Root Distribution of Temperate Forage Species Subjected to Water and Nitrogen Stress

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Introduction

Root growth and distribution patterns can be important in determining forage yield during periods of moisture and nutrient stress. Enhanced rooting depth, in particular, can increase access to water and nutrients found deeper in the soil profile. We examined rooting characteristics of 21 species (9 grasses, 6 legumes, and 6 forbs) that are commonly found in northeastern USA pastures. Species examined covered a range of tolerances to defoliation frequency, drought, and nitrogen availability. This poster presents data on the ability of forage species to adjust allocation of carbon to and within the root system in response to water and nutrient stress. Data from a pot study are also compared to field results to determine if rooting differences observed in multi-species forage mixtures can be explained by inherent species differences in root distribution.

Materials and Methods

Eight week-old plants were transplanted into PVC pots (15 cm diameter x 50 cm deep). One week after transplanting, 50% of the leaf area of each plant was removed. Roots and shoots of each species were harvested 7 d after clipping. A second set of plants were harvested three weeks later. Roots were washed free of soil and root and shoot biomass determined. The experiment was replicated 3 times. Only rooting data are presented here.

Species	Code	Group	Species	Code	Group
American vetch	AV	Legume	Kentucky bluegrass	KB	Grass
Alfalfa	AL	Legume	Orchardgrass	OG	Grass
Birdsfoot trefoil (ARS-2620)	AT	Legume	Perennial ryegrass	PR	Grass
Birdsfoot trefoil (Norcen)	NT	Legume	Prairie grass	PG	Grass
Kura clover	KC	Legume	Reed canarygrass	PC	Grass
Red clover	RC	Legume	Smooth bromegrass	SM	Grass
White clover	WC	Legume	Tall fescue (Jessup Max Q)	JF	Grass
Chicory	CH	Forb	Tall fescue (Barolex)	BF	Grass
Common yarrow	YA	Forb	Timothy	TM	Grass
Dandelion	DN	Forb	Virginia wildrye	WR	Grass
Grey goldenrod	GG	Forb			
Plantain	PL	Forb			
Small burnet	SB	Forb			

Table 1. Species used in greenhouse study.

Results

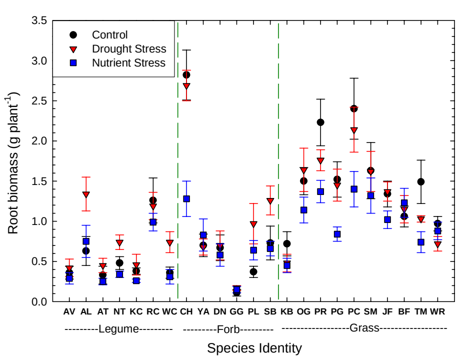

Figure 1. Effects of drought and nutrient stress on root biomass. Although chicory had the largest root system, grasses, on average, had greater root biomass than forbs or legumes. When significant differences existed, root systems tended to be larger under drought stress and smaller with nutrient stress compared with controls.

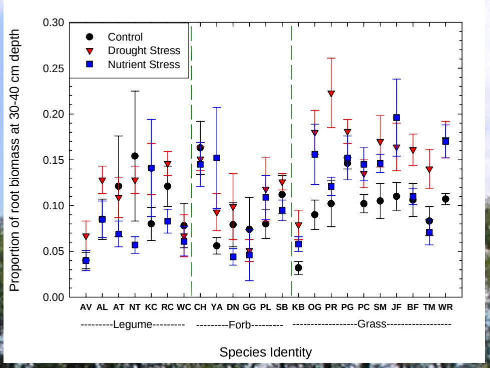

Figure 2. Effects of drought and nutrient stress on rooting depth. Grasses also tended to have deeper root systems than legumes or forbs although differences were not as great as for root biomass. Both drought and nutrient stress caused grass roots to be distributed deeper in the soil profile. Legume and forb root systems were not consistent in there depth response to stress.

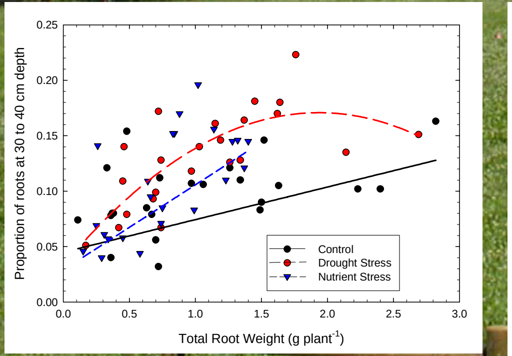

Figure 3. Relationship between total root weight and the proportion of deep roots. As might be expected, plants allocated more biomass to deep roots as total root biomass increased. However, root systems were deeper for any given root weight under stress conditions compared with controls.

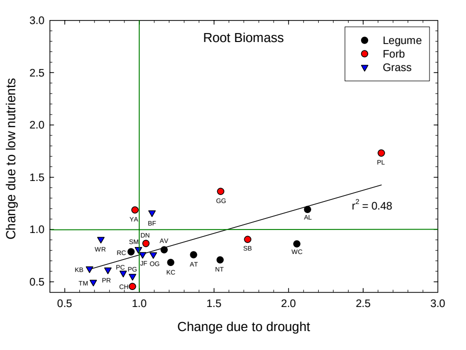

Figure 4. A significant positive relationship existed between a species ability to maintain or increase root growth in response to drought and to nutrient stress. Grass root growth, in general, was more inhibited by stress than were forbs or legumes.

Comparison with Field Data

A field study by Skinner et al. (Agron. J. 98:320-326 (2006)) found that the proportion of roots in the 30-60 cm depth increased as the number of species in the pasture increased (Fig. 5). They could not determine if differences in rooting depth were caused by inherent differences among the species used in the mixtures or if interactions among species caused roots to grow deeper in the soil profile than they normally would.

2-Species Mixture		3-Species Mixture		11-Species Mixture	
Species	Proportion	Species	Proportion	Species	Proportion
OG	0.77	OG	0.80	OG	0.36
WC	0.23	AL	0.19	TF	0.36
		CH	0.01	AL	0.15
				PG	0.05
				SM	0.05
				CH	0.03

Table 2. Species composition for three pasture mixtures from a grazing study in eastern Pennsylvania (Skinner et al. Agron. J. 98:320-326 (2006)).

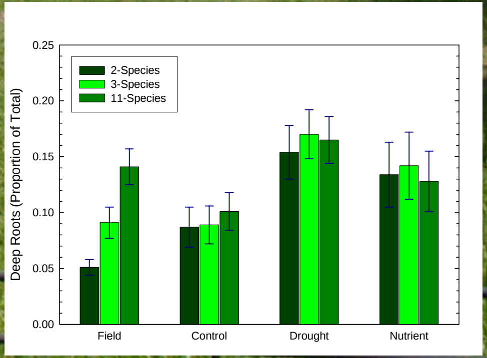

Figure 5. Calculated average rooting depth for hypothetical pasture mixtures based on species composition data from Table 2 and root distribution data from Figure 2. Field data are from Skinner et al. (2006). Increased rooting depth in the 3- and 11-species mixtures could not be fully explained by the inclusion of inherently deeper-rooted species in these mixtures.