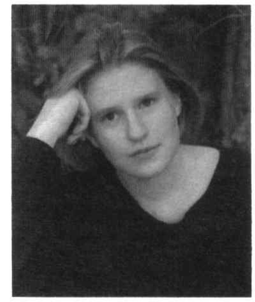
Vesicular-Arbuscular Mycorrhizae Fungi Colonization in Native Grasses



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The health of our native grasses is extremely important. By finding ways to manipulate native grassland growth, we are able to reap the beneficial aspects; such as extended grazing seasons and increased herbage production. This project used defoliation by grazing as a manipulative device that affects native grasses.

Defoliation is the removal of physiologically active material; i.e. eating, clipping, and trampling (Heady and Child 1994). Grazing is a form of defoliation that can be used not only to harvest the grazing resource, but also to improve it 's health (Vallentine 1990). Vallentine (1990) states that the short-term effects of grazing on a plant can be (1) detrimental, (2) beneficial, or (3) neutral. The long term effects of grazing will largely depend not only on the adaptation of the plant to local environmental factors, but also on the relative effects of grazing on associated plants and plant species. However, there are several positive influences of prescribed grazing on forage and soil resources (i.e. stimulation of growth, enhanced nutritive value, reduced water stress, etc.). The challenge in grazing management is to apply a level of intensity that will maintain optimum, sustained plant productivity.

Native grasses adjust to defoliation through two adaptive tolerance mechanisms; (1) physiological changes and (2) changes in the symbiotic soil relationships with rhizosphere organisms (Manske 1996). Vesicular-arbuscular mycorrhizae (VAM) fungi are associated with the root systems of many native grasses. The fungal symbiont of this relationship receives carbohydrates from the roots. The plant symbiont receives increased nutrients (such as phosphorous, nitrogen, and carbon), increased water uptake, improved tolerance to environmental stress (i.e. drought and salt), and increased protection from pathogens (Harley and Smith 1978).

Growth after defoliation has long been linked to pools or reserves of carbohydrates in roots, rhizomes, stem bases, and other ungrazed portions of plants (Heady and Child 1994). At early growth stages, a higher percentage of the total nitrogen of the plant is in the above ground parts, and a higher percentage of the total carbon is in the below ground parts (Allen 1991). Grazing disrupts this carbon-nitrogen ratio. Bacteria in the rhizosphere are limited by access to simple carbon chains under conditions of non-grazing. The amount of exudated carbon increases with defoliation of grass plants at certain phenological growth stages, which effectively increases activity levels of the bacteria and other trophic levels of the rhizosphere, including VAM fungi. An increase in available nutrients is the result for the defoliated grass plant (Manske 1996).

There is no a need to establish VAM fungi in the root systems of most native grasses. VAM fungi has the widest host range and distribution of all mycorrhizal associations (Arora 1991). About 90% of vascular plants are estimated to normally establish mutualistic relationships with VAM fungi. However, there is a need to evaluate how various factors may be used to manipulate VAM fungi colonization levels, so that these levels are most beneficial to the host grass.

The objectives of this study were to determine how the factors of grass species, grazing systems, and time period affect the colonization levels of VAM fungi. By evaluating how the colonization levels are affected, we can observe if the above factors have a beneficial or non-beneficial impact on the root systems of native grasses.

Methods and Materials

The study site is located 20 miles north of Dickinson in southwestern North Dakota, U.S.A. (47'14"N, 102'50"W) on the Dickinson Research Center operated by North Dakota State University. Soils are primarily Typic Haploborolls. Average annual precipitation is 14 in. with 80% occurring as rain between April and September. Temperatures average 19°C (66°F) in summer with average daily maximums of 27°C (80°F) and –11°C (13°F) in winter with average daily minimums of –17°C (2°F). Vegetation is the Wheatgrass-Needlegrass Type (Barker and Whitman 1988) of the mixed grass prairie. The dominant native range species are western wheatgrass, needle-and-thread, blue grama, and threadleaved sedge.

Native rangeland treatments were organized as a paired plot design with 2 replications. The twice over rotation grazing treatment has 3 pastures with each grazed for 2 periods, one period of 15 days between 1 June and 15 July followed by a second period of 30 days prior to mid October for a total of 4.5 months (1 June-17 October) at a stocking rate of 0.49 AUM's/acre. The seasonlong treatment was a 4.5 month long treatment grazed between 16 June to 30 October at a stocking rate of 0.35 AUM's/acre. The long term non-grazed treatments had not been grazed, mowed, or burned for more than 30 years prior to the start of data collection. Commercial crossbred cattle were used on all grazed treatments. Each treatment contained study sites on three range sites of sandy, shallow, and silty.

