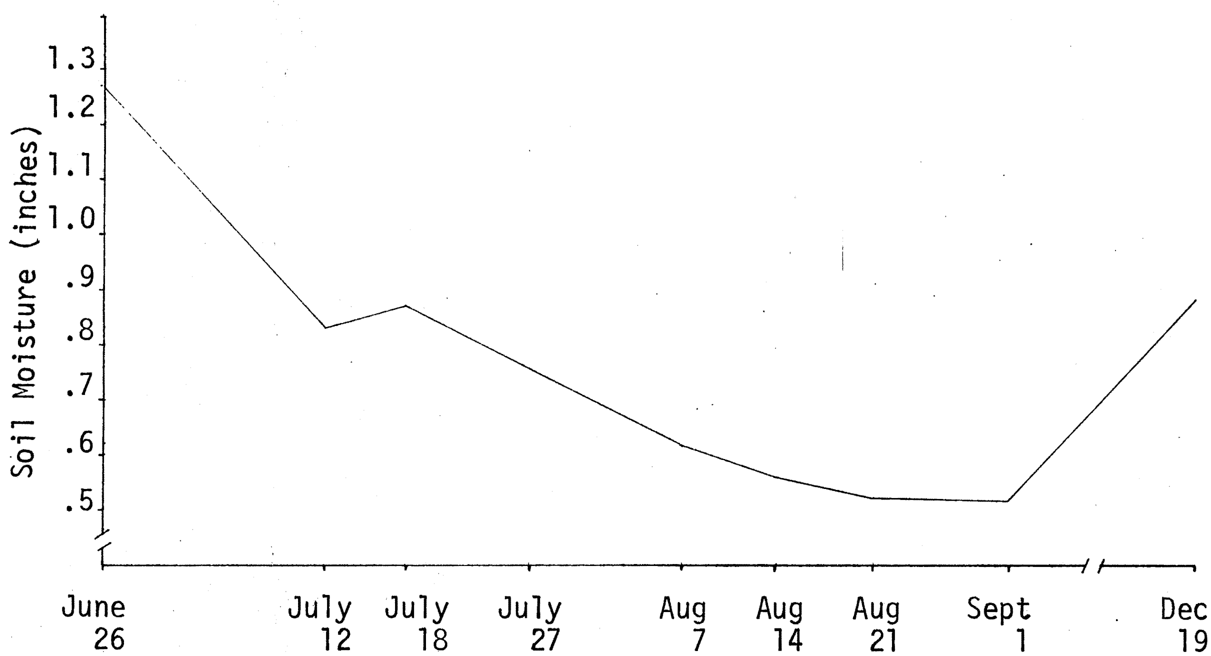

Figure 2. Seasonal average soil moisture on different dates in inches of water per six-inch depth.

Table 4. Seasonal average of soil moisture on different dates from bermudagrass pasture, 1978.

Date	Soil Water[1] (inches)	
6-26	1.27	a
12-19	0.88	b
7-18	0.87	b
7-12	0.83	c
7-27	0.76	d
8-07	0.61	e
8-14	0.56	f
8-21	0.52	g
9-01	0.51	g

[1]Means followed by the same letters are not different, Duncan's Multiple Range Test with P = 0.05.

water content during dates of sampling. The lowest level of soil water was found during late August. The difference between soil water content during July and December was not significant.

Soil water content for the four varieties of bermudagrass on nine dates throught the season is shown in Figure 3. The highest level of soil moisture occurred in June with Oklan and SS-16 varieties. The lowest level of moisture occurred in August and early September with the Midland pastures. In all of the pastures, the soil water declined from June until September.

