Evaluating Potential Forages for Suppressing Foxtail Barley and Downy Brome in Saline Pastures and Hay Fields

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Introduction

Agricultural producers across Canada consider foxtail barley (*Hordeum jubatum* L.) a major weed detrimental to both field crop and livestock production. The plant invades disturbed pastures, hayfields, and cultivated land alike and has proven difficult to control, especially in saline soils. This perennial weed typically produces abundant quantities of wind-dispersed seed which contribute to infestations year after year. The plant's sharp, stiff, barbed awns can penetrate the tender nose and mouthparts of cattle, sheep, and horses, causing infections and lesions. Infected animals eat less, gain less weight, and produce less milk. The current chemical controls include heavy pre-emergence applications and in-crop doses in annual field crops and fall spraying in forage crops.

Foxtail barley has a shallow, fibrous root system that makes it more responsive to control by tillage than many other perennial weeds, and tends to become more of a problem whenever tillage frequency is decreased as in hayfields, pastures, and reduced-tillage grain fields. Seeds are easily carried by the wind, spreading quickly from contaminated field margins, water courses, and adjacent fields. New plants tend to invade any area that is not occupied by other plants, showing behaviour typical of a pioneer invader species. This is why the weed frequently inhabits saline environments.

Although foxtail barley's inability to compete with other vegetation has been known for over 50 years (Cords 1960; Wilson 1967; Best et al. 1978; Badger and Ungar 1990), the use of forage plants to suppress this weed has been limited (Moyer and Boswell 2002). It has also known that foxtail barley frequents a range of saline soils (Dodd and Coupland 1966; Ungar 1974; Badger and Ungar 1990; Kenkel et al. 1999). Yet, we know of no agronomic studies wherein suppressor forages, grown for hay or pasture, were arrayed in relation to known levels of root-zone salinity (Blackshaw et al. 1999). One reason has been the lack of a desirable forage species with superior salinity tolerance to serve as the suppressor for the control of foxtail barley; tall wheatgrass has the tolerance but grows as a bunch grass with low palatability.

Agriculture & Agri-Food Canada scientists recently released >AC Saltlander= green wheatgrass (*Elymus hoffmannii* Jensen & Asay), a perennial forage featuring salinity tolerance approaching and equal to that of tall wheatgrass (*Thinopyrum ponticum* (Podp.) Lui & Wang) (Steppuhn and Asay 2005; Steppuhn et al. 2006). Consequently, AC Saltlander ranks among the few perennial forage species with potential for suppressing foxtail barley growing in saline soils. Preliminary indications reveal that it can gradually suppress foxtail barley at all salinity levels, offering potential as a low-cost, pesticide-reduced control. According to results from controlled testing, AC Saltlander can grow in saline root zones measuring well into the severe range.

The effect of root-zone salinity on forage crops follows the dictates and the confounding influences of weather. For example, forage growers appreciate that ample spring precipitation can enhance forage production in pastures and hayfields at all salinity and salinity-free levels. Snowmelt and rainfall, which infiltrate unsaturated soils in sufficient quantities to move water downward in the profile, will leach in-situ salts below root zones. This lowers salt concentrations, abates soil salinisation, and moderates losses in forage production caused by salinity. If, in contrast, spring precipitation becomes limiting, salt concentrations increase, soil salinisation accelerates, and forage production decreases. This report results from an industry consortium led by the Alberta Beef Producers. The objective of the study is to evaluate potential forage species for suppressing foxtail barley.

Methods

Two Alberta field sites were selected in 2006 with guidance from project partners, land owners'approvals, and on-site inspections. Site #1, characterized as slightly to moderately saline (Table 1), is located on the Hal Peterson Farm near Warner, AB (Dryland Salinity Control Association). Site #2, characterized as slightly to severely salinized (Table 1), is located on the Gordon Chiliak Farm near Oyen, AB (Chinook Applied Research Association).

With the assistance of project partners, each site was evaluated for general salinity (EM38 survey), staked for plot layout (Figure 1), pre-seed treated with glysophate, worked with a double-disc, roto-tilled, and harrow-packed. The same disc-drill, forage plot-seeder (with shanks spaced 30 cm apart) was used at each site. Plot size equalled 6 feet by 40 feet and was replicated six times. Ten forage suppressor treatments were compared to an unseeded control (the control was replicated 12 times):

* Saltmaster seed mix, Proven Seed (consists of 20% each of tall fescue, tall wheatgrass, slender wheatgrass, smooth bromegrass, alfalfa)
* AC Rocket smooth bromegrass (SBG)
* Spredor 4 alfalfa
* AC Saltlander green wheatgrass
* AC Saltlander green wheatgrass, 15 cm row spacing
* Nuttall's salt-meadow grass
* Polar northern wheatgrass (WG)
* Slender and green wheatgrass (SWG & GWG) in alternating rows, 15 cm row spacing
* Poole western wheatgrass (WG)
* Orbit tall wheatgrass

The Warner Site was seeded on May 16^{th}, 2006, while Oyen was seeded on June 29^{th}, 2006, (delayed by wet and cool weather). Just after seeding, the 0-15 cm soil depth was cored by hand next to each subplot and a soil sample obtained for lab analysis.

