Crop varieties for dry saline land

Key messages

- Crop performance varied across saline sites. Salt tolerant species that do well at one site might not perform as well at others. At Tickera, SA, oats performed the best in 2022, while at Wandearah, roughly 90 km away, wheat and barley performed the best in 2023. Seasonal conditions play a role.
- At Tickera, there was a link between wheat grain yield and plant cover from the previous year. Plots which had <40% plant cover at harvest resulted in lower wheat yields the following season.

INTRODUCTION

Dry saline land, often referred to as 'magnesia country,' is an ongoing problem in areas with low to medium rainfall. The condition occurs when soil patches become overly saline, inhibiting the germination and growth of crops and pastures. Salts from subsoil clays are drawn to the surface through evaporation and capillary action, particularly after prolonged hot, dry periods without significant rain to flush the salts away.

Keeping the soil covered to reduce evaporation and limit salt rise is an essential part of managing the patches. Strategies include using mulches such as sand or manure and establishing a living plant cover.

Ideally, growing a productive crop not only maintains soil cover but also enhances the farm's productivity. However, crop establishment on saline soil is challenging; increased salinity impairs water and nutrient uptake by plants and can damage plant tissues, particularly the roots. This often results in poor plant growth and low yields, as most broadacre crops have low to moderate tolerance to soil salinity, which affects both germination and growth. High concentrations of sodium chloride can also be directly toxic to plants.

ASSESSING THE SALT TOLERANCE OF BROADACRE CROP VARIETIES

Trials in the mid north of South Australia investigated the performance of a range of crop species on a saline soil.

Tickera

The soil at the Tickera site is a moderate to strongly alkaline (pH >8.0) clay loam with salinity (ECe) mostly ranging from 5.9–15 dS/m across the site, and one very high salinity area of 37 dS/m. Many broadacre crops are affected when ECe is above 4, and only crops with a strong salinity tolerance will yield well when ECe is greater than 8 (Hughes 2020).

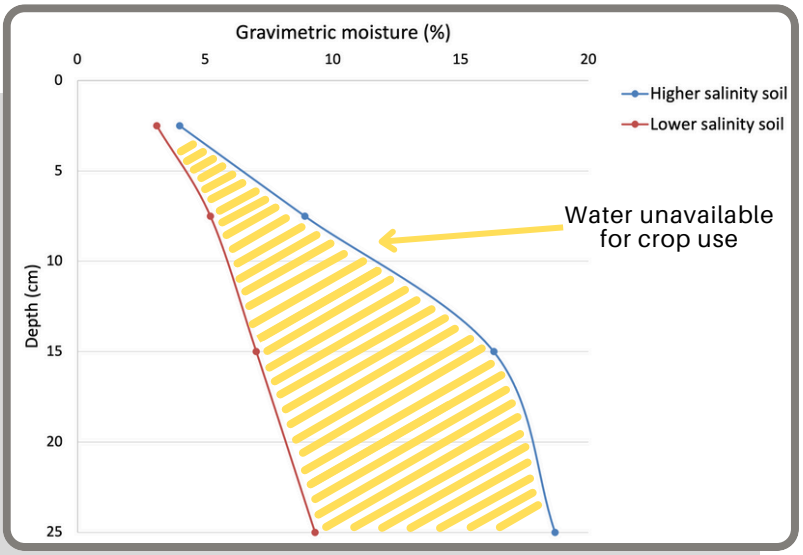
Table 1 lists the crops grown and their expected salinity tolerance. Crops were sown in 2022 to assess their performance and ability to establish and maintain groundcover in the dry saline land patch. Continued groundcover in dry saline land helps reduce salt rise to the surface. The residual effects of these treatments were assessed in 2023 with all plots sown to a Chief CL Plus wheat on May 11, 2023.

Table 1. Crop types and varieties sown in the first season (2022) of the salinity management trial Tickera, SA.

Crop type	Variety	Target plant density (plants/m²)	Expected tolerance to soil salinity level (ECe)
Barley	Compass	150	10
Oats	Mulgara	240	5.4
Triticale	Yowie	200	8
Wheat	Glad_V13*	180#	-
	Glad_V26*	180#	-
	Glad_V3*	180#	-
	Gladius	180	7.5
	Scepter	180	7.5
Lentil	Bolt	120	-
	Highland	120	-
Field Pea	Butler	50	3
Vetch	Timok	50	4
Canola	44Y94	50	8
Safflower	Conventional	40	6

*Near isogenic lines of Gladius wheat (able to accumulate 10x more sodium than current wheat varieties) was sourced from The University of Adelaide. Only two replicates of these varieties were included due to seed availability. #Seeding rates of near isogenic lines ranged from 50 - 80 kg/ha due to limited seed source.

