FALL HARVEST AND FERTILITY LEVELS AS INFLUENCES UPON ROOT CARBOHYDRATES OF WEEPING LOVEGRASS, SWITCHGRASS, AND BIG BLUESTEM

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CHAPTER I

INTRODUCTION

Grasses are cosmopolitan, and in individual numbers exceed all other families of flowering plants. They dominate the vegetation over great expanses of the earth's land surface, and they are exceedingly versatile in their adaptation to habitat. They grow in water and in deserts, at sea level and on high mountain peaks, in dense tropical forests and on treeless plains; wherever flowering plants can live, there grasses will survive (Weinmann, 1955).

Carbohydrates are the primary source of reserve energy stored in the vegetative organs of biennial and perennial forage plants. Reserves of available carbohydrates are essential to survival and to the production of plant tissues during periods when carbohydrate utilization exceeds photosynthetic activity (Smith, et al. 1964).

Seasonal total available carbohydrate (TAC) changes in the storage organs show, in general, a similar pattern in most species of grasses. The TAC decrease in both concentration and amount during the formation of new shoots, more particularly during spring, and increase during maturation is indicative of their function as food reserve substances. A considerable proportion of stored TAC may be lost due to respiration both during the period of winter dormancy and the formation of new tissue under humid conditions (Weinmann, 1961).

There has been a strong belief for a long time that reserve carbohydrates play an important role in the rate of growth of grasses following defoliation. For example, Graber et al. (1927) stated that "These organic reserves are essential to normal top and root development and that their quantity and availability sharply limit the amount of both top and root growth that will occur." Weinmann (1948) believed that the aim of pasture management must be to maintain an adequate level of reserves in the desirable species of a sward. The basis for this belief and the consequent policy for pasture management rests mainly on the changes in concentration which occur after defoliation. There is generally a sharp decline in the concentration of the reserve carbohydrates and this is later followed by a gradual restoration of the concentration to its pre-defoliation level; therefore, it is argued, these substances must be utilized in new growth and the higher the concentration present the faster will regrowth occur (Davidson and Milthorpe, 1965).

Data regarding the effect of fertilizers are insufficient to allow general conclusions to be drawn. However, it would appear that the effect of fertilizers on the total available carbohydrate content of the root is generally small, and probably more of an indirect nature, as a result of their influence on growth in general.

The objectives of this study were to evaluate the effect of a September harvest and fertility variables upon total available carbohydrates and sod reserves.

CHAPTER II

REVIEW OF THE LITERATURE

Grasses belong to the group of herbaceous, green plants, and their physiology is not fundamentally different from that of other members of this group. A knowledge of the living processes of grasses is essential for the understanding of their behavior under different systems of management, and their significance as feeding stuffs (Weinmann, 1955).

Metabolism

Phytosynthesis: Like other green plants, grasses are autotropic organixms, i.e., they build up their bodies entirely from water, mineral salts and carbon dioxide contained in the air. The leaves possess numerous small pores (stomata), through which air, and with it carbon dioxide, can enter. In the plant, the carbon dioxide dissolves in the cell-sap and diffuses into the cells of the chlorenchyatous tissue, i.e., the cells containing chloroplasts. These are round bodies which contain the chlorophyll pigments, and in these cells, most probably on the surface of the chloroplasts, the carbon dioxide combines with water to form carbohydrate (sugar) and oxygen. The oxygen, which is liberated during photosynthesis, escapes through the stomata into the atmosphere (Weinmann, 1955).

Respiration: Living organisms require a supply of readily available energy at all times, and in plants as well as in animals this is provided in essentially the same way by the process

respiration. In this process carbohydrate (sugar) is oxidized (combining with oxygen) to form water and carbon dioxide, with the liberation of a certain amount of energy. In contrast to the photosynthetic process, respiration takes place at all times and in all living tissues (not only in the light and in the chlorenchymatous cells). However, respiration goes on at a much slower rate than photosynthesis, so that, so long as plants are exposed to light, respiration is masked by photosynthesis. Obviously, if photosynthesis did not predominate over respiration, plants would not be able to grow (Weinmann, 1955).

Nitrogen Metabolism: The plant's source of nitrogen is the soil where the nitrogen occurs originally in the form of complex organic compounds in the dead remnants of both plant and animal life. By the action of numerous microorganisms these complex organic compounds are broken down, and the nitrogen is ultimately split off as ammonia which forms ammonium salts in the soil solution. Under favorable conditions, more particularly in soils which are not too acid and contain a good supply of calcium and phosphate, ammonium salts are rapidly oxidized to nitrates by nitrifying bacteria (nitrification). Apart from the nitrogen from organic sources, nitrogen is added to the soil from the air, elementary nitrogen being fixed by the action of microorganisms and possibly also by certain chemical processes. In addition to this, rain water or snow and lightening contribute a certain amount of ammoniacal and nitric nitrogen (Miles, 1958).

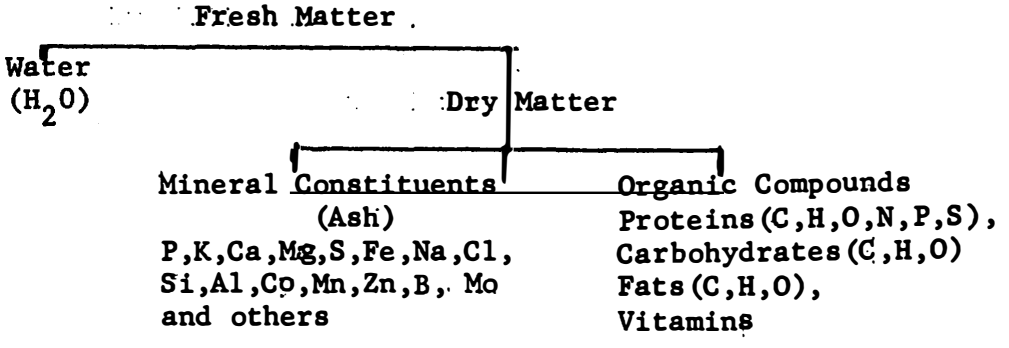
Most green plants, including grasses, can absorb nitrogen in the form of both ammonium and nitrate salts as ammonium and nitrate ions) (Griffith et al., 1964). In soils, where little or no nitrification takes place ammonium salts are probably the predominant form of

available soil nitrogen (Weinmann, 1955). The finding that on the acid and phosphate deficient soils of the Transvall highveld indigenous veld grasses respond better to ammonium sulphate than to other nitrogenous fertilizers suggests that these grasses prefer ammonium salts to nitrates (Hall et al., 1948).

In the plant body the absorbed nitrogen combines with carbohydrate groups to form amino acids, proteins and other nitrogenous compounds (Weinmann, 1955).