Plant establishment at the field study sites was determined in 2006 on July 5^{th} at Warner and on August 3^{rd} at Oyen. Each plot contained six sub-plots (each two by two feet in size) within which plant establishment and shoot biomass measurements were obtained. The first year establishment and survival plus new plant emergence was measured in 2007 on May 8^{th} & 9^{th} at Warner, and on May 30^{th} & 31^{st} at Oyen.

In July of 2006, annual weeds grew and dominated the plots as is typical in forage seedings. Consequently, all plots at the Warner site were mowed at the end of the month. The Oyen site was not mowed until November 2^{nd}, 2006. By November, 2006, a complete set of root-zone soil cores were obtained at every subplot at all sites (Table 1).

At Warner, owing to the 2006 weed control efforts against Canada thistle, all the alfalfa plants under test were lost over the first winter. These plots together with those seeded to Nuttall's salt-grass, which failed to establish, were mowed on May 29^{th} & 30^{th} of 2007 and measurements were discontinued. At Oyen, ample 2007 spring and early summer precipitation resulted in above-average forage growth. In 2007, the above-ground biomass of each treatment forage and associated weeds within each sub-plot was cut, bagged, dried, and weighed: during June 26-28 at Warner and July 4-5 at Oyen. In 2008, shoot biomass harvest was conducted on June 24-26 at Warner and on July 7-9 at Oyen. The plots at Warner and Oyen were mowed following shoot biomass harvests.

Table 1. Average saturated soil paste electrical conductivity (EC_e) from samples taken August 28th, 2006 (Warner Site) and October 20th, 2006 (Oyen Site).

	Conductivity EC_e (dS/m)				
	Warner Site				
Replicate	0-15 cm	15-30 cm	30-45 cm	45-60 cm	All depths
1	0.91	0.74	2.17	4.58	2.10
2	0.89	0.89	3.06	5.57	2.55
3	2.22	3.13	7.60	7.56	5.13
4	0.84	0.73	1.47	2.93	1.49
5	1.34	1.58	3.84	6.58	3.34
6	3.08	4.24	7.15	7.88	5.59
Average	1.55	1.89	4.22	5.85	3.37
	Oyen Site				
1	2.73	8.21	14.85	14.80	10.15
2	3.21	8.53	12.99	13.17	9.48
3	2.57	4.64	8.49	11.41	6.78
4	5.40	13.68	16.67	15.35	12.78
5	2.79	7.15	13.41	13.84	9.30
6	5.23	14.07	18.16	17.51	13.74
Average	3.66	9.38	14.10	14.35	10.37

Results and Discussion

Plant Counts

In 2006, counts of the emerging and early surviving plants by species (5-6 weeks after seeding) showed generally acceptable numbers at the Warner and Oyen sites, although somewhat reduced at the latter (Table 2). This reduction reflected the cool, wet growing conditions at the Oyen site which delayed seeding until June 29th. If one sets the acceptable count for emergence at 60 plants/m^2 for Warner and 40 plants/m^2 for Oyen, western wheatgrass ranked below the standard at both sites. Northern wheatgrass and Nuttall's salt meadow grass failed to reach minimum numbers at either site. Tall wheatgrass and smooth bromegrass emerged with the greatest frequency. The Saltmaster seed mix was next in all-around emergence. AC Saltlander ranked average to plentiful in the standings depending on the site.

Starting in 2006, new foxtail barley plants were present in all treatment plots at each site. In general, the Oyen site counted fewer weed plants than the Warner site. At Warner, downy brome plant numbers exceeded those of foxtail barley in every treatment plot including the unseeded control. This fits the biological character of downy brome as a cool-season pioneer (or invader) species compared to the warmer temperature requirement of foxtail barley. In some treatments, the presence of downy brome appears to have reduced foxtail barley establishment.