Figure A



SALT TOLERANCE

Salt tolerant plants can employ a range of strategies to cope in saline conditions. Two common mechanisms are:

1. Excluding sodium. Selectively absorbing essential nutrients while minimising the uptake sodium ions, preventing the accumulation of sodium in their tissues. Puccinellia can do this.
2. Increasing osmotic pressure. Normally, to take up nutrients, crops make their fine root hairs salty – saltier than the soil water. Water is attracted from the less saline soil to more saline roots, bringing nutrients with it. By increasing osmotic pressure in their roots, the plant can continue to take up water, even in saline soil. But when salinity in the soil is higher than what the plant roots can make, water moves the other way, dehydrating the crop. Figure A compares soil moisture content in a lower salinity and higher salinity area of a dry saline scald. There is more moisture in the higher salinity soil because the crops cannot increase their osmotic pressure enough to take it up.

Saltbush, known for being very salt tolerant, has extra coping mechanisms. It can compartmentalise sodium and chloride into vacuoles within cells, to stop them from interfering with essential cellular function.

Some species of saltbush have specialised salt glands or bladder cells on their leaf surfaces. These structures actively secrete excess salt, which then crystallises on the leaves. This reduces the internal salt concentration in the plant.

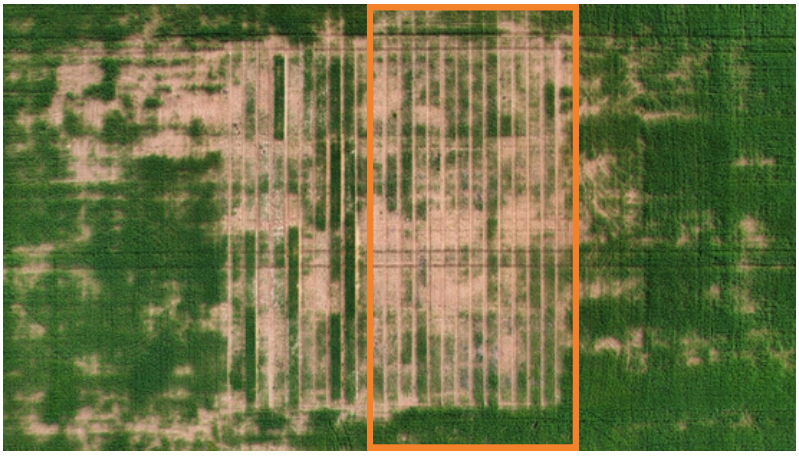


Figure 1. Aerial photo of the salinity management trials at Tickera, SA on July 28, 2023

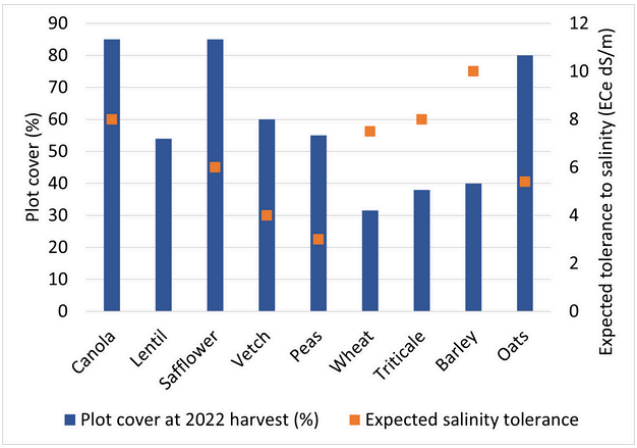


Figure 2. Plot cover at the end of 2022 vs expected salinity tolerance

RESULTS

2022 performance

At the end of 2022, crop cover varied across the plots and there was little relationship between expected salinity tolerance and crop cover (Figure 2). For example, barley struggled despite a high reported salinity tolerance, while canola performed well as expected. The season played a role. The lower crop cover in the cereals (<40%) was attributed to low rainfall from mid-June through July which limited tillering and caused crop damage/death in the more saline patches.

