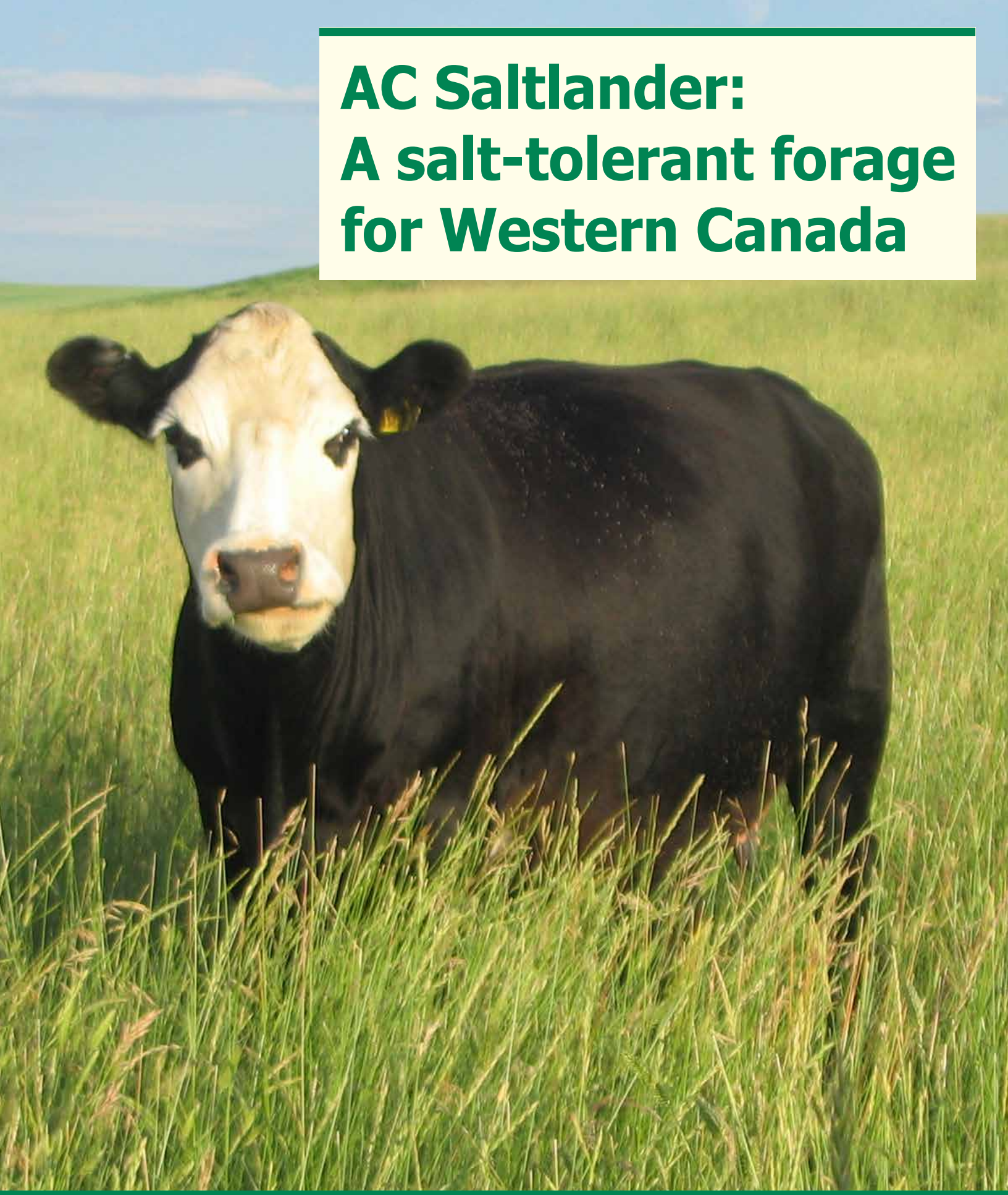
AC Saltlander: A salt-tolerant forage for Western Canada



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AC Saltlander: a salt-tolerant forage for Western Canada

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AC SALTLANDER ESTABLISHMENT AT-A-GLANCE

One year before seeding AC Saltlander (pp. 10-12)

- Grow a salt-tolerant annual crop the year before seeding AC Saltlander
  - Leave standing stubble
- Plan where and what to seed based on salinity levels – map out your field
  - Use soil testing to supplement descriptive information like visible salts, poor crop production, or presence of salt-tolerant weeds like kochia or foxtail barley
  - Include a buffer zone between AC Saltlander and ecologically sensitive areas (native rangeland, riparian areas)
- Divide field into zones based on salinity concentrations
  - Salinity zones will help to determine forage variety choices and seeding rates
- Control Weeds
  - Scout and map out weeds
  - Control perennial and annual weeds pre- and post-harvest
  - Priority: control quackgrass and foxtail barley

Year 1: Planting year

Weed management – pre-seed (p. 13)

- Review seed analysis certificate before buying seed
  - If the seedlot contains weeds, use best management practices to mitigate risks of weed dispersal
- Scout and map weeds
  - Scout for weeds one month before seeding AC Saltlander
- Apply two high-rate glyphosate applications (follow label instructions) pre-seed
  - 1st application: 3 weeks before seeding
  - 2nd application: 1-7 day before seeding
- Avoid tillage in wetter regions as this will bring salts to the surface
- Deep tillage may be appropriate in drier, hotter regions to break up surface hardpan

Seedbed preparation (p. 14)

- Harrow as required to level out furrows and disperse residue from previous crop
- Firm seedbed is essential

Seeding (pp. 14-17)

- Timing:
  - Optimal: spring (mid- to late May)
  - Later seeding (up to early August): seedlings must have at least two leaves going into winter
  - Dormant seeding (November) is an option when water logging prevents spring seeding

- Equipment must provide:
  - Consistent and accurate seed flow
  - Accurate, shallow and uniform seed placement
  - Adequate seed-to-soil contact (i.e. adequate packing)

Carrier or nurse crop (pp. 19-21)

- Prevents seed bridging in the seed box or blockages in the seed tubes
- Mix with seed, up to a maximum of a 1:1 ratio by weight
- Carrier options:
  - Inert material (e.g. garden vermiculite, rice)
  - Granular fertilizer (monoammonium phosphate [11-52-0])
  - Nurse crop (annual cereal)
- Do not seed nurse crop over a 1:1 ratio by weight or it may outcompete the forage crop
- Remove as early as possible for silage or green-feed; do not allow nurse crop to reach maturity as that prolongs competition for light, moisture, space and nutrients

Seeding rate (pp. 21-22)

- AC Saltlander has 242,000 seeds/kilogram (110,000 seeds/pound)
- Low salinity: conventional salt-tolerant forage mix (may or may not include AC Saltlander)
- Low to moderate salinity: salt-tolerant mix that includes 2.8-5.6 kilograms/hectare (2.5-5.0 pounds/acre) AC Saltlander
- Moderate salinity: Monoculture AC Saltlander, 5.6 kilograms/hectare (5 pounds/acre). Optional: add an additional 5.6 kilograms/hectare of another salinity tolerant species (e.g. slender wheatgrass) to diversify forage stand
- Severe salinity: Monoculture AC Saltlander, 11.2 kilograms/hectare (10 pounds/acre); mixes that contain AC Saltlander with other highly salt-tolerant forages may also be an option
- Very severe salinity: Around the perimeter (transition between severely and very severely saline areas) – monoculture AC Saltlander, 11.2 kilograms/hectare (10 pounds/acre)

Fertility (p. 23)

- Test your soil to identify nutrient deficiencies
- Top dress after year of establishment, according to soil test

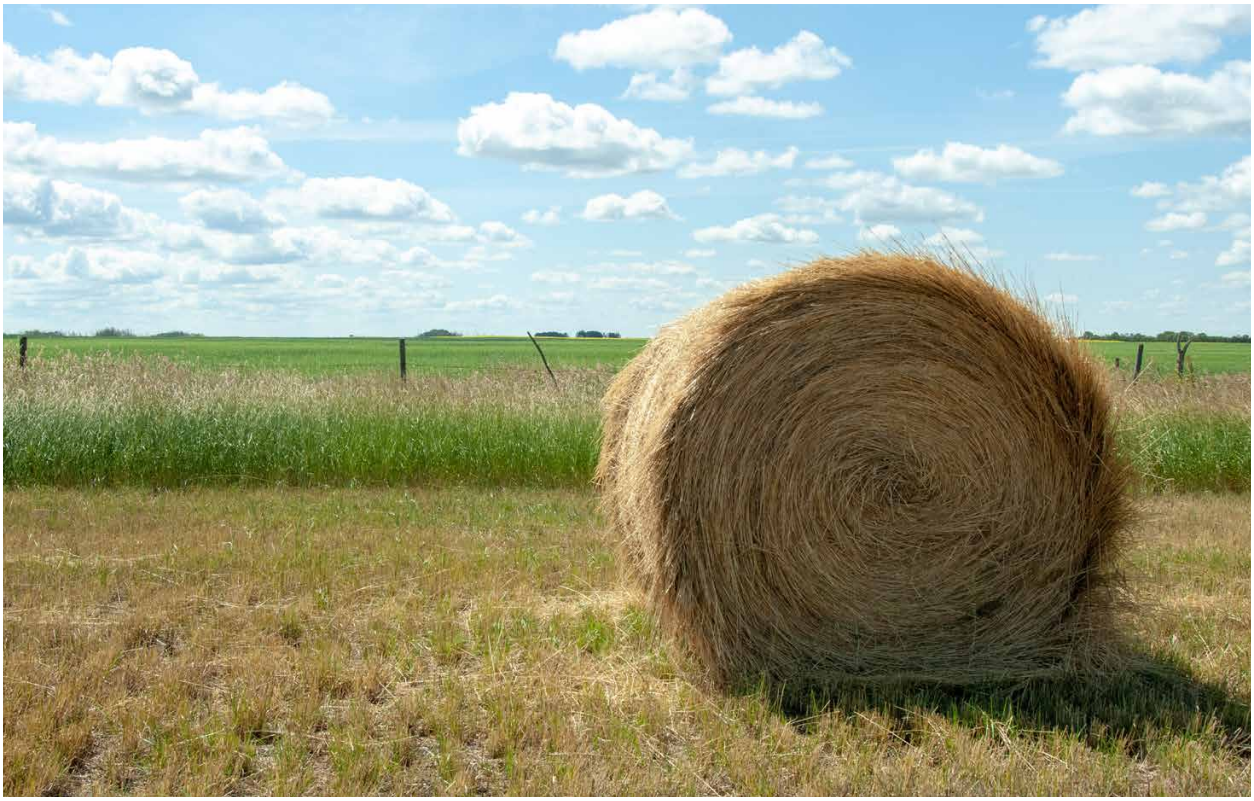
Seeding depth and row spacing (pp. 23-24)