Chemistry

The following scheme indicates the major chemical constituents of grasses, and plants in general; it also gives the chemical elements making up these compounds:



A large proportion of the fresh matter is water, the remainder is known as dry matter. The bulk of the latter consists of organic compounds, the more important ones being proteins, carbohydrates, fats and vitamins (Weinmann, 1955).

Proteins. Proteins contain the elements carbon, hydrogen, nitrogen and sulphur, and certain types of protein also contain the element phosphorus. The molecules of proteins are very complex and are built up from a number of simpler units -- the amino acids. There

exist over twenty different amino acids in nature, and by combination of different numbers and kinds of amino acids many different proteins can be formed. Individual species of plants may possess their own, specific proteins, some of which are more valuable in the nutrition of animals than others (Weinmann, 1955).

The nitrogen content of proteins is taken to be 16%, therefore, the protein content is calculated by multiplying the determined nitrogen by the factor 6.25. The resulting figure is referred to as crude protein because this includes not only true protein but also other organic nitrogenous materials, as well as inorganic nitrogen present in the feed stuff. Of the gross crude protein content, 50 to 70% represents digestible protein, the digestion coefficient being higher in young grass and decreasing as the grass matures (Keim, 1947).

Carbohydrates: The following is a list of the more important carbohydrates occuring in gasses.

1) Sugars

   a) glucose (grape sugar), $C_6H_{12}O_6$,

   b) fructose (fruit sugar), $C_6H_{12}O_6$,

   c) sucrose (saccharose or cane sugar), $C_{12}H_{22}O_{11}$.

2) Polysaccharides

   a) hexosans $(C_6H_{10}O_5)_n$

      dextrins

      starch

      cellulose

   b) pentosans $(C_5H_8O_4)_n$

   c) hemicellulose (combination of pentosans and certain hexosans).

The simple hexose sugars (glucose and fructose) are the building units from which higher sugars and the more complex polysaccharides are built up in the plant body. Fructosans are water soluble polysaccharides built up from fructose. They are characteristic of many grasses of tropical and temperate regions, and have so far, according to the results of many studies not been demonstrated in appreciable amounts (Weimann, 1955).

The carbohydrates discussed so far can be used in the plant as building materials, and in perennial grasses are important as food reserves.

The term "total available carbohydrate" may be defined as including all those carbohydrates which can be used in the plant body as a source of energy or as building material, either directly or indirectly after having been broken down by enzymes (Thompson and Schaller, 1960).

Harrison (1934), explaining his work on carbohydrates, stated that short cloudy days and shade, tended to favor the utilization of carbohydrate reserves in the rhizomes of smooth stalked Kentucky Bluegrass (Poa pratensis) while an increase in the amount of light resulted in the production of new rhizomes with the old rhizomes becoming larger. Lack of sufficient light for carbohydrate snythesis in plants fertilized with nitrogen probably was the limiting factor during the winter season whereas nitrogen was the limiting factor in growth as the days became long and bright.

Waite and Boyde (1953) stated that the reserve carbohydrates were highest in fall, declined over winter with a sharp decline until a minimum regrowth was established in spring, followed by a regeneration of root storage in late spring.

The Roots and Storage Organs of Herbage Plants

The roots and storage organs of herbage plants are important from two aspects. Perennial plants store carbohydrates for use in winter respiration and spring topgrowth. Also, the roots of herbage plants cause changes in the soil in which they are growing, thereby increasing or decreasing the soil's fertility and thus affecting the succeeding crop (Troughton, 1951).

The importance of storage carbohydrate and these reserve patterns have been followed in many management practices, with reference to a wide variety of modifying factors. These reserves are assumed to be used for the growth of new leaves after defoliation (Graber, 1931). The carbohydrate reserves are translocated to the aerial parts and used in the production of new photosynthetic area. When sufficient new photosynthetic tissue is formed, the carbohydrate is replenished in the reserve organ. On a smaller scale, roots follow this same pattern even though they may not be the major storage organ (Waite and Boyd, 1953).

Several research studies have revealed the fact that high tillering is associated with factors that have potentially high photosynthesis and carbohydrate storage, but environmental factors such as rate of nitrogen, light intensity, day length, temperature, defoliation, etc. must also favor rapid growth and utilization of carbohydrate in a dynamic biological system (Auda, Blaser and Brown, 1966).

Defoliation may result in a reduction in the weight of the storage organs or their total available carbohydrate concentration, or both. The degree of reduction increases with the severity of the cutting treatment, and with the species. In general, reduction in TAC reserves

is associated with reduced vigor (Brougham, 1965). Species with a prostrate growth habit and large TAC reserves are more resistant to defoliation than other (Davidson and Milthorpe, 1965).

Sprague and Sullivan (1950) working with ryegrass (Lolium perenne), have shown that date of clipping had little effect on seasonal trends in carbohydrate root reserves, other than a transient depression following clipping. Clipping to 9-cm height in late summer or early fall did not significantly affect the seasonal pattern of carbohydrate root reserves or lead to winter injury to most of perennial grass species (Leigh, 1961).

Chemical Composition

The chemical composition of grasses varied with source of grass strain and the location of the test. Best quality of forage, as judged by crude protein, was produced in the early and mid-summer season. In switchgrass (Panicum virgatum) and big bluestem (Andropogon gerardi) the crude protein was found to be highest from frequent clipping and lowest from once-harvested mature growth (Newell, 1968b).

Effect of Fertilization on Perennial Warm Season Grasses

The warm season grasses are relatively slow in establishment and, because of increased weed competition from added nitrogen, fertilization is frequently of little benefit in the first season. Stands and yields of warm-season grasses would be greatly improved by adequate nitrogen after the first year (Newell, 1968a).

Switchgrass is a vigorous sod forming native, perennial grass that occurs throughout the U. S. under a wide variety of climatic conditions (Gordon et al., 1964). It grows in all types of soils, but thrives best in moist lowlands when the soil is of relatively high fertility (Eberhart and Newell, 1959).

Switchgrass responds to fertilizer as does other perennial grasses, and is able to obtain nutrients not available to other species. Switchgrass with its ability to endure adverse conditions with other species, seems ecologically well adapted in the tall grass prairie (Gordon et al., 1964).

Caddo switchgrass looked promising in a native grass fertilization study at Muskogee, Oklahoma (McMurphy and Tucker, 1966). It responded to nitrogen and it spread more rapidly by rhizomes filling in the plot with a complete stand of switchgrass.

Low levels of nitrogen and phosphorus (on phosphorus deficient soil) will produce satisfactory forage yield increase from hay meadows if weeds and other undesirable plants are controlled (McMurphy, 1970).

Leigh (1961) stated that weeping lovegrass (Eragrostis curvula) yields well and is more palatable under high fertility conditions. Thompson and Schaller (1960) also found out that grasses having strong seedling vigor, such as weeping lovegrass and switchgrass, will respond to low levels of fertilization such as 5-20-0 and 10-20-0.

