EFFECT OF NITROGEN FERTILIZATIN ON THE CARBOHYDRATE RESERVES OF ORCHARDGRASS VARIETIES

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This study relates to the effect of applying nitrogen at 4 rates (0, 160, 320 and 640 pounds per acre (2 X 10⁶ lb. soil) on the carbohydrate reserves of four orchardgrass varieties. Plant tissues were analyzed for reducing sugars and total polysaccharides.

The results indicate that an inverse relationship exists between the carbohydrate reserves and nitrogen fertilizer levels, in that as the level of fertility increases, the percentages of reducing sugars and total polysaccharides decrease.

INTRODUCTION

Carbohydrate metabolism is closely associated with the efficiency of forage production and survival of a perennial grass plant. When nitrogen is added to a grass, it brings about changes in the plant metabolic activity which in turn affects its carbohydrate reserves. Hence, the objective of this study was to seek information regarding the effect of nitrogen fertilization on the carbohydrate reserves of four orchardgrass varieties.

REVIEW OF LITERATURE

Little work seems to have been done on the effect of nitrogen fertilization on the carbohydrate content of orchardgrass particularly on varieties of a single grass species. However, Kuhn and Kemp (1942) in a greenhouse experiment on red fescue species, found that plants of both vegetative and seed types at full bloom accumulated a larger proportion of sugars in their tissues under conditions of high fertility than they did under conditions of low fertility. Carrol (1943) found that heavy and late applications of nitrogenous fertilizer to Kentucky blue-grass resulted in a lower content of bound water, total sugars and pentosan in the high, rather than in the low nitrogen grass. Sullivan and Sprauge (1950, 1953) working on orchardgrass observed that total water soluble carbohydrates were higher in the stubble than in the tops and roots. They further contended that under high nitrogen nutrition the percentages of fructosan and sucrose were less than under low nitrogen. Nowakowski (1962) showed that nitrogen dressings had no effect on the content of reducing sugars

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and sucrose but greatly decreased the fructosan content of ryegrass. Waite (1958), while studying the effect of different levels of (NPK) fertilizer treatments on water soluble carbohydrates of ryegrass, fescue, timothygrass and cockfoot reported that an increase in fertilizer led to a decrease in the content of soluble carbohydrate (sucrose+fructosan), particularly of the fructosan fraction in all species. More recently Adegbola and McKell (1966) have shown that the reducing sugar content of coastal bermuda grass leaves increased with increasing rates of nitrogen fertilization while no significant changes occurred in reducing sugar content of stems and stolons, as well as roots and rhizmes. Similarly, no significant differences in the content of sucrose and fructosan of the leaves due to nitrogen application were observed by them, but in stems and stolons, as well as rhizomes and roots, sucrose and fructosan content decreased with increasing fertilization.

Due to the contradictory statements of the aforesaid workers, the data on the carbohydrate reserves obtained in this investigation may be valuable.

MATERIALS AND METHODS

The varieties used in this study were Potomac, Pennlate, Commercial and Iowa No. 6. The nitrogen fertilizer used was ammonium nitrate at the rates of 0, 160, 320 and 640 pounds of nitrogen per acre (2×10^6 lb. soil). The varieties were seeded in pots in the middle of March, 1961 and grown in the growth chamber where diurnal temperatures were set at 72°F and 64°F with a day length of 16 hours. The pots were irrigated by using a solution balance and adding sufficient water to bring the soil to field capacity. Fertilizer was applied in the end of April. The 640 pound nitrogen rate was split into two equal applications with the second application being made a week later. After the second harvest in the end of June, the remaining stubble was kept for two days in the growth chamber at a reduced day length of 8 hours and temperature of 64°F. The plants were then hardened at 40°F in a cold chamber for 48 hours to simulate field conditions as are found during the later part of the fall period of the year in northern Colorado. Thereafter, the top two inches of the stubble was harvested and placed for three days in a forced draft oven having a temperature of 70°C. The dried samples were ground in a Willey mill to pass a 40-mesh screen and the material analyzed to determine the reducing sugars and total polysaccharides. The Soxhlet extraction method as outlined by Loomis and Schull (1937) was used to separate the alcohol soluble carbohydrates from the alcohol insoluble carbohydrates. The alcohol extract was then analyzed for reducing sugars and the residue for total polysaccharides.