Figure 4 shows the interaction of soil water with regard to different depths and different dates. In this figure, the soil water for depths of 6, 18, 30, 42, and 54 inches have been omitted. Results of interaction between depths and dates verifies that the highest moisture level was found around 24 inches of depth during the month of June. The lowest level of moisture was found around 12 inches of depth during August. The low level of soil moisture might be the result of high evaporation. Soil moisture level declined from late June through December for depths of 36, 48, and 60 inches, but for depths above 24 inches, soil water started to increase after September. The situation of soil moisture for depths of 12 inches was different from other depths. Thus, during early July, soil water in the surface 12 inches increased and then declined until September. A significant increase in soil moisture was seen in early December around 12 inches of depth, which was a result of the high rainfall during November.

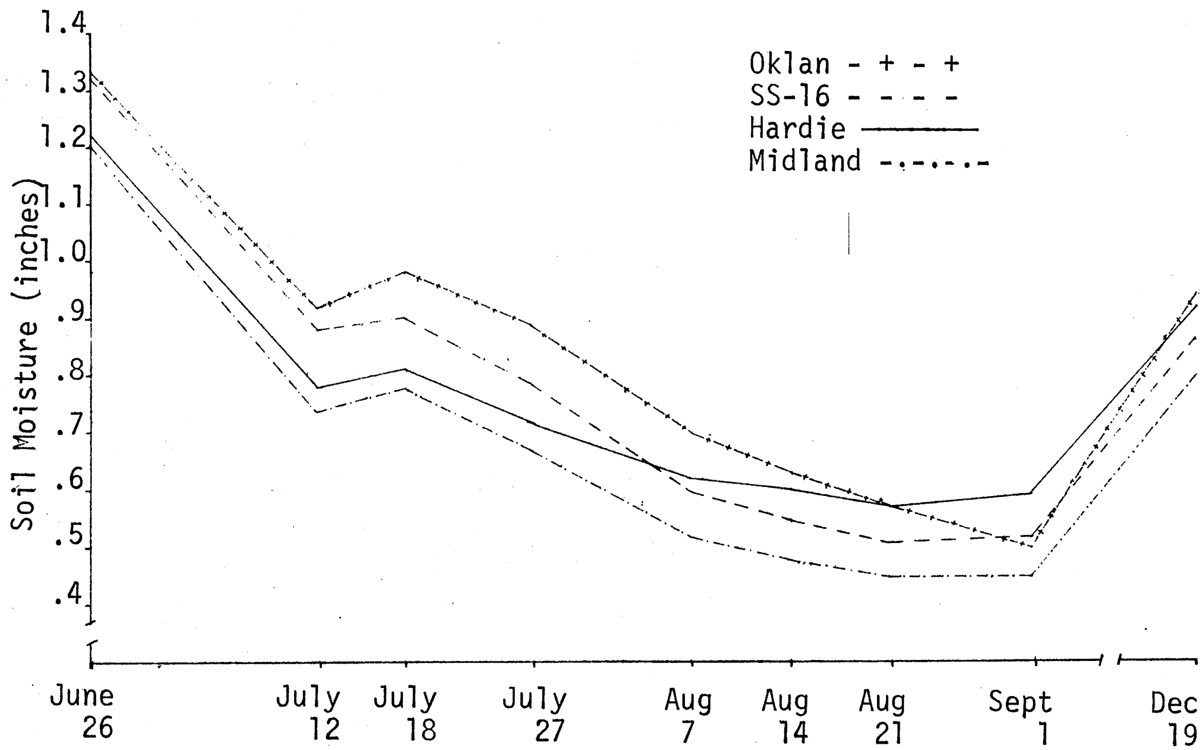

Figure 3. Seasonal average of soil moisture on different dates and varieties in inches of water per six-inch depth.