Nowakowski and Cunningham (1966) have confirmed that light intensity is the dominant factor controlling the yields and chemical composition of grass. However, at different light intensities, yields and chemical composition also depend on the form and level of nitrogen. Reduction in light intensity decreased the percentage of soluble

carbohydrates in grass. The effect of light was greatest at the 100 ppm level and decreased with increasing amounts of nitrogen.

CHAPTER III

MATERIALS AND METHODS

The purpose of this study was to determine the effects of different fertility levels and a September harvest on the root food reserves of the warm season grasses, weeping lovegrass (Eragrostis curvula), switchgrass (Panicum virgatum), and big bluestem (Andropogon gerardi).

The field experiment had been conducted at the Agronomy Research Station, Perkins, Oklahoma. Established stands of these three species had been fertilized from 1965-1969 with different nitrogen and phosphorus treatments. The clipping history of the grass was two harvests (June 1 and August 1) for weeping lovegrass and one harvest (July 1) for the native species plus a last harvest in all plots after frost (December 1) each year.

The fertility treatments selected for this study were all possible combinations of N at 0 and 80 lb/acre and P at 0 and 35 lb/acre, thus giving four treatments.

On September 13, 1969, the root samples were collected and part of each plot was clipped to a 5-cm height. Samples were placed in an ice chest in the field and stored in a deep freeze to prevent chemical changes. On January 26, 1970, root samples were collected from both the clipped and unclipped areas of the plots. Since the weather was cold, no ice was used and samples were stored in the deep freeze.

The root cleaning was carried out following the method suggested by Freiburg (1953) with some modifications. Each sample was thoroughly cleaned, allowed to dry at room temperature, and ground, using a Wiley mill with a 40 mesh screen. The ground plant material was subsequently analyzed for carbohydrate content.

Extraction Procedures

One gram of oven dry, ground plant material from each sample was placed in a 50 ml centrifuge tube containing 10 ml of 80% (v/v) ethyl alcohol. Contents were thoroughly mixed using an electronic super mixer and placed in a hot water bath that had been preheated to 80-85C for one hour. The material was filtered, using Whatman No. 31 filter paper. The tube was washed using 80 % (v/v) ethyl alcohol until it is completely free from the plant material and filtered after each washing. The extract was brought to a standard 100-ml volume, and stored in a freezer (Murphy, 1958).

Alcohol Soluble Carbohydrates

The alcohol soluble carbohydrate content was determined by the methods of Yemm and Willis (1954), and Murphy (1958) with some modifications.

Modifications to Anthrone Reagent: This was prepared as described by Trevelyan and Harrison (1952) by dissolving 0.1 gm of anthrone in 100 ml of H_2SO_4 (95.5%. Sp.gr.1.84), made by adding 76 ml of concentrated H_2SO_4 to 24 ml of distilled water. The reagent was stirred until it was perfectly clear and placed in ice (Shetlar, 1952). The reagent was freshly prepared each day and used within 12 hours.

Modifications to Reaction Conditions: The reaction was mostly carried out under conditions similar to those used by Trevelyan and Harrison (1952). The anthrone reagent (5ml) was pipetted into Pyrex tubes and chilled in ice water. One ml of the solution under test was diluted with nine ml of distilled water, and one ml of this dilution was layered in the acid, cooled for further 5 minutes and then thoroughly mixed while still immersed in ice water. The rack containing the tubes was transferred to a water-bath at a temperature of 90-95C for 12 minutes and then cooled in ice water for 5 minutes. The test solutions were poured into colorimeter tubes and readings were made at 620 mμ on a DB Beckman spectrophotometer. The measurements of test solutions and of reagent blanks were made against pure phenol solution as a reference.

A set of glucose standards (25,50,75, and 100) μg/ml was prepared and analyzed with each set of test solutions to estimate carbohydrate content.

Sod Reserve

The procedure used was that of Burton and Jackson (1962) modified to use a 10-cm sod plug and absolute darkness. The sod plugs were taken January 27, 1970 and kept at nearly constant temperatures (24C) with adequate water for 5 weeks in the dark. Etiolated growth was evaluated for tiller numbers, tiller length and total dry matter produced.

CHAPTER IV

RESULTS AND DISCUSSION

Total Available Carbohydrates

The relationship between nitrogen fertilization and forage yield has been well established, but the dynamic nature of the carbohydrate reserves creates difficulty in establishing relationships. From the time of the fall clipping, September 10, until frost, the soil moisture conditions were excellent and a limited amount of regrowth occurred in all plots. It was assumed that the level of total available carbohydrates (TAC) would be reduced by the regrowth produced after clipping. One factor which remains unknown is how much TAC were added by the process of photosynthesis with these new leaves.

Weeping lovegrass displayed a significant increase in TAC due to nitrogen fertility levels (Fig. 1). However, by January, there were no differences in TAC as a result of fertility or clipping.

No differences in TAC in switchgrass could be detected as a result of fertilization (Fig. 2). The plots clipped in September displayed a significant increase in TAC by January. This increase was neither expected nor could it be explained except perhaps as experimental error.

No significant difference in TAC of big bluestem could be attributed to fertility levels (Fig. 3). However, the plots clipped in September and sampled in January revealed a significant increase

S = September
J = January (unclipped)
Jc= January (clipped in September)