Clarification of the soluble carbohydrate fraction was done in accordance with the method as outlined in A.O.A.C. (1955). Reducing sugars were deter-

ined by Hassid's method (1936). Analysis for total polysaccharides was made by acid hydrolysis on the alcohol extracted residue. Reducing power was determined calorimetrically by the Poe and Edison method (1932). The values were reported in terms of glucose multiplied by the factor 0.90. The values of carbohydrate reserves obtained were correlated with the nitrogen levels.

RESULTS AND DISCUSSION

Percent reducing sugars: Data showing the effect of different fertilizer levels on the percentages of reducing sugars as related to varieties are given in Table 1. There were significant differences for fertilizer and varieties, however, no significant differences were observed in variety by fertilizer interactions.

TABLE 1.—*Percent reducing sugars of 4 orchardgrass varieties as affected by nitrogen fertilisation.*

Variety	Nitrogen added (lbs./acre.)				
	Control	160	320	640	Mean
Potamac ..	2.95	2.87	2.71	2.32	2.71
Pennlate ..	2.96	2.87	2.45	2.31	2.65
Commercial ..	2.65	2.44	2.45	2.02	2.39
Iowa No. 6 ..	2.75	2.49	2.39	2.21	2.46
Mean ..	2.83	2.67	2.49	2.22	

L.S.D. at 5% for varieties and for nitrogen levels was 0.19 and 0.15 respectively.

The control treatment revealed considerably higher percentages of reducing sugars than all the fertilizer levels except 160 pound levels in the potomac and pennlate varieties. The 160 pound nitrogen level showed greater percentages of reducing sugars than the 640 pound level in all the varieties. A relatively large difference existed between the 160 and 320 pound nitrogen levels in the pennlate variety. In comparing 320 and 640 pound levels, the former showed considerably greater reducing sugar content than the latter in the potomac and commercial varieties. These results indicate that an inverse relationship exists between reducing sugars and nitrogen fertilizer levels, in that as the level of fertility increases, the percentage of reducing sugars decreases. To show this relationship more clearly a correlation coefficient was calculated. A negative correlation (-0.68; $P < .05$) was found to exist between the reducing

sugar percentages and nitrogen fertilizer levels. In some way nitrogen fertilizer seems to interfere in the carbohydrate metabolism of the plant. This is probably due to much of the reducing sugar being utilized in the synthesis of protein and other nitrogen compounds within the plants. This contention is supported by the views of Adegbole and Mchell, 1966 *ab*). They observed that addition of nitrogen to a pasture grass results in a change in plant metabolism which results in an increase in the production of protoplasm, proteins, and other nitrogen compounds essential to plant survival. This change in metabolic activity initially affects the carbohydrate metabolism and greater use of carbohydrates in the synthesis of other compounds reduces the level of reserve carbohydrate present in the storage areas.

Total polysaccharides : The effect of N fertilizer levels on the total polysaccharide percentage of different orchardgrass varieties is shown in Table 2.

TABLE 2.—*Percent total polysaccharides in four orchardgrass varieties as influenced by nitrogen fertilization.*

Variety	Nitrogen added lbs./acre.				
	Control	160	320	640	Mean
Potomac ..	6.03	4.97	4.52	4.09	4.90
Pennlate ..	5.96	5.24	4.77	4.29	5.06
Commercial ..	5.99	5.51	5.09	4.53	5.28
Iowa No. 6 ..	5.96	5.65	5.26	4.95	5.46
Mean ..	5.99	5.35	4.91	4.47	..

L.S.D. at 5% for nitrogen levels was 0.37.

There were no significant differences among varieties or the interactions of fertilizers by varieties. Fertilizer levels were, however, highly significant.

The control treatment revealed considerably higher percentages of total polysaccharides than all the fertilizer levels except the 160 pound levels in the Iowa No. 6 and commercial varieties. The 160 pound level exceeded the 230 and 640 pound nitrogen applications. The 320 pound level exceeded the 640 pound level in all the varieties. A negative correlation coefficient of (—0.81)

was found in comparing total polysachharide percentages and nitrogen fertilizer levels. This relationship is similar to the one found within reducing sugar percentages. Much of the sugars being used in the synthesis of proteins and other nitrogen compounds within the plants seems to be the main reason for a significant negative correlation between total polysaccharides and nitrogen fertilizer levels.

Whereas, the observations in this study are generally in agreement with the conclusions of Carrol, 1943 ; Sullivan and Sprague, 1950, 1953 ; and Waite, 1958, they differ with the findings of Adagbola and Mckell, (1966), Kuhm and Kemp, (1942), and Nowakoswki, (1962). The difference in trend of results of this study and those of other workers may be due to the difference of species, levels of fertility employed and environmental conditions under which these studies were carried out.

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