In 2006, almost all candidate suppressor forages became established at both sites, resulting in a successful initiation of the study. Over winter, some of the established plants died, and some new seeds germinated. The 2007 plant count data provides comparisons of total establishment and survival among the candidate suppressor forages (Table 3). In 2007, the total plant counts of the test forages (the 2006 survivors and the 2007 newly emerged) one year after seeding more-or-less matched those recorded in 2006 (Tables 2 & 3). That is, the rankings among the suppressor treatments remained the same in both years at each site (Oyen & Warner).

At Warner, the presence of downy brome complicated the weed plant frequencies measured after one year. The average number of downy brome plants decreased by two to three-fold under all treatments including in the unseeded control plots. Between 2006 and 2007, the average frequency of foxtail barley plants increased by 3 to 19 plants per square metre in the Saltmaster, smooth bromegrass, green wheatgrass, alfalfa, and nearby unseeded control plots. But, average foxtail barley counts tended to decrease by 3 to 10 plants per square metre in the alternating slender/green wheatgrass, northern wheatgrass, tall wheatgrass, western wheatgrass, and nearby unseeded control.

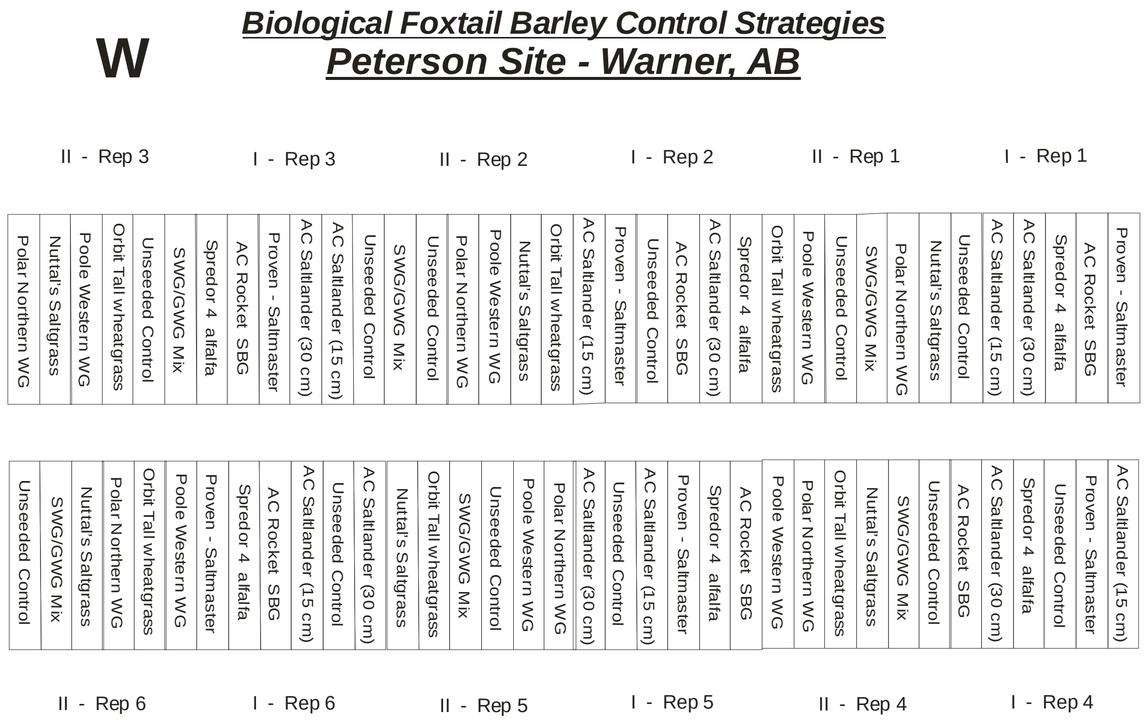
At Oyen, the average foxtail barley count in 2007 increased considerably over the 2006 count under all treatments including the unseeded control. This followed the classic pattern for foxtail barley contamination. In 2006, this plot site was treated with glyphosate, pre-worked into a forage seedbed, and seeded on the 29th of June. Coming late within the seasonal window for seeding, this preparation eliminated the existing and early germination of foxtail barley plants. In response to the early summer rains, the forage emergence was good and followed as expected for the different salinity levels of the plots. The pre-seeding preparations in 2006 minimized the foxtail barley emergence. In the fall, fresh foxtail barley seed blew in from off-plot sources. These new seeds germinated early in 2007 wherever opportunities existed in response to the excellent growing conditions. From 2006 to 2007, the average plant count of seeded forages at Oyen: (1) decreased for alfalfa, smooth bromegrass, Saltmaster, and northern wheatgrass, (2) remained the same for the green and tall wheatgrasses, and (3) increased for the slender/green wheatgrass and western wheatgrass treatments.