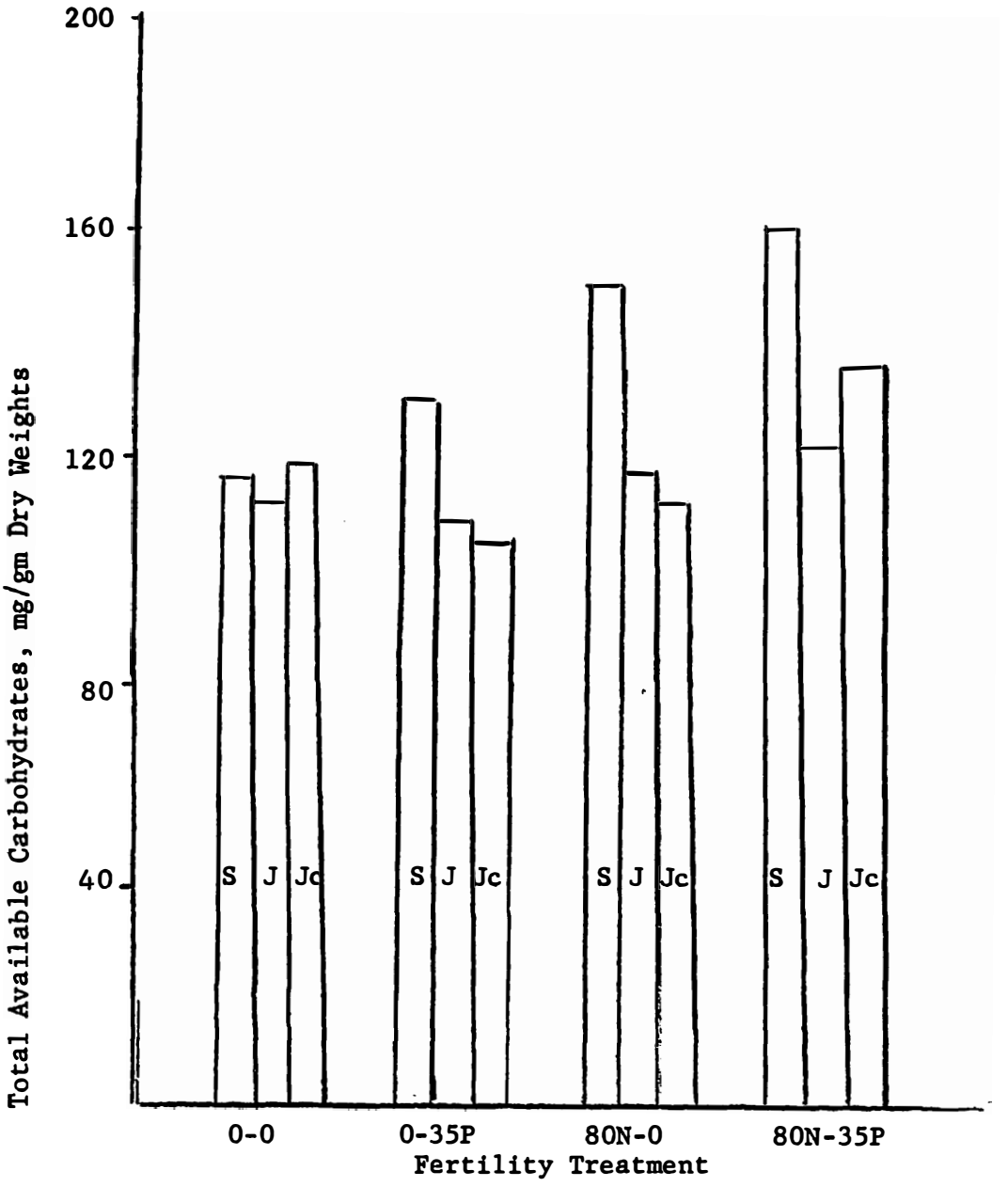


Fig. 1. Total Available Carbohydrate Content of Weeping Lovegrass as Influenced by Fertility, Clipping, and Time of Year. Significant Difference (P.05) due to Fertility in September.

S = September
J = January (unclipped)
Jc= January (clipped in September)

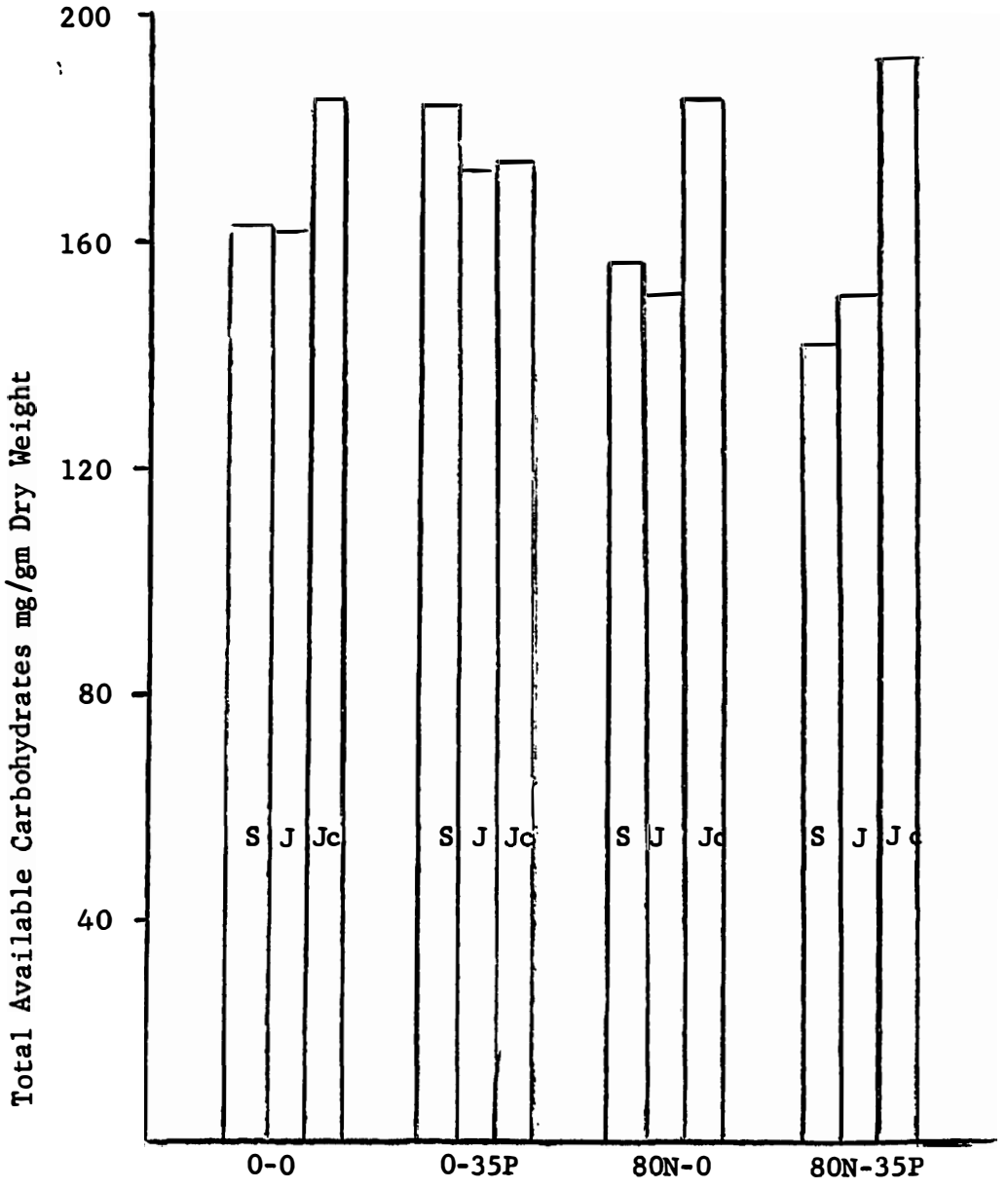


Figure 2. Total Available Carbohydrate Content of Switchgrass as Influenced by Fertility, Clipping, and Time of Year. Significant Difference (P . 05) between September and January Clipped in September.