- Depth: 1.9 centimetres (0.75 inches)
- Row spacing: 30 centimetres (12 inches) or less

Weed management – post-seed (pp. 24-26)

- Monitor forage growth stage and weed emergence
  - Apply a post-emergence broadleaf herbicide if needed when AC Saltlander is at the second or third leaf stage
  - OR mowing may be an option depending on weed species; mow weeds when they have grown significantly but prior to seed set; bale or spread weed biomass to prevent smothering of AC Saltlander seedlings

TABLE OF CONTENTS



AC Saltlander stand seeded in June 2017 near Nokomis, Saskatchewan: Photos taken August 2018.

INTRODUCTION

The issue of soil salinity

Salinity is a major soil degradation problem. Severe soil salinity is estimated to affect at least 2.2 million hectares (5.4 million acres) on the Canadian Prairies with a much greater area impacted by less severe salinity levels (Prairie Farm Rehabilitation Administration 2000). In economic terms, this was equal to $257 million per year (1998 dollars) in lost income for Canadian farmers and likely much more today (Forge 1998). A plant's ability to grow in saline soil depends on its salt tolerance. Salt tolerances are usually categorized in relation to soil electrical conductivity levels, measured in deciSiemens per metre (dS/m) (Table 1).

Soil testing is the only accurate way to determine soil salinity values. However, salinity levels can be estimated based on visual observation of salt on the soil surface. A visual guide was developed based on test results from AAFC's Salt Tolerance Testing Lab at Swift Current, Saskatchewan (Steppuhn et al. 2007) (Table 2).

Most crop and pasture plants do not establish or survive long in highly saline areas, allowing salt-tolerant weeds (i.e. invasive species with low forage value) to invade (Figure 1). These non-productive areas are often ignored and unmanaged because rehabilitation is difficult and costly. A recommended practice is to establish permanent plant cover to reduce the impacts of salinity. "A perennial species that can establish, persist, provide competition to weeds and provide good quality forage is an ideal tool for reclamation of saline soils" (Iwaasa et al. 2019a). Unfortunately, the more severe the salinity, the narrower the choice of adapted forage species (Table 3). Furthermore, even with higher salt-tolerant forage species, favourable conditions are required (e.g. good soil moisture and temperature, no soil crusting) for successful germination and establishment.

More detailed information on reclaiming saline affected soils can be found in the Saskatchewan Forage Council factsheet *Revegetation of saline soils using salt tolerant grasses*, developed by Agriculture and Agri-Food Canada and the Saskatchewan Ministry of Agriculture (Steppuhn et al. 2007).

Table 1. Soil salinity classes and electrical conductivity (dS/m)

Soil Depth (cm)	Non	Slight	Moderate	Severe	Very Severe
0-60	<2	2-4	4-8	8-16	>16
60-120	<4	4-8	8-16	16-24	>24

Adapted from Eilers 1984

Table 2. Visual guide to estimating soil salinity

Salinity class	Electronic conductivity (dS/m)	Visual observation at soil surface
Non-saline	0-2	Rarely see visible signs of salt
Slightly saline	2-5	Infrequently see visible signs of salt
Moderately saline	5-8	Frequently see visible signs of salt
Severely saline	>8	Almost always see visible signs of salt

Source: Steppuhn et al. 2007

Table 3. Relative tolerance of forage crops to salinity

Salinity level	Forage Crops
None to slightly saline (0-4 dS/m)	Alsike clover, meadow brome, orchard grass, red clover, timothy
Moderately saline (4-8 dS/m)	Alfalfa (salt-tolerant varieties), bird's-foot trefoil, brome (smooth), cicer milkvetch, fescue (meadow and tall forage type), reed canary grass, sweet clover, wheatgrass (crested and intermediate)
Severely to very severely saline (8-16 dS/m)	AC Saltlander green wheatgrass, alkaligrass, saltmeadow cordgrass, wheatgrass (slender, tall, and western), wild rye (Altai, beardless and Russian)

Adapted from Prairie Farm Rehabilitation Administration 2000

photo: Matt Lavin (cc-by-sa 2.0)

Figure 1. Severely saline land on the Canadian Prairies is typically unproductive and dominated by bare salt-encrusted soil (left) and nuisance weeds such as foxtail barley (right).

AC Saltlander - background and benefits

Green wheatgrass (*Elymus hoffmannii*) is a naturally occurring hybrid between bluebunch wheatgrass (*Pseudoregneria* spp.) and quack grass (*Elymus repens*) from Eurasia (Figure 2). Seed collected in Turkey was grown in the United States with initial selections focused on enhancing the bunchgrass growth form, plant vigour, leafiness, seed production and pest resistance. Agriculture and Agri-Food Canada (AAFC) scientists in Swift Current, Saskatchewan further selected for high salinity tolerance, winter hardiness, erect growth form, leafiness and green plant colour leading to the development of AC Saltlander (Steppuhn et al. 2006).

Orbit tall wheatgrass ranks as the most salt-tolerant of the perennial forages, but it suffers from poor palatability (Tremblay 2007). In addition, tall wheatgrass is a bunchgrass which means there is space between plants, allowing for weeds like foxtail barley to persist in saline soils. AC Saltlander, with similar high salt tolerance, is very palatable. In terms of relative yield and salinity tolerance, AC Saltlander performs as well or better than Orbit tall wheatgrass in saline soils up to very severe salinity (Steppuhn and Asay 2005) (Figure 3). Furthermore, with AC Saltlander's creeping root system, it can outcompete foxtail barley (Wall and Steppuhn 2015).

AC Saltlander's drought tolerance is similar to intermediate wheatgrass and requires approximately 33 centimetres (13 inches) of annual precipitation, making it well-adapted to most areas in the Prairies (Steppuhn et al. 2006). Saline areas tend to be in low-lying, flood-prone areas. Initial findings from an ongoing study show that AC Saltlander's waterlogging tolerance is better than smooth brome, with plants surviving over five weeks of flooding in laboratory tests under non-saline and slightly saline conditions (Gu et al. 2019).

Figure 2. Robust AC Saltlander plants.

Despite AC Saltlander and tall wheatgrass' high salt tolerance, yield declines for both species as salinity increases (Figure 3). For example, yield of both grasses will be reduced by over 50% when grown in severely saline soil (8 dS/m) (Steppuhn et al. 2006). Furthermore, while AC Saltlander can survive at the highest salinity levels (10-20 dS/m) (Steppuhn and Asay 2005), expect only very low production. That said, AC Saltlander provides a unique opportunity to get a foothold in moderately to severely saline areas and compete with nuisance weeds where most other forages simply cannot grow well or at all. Moreover, research has shown that AC Saltlander will gradually suppress foxtail barley and downy brome, acting as a potential low-cost biological management tool to control or significantly reduce persistent weeds in saline areas (Steppuhn et al. 2018) (Figure 4).

AC Saltlander is one of the few perennial forage species that combines exceptional salt tolerance with good productivity, palatability and nutritional qualities. In addition, it has both good grazing tolerance in pastures and good persistence in hay fields (Steppuhn et al. 2006, Hybner et al. 2014). In fact, it produces good forage quality and yield under saline conditions, comparable to smooth brome under non-saline conditions (Steppuhn and Asay 2005).

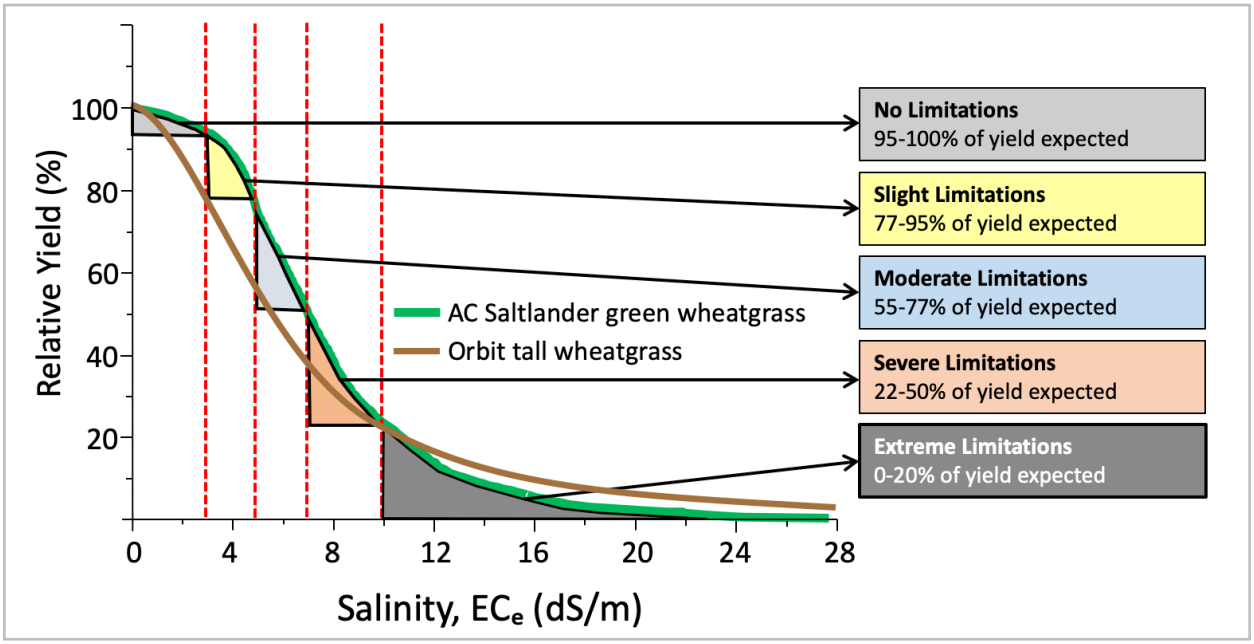


Figure 3. Comparing relative yield limitations based on salinity of AC Saltlander and Orbit tall wheatgrass. Adapted from Steppuhn et al. 2006.