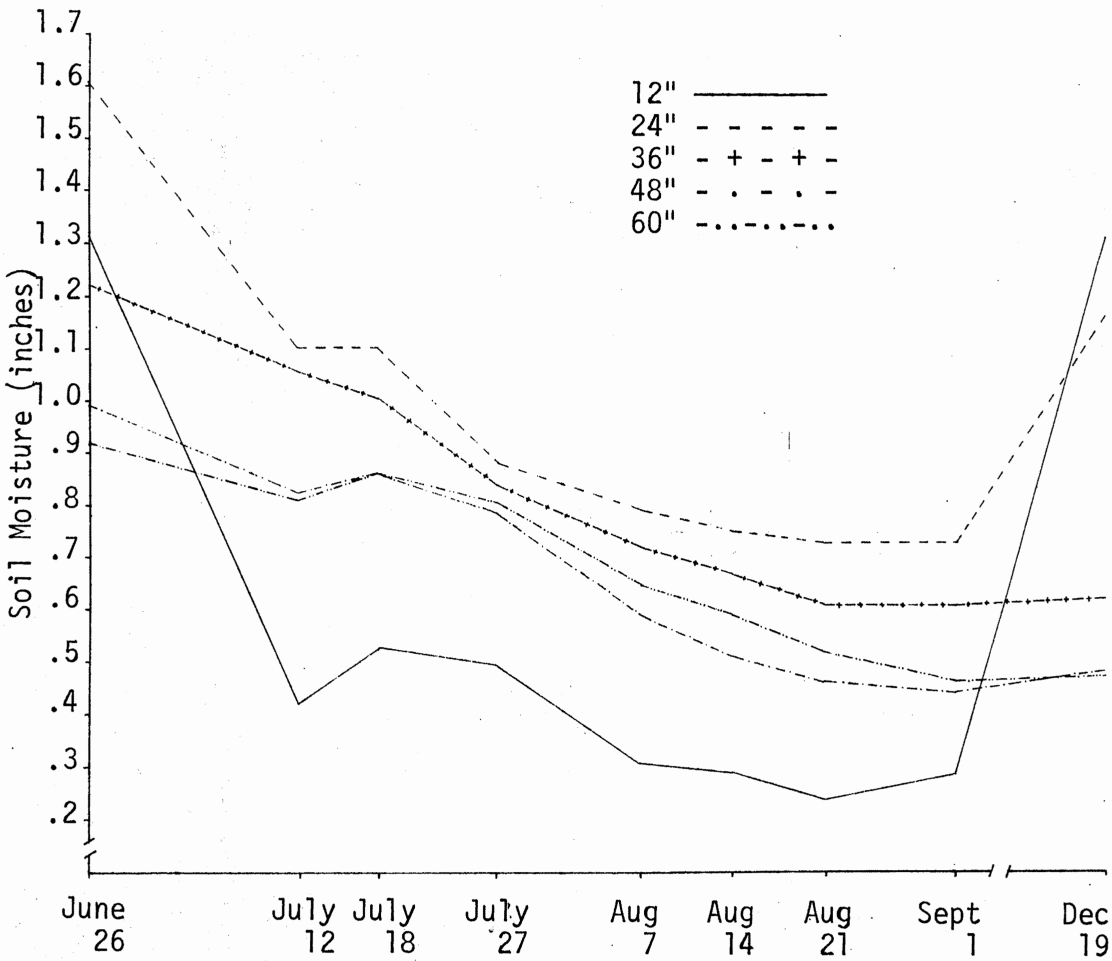

Figure 4. Seasonal average of soil moisture at different depths and different dates, 1978.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was undertaken with the objectives of evaluating various factors that influence changes in soil moisture under field conditions. The neutron probe method was used to measure soil moisture. Relationships were studied between moisture trends in the vegetated plots with regard to depth and time.

The highest level of moisture was held around 24 inches of depth, and the lowest level was held around 12 inches of depth. Soil moisture declined from June through September. The highest level of soil moisture occurred during June. With respect to depth and time, it was accepted that the highest level of moisture occurred during June, which was around 24 inches of depth. The lowest level occurred during late August and early September, and was around 12 inches of depth.

The plots, covered with Oklan or SS-16 bermudagrasses, had the highest level of soil moisture during June. Midland cultivare plots had the lowest level of soil moisture during late August and early September.

Results of this study indicate the need for additional research to characterize fundamental factors that influence the efficiency of water use, and the use of a favorable variety in the areas where drought is a problem.

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