S = September
J = January (unclipped)
Jc= January (clipped in September)

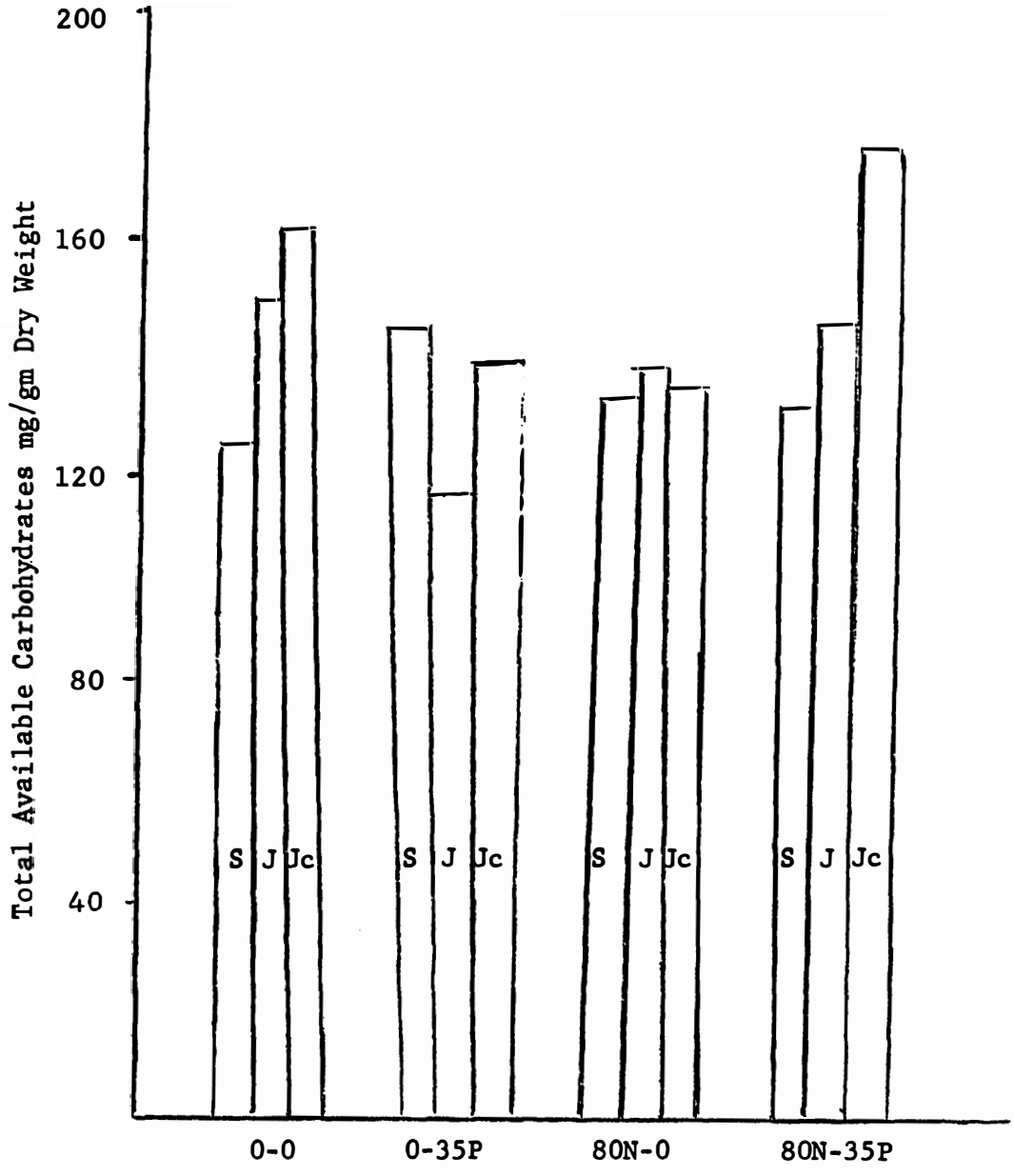


Figure 3. Total Available Carbohydrate Content of Big bluestem as Influenced by Fertility, Clipping, and Time of Year. Significant Difference (P.05) Between September and January Clipped in September.

in TAC.

Switchgrass in general possessed the highest levels of TAC with lovegrass having the lowest levels while TAC levels for big bluestem were intermediate.

Sod Reserve

Weeping lovegrass sod reserves as measured by total production were not significantly affected by fertilization or September clipping (Fig. 4). However, the clipping x fertilization interaction was significant due to a high production from the 80N-0 unclipped plot.

Switchgrass had significant increases in sod reserves as a result of fertility level. The 80N-0 treatment had greater sod reserves than the rest of the treatments (Fig. 5). The effect of a September clipping was nonsignificant.

Big bluestem fertilized with 80N-35P and unclipped in September had a much greater sod reserve than any other treatment. The rest of the treatments were more or less similar to the check plot, and no other difference could be detected.

Tiller numbers and total tiller length of the sod reserves are related to production per pot. However, these data are presented to give further insight to the production characteristics of these grasses.

Numbers of tillers were apparently not influenced by fertility level, clipping treatment or species (Table I).

Total tiller length appeared to be favorably influenced by fertilizers, but clipping had no apparent effect (Table II).

