# REVEGETATION OF SALINE SOILS USING SALT TOLERANT GRASSES

Sask Forage Council

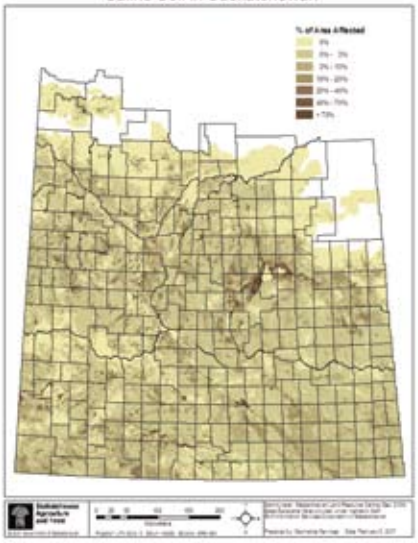
*According to Agriculture and Agri-Food Canada estimates, approximately 5.52 million acres of agricultural land in Saskatchewan is at moderate to high risk of salinization. Depending on the level and type of salts present in the soil, the impact on crops ranges from minor yield reductions to establishment failure. Salinization of cropland can reduce its economic and environmental viability. Moderate to severely saline soils can be reclaimed using salt tolerant perennial grasses, while providing a forage crop.*

## What are saline soils?

Saline soils are those which contain sufficient soluable salts to impair productivity. In Saskatchewan, saline soils are generally rich in sulphate salts, existing as compounds of sodium, magnesium, and calcium. Soil salts arise from the weathering of minerals and rocks by mechanical and chemical processes, which release salts into the soil. In Saskatchewan, the majority of soil salts originate from very old sedimentary rocks laid-down by seas that once covered most of Saskatchewan. Later, glaciers mixed these marine deposits with younger, non-marine sediments, resulting in the near surface glacial till and melt water deposits found today. The movement of salinized ground water has also contributed salts to the soil. A saline soil conducts electrical current better than a non-saline soil, as measured by the strength of a calibrated current directed through water extracted from a sample of soil under standard conditions. The electrical conductivity (EC) is measured in deciSiemens/metre. Levels of soil salinity as related to soil texture are included in *Table 1.*

## How do saline soils impede plant growth?

Plants obtain water and water-soluble nutrients from the soil by maintaining a concentration of soluble material in their cells great enough to cause the movement of soil water and dissolved nutrients into root cells. The osmotic difference between the soil water and the water inside the root cells creates a gradient into the roots that allows the plant to obtain moisture and nutrients from the soil. When the concentration of dissolved salts in the soil water increases, the osmotic gradient between the soil water and plant roots is lessened or eliminated. When the plant loses the ability to absorb adequate amounts of water and nutrients, drought stress and nutrient deficiencies occur in the plant.




Source: Saskatchewan Agriculture and Food

## Relative salinity tolerance of grasses

Considerable variation in salinity tolerance exists between grass species (*Table 2*). Some species have a greater ability to offset unfavourable soil osmotic conditions by accumulating compounds in their cells that maintains osmotic flow into the roots. Some species, such as Dahurian wildrye,

**Table 1. Relative salinity (deciSiemens/metre, saturated extract) ratings of various soil textures**

| Soil texture | Salinity level | | | | |
|---|---|---|---|---|---|
| | Non saline | Slightly saline | Moderately saline | Severely saline | Very severely saline |
| sand | 0-1.8 | 1.9-3.9 | 4.0-7.8 | 7.9-15.9 | 15.9+ |
| sandy loam | 0-1.9 | 2.0-3.8 | 3.9-7.9 | 8.0-15.8 | 15.8+ |
| loam | 0-2.0 | 2.1-4.0 | 4.1-7.9 | 8.0-15.8 | 15.8+ |
| clay loam | 0-2.0 | 2.1-4.0 | 4.1-8.0 | 8.1-16.0 | 16.0+ |
| clay, peat | 0-2.0 | 2.1-4.0 | 4.1-7.9 | 8.0-15.8 | 15.8+ |

have greater seedling vigor and relative yield potential than other grasses. Under saline soil conditions, relative performance remains constant and species with greater seedling vigour and yield potential have superior performance.

