UNIVERSITY OF SASKATCHEWAN
College of Agriculture and Bioresources
DEPARTMENT OF ANIMAL AND POULTRY SCIENCE
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Evaluation of Alfalfa and Grass Species in Binary and Quaternary Mixtures for Soil Salinity Control

Enkhjargal Darambazar [1], Bill Biligetu[2], Jeff Schoenau[3], Daalkhaijav Damiran[1], and Bart H.A. Lardner[1*]
[1]Department of Animal and Poultry Sciences, University of Saskatchewan, Saskatoon, SK
[2]Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK
[3]Department of Soil Sciences, University of Saskatchewan, Saskatoon, SK
*Tel: (306) 966-2147; bart.lardner@usask.ca

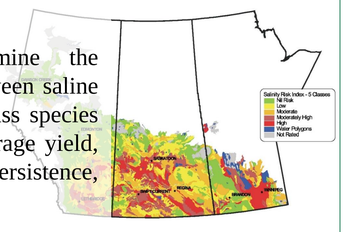
ABSTRACT

There are 600,000 acres in Saskatchewan where the soil salinity has effectively reduced the yield potential to zero and several million acres where salinity has reduced yield [1].

These acres may benefit from reclamation with saline tolerant forages and then be returned to a higher productivity state in the future.

High salinity soil in Saskatchewan

OBJECTIVE: Determine the effect of synergies between saline tolerant legume and grass species and soil salinity on forage yield, quality, composition, persistence, and weed invasion.



MATERIALS and METHODS

Study area: NE 21-34-03 W3, LFCE, Clavet, SK, the Dark Brown soil zone.

Treatments: Alfalfa (HaALF, cv. Halo, *Medicago sativa* L.) seeded in binary mixture with creeping meadow foxtail (CRF, cv. Garrison, *Alopecurus arundinaceus* Poir.) or smooth bromegrass (SBG, cv. Carlton, *Bromus inermis* Leyss.) or slender wheatgrass (SWG, cv. Revenue, *Agropyron trachycaulum* Malte) or in quaternary mixture with all 3 grasses (HaALF-CRF-SBG-SWG).

Experimental design: Randomized Complete Block (n=4).

Measurements: soil nutrients, electrical conductivity (EC), pH, stand establishment, botanical composition, weed invasion incl. foxtail barley (*Hordeum jubatum* L.), yield, and quality in 2019-2020.

Data analysis: Proc Mixed Model of SAS (2003), significance at $P < 0.05$.

A plot of Halo Alfalfa and grass mixtures in Clavet, SK (early 2nd yr, 28 May 2020) Plot size: 6.2 m × 1.2 m Harvest date: 9 September 2020.

RESULTS and ANALYSIS

Table 1. Soil characteristics at depth 0-60 cm (2019)

Parameter	Mean	SEM
% DM		
Moisture	29.2	1.23
Particulate Organic Carbon	1.2	0.11
kg ha^{-1}		
Available Nitrate-N	3.9	0.59
Available Sulfate-S	1249.1	50.69
Available Phosphate-P	17.0	1.40
Available Potassium	635.2	43.85
pH	7.8	0.02
EC, dS m^{-1}	6.6	0.15

Soils: Loamy (sand: 47.9 ± 5.72%; silt: 45.5 ± 5.61%; and clay: 6.6 ± 2.09%).

Soil salinity: Saline (EC > 4.0 dS m^{-1} and pH < 8.5) [2; 3] and according to the U.S. soil salinity classification [4], moderately (EC 4-8.0 dS m^{-1}) saline (Table 1). The magnitude of EC at 30-60 cm depth was lower ($P < 0.05$) (5.9 dS m^{-1}) than either at 0-15 cm (7.2 dS m^{-1}) and 15-30 cm (6.9 dS m^{-1}) depths.

Fig. 1. Dry matter yield and establishment score

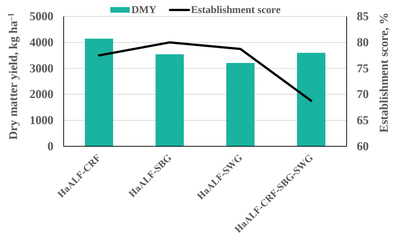
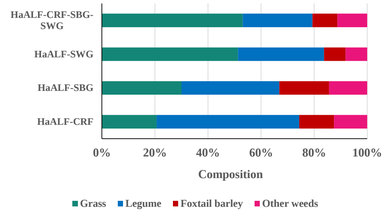


Fig. 2. Botanical composition



Stand establishment: The binary mixtures (HaALF-CRF, HaALF-SBG, and HaALF-SWG) were similar with each other ($P > 0.05$; avg. 78.8%) but were ~15% greater than quaternary mixture (HaALF-CRF-SBG-SWG; 68.8%) system (Fig. 1).

Yield: Ranged 3210.2-4147.8 kg ha^{-1} HaALF-CRF produced 11 to 14% greater DMY relative to the other forage mixtures.

Weed invasion: HaALF-SWG (16.3%) was less, whereas HaALF-SBG (33.1%) was more susceptible to weeds incl. foxtail barley (Fig. 2).