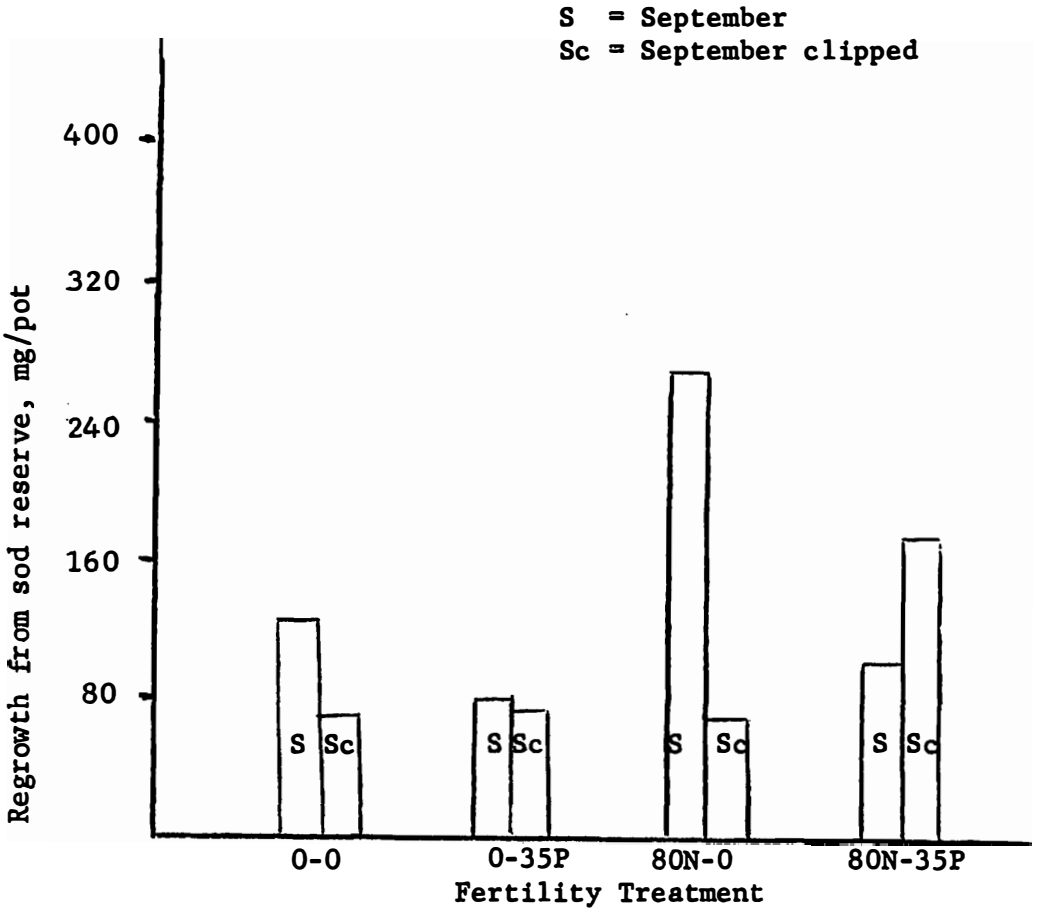


Figure 4. Regrowth from Sod Reserves for Weeping Lovegrass (Significant Interaction of Clipping x Fertilization, P.05).

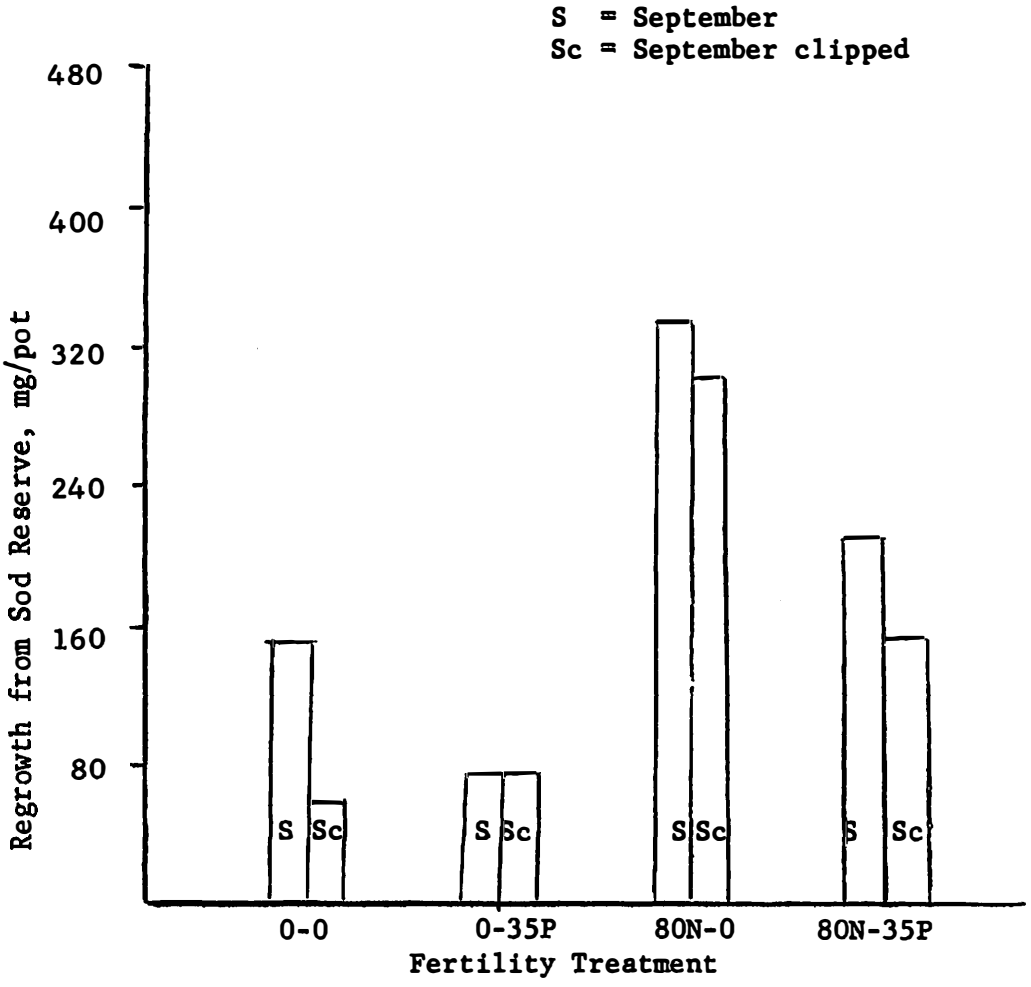


Figure 5. Regrowth from Sod Reserves for Switchgrass (Significant Difference Due to Fertilization, P.05).