AC Saltlander key characteristics

- Exceptional salinity tolerance, good palatability and nutritional qualities
- Similar forage quality and yield compared to smooth brome and orchard grass under non-saline conditions
- Spreading rhizomes aid in stand establishment and between-row plant coverage
- Can displace foxtail barley and downy bromegrass
- Tolerates moderate grazing pressure and recovers well after defoliation

Figure 4. Left: Field near Oyen, Alberta dominated by foxtail barley. Right: Plots in same field four years after seeding AC Saltlander plots. Plots with AC Saltlander successfully out-competed foxtail barley (Wall and Steppuhn, 2015).

Plant characteristics

AC Saltlander looks similar to its quackgrass parent, with a few distinct morphological differences (Figures 5, 6, 7) (Table 4). AC Saltlander is moderately aggressive, spreading more than its non-creeping bluebunch wheatgrass parent but less than its quick-spreading rhizomatous quackgrass parent (Table 4) (Steppuhn et al. 2006). This makes AC Saltlander less of an invasive threat than quackgrass in non-saline soils. However, its creeping growth form still allows it to move beyond seed rows to compete with and suppress foxtail barley and other weeds (Figure 5). Over the long term, the vegetative spread can increase AC Saltlander persistence on saline land, thereby sustaining forage production and reducing weed control costs.

Table 4. Morphological attributes of AC Saltlander green wheatgrass and quackgrass

Attribute	AC Saltlander	Quackgrass
Mid-season average height	76 cm (30 in)	72 cm (28 in)
Length of the awns and awn-like extensions in the bottom floret (the first developed) of each spikelet	5-8 mm (0.2-0.3 in)	1-2 mm (0.04-0.08 in)
Florets per spikelet	3	5
Flag leaves	longer	shorter
Vegetative spread, non-saline hay or pasture (after two growing seasons)	84-88 cm (33-35 in)	172 cm (68 in)

Sources: Steppuhn et al. 2006, Barkworth et al. 2007, Hybner et al. 2014.

Figure 5. AC Saltlander plant (left) and creeping rhizome (right)

Figure 6. AC Saltlander spike

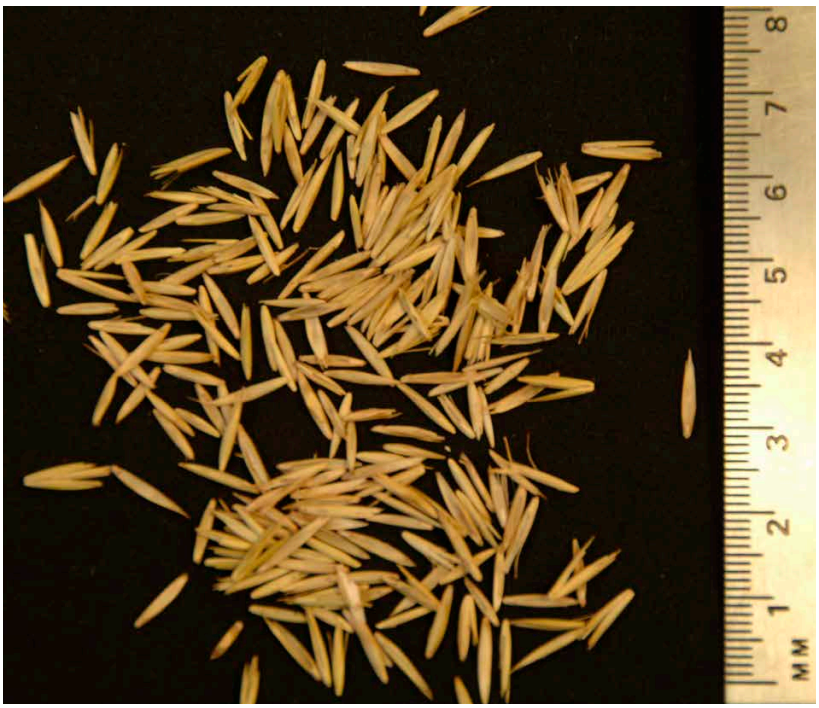


Figure 7. AC Saltlander seeds - 242,000 seeds/kilogram (110,000 seeds/pound)

Forage utilization, yield and quality

AC Saltlander is a cool season grass and remains greener during the late summer more than other wheatgrasses [hence common name, *green* wheatgrass] (Steppuhn et al. 2006). It can be grown as a monoculture or in mixtures and can provide nutritious forage during the spring to summer grazing period (Figure 8). Haying: On the prairies, usually only one cut can be taken on most hay fields. During years with high moisture, producers may take a second cut in the fall. Grazing: In pasture situations, one can graze AC Saltlander early in the season, allow for adequate rest for full regrowth and then graze again in fall. Stockpiling an AC Saltlander pasture for grazing in the late fall or winter may be possible but this practice has yet to be researched thoroughly.

photo: Miller Seeds

Figure 8. AC Saltlander is excellent for pasture (left) or hay production (right).

AC Saltlander produces excellent dry matter yields, similar to tall wheatgrass under saline conditions. Under non-saline conditions, it may out-produce Altai wild rye, Russian wild rye and smooth brome. Results from a four-year study found that AC Saltlander and smooth brome forage dry matter production was similar during June grazing, with AC Saltlander higher overall in all years (Steppuhn et al. 2011). However, these are preliminary results and additional years of data collection will be required to indicate how AC Saltlander performs over the long term.

In a simulated grazing study at Swift Current, Saskatchewan forage quality of AC Saltlander was comparable to Carlton smooth brome when grazed at the boot to flag leaf stage (Table 5) (Steppuhn et al. 2006).

In a four-year (2008-2011) grazing study at Swift Current, Saskatchewan, yearling steers did not seem to have a grazing preference between AC Saltlander and smooth brome. However, average daily gains were numerically higher (but not statistically

significant) in the AC Saltlander treatment than in the smooth brome treatment. Average daily gain over all treatments and years was 1.22 kilograms per day (2.69 pounds per day) (Steppuhn et al. 2011). As this has been the only AC Saltlander grazing research study in Western Canada, more research is needed to evaluate how best to use AC Saltlander to achieve the optimum animal and sustainable forage production.

Dry matter yield (clipped in late June, 2018) from AAFC demonstration projects averaged 2089 kilograms/hectare (1864 pounds/acre) near Nokomis, Saskatchewan and 6691 kilograms/hectare (5970 pounds/acre) at Morden, Manitoba. No synthetic fertilizer was applied at either site. As expected, forage yields in low to moderate salinity areas were greater than in moderate to severe salinity areas (Table 6, Figures 9,10) (Houston et al. 2018). Although more research is required to study the use of AC Saltlander for stockpiled grazing, the Nokomis and Morden studies suggest that there may be potential for it: feed quality kept well into September, and uncut plants with seed heads remained upright until the following spring (Bill Houston personal communication 2019).

Table 5. Mean forage quality of Carlton smooth bromegrass and AC Saltlander green wheatgrass grown as hay (cut at heading stage) and simulated pasture (vegetative stage) in slight to non-saline soils during 2001 and 2002 (averaged) at Swift Current, Saskatchewan

	Forage Hay		Simulated Pasture	
Analysis (%)	AC Saltlander	Carlton smooth brome	AC Saltlander	Carlton smooth brome
Crude protein	15.1 ± 0.7	16.5 ± 0.6	18.8 ± 0.4	19.5 ± 0.6
Organic matter digestibility	61.8 ± 1.0	62.0 ± 1.4	67.2 ± 0.6	69.3 ± 0.9
Acid detergent fibre (ADF)	29.4 ± 0.8	28.7 ± 0.9	25.2 ± 0.4	24.9 ± 0.7
Neutral detergent fibre (NDF)	52.6 ± 1.2	51.5 ± 1.3	47.2 ± 0.7	46.2 ± 1.2

Source: Steppuhn et al. 2006

Table 6. AC Saltlander dry matter yields in late June, 2018 near Morden, Manitoba and Nokomis, Saskatchewan under two salinity levels (Morden seeding rate = 11.1 kg/ha [10 lb/ac], Nokomis seeding rate = 12.4 kg/ha [11lb/ac])

	Yield kg/ha (lb/ac)	
Location	Low to moderate salinity	Moderate to severe salinity
Morden	7,700 (6,870)	6,832 (6,095)
Nokomis	2,291 (2,044)	2,149 (1,917)

Figure 9. AAFC demonstration project, Nokomis, Saskatchewan, 2018 (established in 2017). AC Saltlander plot seeded at 12.4 kg/ha (11.1 lb/ac). Left: Field after mid-July hay cut with strip of AC Saltlander remaining to show stand growth (low to moderate salinity, 2-8 dS/m). Right: Taken during biomass data collection in late June 2018 in the low to moderate salinity area.