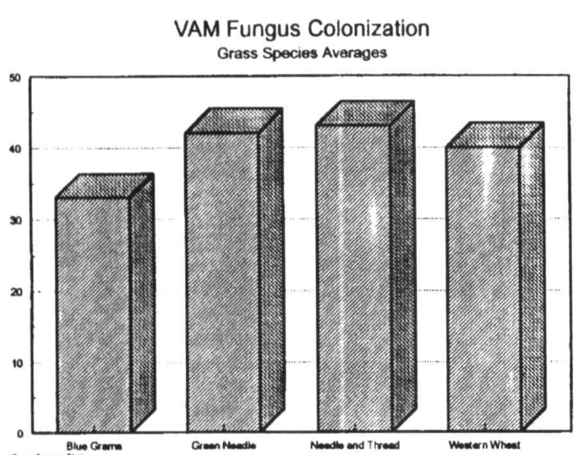
During each month of June, July, and August, two replications of blue grama, needle-and-thread, western wheatgrass, and green needlegrass were randomly collected from the silty range sites. With the use of a golf-cup cutter, two root samples were randomly collected from each native grass.

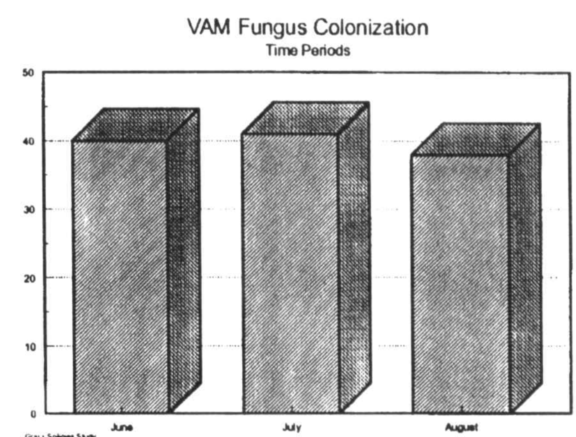
Root samples were processed at North Dakota State University, in the Plant Pathology department (under the supervision of Dr. Robert Stack). Root samples were cleaned in 10% potassium hydroxide at 90°C in order to remove excess protoplasm, debris, and cellular structures. Samples were then neutralized in 10% lactic acid and stained in 5% trypan-blue lactophenal stain to enhance mycorrhizal structures (Phillips and Hayman 1970). The extent of infection was determined by assessment of colonization (Giovanetti and Mosse 1980) as modified by Struble (1990). Root samples were sliced into 100 segments, each segment evaluated under a microscope. Percent colonization was based on the number of segments per 100 that showed positive colonization. Results were statistically analyzed using SAS (1989) for significance at $P<0.05$.

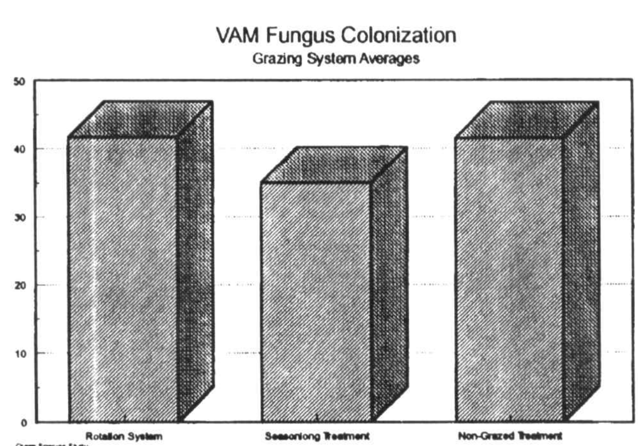
Results and Discussion

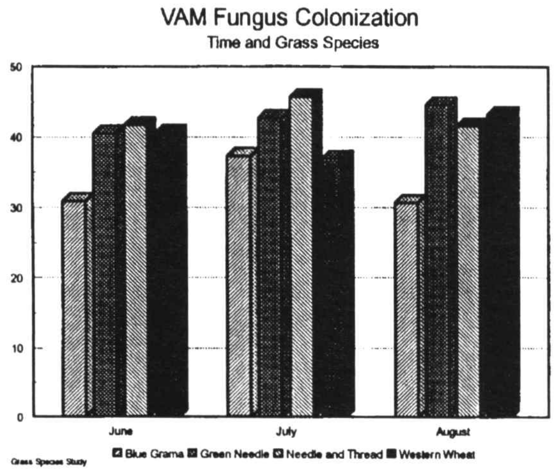
The root segment samples contained a percentage of aged root portions, which were no longer infected with living VAM fungi. These aged portions were counted in the percent colonization and recorded as non-infected samples. This resulted in reduced infection levels of the samples, accounting for low percentage rates.