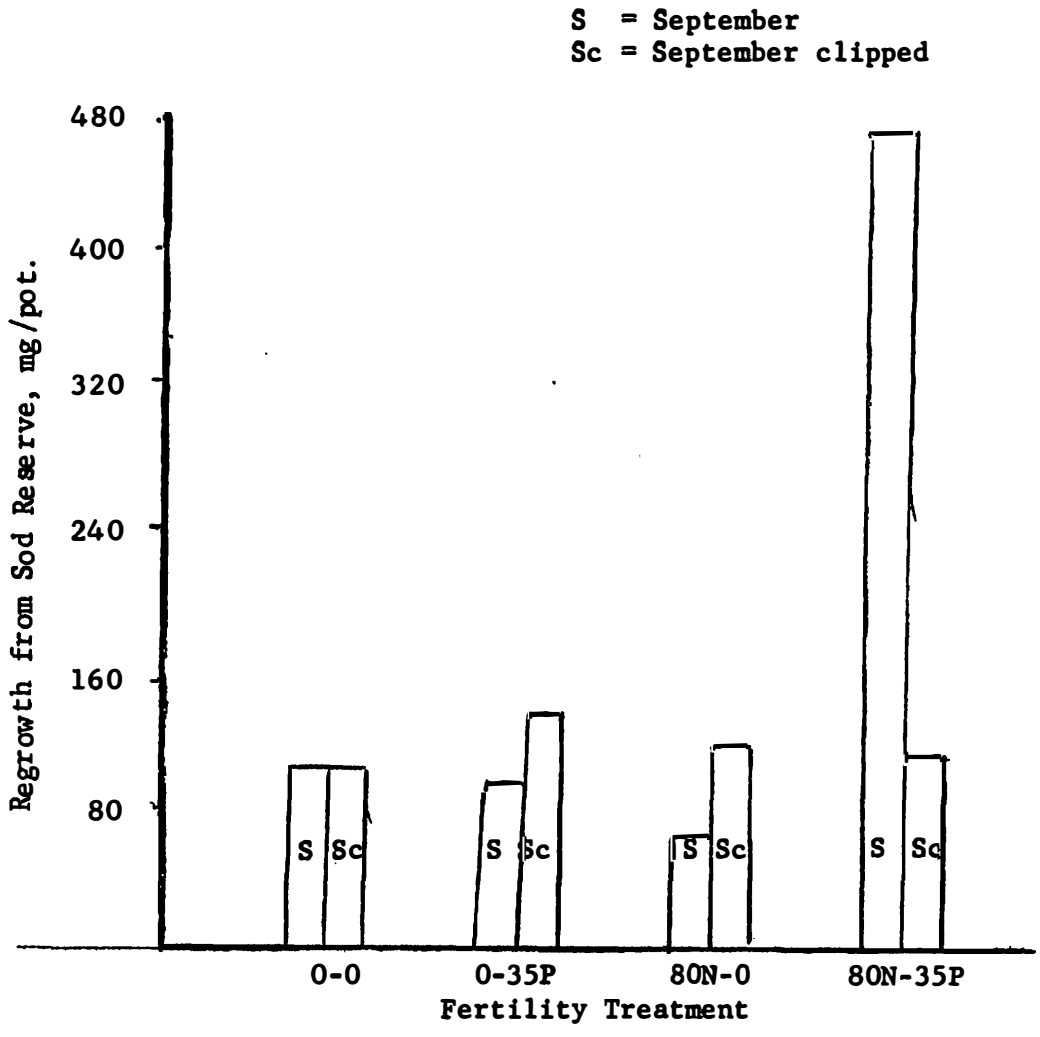


Figure 6. Regrowth from Sod Reserves for Big Bluestem (Significant Interaction of Clipping x Fertilization, P.05).

TABLE I

TILLERING (PER POT) AS INFLUENCED BY FERTILITY AND A SEPTEMBER CLIPPING(AVERAGE FROM 10-CM SOD PLUG)

Clipping Treatment	Fertility Treatment			
	0-0	0-35P	80N-0	80N-35P
	Weeping Lovegrass			
Unclipped	13	8	16	8
Clipped	12	9	7	15
	Switchgrass			
Unclipped	10	6	17	10
Clipped	6	8	12	15
	Big Bluestem			
Unclipped	12	13	5	16
Clipped	8	16	11	11

TABLE II

TOTAL TILLER LENGTH (CM/POT) AS INFLUENCED BY FERTILITY AND A SEPTEMBER CLIPPING (AVERAGE FROM 10-CM SOD PLUGS)

Clipping Treatment	Fertility Treatment			
	0-0	0-35P	80N-0	80N-35P
	Weeping Lovegrass			
Unclipped	231	147	441	206
Clipped	186	173	121	364
	Switchgrass			
Unclipped	94	49	307	157
Clipped	65	85	179	226
	Big Bluestem			
Unclipped	186	166	80	363
Clipped	50	115	138	184

Discussion

The high experimental error made it difficult to detect true differences. More refinement of technique might help reduce this error but certainly more replications would help. The well-known statistic "t" as outline by Federer (1955) was used to determine number of replications needed. For the total available carbohydrates an estimated six replications for weeping lovegrass to 28 replications for big bluestem would be necessary to have a 50% chance of detecting a difference of 30 mg/gm of total available carbohydrates.

Further studies to determine the precise effects of clipping and fertilization upon the total available carbohydrates of these species are warranted.

For the sod reserve study the number of replications would be six to nine to give a 50% chance of detecting a difference of .10 gm/pot which is a large difference. If one wanted better than a 50% chance of detecting these differences, then more replications would be required (Federer, 1955). The tillering was even more variable.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was to evaluate the effect of long time fertility levels and a September harvest upon the total available carbohydrates (TAC) and sod reserve levels of the grass species, weeping lovegrass, big bluestem, and switchgrass.

Total available carbohydrates were significantly increased by fertilization in weeping lovegrass in September. However, by January no difference could be detected in weeping lovegrass TAC due to fertility. No differences in TAC content of switchgrass and big bluestem as a result of fertility could be detected. Ordinarily one might expect a decrease in root reserves as a result of a September clipping. However, this was not true with switchgrass and big bluestem. Both species had significantly greater TAC in January when September clipping occurred. If not experimental error, then this could be a product of a new leaf growth before frost being more efficient photosynthetically.

Sod reserves were evaluated by measuring etiolated growth from a 10-cm sod plug placed in a dark room. In general, the fertilization with nitrogen increased the sod reserves. This would be an indication that greater root development occurred with fertilization. No significant difference could be attributed to clipping in September.

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APPENDIX

TABLE III

ANALYSIS OF VARIANCE FOR TOTAL AVAILABLE CARBOHYDRATES OF WEEPING LOVEGRASS (SEPTEMBER VS. JANUARY UNCLIPPED)

Source	df	SS	MS	F	
Total	31	20,820.32			
Replication	3	617.05	205.68	0.113	ns
Dates	1	4,429.29	4,429.29	2.433	ns
Replication x dates	3	5,461.62	1,820.54		
Fertility	3	3,962.76	1,320.92	4.691	*
Fertility x dates	3	1,281.10	427.03	1.517	ns
Error	18	5,068.50	281.58		

*Indicates significance at 0.05 probability level
ns indicates nonsignificance
CV = 13%

TABLE IV

ANALYSIS OF VARIANCE FOR TOTAL AVAILABLE CARBOHYDRATES OF WEEPING LOVEGRASS (SEPTEMBER VS. JANUARY CLIPPED)

Source	df	SS	MS	F	
Total	31	25,421,36			
Replication	3	2,886.66	962.22	0.969	ns
Dates	1	2,943.36	2,943.36	2.965	ns
Replication x dates	3	2,978.15	992.72		
Fertility	3	4,823.42	1,607.81	2.819	ns
Fertility x dates	3	1,422.98	474.33	0.832	ns
Error	18	10,266.79	570.38		

ns indicates nonsignificance
CV = 19%

TABLE V

ANALYSIS OF VARIANCE FOR TOTAL AVAILABLE CARBOHYDRATES OF SWITCHGRASS (SEPTEMBER VS. JANUARY UNCLIPPED)

Source	df	SS	MS	F
Total	31	27,292.80		
Replication	3	1,364.81	454.94	1.07 ns
Dates	1	314.87	314.87	0.744 ns
Replication x dates	3	1,269.68	423.23	
Fertility	3	4,630.25	1,543.42	1.466 ns
Fertility x dates	3	765.46	255.15	0.242 ns
Error	18	18,947.73	1,052.65	

ns indicates nonsignificance
CV = 20%

TABLE VI

ANALYSIS OF VARIANCE FOR TOTAL AVAILABLE CARBOHYDRATES OF SWITCHGRASS (SEPTEMBER VS. JANUARY CLIPPED)