Figure 10. AAFC demonstration project, Morden Manitoba, 2018 (established in 2017). AC Saltlander plot seeded at 11.2 kg/ha (10 lb/ac). Left: AC Saltlander plots September 5, 2018 in a pure stand on the left and mixed with slender wheatgrass on the right (low to moderate salinity, 2-8 dS/m). Right: Taken during biomass data collection June 27, 2018 in a low to moderate salinity area.

AC SALTLANDER ESTABLISHMENT

As with any forage crop, successful AC Saltlander establishment requires careful planning. Factors to consider include location and timing of seeding, seedbed preparation, seeding equipment, weed management, seeding rates and fertility. It is important to note that although AC Saltlander is a good option for establishing forage in saline areas, it is not a miracle plant or quick-fix for managing saline areas. In moderately to severely saline areas, it may take time for AC Saltlander to become established. Have realistic expectations and patience: managing saline areas requires a multi-year approach.

Plan where to seed

A key first step in the planning process is to map salinity levels within the field. Detailed soil testing is recommended to supplement conductivity mapping (e.g. EM 38, VERIS) and descriptive information like soil characteristics (e.g. visible salts [Table 2] or texture), poor crop production, or presence of salt-tolerant weeds (e.g. kochia, foxtail barley). As AC Saltlander seed cost is high compared to other forage options due to low seed production, a detailed soil salinity map allows you to mark out different salinity zones, each with a different forage species suited to specific salinity levels to reduce seed cost:

- Non- to moderately saline areas: A lower-cost conventional saline forage mix with or without AC Saltlander (see Table 3 for salt-tolerant forage options)
- Low to moderately saline zone: AC Saltlander planted at a lower seeding rate with or without a salt-tolerant forage mix
- Moderately to severely saline zone: AC Saltlander as a monoculture at a high seeding rate
  - Optional: add an additional 5.6-11.2 kilograms/hectare (5-10 pounds/acre) of another high salinity species (e.g. slender wheatgrass) to diversify the forage stand

In very severely saline depressions transitioning into seemingly uninhabitable salt-affected land, focus on establishing AC Saltlander at a high rate around the perimeter. The perimeter area seeded should (1) span both the severely saline and less saline zones and (2) be roughly equal in size to the severely saline depression. The objective is to establish AC Saltlander on the fringes, providing the greatest opportunity for it to spread into the severely saline environment (see *Cost-saving strategies for growing AC Saltlander,* page 26).

Figure 11. Saline fields previously in annual cropland and not adjacent to native rangeland make ideal locations to establish AC Saltlander. AC Saltlander can suppress weeds and provide quality forage.

Saline fields previously in annual cropland and not adjacent to native rangeland make ideal locations to establish AC Saltlander (Figure 11). Avoid seeding AC Saltlander in ecologically sensitive areas such as native rangeland or riparian areas because of its creeping and competitive nature. In these natural areas, use grazing management strategies (e.g. temporary exclusion, strategic water placement, rotational grazing) to relieve grazing pressure to help degraded saline areas recover. If seeding AC Saltlander adjacent to a natural area, have a good understanding of any noxious or nuisance weeds in the seed (as indicated in the seed analysis certificate) that could spread into the natural area and degrade its health. Include mitigation measures such as 1) establish buffer strips to reduce the risk of encroachment, 2) scout the seeded, buffer strip and adjacent natural areas to detect presence of weeds and 3) quickly eradicate or control unwanted plants.

Weed management: one year before seeding AC Saltlander

AC Saltlander seedlings must emerge with as little competition as possible. Address weed issues in the year before seeding to ensure the best chance at preventing weeds from inhibiting AC Saltlander establishment. Ideally, the land should have a good history of weed control and a depleted weed seed bank.

- Consider the cropping and herbicide application history for the field. Some herbicides have a carryover effect into the next season (including glyphosate enhancers) that will injure AC Saltlander or prevent establishment. If you are unsure of potential herbicide residual issues, contact your local chemical sales representative or forage agrologist.
- Scout and map out weed populations to determine where weed pressure is highest. Also, not all weeds can be controlled with the same management practice. Perennial weeds, given their extensive root reserves, should be prioritized since they can be more difficult to control than annual weeds like kochia (Gabruch et al. 2005). To control weeds such as Canada thistle and dandelion, apply an appropriate broadleaf herbicide for perennial weed control (Figure 12). In addition, it is very important to control perennial grassy weeds (e.g. quackgrass) before seeding AC Saltlander as there may be no chemical control options after establishment.

Figure 12. Glyphosate applied to weeds (yellowed plant material).

- A high foxtail barley population will have an associated large weed seed bank in the topsoil layer. Therefore, controlling foxtail barley should also be a priority.
- In the year before planting, if you have a wild oat problem, plant an annual crop other than tame oats
- Once AC Saltlander is seeded the following year, there are no grassy weed herbicide options that will not also harm AC Saltlander.

- Refer to provincial weed control guides, keeping in mind potential carryover herbicide impacts on AC Saltlander establishment.
- Leave standing stubble after harvesting the annual crop, and plan to direct-seed AC Saltlander into the stubble (Figure 11). Tillage is discouraged for three reasons: i) tillage produces a larger weed flush than direct seeding, ii) tilled saline land dries out the seed bed, making it more susceptible to erosion and (iii) tillage softens the seed bed which reduces the amount of seed-to-soil contact.

Purchase AC Saltlander and salt-tolerant forage seed according to the analysis of your salinity map (see *Plan where to seed*, page 10). Also, study the seed analysis certificates for potential noxious weed concerns. If possible, avoid seed containing noxious weeds, or understand the consequences, risks and the mitigation options and effort required for scouting and controlling weeds in seeding area and on adjacent land (see Box: *AC Saltlander seed analysis*).

AC Saltlander seed analysis

AC Saltlander seed sold in Canada meets all CFIA requirements to be labelled and distributed as Canada Certified No. 1 seed. However, it is currently produced in a region where the secondary noxious weeds downy brome (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*) are present. As a result, some seed lots may contain weed seeds at very low levels (i.e. low enough to meet Canada Certified No. 1 standards: up to 4 secondary noxious weed seeds/25 grams of seed and up to a total of 50 weed (noxious and non-noxious) seeds/25 grams of seed).

Both bromes are annual weeds that can produce large numbers of seed. Therefore, preventing subsequent seed set is important to reduce the chance that these weeds become established. Downy brome seed production and competitive ability may be impaired in environments where soil salinity is greater than 4 dS/m in the rooting zone (Rasmuson and Anderson 2002). Furthermore, downy brome can be outcompeted by a healthy AC Saltlander stand (Steppuhn et al. 2018).

The bottom line: when purchasing any forage seed, including AC Saltlander, you should request a copy of the seed analysis certificate from the supplier. If the seedlot contains weeds, use best management practices to mitigate risks of weed dispersal. In sites that are close to natural areas, the risk of weed invasion could be a determining factor in choosing a forage option.

See APPENDIX B (page 34) for downy and Japanese brome identification and risk mitigation strategies.

Weed management: pre-seeding

Despite best efforts to control weeds in saline areas, high populations of weedy species will likely continue to be present, especially salt-tolerant plants like foxtail barley and kochia (Figure 13). Even though AC Saltlander has been shown to reduce or suppress foxtail barley and kochia (Wall and Steppuhn 2015), weed management strategies will need to be implemented to maximize establishment success. In addition to scouting for weeds one year prior, continue to scout for weeds one month before seeding AC Saltlander as part of your overall weed management strategy.

The most commonly used options for addressing weed issues before seeding are minimal tillage and chemical control. Deep tillage in wetter climates is not recommended as it can bring salts to the surface (Manitoba Agriculture, Food and Rural Initiatives 2008). However, in drier and warmer climates with a higher evaporation rate (Brown soil zone), deep tillage can break up the hardpan and dilute the heavy saline surface layer (Ken Miller personal communication 2019). In general, zero tillage and pre-seed chemical control should be considered for all saline soils, especially severely saline soils.

Prior to planting, apply two high-rate glyphosate pre-seed burn-offs (follow label instructions) (Figure 12). Make your first application three weeks before seeding followed by the second application within seven days of seeding.

photo: Matt Lavin (cc-by-sa 2.0)

Figure 13. Common weeds found in saline areas: kochia (left) and foxtail barley (right).

Seedbed preparation

AC Saltlander seedlings are vigorous and can establish quickly even under relatively unfavourable conditions. However, proper seedbed preparation is vital to ensure even and rapid germination. A level field is important: a smooth and firm seedbed allows accurate seed placement and good seed-to-soil contact. Heavy harrows may be required to remove deep furrows. Firmness is important because deep furrows created during seeding can leave steep slopes that may slump after a heavy rain, burying seeds deep and reducing the likelihood of good forage establishment. If seeding AC Saltlander into last year's annual crop stubble, be aware that some combines do not spread chaff well, leaving windrows. This may create a heavy volunteer crop, especially with barley. In addition, heavy residue may smother emerging grass seedlings.

To level the field and disperse residue, harrow at an angle against the seed rows of the previous crop in the fall or just prior to spring seeding (Figure 14).

If tillage is required, use equipment that can maintain shallow tillage depths, preserve surface residue, and help to prepare a firm, shallow seed bed. Pack or harrow-pack the site to level and firm up the soil after tillage.

While the recommended practice is to seed AC Saltlander into stubble, there is increased interest in sod seeding (Figure 15). However, seeding into existing forage sod presents significant challenges. Old roots and surface residue can make it difficult to obtain good seed placement and even emergence. In addition, existing sod and emerging weeds (e.g. foxtail barley) may compete for moisture and nutrients, potentially resulting in poor seedling survival. Furthermore, the combination of poor seedbed conditions, weeds or allelopathy may limit forage establishment.