The Nuttall's salt meadow grass at either Oyen or Warner averaged no greater than six plants per square metre after two years of good spring precipitation (Table 2 and 3). On the basis of plant counts at these Alberta sites, we are labelling this treatment as a failure. Northern and western wheatgrasses behaved very similarly to each other. Plants of these candidate wheatgrass suppressors were found at both Warner and Oyen in both years. However, average weed counts under these treatments increased at both sites from 2006 to 2007 despite the presence of established forage plants.

Above-Ground (Shoot) Biomass

The average above-ground forage biomass, cut in 2007 and 2008, from the green and tall wheatgrass, smooth bromegrass, and the Saltmaster mix treatments at Warner each exceeded the combined shoot biomass of the foxtail barley and downy brome weeds (Figures 2 and 3). The tall and green wheatgrasses tended to rank as the top two forages in average shoot biomass production; the western and northern wheatgrasses along with the Nuttall's salt meadow grass produced the least. All three of these poor producers also allowed the combined foxtail barley and downy brome weed biomass to exceed the forage biomass. Of the three green wheatgrass treatments in 2007, the alternating slender/green treatment on average seemed to yield the most above-ground biomass, ten times greater than that of either of the two grassy weeds. In 2008, the suppressor forages of the green and tall wheatgrass treatments completely dominated their respective plots, rendering the foxtail barley and downy brome nearly non-existent. The tentative success of the green wheatgrass and the tall wheatgrass treatments implies that root-zone salinity plays a role in the efficacy of the suppressor forages.

At Oyen, the average 2007 and 2008 above-ground biomass for the alfalfa, smooth bromegrass, tall wheatgrass, green wheatgrass, Saltmaster mix, and the slender/green alternating wheatgrass treatments, each exceeded the average foxtail barley shoot biomass (Figures 4 and 5). Conversely, the average shoot biomass of the weed exceeded those of the northern and western wheatgrasses and the Nuttall's salt meadow grass. Like at Warner, the green wheatgrass treatments appeared near if not at the top in weed suppression and forage production. And, among the three green wheatgrass treatments, the alternating slender/green treatment tended to rank as the best. The better than average growing season precipitation during 2007 at Oyen likely reduced the negative effects of root-zone salinity at that site. Between 2007 and 2008, the shoot biomass of the foxtail barley increased in the control, Nuttall's salt-grass, northern wheatgrass, western wheatgrass, alfalfa, smooth brome, Saltmaster mix, and tall wheatgrass plots. The foxtail barley biomass appeared not to have increased in any of the green wheatgrass plots.



Candidate Suppressor Forages for Foxtail Barley Control Strategies

* Saltmaster seed mix, Proven Seed (consists of 20% each of tall fescue, tall wheatgrass, slender wheatgrass, smooth bromegrass, alfalfa)
* AC Rocket smooth bromegrass (SBG)
* Spredor 4 alfalfa
* AC Saltlander green wheatgrass
* AC Saltlander green wheatgrass, 15 cm row spacing
* Nuttall's salt-meadow grass
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Figure 1. Plot seeding plan at the Hal Peterson Farm, near Warner, AB (same layout at Oyen); each plot includes six sub-plots (0.61 m x 0.61 m). Plot dimensions are 12.2 m long by 1.8 m wide. Seeding row spacings are 30 cm unless otherwise noted. Boundary and central pathway were seeded to alternating rows of Dahurian wildrye (DWR), and green wheatgrass (GWG).

Table 2. Average 2006 plant emergence and early survival at the two field test sites as frequency (number of plants per square metre) n number of weeks after seeding. [GWG = green wheatgrass; SWG = slender wheatgrass]

Suppressor treatment Site (n) .	Emergence and early survival (number per square metre) Forages	Foxtail barley	Downy brome
Warner, AB (5 weeks)			
Spredor 4 alfalfa	131.7	5.0	91.5
AC Saltlander GWG			
15 cm rows	100.9	3.4	80.4
30 cm rows	84.9	2.4	90.7
Smooth bromegrass	105.6	3.2	72.7
Saltmaster mix	95.8	4.6	68.0
Unseeded control-I	0	0.6	135.5
SWG/GWG	79.2	15.0	51.4
Nuttall's salt grass	1.1	24.8	72.8
Northern wheatgrass	47.4	28.7	63.6
Tall wheatgrass	121.2	12.5	43.9
Western wheatgrass	32.5	22.3	60.4
Unseeded control-II	0	24.3	46.8
Oyen, AB (5 weeks)			
Spredor 4 alfalfa	72.3	15.8	
AC Saltlander GWG			
15 cm rows	46.9	16.8	
30 cm rows	46.4	9.6	
Smooth bromegrass	60.6	13.4	
Saltmaster mix	51.8	11.6	
Unseeded control-I	0	15.3	
SWG/GWG	40.8	8.7	
Nuttall's salt grass	0.8.	14.1	
Northern wheatgrass	20.8	15.2	
Tall wheatgrass	62.4	10.8	
Western wheatgrass	5.9	10.8	
Unseeded control-II	0	8.8	