Source	df	SS	MS	F
Total	31	36,113.23		
Replication	3	1,853.21	617.74	1.163 ns
Dates	1	3,980.32	3,980.32	7.492 *
Replication x dates	3	1,593.77	531.26	
Fertility	3	495.03	165.01	0.130 ns
Fertility x dates	3	5,265.65	1,755.22	1.378 ns
Error	18	22,925.25	1,206.96	

*Indicates significance at 0.05 probability level
ns = nonsignificance
CV = 20%

TABLE VII

ANALYSIS OF VARIANCE FOR TOTAL AVAILABLE CARBOHYDRATES OF BIG BLUESTEM (SEPTEMBER VS. JANUARY UNCLIPPED)

Source	df	SS	MS	F
Total	31	27,542.46		
Replication	3	6,132.42	2,044.14	0.862 ns
Dates	1	49.47	49.47	0.028 ns
Replication x dates	3	7,110.65	2,370.22	
Fertility	3	406.87	135.62	0.023 ns
Fertility x dates	3	3,440.43	1,146.81	0.198 ns
Error	18	10,402.62	5,779.23	

ns indicates nonsignificance
CV = 57%

TABLE VIII

ANALYSIS OF VARIANCE FOR TOTAL AVAILABLE CARBOHYDRATES OF BIG BLUESTEM (SEPTEMBER VS. JANUARY CLIPPED)

Source	df	SS	MS	F
Total	31	31,940.95		
Replication	3	19,066.93	6,355.64	21.983 *
Dates	1	2,680.76	2,680.76	9.272 *
Replication x dates	3	867.35	289.12	
Fertility	3	1,900.82	633.61	1.198 ns
Fertility x dates	3	3,902.26	1,300.75	2.459 ns
Error	18	9,522.83		

*Indicates significance at 0.05 probability level
ns indicates nonsignificance
CV = 16%

TABLE IX

ANALYSIS OF VARIANCE FOR SOD RESERVE OF WEEPING LOVEGRASS

Source	df	SS	MS	F
	31	.268,419		
Replication	3	.026,527	.008,842	
Fertility	3	.037,246	.012,415	2.886 ns
Replication x Fertility	3	.038,708	.004,301	
Clip	1	.018,770	.018,770	3.373 ns
Clip x Fertility	1	.080,371	.026,790	4.815 *
Error	12	.066,797	.005,564	

*Indicates significance at 0.05 probability level
ns indicated nonsignificance
CV = 62%

TABLE X

ANALYSIS OF VARIANCE FOR SOD RESERVE OF SWITCHGRASS

Source	df	SS	MS	F
Total	31	.610,411		
Replication	3	.064,746	.021,582	
Fertility	3	.285,059	.095,020	8.179 *
Replication x Fertility	9	.104,551	.011,617	
Clip	1	.014,238	.014,238	1.408 ns
Clip x Fertility	3	.020,488	.006,829	0.675 ns
Error	12	.121,321	.010,110	

*Indicates significance at 0.05 probability level
ns indicates nonsignificance
CV = 60%

TABLE XI

ANALYSIS OF VARIANCE FOR SOD RESERVE OF BIG BLUESTEM

Source	df	SS	MS	F
Total	31	.999,800		
Replication	3	.122,400	.040,800	
Fertility	3	.209,369	.069,790	2.255 ns
Replication x Fertility	9	.278,481	.030,942	
Clip	1	.038,503	.038,503	3.575 ns
Clip x Fertility	3	.221,791	.073,930	6.864 *
Error	12	.129,256	.010,771	

*Indicates significance at 0.01 level
ns indicates nonsignificance
CV = 69%

TABLE XII

ANALYSIS OF VARIANCE FOR TILLER NUMBER OF WEEPING LOVEGRASS

Source	df	SS	MS	F
Total	31	1,575		
Replication	3	411	137	
Fertility	3	81	27	0.16 ns
Replication x Fertility	9	497	55	
Clip	1	2	2	0.01 ns
Clip x Fertility	3	274	91	0.88 ns
Error	12	310	26	

ns indicates nonsignificance
CV = 46%

TABLE XIII

ANALYSIS OF VARIANCE FOR TILLER NUMBER OF SWITCHGRASS

Source	df	SS	MS	F
Total	31	1,192		
Replication	3	82	27	
Fertility	3	362	109	2.95 ns
Replication x Fertility	9	329	37	
Clip	1	3	3	0.12 ns
Clip x Fertility	3	139	46	1.77 ns
Error	12	313	26	

ns indicates nonsignificance
CV = 46%

TABLE XIV

ANALYSIS OF VARIANCE FOR TILLER NUMBER OF BIG BLUESTEM

Source	df	SS	MS	F
Total	31	2,383		
Replication	3	456	152	
Fertility	3	222	74	0.79 ns
Replication x Fertility	9	846	94	
Clipping	1	0	0	0
Clip x Fertility	3	153	51	0.86 ns
Error	12	706	59	

ns indicates nonsignificance
CV = 64%

TABLE XV

ANALYSIS OF VARIANCE FOR TOTAL TILLER LENGTH OF WEEPING LOVEGRASS

Source	df	SS	MS	F
Total	31	790,305		
Replication	3	158,276	52,759	
Fertility	3	84,483	29,161	3.031 ns
Replication x Fertility	9	86,602	9,622	
Clipping	1	16,741	16,741	1.013 ns
Clip x Fertility	3	242,860	80,953	4.898 *
Error	12	198,343	16,529	

*Indicates significance at 0.05% probability level
ns indicates nonsignificance
CV = 55%

TABLE XVI

ANALYSIS OF VARIANCE FOR TOTAL TILLER LENGTH OF SWITCHGRASS

Source	df	SS	MS	F
Total	31	362,209		
Replication	3	12,577	4,192	
Fertility	3	176,441	58,814	9.754 *
Replication x Fertility	9	54,269	6,030	
Clipping	1	1,391	1,391	0.231 ns
Clip x Fertility	3	45,394	15,131	2,517 ns
Error	12	72,137	6,011	

*Indicates significance at 0.05 probability level
ns indicates nonsignificance
CV = 53%

TABLE XVII

ANALYSIS OF VARIANCE FOR TOTAL TILLER LENGTH OF BIG BLUESTEM

Source	df			
Total	31	872,319		
Replication	3	137,824	45,942	1.672 ns
Fertility	3	149,423	46,808	
Replication x Fertility	9	250,188	27,989	
Clipping	1	47,432	47,432	2.467 ns
Clip x Fertility	3	65,700	21,900	1.139 ns
Error	12	230,749	19,229	

ns indicates nonsignificance
CV = 87%

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