Seeding date

When possible, seed in May to take advantage of moist soil conditions and seasonal rainfall to maximize establishment success. Early spring seeding also provides the best opportunity to give AC Saltlander a competitive advantage by getting ahead of weed growth. However, excessive soil moisture can make seeding challenging. Saline land is often inaccessible due to wet spring soil conditions (e.g. low-lying areas or poor drainage). Sometimes, if water pools on the surface after seeding, soil may crust over when drying (see Box: Soil crusting), significantly reducing seedling emergence. Depending on soil texture, seeding into very moist soil may result in poor seed-to-soil contact (e.g. opener cuts may stay open or fail to seal completely in clay soils). Moist soil may stick to discs or packer wheels and disrupt seed placement.

Later seeding of AC Saltlander, even into the beginning of August is possible, but seedlings must have at least two leaves going into winter to survive (Ken Miller personal communication 2017). Summer seeding dates come with a higher risk of not receiving timely precipitation.

Soil crusting

Saline soils are susceptible to crusting, especially after a heavy rain. If this occurs shortly after seeding, AC Saltlander will have a very difficult time emerging. Reseeding may be required.

Later seeding also comes with a higher probability of heavy rainfall events followed by hot weather, which can significantly increase the potential for soil crusting.

Dormant seeding in November is another option when spring water logging has been a problem. Excellent stands have been obtained on sites when seed is planted late enough in the fall to ensure it does not germinate until the following spring (Ken Wall personal communication 2019). AAFC (Swift Current, Saskatchewan) is developing best management practices for dormant seeding using both conventional and direct seeding (*Development of best management practices for cost-effective and successful establishment of saline forages for Saskatchewan*, to be completed in 2021).

Figure 14. A stubble field that has been harrowed at a 45° angle to the rows will help evenly spread debris, level furrows and make for ideal seeding conditions. Debris also helps conserve soil moisture which will assist in AC Saltlander establishment. AAFC demonstration project, Nokomis Saskatchewan, 2017.

Figure 15. Sod seeding AC Saltlander. AAFC demonstration project, Castor AB, 2017.

Seeding equipment

Seeding equipment for AC Saltlander and other perennial forages must provide the following:

- Consistent and accurate seed flow
- Accurate and uniform seed placement (shallow uniform seeding)
- Adequate seed-to-soil contact (i.e. adequate packing)

If using a drill, use low disturbance hoes or disc openers to maintain a smooth, level field. Specialized forage drills are ideally suited to seed forage crops (Figures 16, 17) but many conventional and no-till drills (air seeder, air drill, planters, box drills) can achieve equivalent results. In addition, many modern drills have section controls, rate controllers and multiple seed boxes to seed more than one blend in a single operation. Broadcasting the seed on the surface followed by harrowing and packing the site may also be an option. However, broadcast-seeded fields are much more dependent on timely rains for successful establishment than other seeding methods (Mackenzie and Tremblay, 2007).

Verify that the seeding equipment can achieve a consistent and accurate seed flow. Seed agitators in the seed box are recommended as they prevent gaps in seed delivery into the tubes (Figure 17). AC Saltlander seed can be mixed with inert carriers or a cereal nurse crop up to a maximum of a 1:1 ratio by weight to help seed flow smoothly and prevent bridging in the seed delivery tubes. Options for inert carriers include vermiculite, 11-52-0 fertilizer, rice, clay coat on the seed, and cracked wheat (see *Using a carrier or nurse Crops*, page 19).

If direct seeding, equipment must be able to penetrate to an accurate, shallow and consistent depth. If possible, select equipment with depth bands or gauge wheels linked to openers on the drill. Row spacing on forage drills typically range from 15-30 centimetres (6-12 inches), depending on the soil zone. Moister soil regions (e.g. Black Soil Zone) can tolerate closer row spacing (as low as 6 inches). Thirty-centimetre (12-inch) row-spacing is the most common and is ideal for AC Saltlander as it allows enough space for plants to establish, while close enough to allow for the rhizomes to spread out and fill in the between-row areas in a reasonable amount of time.

The equipment must have a packing system to close and seal the furrows and to guarantee good seed-to-soil contact. Some drills have a press and closing wheel combination (see Box: *Drill seeding tips*).

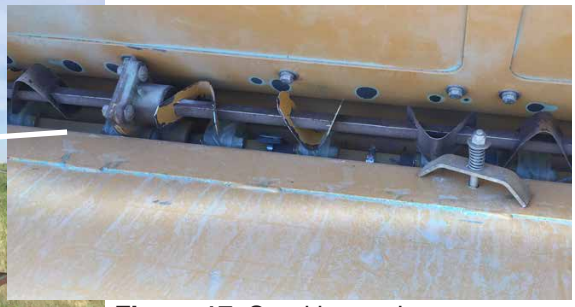


Figure 17. Seed box agitators ensure seed flows evenly and consistently through the delivery tubes.

Figure 16. Example of a specialized grass drill that has two recommended features: drills and packers.

Drill seeding tips

- Before seeding or at row ends, set the drill so the openers are just above soil surface with the seed flow triggered. Drive the drill a short distance and observe the seed placement on a smooth, hard surface to ensure seed is flowing from all openers at the correct rate.
- Use a high visibility carrier (e.g. 11-52-0 granular fertilizer or cereal crop) to help set the seed depth as AC Saltlander alone may be difficult to see in the soil. Alternatively, you can increase the seeding rate of AC Saltlander to see the seed better and gauge seeding depth.
- Seeder with gravity feed seed boxes:
  - Use a low speed setting: open the fluted feed wheel wider to reduce bridging in the box.
  - If possible, monitor for plugged seed tubes: seed will flow over the top of the feed cup when hoses are plugged. On most drills, this should be visible from the tractor seat.
  - Monitor the seed level inside of the box especially if it doesn't have a seed agitator. Shallow indentations in the surface of the seed mix over each run opener indicates that seed is flowing.
  - Fill the seed box to a maximum of 30-40 centimetres (12-14 inches) in a box drill and 60 centimeters (24 inches) in an air drill to prevent seed compaction. Stir every hour or as needed.

Seed mixes

Salinity levels are often uneven across a field: develop a mixture that includes species with high salinity tolerance instead of strictly based on maximizing forage yield. This strategy widens the mix' overall salinity tolerance and adaptability and introduces a broader range of forage quality traits, growth characteristics, and other stress tolerances like drought and excessive moisture. For example, forage-type tall fescue may be useful in a forage mix in high soil moisture areas as it has both high salinity and good waterlogging tolerance. In addition, lower salinity tolerant grasses perform well in low to moderate salinity areas whereas in the higher salinity areas, AC Saltlander and other high salinity forages will dominate. Some short-lived forage varieties are quick to establish, providing early ground cover to suppress weed growth and limit soil erosion.

As an example, slender wheatgrass is typically included in a saline forage mixture because it has good salinity tolerance, rapid establishment and provides good weed competition for the first few years. It also has a lower cost, is readily available, and provides good forage yield and quality (Figure 18). However, slender wheatgrass is a bunchgrass (i.e. won't spread vegetatively) which limits its competitiveness with weeds such as foxtail barley and is relatively short lived, especially under saline conditions. When used in a mix, AC Saltlander will fill in the stand by means of its creeping nature as the slender wheatgrass stand declines. Other salt-tolerant forage species that can be seeded with AC Saltlander in low to moderately saline conditions include smooth brome and legumes like salt-tolerant alfalfa varieties (both creeping and tap-rooted) (Table 3).

It is important to know what species are in the commercial seed mix as well as their salt tolerance and longevity to ensure that the forage seed mix is appropriate for your field conditions. Contact your local seed sales representative or forage agrologist for more information on pre-packaged or custom blended saline forage mixes.

Figure 18. AC Saltlander and slender wheatgrass mix in moderate salinity. Second year of establishment. Nokomis, Saskatchewan Demonstration, 2018.

AC Saltlander and alfalfa mix

There is a lot of interest in mixing grasses with alfalfa to increase forage production and quality, and to add a nitrogen fixing forage into the field to supplement soil fertility (Figure 19). Alfalfa varieties with moderate salt tolerance can be a suitable option for low to moderately saline areas. In addition, the deep-rooted alfalfa will help contain the salinity in the area by drawing moisture from deeper in the soil profile.

Figure 19. AC Saltlander and a salt-tolerant variety of alfalfa in moderately saline soil. Very little to no alfalfa established in the severely saline area. Nokomis, Saskatchewan. 2018.

However, alfalfa stands typically decline over time when in a mix with forage grasses, especially with competitive, spreading rhizomatous plants such as AC Saltlander. In addition, weeds are also more difficult to control in a legume and grass mixture as most broadleaf herbicides will kill the legumes (Renz 2011).

Using a carrier or nurse crop

Since AC Saltlander seed is light and chaffy, like many other forage grasses, there can be a tendency for the seed to bridge in the seed box or develop blockages in the seed tubes. To reduce the chance of this happening, mix in a carrier or nurse crop at the time of seeding up to a maximum of a 1:1 ratio by weight. In addition to seed flow, a carrier can aid in seed placement and germination. The carrier can be an inert material (e.g. garden vermiculite, rice), a granular fertilizer (monoammonium phosphate [11-52-0] [Wark et al. 2004]), or an annual cereal (nurse) crop (Figure 20).

Using an inert carrier means that another seeded crop will not be competing for resources as seedlings become established. However, this also means that bare ground may be exposed for a longer period increasing the potential for soil erosion and weeds that will then require additional management. Alternatively, a nurse crop will not only help with seed flow, but it will also help stabilize soil, compete with weeds, and protect the seed and seedlings from wind and water erosion. In addition, the nurse crop provides a forage crop to harvest in the first year. On the negative side, the nurse crop will compete with AC Saltlander seedlings for sunlight, nutrients, space and moisture which may result in reduced seedling establishment, forage yield and stand longevity.

When selecting a nurse crop, select a cereal that is predominantly upright and does not have a large vegetative spread – semi-dwarf durum or semi-dwarf wheat are both good options. If you have a heavy wild oat weed problem, do not grow oats as there is no in-crop chemical control option for wild oats that will not also negatively affect a mixed oat and AC Saltlander stand. Although AC Saltlander can out-compete wild oats once established, thick wild oat patches compete with AC Saltlander seedlings and can reduce establishment success. Barley is suitable although it has a larger footprint and can be a significant competitor, leading to a higher risk of smothering AC Saltlander seedlings. In addition, while barley is one of the more salt-tolerant cereals (Ballantyne 1962), AAFC experience has shown that barley may have poor germination in moderately to severely saline soils (Alan Iwaasa personal communication 2019).