Table 3. Average 2007 plant count (established and survived plus newly emerged) at Warner, Oyen, and Swift Current field test sites recorded as frequency (number of plants per square metre) one year after seeding. [GWG = green wheatgrass; SWG = slender wheatgrass]

Suppressor treatment	Emerged and survived		
.	Forages	Foxtail barley	Downy brome
Warner, AB			
Spredor 4 alfalfa	11.9	24.2	28.4
AC Saltlander GWG			
15 cm rows	42.7	10.2	32.1
30 cm rows	31.7	10.0	31.7
Smooth bromegrass	35.4	10.8	27.1
Saltmaster mix	24.0	11.7	28.9
Unseeded control-I	0	13.8	51.4
SWG/GWG	46.6	12.5	19.6
Nuttall's salt grass	0.5	21.2	34.4
Northern wheatgrass	13.6	16.4	35.7
Tall wheatgrass	49.3	7.4	19.2
Western wheatgrass	7.4	17.3	32.6
Unseeded control-II	0	21.1	31.0
Oyen, AB			
Spredor 4 alfalfa	42.1	130.9	
AC Saltlander GWG			
15 cm rows	45.4	78.3	
30 cm rows	44.1	93.3	
Smooth bromegrass	52.8	88.1	
Saltmaster mix	41.7	65.3	
Unseeded control-I	0	131.2	
SWG/GWG	69.8	35.1	
Nuttall's salt grass	5.7	62.5	
Northern wheatgrass	14.0	73.4	
Tall wheatgrass	56.4	44.1	
Western wheatgrass	18.8	59.5	
Unseeded control-II	0	48.0	

