ROOT MASS AND ROOT DISTRIBUTION OF IRRIGATED BROME AS AFFECTED BY LONG TERM NITROGEN FERTILIZATION

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INTRODUCTION

Many factors affect the productivity of grassland but in south west Saskatchewan, the primary factor limiting the growth of irrigated brome is the supply of available nitrogen. The response of top growth to nitrogen is fairly well established but far less is known about the effects of nitrogen fertilizer applications on the root system.

The importance of the root system to sustained production of grassland is often overlooked. The volume of soil occupied by the roots determines the effective water and nutrient reservoir. Increasing nitrogen levels of the rooting medium has been reported by a large number of authors to increase root growth but at a much smaller rate than the increase seen in top growth. In addition, various authors have noted that while forage above-ground production is increased over a wide range of N levels, root weights are increased only over the lower N levels.

It has also been reported several times that N fertilizer applications can affect root distribution through the soil profile. The percentage of roots at depth decreases with increasing N applications, leading to a concentration of roots in the surface layers of the soil.

Since N is crucial to high grass productivity, a study was set up at Swift Current with the objectives of better defining the response of irrigated bromegrass to N fertilizers, to examine the long term effects of N fertilizer upon the bromegrass stand, and the long term effects upon the subsequent responsiveness of that stand to N fertilizer. This report will discuss the effects of the first five years of fertilization upon the root mass and distribution. The effect of N upon the above ground productivity will also be shown.

METHODS AND MATERIALS

In 1977 an old established stand of bromegrass was divided by dykes into twelve plots 17 m by 100 m. The plots are located on the irrigation area of the Swift Current Research Station in a silty-clay to clay loam alluvial soil. Urea fertilizer was applied to each plot in the spring of 1978 and each subsequent year at the rates of 0, 50, 100, and 200 kg N/ha in a randomized complete block design. Plots were flood irrigated, based upon plant need and water availability, at irregular intervals during the growing season and in the fall using gated pipe.

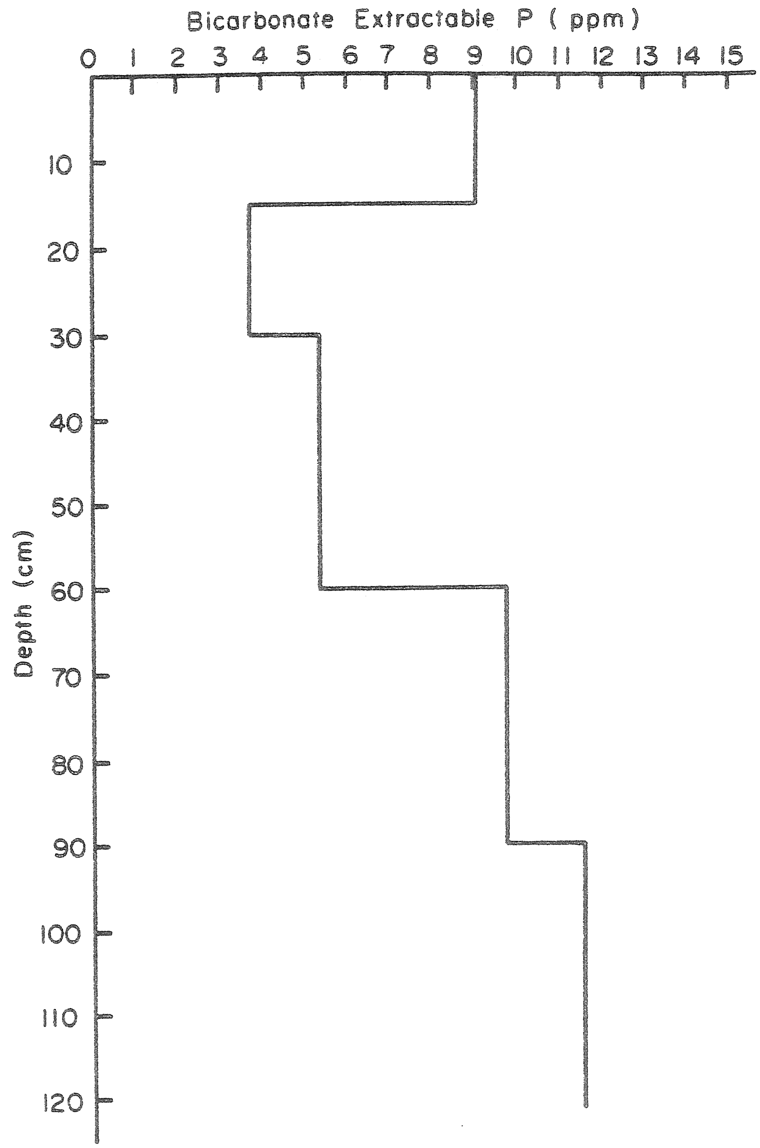

Figure 1. Bicarbonate Phosphorus Concentration in a Clay-loam Soil Under Irrigated Bromegrass.