Using a nurse crop: In AAFC's demonstration project near Nokomis, Saskatchewan, a semi dwarf wheat variety was seeded as nurse crop with AC Saltlander. The upright cereal stand offered protection for AC Saltlander seedlings as well as provided good forage production as greenfeed in the first year. After cutting, a healthy, thick AC Saltlander stand was exposed (Figure 21).

Using an inert carrier (rice): In AAFC's demonstration project in Morden, Manitoba, rice was used as a carrier crop to aid in seed flow. This inert carrier provided the same benefits as a cereal while not having to deal with the potential competition of a cover crop. Using an inert carrier (fertilizer): In AAFC's AC Saltlander demonstration trial at Brandon, Manitoba, the forage was mixed with both monoammonium phosphate fertilizer [11-52-0] and oats* to improve seed flow and establish a nurse crop, at a ratio of 1:1:0.5 (AC Saltlander:fertilizer:oats) by weight. All sites had very successful establishment (see Box: *Tips for using a carrier or nurse crop*).

*Oat was used as a nurse crop as there were no wild oat issues on this site.

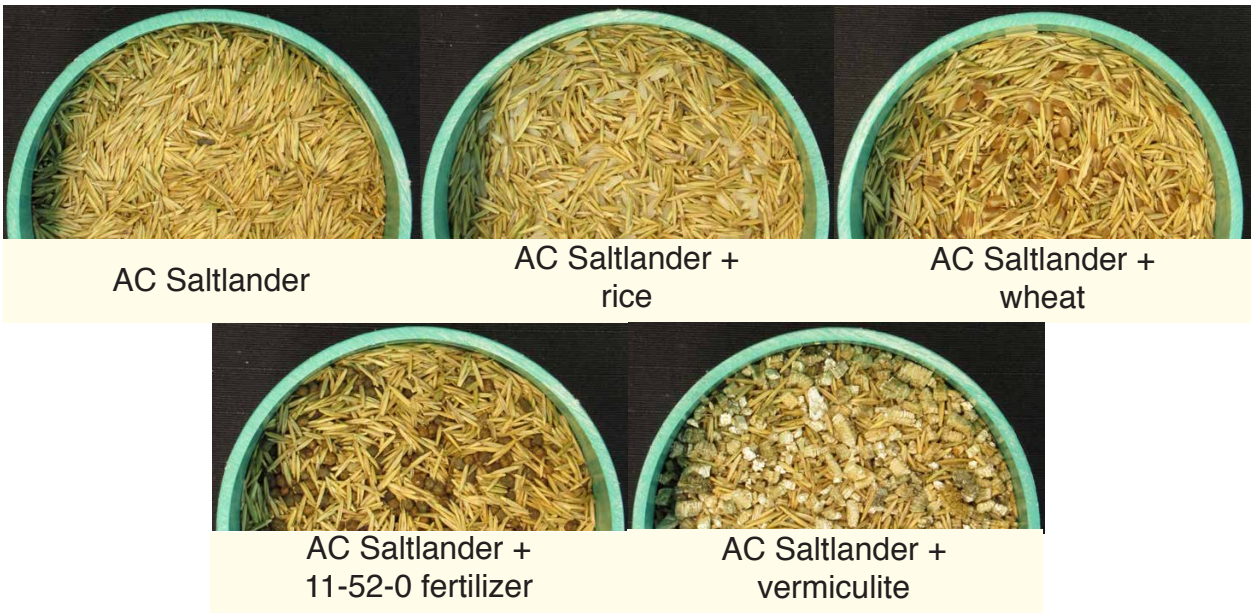


Figure 20. AC Saltlander seed and various types of carrier or nurse crop seeds (1:1 ratio by weight).

Figure 21. Left: AC Saltlander field seeded with semi-dwarf wheat nurse crop. Right: After the annual crop was harvested for forage, a robust AC Saltlander stand was exposed (Nokomis, Saskatchewan 2017. AC Saltlander seeded at 12.4 kg/ha = 11 lb/ac).

Tips for using a carrier or nurse crop

- Use a 1:1 mix (by weight) of seed:carrier or nurse crop.
- Caution – do not seed nurse crop over a 1:1 ratio as it may outcompete the forage crop.
- Test the flow of the carrier or nurse crop in dry runs with the seeder, making sure there is no bridging in the seed box or blockage in the seed tubes.
- Depending on what you mix with AC Saltlander, you may have to increase the carrier/nurse crop component to improve seed flow, or in other cases, you may be able to reduce the carrier/nurse crop component.
- Remove the nurse crop as early as possible (silage or green-feed) rather than waiting to harvest as grain to reduce competition for sunlight, moisture, space and nutrients.
- When harvesting the nurse crop, collect swaths as soon as possible to allow AC Saltlander seedings to continue growing.
- If seed box has no agitator, check frequently for separation of seed mix and remix as required.

Seeding rate

AC Saltlander monoculture

Under slight to moderately saline dryland conditions, seed AC Saltlander at 5.6 kilograms/hectare (5 pounds/acre). Under higher salinity levels (moderate to severe), seed at 11.2 kilograms/hectare (10 pounds/acre) (Gu et al. 2018, Ken Wall personal communication 2019).

AC Saltlander mixes

Seeding rates for salt-tolerant forage mixtures depends on salinity level and the forage species in the mix. In general, in lower salinity soils, you can cut the AC Saltlander rate up to half and add another salt-tolerant forage or forage mix to bring the overall seeding rate back up. For example, in non- to low salinity area, use 2.2-3.4 kilograms/hectare (2-3 pounds/acre) AC Saltlander and 2.2-3.4 kilograms/hectare (2-3 pounds/acre) of a salt-tolerant forage mix that may include other grasses and a salt-tolerant legume for a total of at least 5.6 kilograms/hectare (5 pounds/acre). In low to moderate salinity areas, seed a salt-tolerant mix that includes 2.8-5.6 kilograms/hectare (2.5-5.0 pounds/acre) of AC Saltlander.

Depending on the species, there may be suitable salt-tolerant forage mixes for moderately to severely saline soils. According to a 5-year study in North Dakota, a salt-tolerant forage mix that included AC Saltlander (50% AC Saltlander, 25% Revenue slender wheatgrass and 25% Courtney tall fescue, seeded at 34 kilograms/hectare [30 pounds/acre]) yielded slightly better (0.25-0.50 tons/acre = 0.56-1.2 tonnes/hectare advantage) than AC Saltlander alone (seeded at 17 kilograms/hectare [15 pounds/acre]) in a moderately to severely saline site (Duckwitz et al. 2018). However, the AC Saltlander seeding rate in both the mix and the monoculture plots were the same and well above AAFC's recommended monoculture rate. Furthermore, the yield advantage over the 5-year study may not justify the extra cost and effort for using this particular mix. However, there are advantages to selecting a mix beyond simple yield considerations such as aiding in establishment, wider environmental adaptation, seasonality of use and longevity. This topic requires further study.

AAFC researchers in Swift Current, Saskatchewan are developing best management practices to establish AC Saltlander on a range of salinity levels (slight to severe salinity) in both irrigated and dryland conditions. They are evaluating seeding methodology and determining the optimum seeding rate for each salinity level (Iwaasa et al. 2019b). In addition, further research is planned to investigate different ratios of alfalfa and AC Saltlander for increased stand longevity and production.

Regardless of seeding rate, patience and realistic expectations are required when trying to establish a forage crop on saline soils, especially in moderately to severely saline areas. Compared to other salt-tolerant grasses, AC Saltlander provides the best opportunity for successful establishment and persistence over a wide range of saline conditions. However, favorable environmental conditions and time are required for successful forage establishment.

Notes

- Based on AAFC research, in moderately to severely saline soils, AC Saltlander seeded as a monoculture at 11.2 kilograms/hectare (10 pounds/acre) is more likely to be successful than a mixture (Gu et al. 2017, Wall and Steppuhn 2015).
- Seeding rate recommendations are based on pure live seed (i.e. the actual seeding rate needs to be increased to account for non-viable seed). Ask seed suppliers to provide seed analysis certificates that include purity and germination percentage before buying forage seed.

Fertilizer use

Nitrogen is often the most limiting nutrient in grass production. However, forages also require sufficient potassium, sulphur, phosphorous and micronutrients for optimum yield and forage quality – test your soil to identify potential deficiencies. Grazing removes less nutrients and organic matter than haying since cattle return nutrients to the field through manure and urine; however, there is still a net loss of nutrients from pasture. Salt-tolerant alfalfa can be used to supplement soil nitrogen on low to moderately saline soils, provided inoculants are used properly and root nodulation is active and abundant.

Fertilizer may be applied at time of seeding. A general guideline if fertilizing at time of seeding is to place fertilizer at least one inch (2.5 centimetres) away from seed to ensure seedlings are not damaged (Pastl and Wohlberg 2012). Granular monoammonium phosphate fertilizer (11-52-0) at a 1:1 ratio by weight with seed will provide some nitrogen and phosphorous while helping to ensure good seed flow (Wark et al. 2004).

AAFC researchers are evaluating the potential of fertilizing AC Saltlander to increase production and improve persistence. Results from a study by Gu et al. (2018) showed no statistical advantage in biomass production with high versus low nitrogen application on moderately to very severely saline land. In a mostly grass forage stand, apply a nitrogen check strip to evaluate response (i.e. biomass production increase) before applying it to the entire field. More research is required, especially looking at the potential benefits of adding nitrogen to AC Saltlander five or six years after seeding on slight to moderately saline soil conditions. AAFC will be conducting further research on fertilization of AC Saltlander stands both during planting and for older stand revitalization (see *Stand longevity*, Page 26).