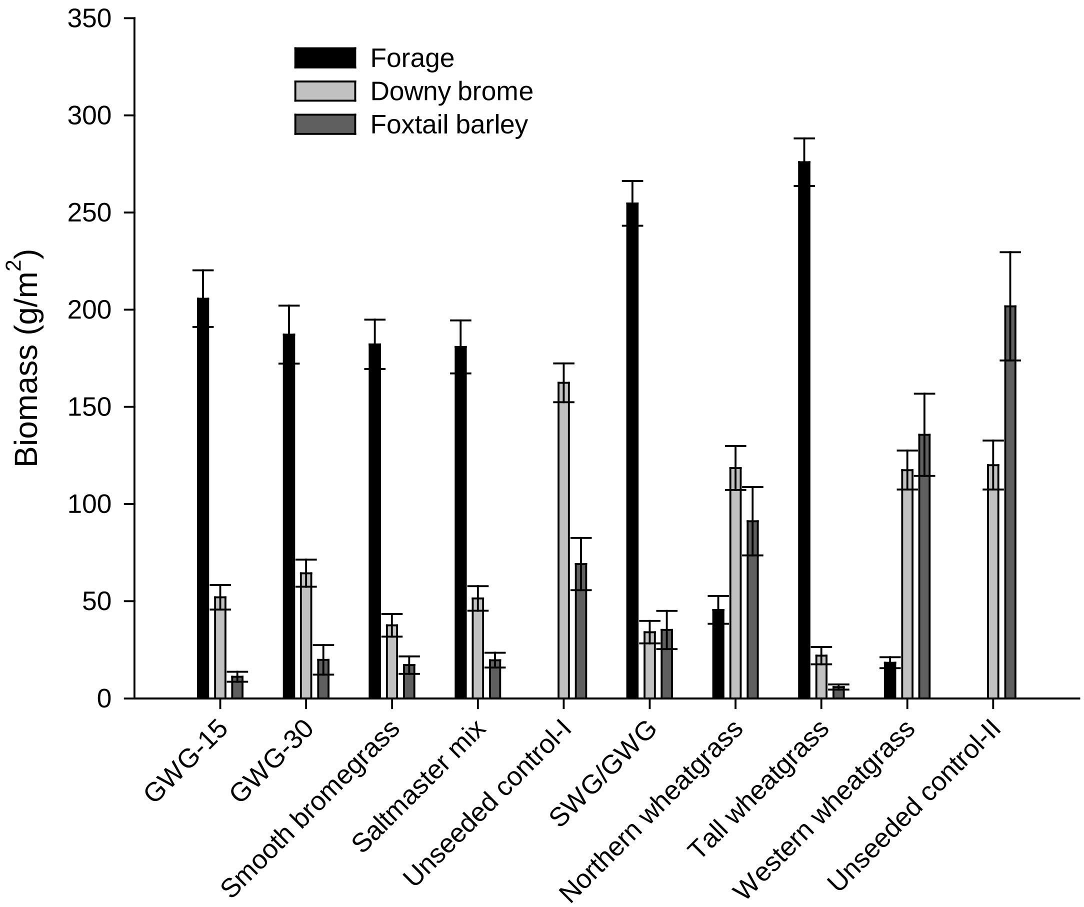

Figure 2. Mean above-ground biomass for suppressor forages and weeds by treatments at the Warner Site, June 26-28, 2007; GWG = green wheatgrass, 15 & 30 cm row spacings; SWG = slender wheatgrass

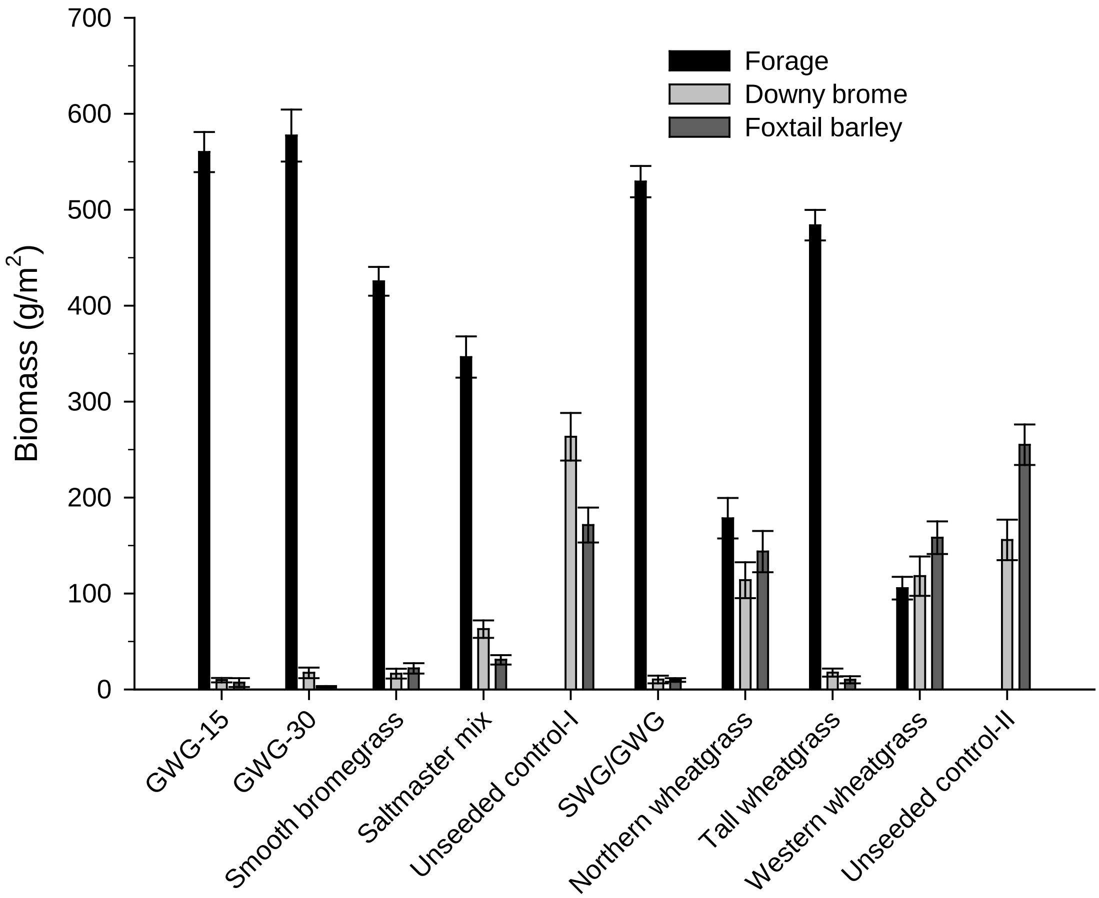

Figure 3. Mean above-ground biomass for suppressor forages and weeds by treatments at the Warner Site, June 24-26, 2008; GWG = green wheatgrass, 15 & 30 cm row spacings; SWG = slender wheatgrass