When the bromegrass was in flower - usually late June or early July - a 60 cm by 3.0 m sample was taken from each end of each plot at random using a Swift Current Forage Harvester IV so that dry matter production could be estimated. Following sample taking, the plots were cut for hay.

Plant samples were analysed for N and P to determine concentration, uptake, and apparent fertilizer recovery. Soil samples were taken each fall and analysed for NO_3 and bicarbonate extractable P.

In the fall of 1982, after the plots had been fertilized for five years, three soil cores 15 cm in diameter and 105 cm deep were taken at random from each plot. Each soil core was divided into eight segments representing the depths of 0-7.5 cm, 7.5-15 cm, 15-22.5 cm, 22.5-30 cm, 30-45 cm, 45-60 cm, 60-90 cm, and 90 cm+. A root washing machine was used to separate the roots from the soil in each segment following dispersion of the clays with a 4% sodium carbonate solution. All segments of one core, separated by 20 mesh screens, were washed together. A small quantity of roots escaped through the screens that separated each segment and were caught on a 60 mesh sieve. This small quantity of roots was assigned to the core as a whole. It was assumed to have come from each segment in proportion to the amount of roots in that segment.

The root samples were separated from small stones and residual silt after being in the root washer by floatation, dried at 65°C and weighed. The root samples were then ashed in a muffle furnace at 450°C to estimate organic matter and soil contamination. Chemical analysis was not carried out on the root samples or the ash.

RESULTS AND DISCUSSION

At no time during the course of the five years was any build-up of NO_3-N observed indicating an accumulation of residual fertilizer. Bicarbonate extractable P in the top 15 cm was at all times adequate for grass production although soil samples taken in the fall of 1982 show an interesting distribution of P in the profile (Figure 1).

In every year, above ground dry matter responded linearly to N applications. Average yield varied from 1710 kg DM/ha at the 0 kg N rate to 6626 kg DM/ha at the 200 kg N rate (Figure 2). Annual production was variable, however, depending on the availability of water for crop growth from both irrigation and precipitation. Unfertilized yields varied between 800 kg DM/ha in 1980 to 3044 kg DM/ha in 1982. Fertilized yields also varied from year to year between, at the 200 kg N/ha rate, 5659 kg DM/ha in 1980 and 7833 kg DM/ha in 1981 (Figure 3).

In 1983 (data not shown), unlike previous years, response was curvilinear. However, again unlike previous years, a second cut was taken from the fertilized plots that yielded almost as much as the first cut especially at the higher N rates. This unusual response was attributed to two factors, namely inadequate irrigation in the spring leaving residual N to stimulate second growth and secondly, the first cut was taken too early leaving behind many plants that had not fully expressed their growth potential for that year. Many of the second cut plants had produced heads.

There were no differences between N treatments in the mass of roots in each segment of the soil profile nor in the distribution of roots over that profile. This contrasts with the increases in roots found by other workers which were caused by N fertilization over a period of time. It is suggested that these contrary results are a function of the age of the stand and its growing conditions.

In this old established stand it is suggested that the brome roots had proliferated prior to the first application of N to the extent that they occupied all the pore space in the soil that was available to them.