Fertilizer use with AC Saltlander

- Test your soil to identify nutrient deficiencies.
- Top dress with required nutrients according to soil test after establishment year.
- When adding fertilizer, apply the proper amount and in the proper location. Contact your local forage agrologist or nutrient specialist for more information and advice.

Seeding depth and row spacing

Accurate and uniform seed placement is crucial to successful establishment (Figure 22). Seeding too deep is often the major reason for establishment failure. Specialized grass seeders are the best seeding option as they have depth bands or gauge wheels linked to openers on the drill which provide accurate seed depth control (see *Seeding equipment*, page 16).

AC Saltlander should be planted no deeper than 1.9 centimetres (0.75 inches) deep and no shallower than 0.6 centimeters (0.25 inches) Deeper seeding results in poor emergence. Between-row spacing depends on your seeding equipment but should not exceed 30 centimetres (12 inches) to maintain adequate AC Saltlander plant density.

Figure 22. Accurate and uniform seed placement at a consistent depth of 1.9 cm (0.75 in) led to successful AC Saltlander establishment. A specialized grass drill with 30 cm (12 in) row spacing was used for seeding. AAFC demonstration project, 2018, Nokomis, Saskatchewan. Plot seeded at 12.4 kg/ha (11.2 lb/ac).

AC Saltlander seeding tips

- It is better to seed shallow rather than too deep
- Target (maximum) depth = 1.9 centimetres (0.75 inches); minimum depth = 0.6 centimetres (0.25 inches)
- Recommended spacing: 30 centimetres (12 inches) or less
- A firm seed bed is required before seeding to allow for accurate seed placement and good seed-to-soil contact

Weed management: post-seeding maintenance

Weed control before and after seeding is crucial as weed competition can negatively impact establishment and longevity of AC Saltlander and other forages. Saline areas typically have a large annual and perennial weed seed bank. Kochia and foxtail barley are common weeds in saline areas. Both are high seed producers but their seed has relatively short viability in the soil (1-3 years). Preventing seed production before and during establishment is a key strategy to control these weeds.

In a pre-seed burn-off, early season weed species would have been treated. However, the mid-season weed species likely would not yet have emerged and will compete with AC Saltlander seedlings. A post-seeding weed management plan includes monitoring forage growth stage and weed emergence. Often, post-emergence chemical weed control is recommended in the first growing season. Apply a broadleaf herbicide when AC Saltlander is at the second or third leaf stage. Follow label recommendations. Be aware that if a salt-tolerant legume (e.g. alfalfa) is included in the stand, there may be limitations on the herbicides that are available for weed control.

If a field does not have extensive weed issues, spot spray with an appropriate chemical to control patches. Do not use a non-selective herbicide (e.g. glyphosate) for spot spraying as it will kill AC Saltlander plants and create bare soil for weed invasion. For information on applicable herbicides, refer to your provincial crop protection guide. For specific recommendations to local conditions refer to provincial weed control publications, herbicide label information, chemical representatives and experienced applicators.

Depending on the weed species, mowing is an option for controlling weeds post-seeding in the establishment year. Mow weeds when they have grown significantly but prior to seed set. This reduces competition and future weed flushes. Cutting height should be high enough to avoid removing a large portion of forage seedlings but low enough to remove the majority of the weeds. Mowing can be particularly effective before weeds head out and are less than 30 centimetres (1 foot) tall. If weeds are over 60 centimetres (2 feet) tall, mow the field twice crossways to break up and spread the residue to avoid smothering forage seedlings. If the weeds are thick enough to create windrows when mowed, consider swathing and baling. Remove windrows or bales as quickly as possible to avoid smothering forage seedlings.

For short weeds like foxtail barley, mowing is not a good option since mowing at any growth stage will damage forage seedlings (note: foxtail barley is a nuisance weed that should be addressed before seeding). it is better to avoid mowing these areas to allow AC Saltlander to establish. If there is enough AC Saltlander established there is a good chance it will eventually spread into these weedy locations and suppress foxtail barley.

As Japanese and downy brome are noxious weeds that may be found in small quantities in AC Saltlander seed lots, monitor for these bromes during the first five years after planting AC Saltlander. They are typically winter annuals (germinating in the late summer/early fall in response to precipitation), surviving the winter as a grassy rosette and resume growth and produce seed early in the following season. However, they can germinate any time during the growing season and produce seed during the same year (Beck 2011). Seed may persist for up to five years (Beck 2011), although it is uncommon for it to remain viable for more than one year under field conditions (Zouhar 2003).

Japanese and downy brome only propagate by seed, so preventing seed set and spread is important to reduce the chance of these weeds becoming problematic. If allowed to set seed, care must be taken to prevent the spread of seed onto other land by the transfer of harvested hay or in the equipment used in seeding, maintenance and harvest. Even wildlife poses a risk of transferring these seeds into new areas (Zouhar 2003). While

Weed control tips

- Control quackgrass before seeding because it will be impossible to control after seeding.
- Foxtail barley is a major nuisance weed, and its associated large seed bank will require significant management before and after seeding - foxtail barley issues should be addressed before seeding
- There may be in-crop chemical control options depending on the weed issue. Contact your local chemical representative for more information.

AAFC research has shown that a healthy AC Saltlander stand can suppress downy brome and foxtail barley under moderately to severely saline conditions (Figure 4) (Steppuhn et al. 2018), be aware of the risks and options for mitigation, as well as situations where proximity to sensitive lands could be a determining factor in deciding where to seed AC Saltlander.

Stand longevity

Initial establishment success, management, soil fertility, weed competition and growing conditions all affect AC Saltlander stand persistence and longevity. AC Saltlander is known to remain productive for at least four to five years (Gu et al. 2017); there are cases where the stand looked good after ten years (Alan Iwaasa personal communication 2019). If grazing, provide optimum grazing conditions (timing and length of grazing) and duration of rest. Research indicates AC Saltlander can tolerate moderate grazing. However, further work is needed to determine AC Saltlander re-growth potential under different environmental conditions over multiple years.

While we recommend incorporating alfalfa into an initial seed mix as an option for slight to moderate salinity, there has been interest in incorporating a legume into an existing stand to boost soil nitrogen to improve AC Saltlander's longevity and as a rejuvenation method. This may be an option in slight to moderately saline soils but would not be recommended for moderately to severely saline soils until higher salt-tolerant alfalfa varieties are developed.

AAFC researchers are evaluating the potential of fertilizing AC Saltlander to increase production and improve persistence.

Cost savings strategies for growing AC Saltlander

Investing in AC Saltlander can help turn degraded areas into productive areas for your farm where many other forages cannot establish or persist. As a result, AC Saltlander can provide not only short-term benefits but significant production gains over the long term.

AC Saltlander has higher seed costs than many other forage grass varieties (due to low seed yield), at approximately $25 per kilogram ($11.33 per pound) or $280 per hectare ($113 per acre, 2019 cost) when seeded at the full recommended rate (11.2 kilograms/hectare = 10 pounds/acre). However, recent research has shown that lower seeding rates can be used in low to moderately saline conditions, as low as half the recommended full rate (5.6 kilograms/hectare = 5 pounds/acre). This rate can still provide very good establishment for a monoculture AC Saltlander stand while cutting seed costs in half (Gu et al. 2017, Houston et al. 2018). To cut costs further in low to moderate salinity areas, use either a conventional saline forage mix with or without AC Saltlander, or a 1:1 mixture of AC Saltlander and another salinity tolerant species like slender wheatgrass.

To develop of a prescriptive plan for seeding (see *Plan where to seed*, page 10), map out salinity levels across the field (Figure 23). Determine the area to be seeded for each salinity zone and select appropriate forage(s) for each salinity level. For example:

- In low salinity zones, select a conventional salt-tolerant forage mix (may or may not include AC Saltlander).

- In low to moderate salinity zones, areas, seed a salt-tolerant mix that includes 2.8-5.6 kilograms/hectare (2.5-5.0 pounds/acre) of AC Saltlander.
- In moderate salinity zones, seed AC Saltlander at 5.6 kilograms/hectare (5 pounds/acre) in a monoculture. Optional: add an additional 5.6 kilograms/hectare (5 pounds/acre) of another salinity tolerant species (e.g. slender wheatgrass) to diversify the forage stand.
- In moderate to severe salinity zones, seed AC Saltlander at the high seeding rate of 11.2 kilograms/hectare (10 pounds/acre) in a monoculture. Optional: add an additional 5.6-11.2 kilograms/hectare (5-10 pounds/acre) of another high salinity species (e.g. slender wheatgrass) to diversify the forage stand.
- In severe salinity zones seed AC Saltlander as a monoculture at the original recommended seeding rate (11.2 kilograms/hectare = 10 pounds/acre) to give it the best opportunity for establishment success.
- In very severe salinity zones where little grows, seed around the perimeter with AC Saltlander at 11.2 kilograms/hectare (10 pounds/acre) to provide the best opportunity to establish productive vegetation. The perimeter area seeded should (1) span both the severely saline and less saline zones and (2) be roughly equal in size to the severely saline depression. The objective is to establish AC Saltlander around the fringes and allow it to slowly spread further into these typically uninhabited areas. (Figure 23, Table 7).

AAFC research to determine the most effective and efficient balance among seeding rate, salinity level and stand establishment success to minimize costs is ongoing.