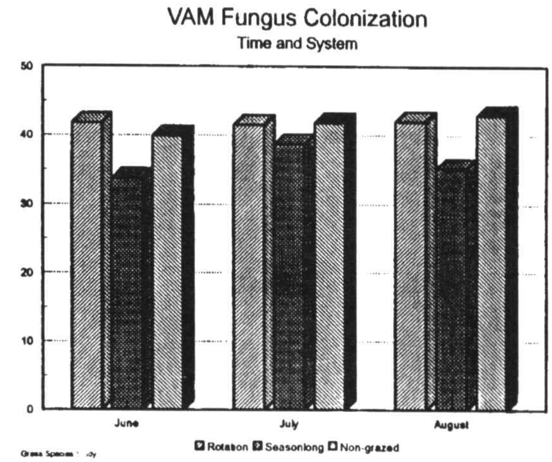
There was no significant difference in VAM fungi colonization levels found among the 3 cool season grasses of needle-and-thread (43.0%), green needlegrass (42.6%), and western wheatgrass (40.2%). The warm season grass, blue grama, had a lower colonization level of 32.9%, which was significantly lower than the three cool season grasses. This difference between warm and cool season grasses may be due to the phenological growth differences between the two. During the time period studied, the months of June through August, a warm season grass is generally experiencing a peak production time, while cool season grasses are dropping from high growth stages. VAM fungi colonization levels may fluctuate according to characteristics of the plant, i.e. cool or warm season, and the growth period the plant may be currently undergoing.

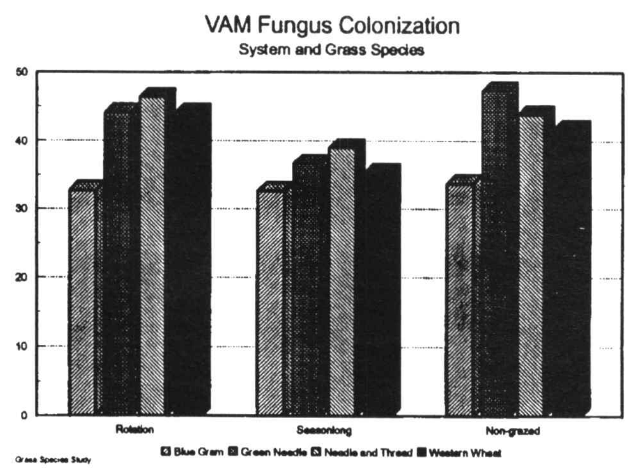












VAM colonization levels were not different (P>0.05) among the 3 time periods; June (38.5%), July (40.6%), and August (40.0%). VAM fungi may follow a growth pattern, which includes an increase or decrease in colonization levels based on time. This data showed that through the middle of the grazing season (June-August), colonization levels remained steady.

The rotation grazing system showed a 41.8% colonization level of VAM fungi, followed by the non-grazed native prairie having a colonization level of 41.5%. The seasonlong grazing treatment was lower (P<0.05) than the rotation grazing system and non-grazed treatment, with a colonization level of 35.1%. As stated earlier, seasonlong grazing provides native grasses with a continual grazing period extending between 4.5 to 6.0 months. Rotation grazing allows for native grasses to experience periods of grazing and rest alternately. Rotation grazing appears to have a more beneficial impact on the level of VAM fungi colonization in the root systems of native grasses than seasonlong grazing. Allowing native grasses to experience periods of rest between grazing periods may result in an increase in the activity level of the rhizosphere, including fungi.

Summary

This study suggests that a rotation grazing system may be most conducive to VAM fungi colonization levels. Manipulating native grasses through positive grazing systems may result in increased herbage production, stocking rate, and extended grazing season. To see this achieved, we must identify an ideal growth situation for native grasses. Remembering the below ground affects of grazing when evaluating various grazing systems may help to identify these situations. Grazing systems may be a tool to improve the levels of VAM fungi associated with native grass root systems.

An expanded VAM fungi study may be needed to determine relationships between VAM colonization levels and grazing systems. By increasing the number of replications, grass species, and time period evaluated, a broader observation of the relationship between native grasses and grazing systems may be concluded. Increasing grass species would further explain how colonization levels vary according to warm vs. cool season grass types. An expanded study period could allow for an overview of the timed growth cycle of VAM fungi. It would also be beneficial to correlate the results of VAM fungi colonization studies with those studies observing above and below ground biomass, carbon, nitrogen, and phosphorous cycle relationships, and axillary bud development to identify interactions throughout the entire grassland community.

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Editor's Note: This paper was the 1st place winner of the High School Youth Forum presentations at the SRM Annual Meeting in Wichita, Kansas.