**Table 2. Relative salt tolerance of grasses**

| Perennial forages for saline soils, flooded areas and peat (Based in part on test results from Canada's Salt Tolerance Lab at Swift Current) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Limited spring flooding (up to two weeks)** | | | | | | | | | |
| **Candidate forages for seed mixtures** | **Occurrence of visible surface salts (Salinity Rating [1])** | | | | | | | | **Seeding rate [2] lb./ac.** |
| | Almost always | | Frequently | | Infrequently | | Rarely | | |
| | Pasture | Hay | Pasture | Hay | Pasture | Hay | Pasture | Hay | |
| Green wheatgrass [3] | X | X | X | X | X | X | | | 10 |
| NewHy [3] | | | X | X | X | X | | | 10 |
| Russian wild ryegrass [4] | | | X | | X | | X | | 8 |
| Nuttall's saltgrass [5] | | | X | | X | | | | |
| Slender wheatgrass | | | | X | | X | X | X | 8 |
| Intermediate wheatgrass | | | | X | | X | | X | 10 |
| Crested wheatgrass | | | X | X | X | X | X | X | 7 |
| Smooth bromegrass | | | | X | | X | | X | 8 |
| Meadow bromegrass | | | X | | X | | X | | 12 |
| Awned wheatgrass [5] | | | | | X | | X | | |
| Northern wheatgrass | | | | | X | X | X | X | 7 |
| Western wheatgrass | | | | | X | X | X | X | 10 |
| Dahurian wild ryegrass [6] | | | | | | X | | X | 12 |
| Alfalfa [7] | | | | | X | X | X | X | 6-8 |
| Green needlegrass [5] | | | | | | | X | | |
| **Limited spring flooding (two - five weeks)** | | | | | | | | | |
| **Candidate forages for seed mixtures** | **Occurrence of visible surface salts (Salinity Rating [1])** | | | | | | | | **Seeding rate [2] lb./ac.** |
| | Almost always | | Frequently | | Infrequently | | Rarely | | |
| | Pasture | Hay | Pasture | Hay | Pasture | Hay | Pasture | Hay | |
| Tall wheatgrass | | X | | X | | X | | | 12 |
| Green wheatgrass [3] | X | X | X | X | X | X | | | 10 |
| NewHy [3] | | | X | X | X | X | | | 10 |
| Slender wheatgrass | | | | X | | X | | X | 8 |
| Intermediate wheatgrass | | | | X | | X | | X | 10 |
| Tall fescue | | | X | X | X | X | X | X | 8 |
| Smooth bromegrass | | | | X | | X | | X | 8 |
| Meadow bromegrass | | | | | X | | X | | 12 |
| Creeping foxtail [8] | | | | | X | X | X | X | 5 |
| Western wheatgrass | | | | | X | | X | | 10 |
| Orchard grass | | | | | X | | X | | 10 |
| Sweetclover [9] | | | | | | X | | X | 8 |
| Alfalfa [7] | | | | | X | X | X | X | 4-8 |
| Reed canarygrass | | | | | | X | | X | 5 |
| Alsike clover | | | | | | X | | X | 4 |
| Timothy | | | | | | X | | X | 5 |

**1)** Approximate salinity rating by visual occurrence
Rarely (0 -2 dS/m), Infrequently (2 - 5 dS/m), Frequently (5 -8 dS/m), Almost always (>8 dS/m)
**2)** Required to achieve a pure stand; use as a guide for various seed mixtures
**3)** AC Saltlander (Canadian) and NewHy (American)
**4)** Variety: Tetracan (Canadian)
**5)** Reclamation species
**6)** If rapid establishment is important
**7)** Watch for possible bloat when grazed
**8)** Variety: Garrison (American)
**9)** For special purposes

## Salt tolerant wheatgrasses

Recently, new grasses have been developed that have improved salt tolerance, yield, and quality compared to grass species traditionally used for saline soil reclamation.