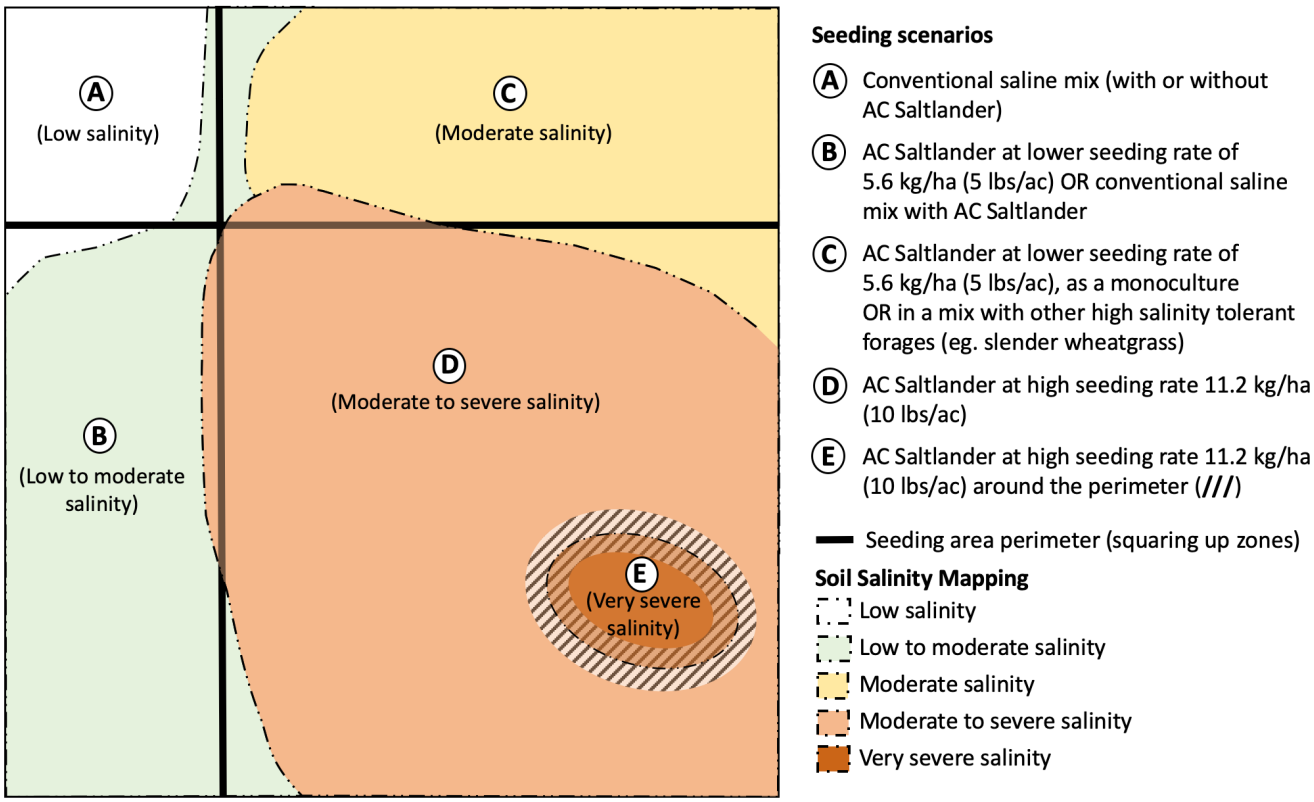


Figure 23. Example of seeding scenarios on a quarter section - a mix of species based on soil conditions can help reduce the overall seeding cost.

Table 7. Example seeding costs using a prescriptive approach on saline soils for figure 23 - seeding scenarios

Zone	Salinity Range	Species	Seeding rate kg/ha	(lb/ac)	Seed price* $/kg	($/lb)	Area ha	(ac)	Cost	Cost/ ha	(Cost/ ac)
A+B	Slight to moderate	AC Saltlander	1.7	(1.5)	$25.00	($11.33)					
		Salt tolerant alfalfa	1.1	(1.0)	$11.01	($5.00)					
		Smooth bromegrass	1.7	(1.5)	$13.21	($6.00)					
		Slender wheatgrass	1.1	(1.0)	$8.81	($4.00)					
		Total seed mix	5.6	(5.0)	$15.49	($7.03)	20.2	(50)	$1,752	$87	($35)
C	Moderate	AC Saltlander	5.6	(5.0)	$25.00	($11.33)	14.2	(35)	$1,988	$140	($57)
D	Moderate to severe	AC Saltlander	11.2	(10.0)	$25.00	($11.33)	28.3	(70)	$7,924	$280	($113)
E	Very severe	AC Saltlander†	11.2	(10.0)	$25.00	($11.33)	2.0	(5)	$280†	$140	($56)
Total							**64.7**	**(160)**	**$11,944**	**$185‡**	**($75)‡**

* Seed costs are based on 2019 prices.

†1.0 hectares (2.47 acre) seeded planted only around the perimeter of the very severe zone

‡Average of total cost calculated over entire quarter section (64.7 hectares = 160 acres)

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APPENDIX A: TIPS TO IDENTIFY AC SALTLANDER (Steppuhn et al. 2006, Barkworth et al. 2007)

Plant

- Tall plant: Average height mid-season 764 mm (30.1 in)
- Stems are erect at the base
- Long flag leaves
- Upright

Root system

- Upright crown with distinct rhizomes

Inflorescence

- A long, spike-like raceme ranging from 5-25 cm (2-10 in)

Spikelets

- Spikelets are 15-27 mm (0.06-0.11 in) long with 3 florets
- Glumes are equal, 5-11 mm (0.02-0.04 in) long 1.3-1.8 mm (0.05-0.07 in) wide with break off point at the glumes
- Paleas at the bottom of floret are awnless
- Lemmas 5-8 mm long (0.2-0.31 in)

Sheath

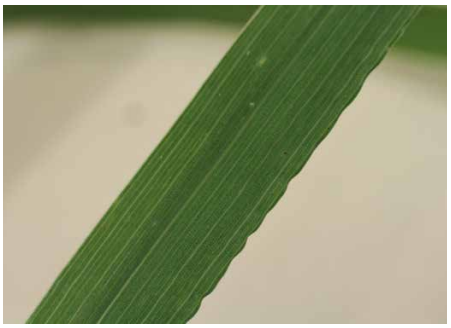
- Sheath is commonly glabrous (hairless) or somewhat scabrous (rough)

Ligule

- Very short, < 1mm (0.03 in)
- Broad and flat

Auricle

- Long claw-like and distinct (can be one or two)



Leaf

- Leaf blades are 5-13 mm (0.02-0.05 in) wide
- Flat surface or can have edges rolled over the upper surface toward the mid-rib.
- Smooth surface with no hairs

Nodes

- Swollen and distinct
- Typically stem has a bend at node

APPENDIX B: TIPS TO SCOUT, IDENTIFY AND MANAGE JAPANESE AND DOWNY BROME

Japanese and downy brome are annual weeds that can produce seed in the first year or survive as a winter-annual and head out the following spring. Both bromes propagate only by seed but since they are high seed producers, it is crucial to prevent seed set. Important times to scout for these bromes include mid- to late summer of the year of seeding or in late May of the second year of AC Saltlander establishment. Japanese and downy brome head out earlier than AC Saltlander so there is typically a one-week window in late May where the silvery, fuzzy brome heads are clearly visible. The best time for rogueing is after dawn or near dusk when the sun is lower in the sky helping to spot these weeds in the stand. Do not spray with a broad-spectrum chemical (i.e. glyphosate) as it will kill all vegetation and allow for weeds to re-establish. If found, pull up entire plant including the root, bag and dispose. There are various ways to dispose of weeds including deep burial and compost. For more infomation, contact your provincial weed specialist.

Japanese and downy brome do not appear to be very salt tolerant. However, they can establish in slight to moderately saline areas. Research has shown that AC Saltlander, as a rhizomatous perennial, can outcompete downy brome and foxtail barley over the long term. Although research did not include Japanese brome, it seems reasonable to expect a similar response. Regardless, having a weed management plan is essential to ensure a productive and thick AC Saltlander stand with no serious weed issues.

Japanese brome

- Annual or winter annual that can reach 1 m (39 in)
- Much finer leaves and is a finer looking plant than downy brome

Downy brome

- Annual or winter annual that can reach 15-60 cm (2-24 in) tall
- Thicker leaves and a more robust looking plant than Japanese brome.
- Light green, soft hairy appearance

Japanese brome

Inflorescence

- Long branches and pedicels. Usually drooping to one side when mature
- More upright head than downy brome

Spikelets

- The awn on the seed is equal to or shorter than its seeds and straight to bent/twisted at maturity
- Spikelets are 12-30 mm (0.5-1.2 in)

Ligule: Membranous with serrations on ligule end, has a blunt end (0.4-1.6 mm)

Auricle: Absent

Sheath: Covered with soft, dense hairs

Downy brome

photo: Matt Lavin cc-by-sa 2.0

Inflorescence

- Panicles are more droopy than Japanese brome and can bend nearly downward

photo: Matt Lavin cc-by-sa 2.0

Spikelets

- The awn is distinctly longer than the seed, and grows straight out from the tip of the seed
- Spikelets are 19-38 mm (0.75-1.5 in)

photo: Fred Fishel cc-by-nc 3.0

Ligule: Longer and serrations on end of ligule are more jagged than Japanese brome

Auricle: Absent

Sheath: Covered with soft, dense hairs

Japanese brome

Crown

- Shoots in a cluster arising from the crown
- Stems and leaves are covered with soft, fine hairs

Leaf

- Leaf blades are flat and open
- Blades are approximately 25-203 mm (1-8 in) long, and 0.8-1.6 mm (0.03-0.06 in) wide

Top leaf surface

- covered with soft, thin hair

Bottom leaf surface

- Covered with soft, thin hairs

Downy brome

Crown

- Finely divided root system. Shoots in a cluster, spread out crown
- Stems and leaves at the base covered with soft, fine hairs

Leaf

- Leaf blades are flat and wider than Japanese brome
- Blades are approximately 40-160 mm (1.6-6.3 in) long, and 2-4 mm (0.08-0.16 in) wide

Top leaf surface

- covered with soft, thin hair

Bottom leaf surface

- Covered with soft, thin hairs

NOTES

NOTES

AC Saltlander: A salt-tolerant forage for Western Canada