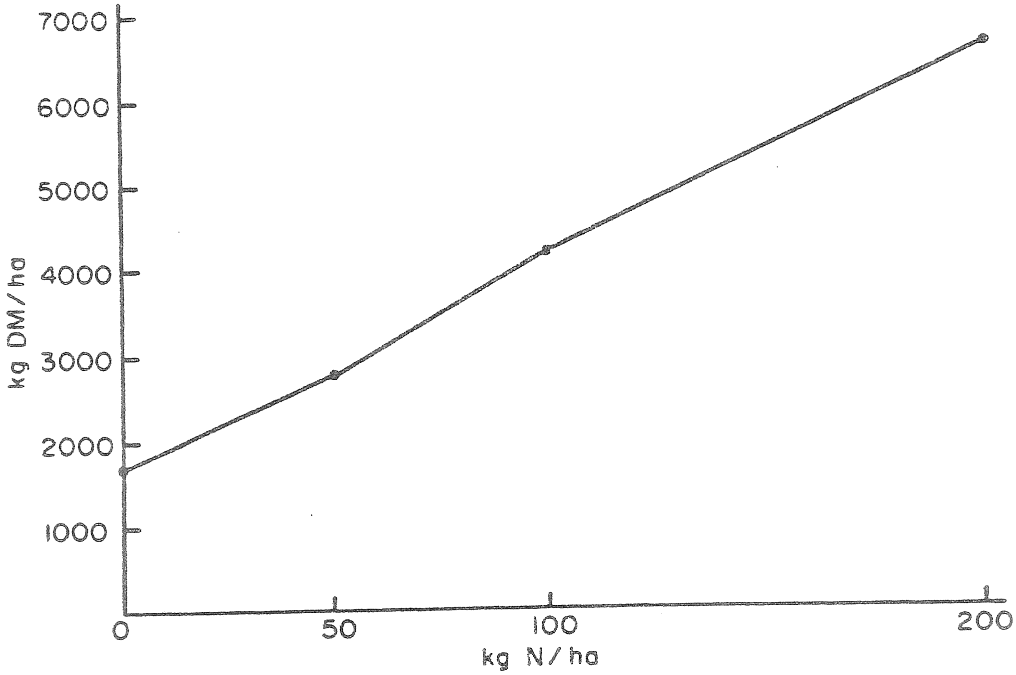

Figure 2. Response of Irrigated Brome to Urea-N.
(5 year mean)

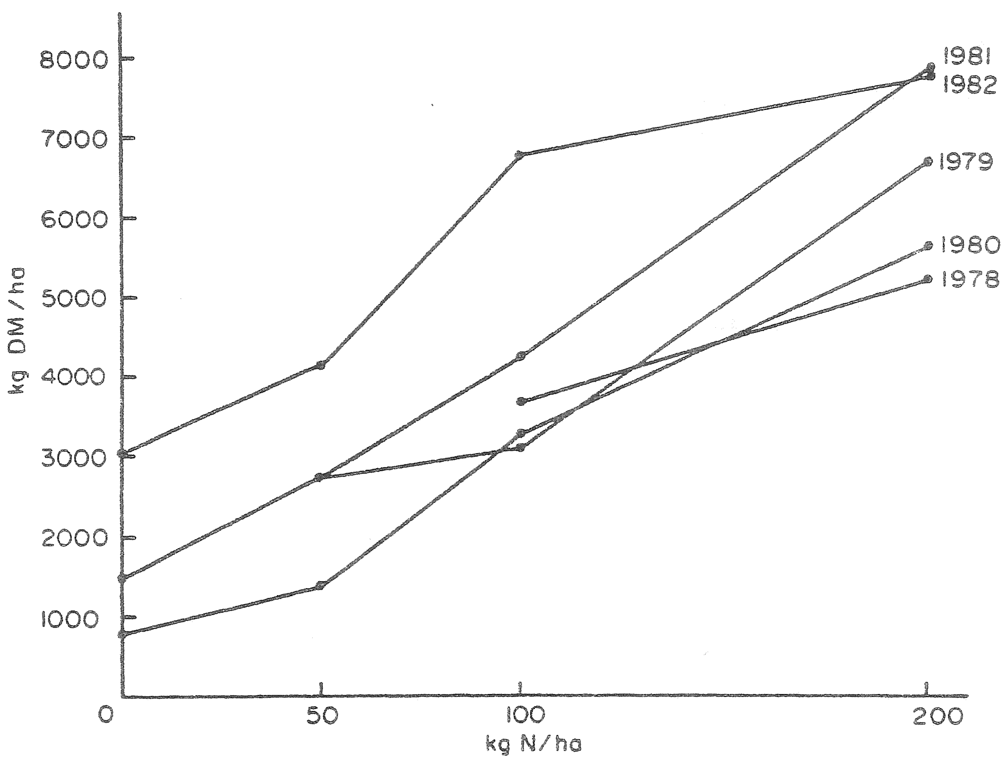

Figure 3. Yield Response of Irrigated Brome to Urea-N.
(by year)

Table 1. Estimated Volume of Roots in Each Soil Segment as a Percentage of the Total Soil Volume.

Depth (cm)	Root Volume[1] (%)
0-7.5	4.97
7.5-15	1.65
15-22.5	1.37
22.5-30	0.98
30-45	0.64
45-60	0.50
60-90	0.26
90-105	0.11

[1]Volume of roots in each segment calculated assuming root dry weight is 10% of fresh weight, root density is unity, and soil density is 1.33.

Most roots are >60μm in diameter and in a typical clay-loam soil, pores of a size that roots could occupy, both ≥60μm and <60μm, would constitute between 10 and 20% of the total soil volume. This pore volume potentially available for roots would be further reduced by the need for 'continuous' pores, and the need for pores for gaseous exchange and water holding. Thus the estimates of the percentage of the soil volume occupied by the roots (Table 1) indicate that a large portion of the available pore space is occupied by roots especially in the top 7.5 cm. It should be noted that these estimates are low since they do not include the volume occupied by the small roots caught on the 60 mesh screen (approx. 8%) nor the even smaller roots that passed through the screens and for which no estimate can be made.