## NewHy hybrid wheatgrass

NewHy hybrid wheatgrass was developed by crossing quackgrass (*Elytrigia repens* or *Agropyron repens*) with bluebunch wheatgrass (*Pseudoroegneria spicata* or *Agropyron spicatum*). The hybrid was developed by the United States Department of Agriculture and the Utah Agricultural Experiment Station and was released in 1989. NewHy was registered in Canada in 1991, but presently does not fall within Canadian Food Inspection Agency requirements for registration. Objectives of the hybrid development program were to combine the persistence, vigour, productivity and salinity tolerance of quackgrass with the forage and seed quality, drought tolerance and bunchgrass growth form of bluebunch wheatgrass.

Photo credit: Proven Seed/Viterra

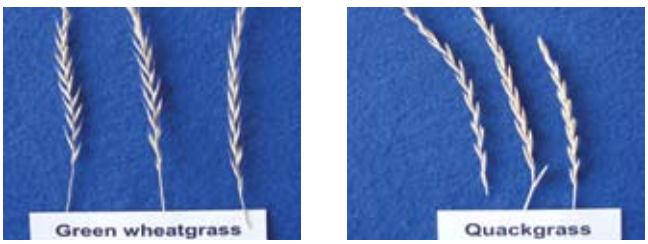
*Mature NewHy hybrid wheatgrass*

NewHy hybrid wheatgrass is best suited to sites that are slightly to moderately saline and that receive more than 35 cm of precipitation annually. Salinity tolerance and yield potential of NewHy hybrid wheatgrass is somewhat less than tall wheatgrass, but forage quality is greater. Chemical analysis of forage quality is similar to that of intermediate wheatgrass. NewHy begins growth early in the season and remains palatable later in the season than most other wheatgrasses. NewHy spreads by rhizomes, but significantly less so than quackgrass. Under semiarid conditions, rhizome growth varies from 10 to 100 cm/year, with 85% of the plants having less than 50 cm rhizome growth annually.

## Green Wheatgrass

### Origin

Green wheatgrass (*Elymus hoffmannii*) is believed to originate from a naturally occurring hybrid between one of a group of bluebunch wheatgrasses (*Pseudoroegneria strigosa , Pseudoroegneria geniculata, Pseudeoroegeria stripifolia*) of Eurasian origin, and quackgrass (*Agropyron repens, Elymus repens, Elytrigia repens*). Selections were made from seed collected from Turkey. Initial selections in Utah were conducted to enhance bunchgrass growth




*Inflorescence differences can assist in differentiating green wheatgrass from quackgrass*

Photo credit: Agriculture and Agri-Food Canada - Semiarid Prairie Agricultural Research Centre

form, vigour, leafiness, seed production and pest resistance. Further salt tolerance testing and selection for salinity tolerance, palatability and winter hardiness occurred at the Semiarid Prairie Agricultural Research Centre (SPARC) at Swift Current, Saskatchewan. This program led to the development of AC Saltlander in 2004. Green wheatgrass and quackgrass seed are similar in appearance, however, morphological differences between the two species make them distinguishable in the field. Green wheatgrass grows taller than quackgrass, but awn length differences are the most useful characteristic to distinguish the two species. Awns on the lemmas of mature, lower florets are 5 to 8 mm long on green wheatgrass, whereas quackgrass awns are 1 to 2 mm in length. Green wheatgrass has three florets per spikelet and are broadly displayed, whereas quackgrass has a narrow spikelet containing 5 florets. There are 246,700 green wheatgrass seeds per kilogram (111,000 seeds/lb). Recommended seeding rate of green wheatgrass in saline soil is 10 kg/ha (10 lbs/ac).

Photo credit: Agriculture and Agri-Food Canada - Semiarid Prairie Agricultural Research Centre

*Four year old stand of AC Saltlander.*

### Salinity Tolerance

Green wheatgrass has shown excellent potential for use in vegetating saline soils. Relative salinity tolerance of green wheatgrass was compared to tall wheatgrass and NewHy wheatgrass at the Semiaird Prairie Agricultural Research Centre Salinity Testing Lab. Emergence, seedling survival, and emergence rate were measured in soils containing chloride and sulphate salts at solution EC levels ranging from 1.5 dS/m to 50 dS/m. Green wheatgrass, tall wheatgrass and NewHy all can emerge and survive at salinity solution levels approaching 24 dS/m.