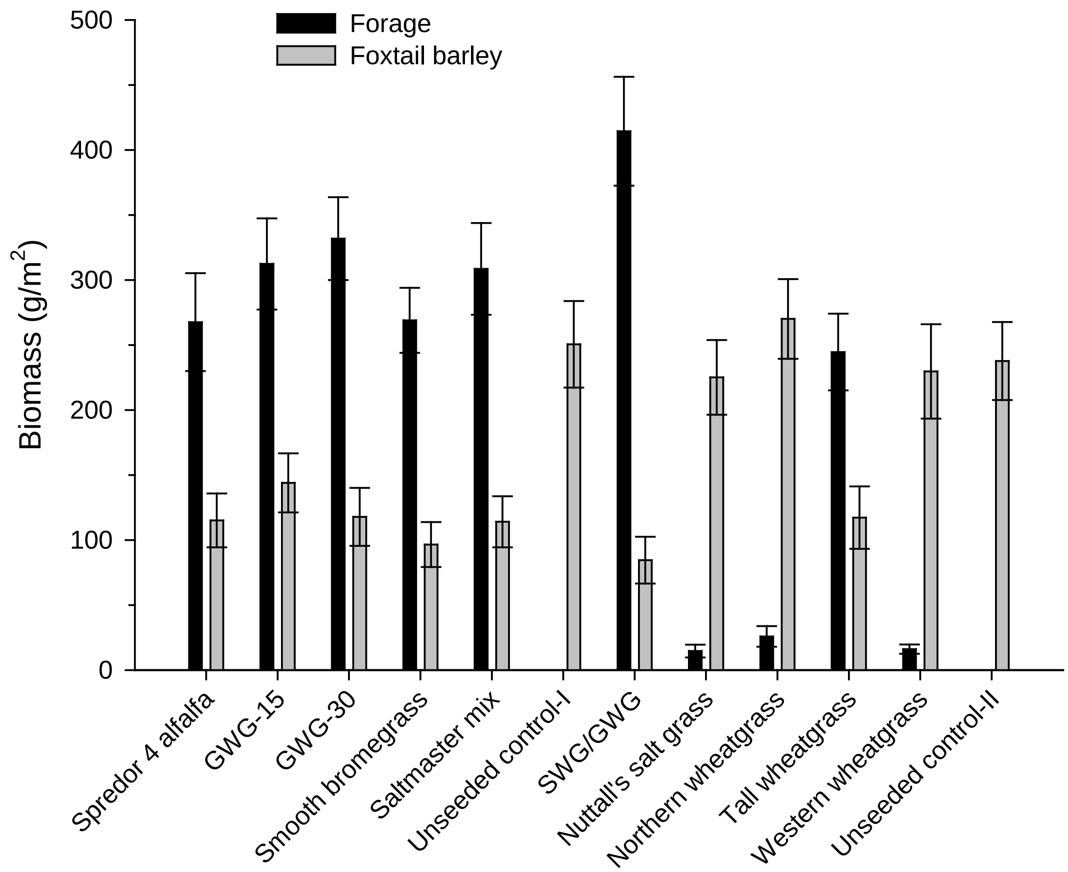

Figure 4. Mean above-ground biomass for suppressor forages and weeds by treatments at the Oyen Site, July 4-5, 2007; GWG = green wheatgrass, 15 & 30 cm row spacings; SWG = slender wheatgrass