Table 2. Basic chemical composition, protein subfractions, nutrient yield, and energy values of Halo alfalfa and grass mixtures grown in saline soil at LFCE, Clavet, SK

	HaALF-CRF	HaALF-SBG	HaALF-SWG	HaALF-CRF-SBG-SWG	*P*-value
Structural carbohydrate profile (%, DM)					
Acid detergent fibre (ADF)	39.1 ± 1.71	36.5 ± 1.71	41.2 ± 1.71	38.7 ± 1.71	0.343
Neutral detergent fibre (NDF)	55.9 ± 2.26	53.9 ± 2.26	58.6 ± 2.26	56.4 ± 2.26	0.559
Acid detergent lignin (ADL)	7.7 ± 0.55	7.3 ± 0.55	8.0 ± 0.55	7.9 ± 0.55	0.806
Crude protein profile (%, CP)					
Crude protein (CP % DM)	10.9 ± 1.20	11.7 ± 1.20	9.5 ± 1.20	10.9 ± 1.20	0.617
Soluble protein (SP)	3.8 ± 0.34	4.1 ± 0.34	3.7 ± 0.34	4.0 ± 0.34	0.822
Neutral detergent insoluble CP (NDICP)	2.4 ± 0.36	2.6 ± 0.36	2.0 ± 0.36	2.7 ± 0.36	0.612
Acid detergent insoluble CP (ADICP)	1.3 ± 0.06	1.3 ± 0.06	1.2 ± 0.06	1.3 ± 0.06	0.453
Rumen degradable CP (RDCP)	67.3 ± 0.86	68.1 ± 0.86	69.7 ± 0.86	68.2 ± 0.86	0.310
Total digestible nutrients (TDN % DM)	54.9 ± 1.04	56.3 ± 1.04	53.7 ± 1.04	55.0 ± 1.04	0.418
Nutrient yield obtainable per hectare (kg ha^{-1})					
Crude protein yield (CPY)	463.5 ± 84.73	413.3 ± 84.73	301.0 ± 84.73	398.0 ± 84.73	0.601
Total digestible nutrients yield (TDNY)	2273.3 ± 361.15	1989.8 ± 361.15	1749.8 ± 361.15	1970.7 ± 361.15	0.788
Energy values (Mcal kg^{-1} DM)					
Net energy for gain (NEG)	0.2 ± 0.00	0.2 ± 0.00	0.2 ± 0.00	0.2 ± 0.00	.
Net energy for maintenance (NEM)	1.2 ± 0.04	1.2 ± 0.04	1.1 ± 0.04	1.2 ± 0.04	0.364

Table 3. Mineral composition of Halo alfalfa and grass mixtures grown in saline soil at LFCE, Clavet, SK

	HaALF-CRF	HaALF-SBG	HaALF-SWG	HaALF-CRF-SBG-SWG	*P*-value
Macroelements (% DM)					
Calcium	0.6 ± 0.09	0.6 ± 0.09	0.5 ± 0.09	0.5 ± 0.09	0.636
Phosphorus	0.2 ± 0.02	0.2 ± 0.02	0.2 ± 0.02	0.2 ± 0.02	0.834
Potassium	1.3 ± 0.14	1.6 ± 0.14	1.5 ± 0.14	1.5 ± 0.14	0.527
Magnesium	0.4 ± 0.03	0.4 ± 0.03	0.3 ± 0.03	0.3 ± 0.03	0.277
Sodium	0.1 ± 0.03	0.2 ± 0.03	0.2 ± 0.03	0.1 ± 0.03	0.160
Microelements (mg kg^{-1} DM)					
Copper	5.0 ± 0.67	5.8 ± 0.67	5.8 ± 0.67	5.0 ± 0.67	0.743
Zinc	11.5 ± 1.83	9.5 ± 1.83	7.8 ± 1.83	10.0 ± 1.83	0.562
Iron	133.5 ± 14.30	137.0 ± 14.30	123.0 ± 14.30	134.0 ± 14.30	0.906
Manganese	44.8 ± 3.55	47.0 ± 3.55	52.5 ± 3.55	53.5 ± 3.55	0.284

Chemical composition:

- Mixtures did not differ in chemical composition ($P > 0.05$);
- CP averaged at 10.7 ± 1.2%, NDF 56.2 ± 2.3%, ADF 38.9 ± 1.7%, and TDN 55.0 ± 1.0%;
- Nutrient yields from a hectare were CPY 394.1 ± 84.7 kg ha^{-1} and TDNY 1995.9 ± 361.2 kg ha^{-1} (Tables 2 & 3).

CONCLUSIONS

Preliminary results suggested that high forage yield and good quality can be produced with adequate uptake and removal of nutrients by Halo alfalfa and grass mixtures on the saline soil. Binary mixtures of alfalfa cv. Halo with creeping meadow foxtail cv. Garrison, smooth bromegrass cv. Carlton, and slender wheatgrass cv. Revenue established better than the quaternary mixture. Although weed invasion was quite high in all mixtures, Revenue slender wheatgrass in mixture with Halo alfalfa had less infestation, while Carlton smooth bromegrass was more susceptible to weeds including foxtail barley. Overall, Halo alfalfa in mixture with creeping meadow foxtail produced greater forage yield showing a potential to be a viable alternative for salinity control in the Dark Brown soil zone.

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