Tall wheatgrass showed superior emergence and seedling survival, compared to NewHy or green wheatgrass. However, the rate of emergence of NewHy and green wheatgrass was greater than that of tall wheatgrass, inferring superior seedling vigour compared to tall wheatgrass. There was no significant difference between NewHy and green wheatgrass emergence and seedling survival.

Photo credit: Agriculture and Agri-Food Canada - Semiarid Prairie Agricultural Research Centre

*Seed production plot of green wheatgrass – establishment year*

### Growth and Production

Green wheatgrass has a creeping root system. Under non-saline conditions, green wheatgrass rhizome spread is approximately half that of quackgrass. With increasing soil salinity, rhizome production decreases but competitive ability is maintained, allowing green wheatgrass to compete well with foxtail barley and other weeds. Research at Semiaird Prairie Agricultural Research Centre indicated crop height in all species was significantly reduced when soil salinity levels exceeded 7 dS/m. The decline in crop height with increasing soil salinity was similar among tall wheatgrass, green wheatgrass and NewHy. However, biomass measurements in the same study indicated that green wheatgrass production was equal or superior to tall wheatgrass at lower soil salinity levels, but decreased to slightly less than tall wheatgrass at increased soil salinity levels. NewHy yields were lower than tall and green wheatgrass at all soil salinity levels. Green wheatgrass yields are superior to Altai wildrye and tall fescue. Yield comparisons between green wheatgrass, Russian wildrye, and crested wheatgrass are included in *Table 3*.

**Table 3. Dryland forage yields (kg/ha) of green wheatgrass, crested wheatgrass and Russian wildrye at Swift Current, Saskatchewan.**

| Year | Species | | |
|---|---|---|---|
| | crested wheatgrass (variety Kirk) | Russian wildrye (variety Swift) | green wheatgrass |
| 1996 | 4056 | 1909 | 3922 |
| 1997 | 5903 | 4329 | 4497 |
| 1998 | 2541 | 2557 | 1505 |
| 1999 | 4076 | 3088 | 3341 |
| 2000 | 1496 | 1140 | 1087 |
| **average** | **3614** | **2605** | **2870** |

Green wheatgrass begins growth early in spring and remains palatable later in the season than most other wheatgrasses. Green wheatgrass exhibits good regrowth following defoliation and is moderately grazing tolerant.

### Forage Quality

Green wheatgrass palatability and forage quality are superior to tall wheatgrass. Neutral detergent fibre and crude protein levels of green wheatgrass are similar to intermediate wheatgrass. Digestibility, crude protein, phosphorous content, calcium, and neutral detergent fibre of green wheatgrass are compared to those of crested wheatgrass and Russian wildrye in *Table 4*.

**Table 4. Forage quality of green and crested wheatgrass and Russian wildrye at Swift Current, Saskatchewan.**

| Analysis % | Species | | |
|---|---|---|---|
| | crested wheatgrass (variety Kirk) | Russian wildrye (variety Swift) | green wheatgrass |
| digestibility | 50.9 | 50.9 | 50.7 |
| crude protein | 5.3 | 6.88 | 6.38 |
| phosphorous | 0.13 | 0.17 | 0.13 |
| calcium | 0.23 | 0.32 | 0.39 |
| neutral detergent fibre (NDF) | 56.1 | 66.2 | 53.2 |
| acid detergent fibre (ADF) | 32.4 | 38.9 | 30.4 |

## *Management considerations when using grasses for saline soil reclamation*

- Seed a mixture of species. Saline soils are highly variable so seeding a number of species with differing salinity tolerances will increase productivity of the stand.
- Use deep rooted species, if possible. Species with deep roots draw down soil water levels, reducing upward movement of salts.
- Dormant seed in flood prone areas. Fields that are too wet to seed in spring can be seeded the previous fall (just prior to freeze up), when soil moisture levels are lower. High soil moisture levels in the spring can reduce salt concentrations in the rooting zone thereby increasing establishment success.

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