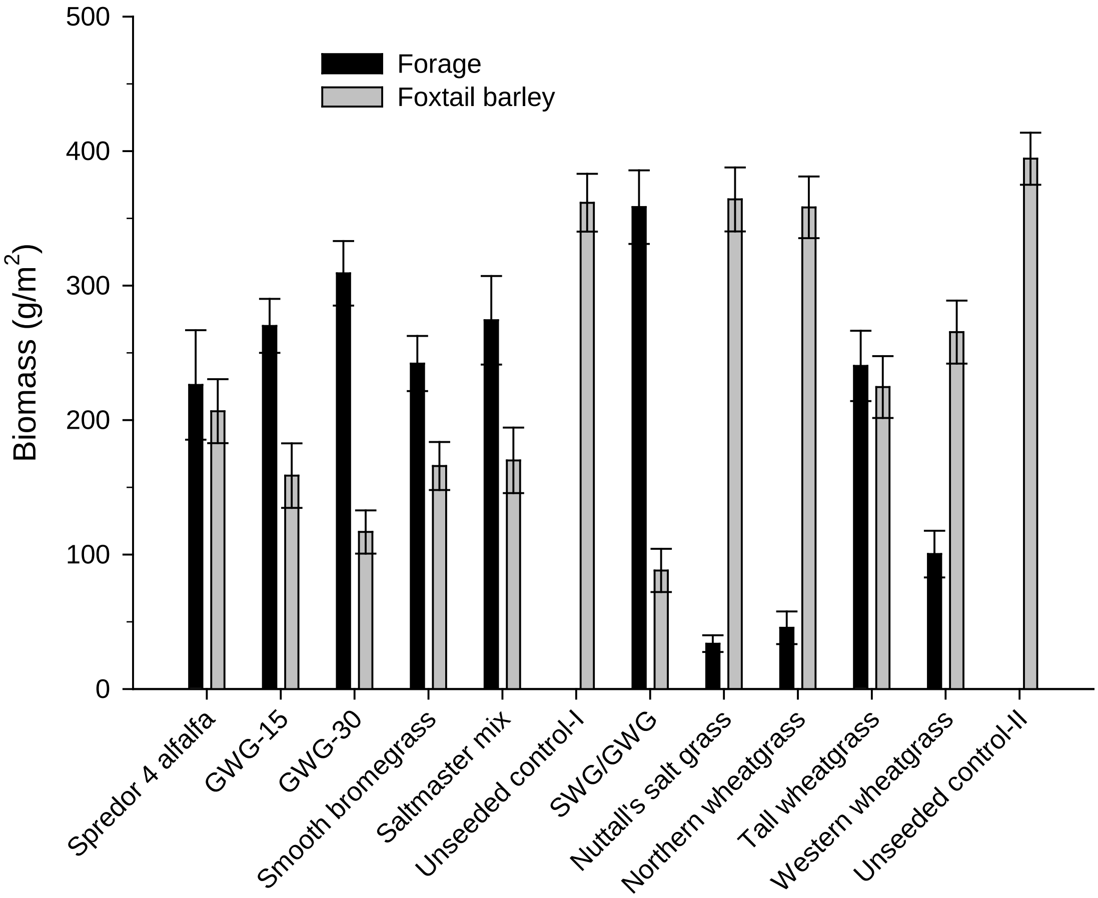

Figure 5. Mean above-ground biomass for suppressor forages and weeds by treatments at the Oyen Site, July 7-9, 2008; GWG = green wheatgrass, 15 & 30 cm row spacings; SWG = slender wheatgrass

Both sites experienced severe drought conditions during the 2009 growing season. Consequently the sites were not harvested in 2009 due to poor plant growth. Both sites received some precipitation in the fall of 2009. This caused the sites to “green” up slightly and allow some visual observations. Further measurements are planned for 2010.

Visually, it appeared that the foxtail barley populations at the Oyen Site increased from 2008 to 2009, while most of the forages may have decreased in many of the plots. The green wheatgrass tended to show the least foxtail barley and seemed to be the most effective in competing with the foxtail barley under the drought conditions of 2009. Most of the slender wheatgrass in the green wheatgrass/slender wheatgrass plots had disappeared from these stands. As expected, the green wheatgrass has spread, filling the area vacated by the slender wheatgrass.

The Nuttall's salt meadow grass, alfalfa, northern wheatgrass and western wheatgrass appear to be losing the competition against the foxtail barley. Although the tall wheatgrass seems to be growing fairly well, the foxtail barley has invaded the space between the rows of the tall wheatgrass. The Saltmaster forage mix appears to be losing ground as well. The tall fescue, slender wheatgrass and most of the alfalfa has all but died out, leaving only the tall wheatgrass and some smooth bromegrass. These plant numbers of each forage species likely cannot maintain a dense enough stand to effectively compete with the foxtail barley.

Visually, the Warner plots appeared to have fared better in 2009 than the Oyen plots, perhaps in part due to lower levels of salinity. The green wheatgrass plots and the tall wheatgrass plots showed the tallest, if not the densest, forage populations; these forage crops have almost eliminated the foxtail barley and downy brome plants in their stands. Slender wheatgrass was still evident in the plots where it was seeded together with green wheatgrass. The smooth bromegrass and the Saltmaster forage mix appeared to rank next in terms of competitiveness. The least competitive treatments were Nuttall's salt meadow grass, northern wheatgrass, and western wheatgrass.

Conclusions

Preliminary conclusions indicate that it is possible to suppress foxtail barley and downy brome using the forage crops currently available. However, the more severe the salinity, the greater the challenge for the forage to suppress the weeds, and the narrower the choice of forage species that will succeed. The forages which establish slowly appear simply unable to compete effectively with foxtail barley and/or downy brome.

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