Root mass over the whole profile totalled 13888 kg DM/ha (Table 2), considerably more dry matter than was harvested from above ground in 1982. Similar quantities of root mass have been reported previously for grasslands on the Prairies as has the presence of the majority of roots (71%) in the top 30 cm. Contamination of the root samples with residual soil is always a problem but consideration of the organic matter percentage indicates that it is only significant when the weight of roots in any segment is low.

The distribution of roots through the profile shows a decreasing root mass with increasing depth. This type of distribution of roots is well known and is caused by problems of gaseous exchange, nutrient and water distribution and availability. Figure 4 shows the distribution on a kg DM/ha/cm depth basis because of differences in the size of the various soil core segments.

Thus although considerable increases in hay yield can be achieved by applications of N, there appears to be little or no effect upon the root mass or distribution of old established grass stands. Very large root masses, concentrated in the surface soil, tend to develop which may occupy all the available pore space. It should be noted, however, that no

Depth (cm)	Root Weight (kg/ha)	Ash Weight (kg/ha)	Organic Matter (%)
0-7.5	4976	1048	78.9
7.5-15	1654	392	75.5
15-22.5	1371	357	77.0
22.5-30	977	227	76.9
30-45	1270	289	77.8
45-60	973	238	77.0
60-90	1041	278	75.2
90-105	446	165	58.1
--	1180	407	66.0
0-105	13888	3401	73.6

Table 2. Weight of root dry matter, ash weight and percentage organic matter in each segment of the soil profile.

distinction between living and dead roots was made in this study, nor was any estimate made of the changes in roots that could occur during the course of a growing season. These factors deserve further investigation.

ACKNOWLEDGEMENTS

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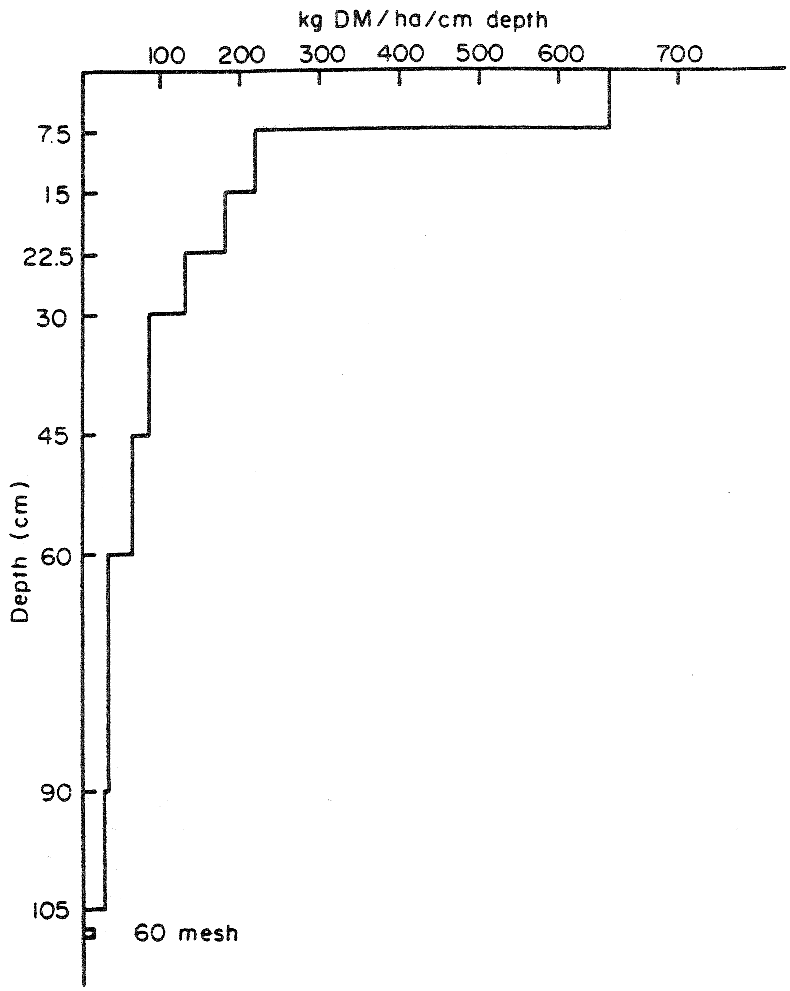

Figure 4. Distribution of Brome Roots Down the Soil Profile.