Grain yield was variable across the site. Oats had the highest yield (0.9 t/ha). While oats are reportedly less tolerant of saline conditions than other cereals, previous SAGIT funded research[1] has shown improved tolerance from some oat varieties, including Mulgara. Barley, peas, and safflower averaged 0.53 t/ha. Wheat, triticale, lentil and vetch were the lowest yielding. Canola grain yield was not recorded due to severe bird damage prior to harvest.

2023 wheat performance

In 2023, wheat emergence was low 18 days after sowing, varying between 11 and 44%. The variability is related to the natural variability of soil salinity levels across the trial (Figure 1). Despite variation in emergence, there were only minor differences among treatments at the end of the season.

Grain yields across the trial were similar to the control treatments, ranging from 0.51–0.99 t/ha. There were no differences in grain quality among the treatments with all samples meeting H2 receival standard. On average grain protein was 12.1%, test weight 76.7 kg/hL and screenings 4.0%.

Carryover effects in the 2023 wheat crop

Crop type and % groundcover had a carryover effect on the 2023 wheat crop. There was a moderate relationship (R^2=0.62) between plant cover at harvest in the 2022 season and wheat grain yield in 2023. Crops that had higher groundcover at harvest in 2022 generally had higher grain yields in 2023 compared to those with low (<40%) groundcover (Figure 3).

Crops with more groundcover at harvest had more residue cover over summer, meaning there was likely less soil evaporation and salt accumulation.

[1] https://sagit.com.au/project/identification-of-sodicity-tolerant-oat-varieties-ua416/page/2/?et_blog

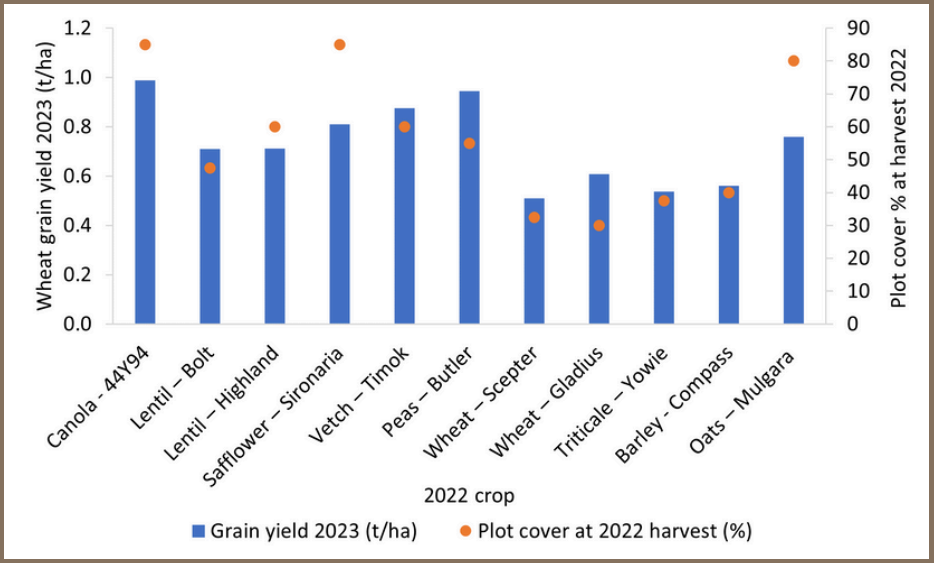


Figure 3. Wheat grain yield (2023) for the various crop types / varieties sown in 2022 and their respective plot cover % at harvest for salinity management trial at Tickera, SA

WANDEARAH

Another trial in 2023 at Wandearah, SA, assessed crop tolerance to salinity on dry saline land. Topsoil salinity (ECe) was 9.4 dS/m on the saline patch and 3.3 dS/m on the surrounding high production zone (Table 2).

Depth (cm)	Trial site (ECe)	High Production Zone Surrounding Paddock (ECe)
0-10	9.4	3.3
10-20	4.3	7.2
20-40	7.9	11
40-60	13	16

Table 2. Soil salinity ECe (dS/m; estimated)

At this site, wheat and barley were the highest yielding crop types, followed by oats, canola and safflower. The oat yield result should be treated with caution, however, as one plot was removed due to a miss spray. In other similar trials oats have been the highest yielding species.

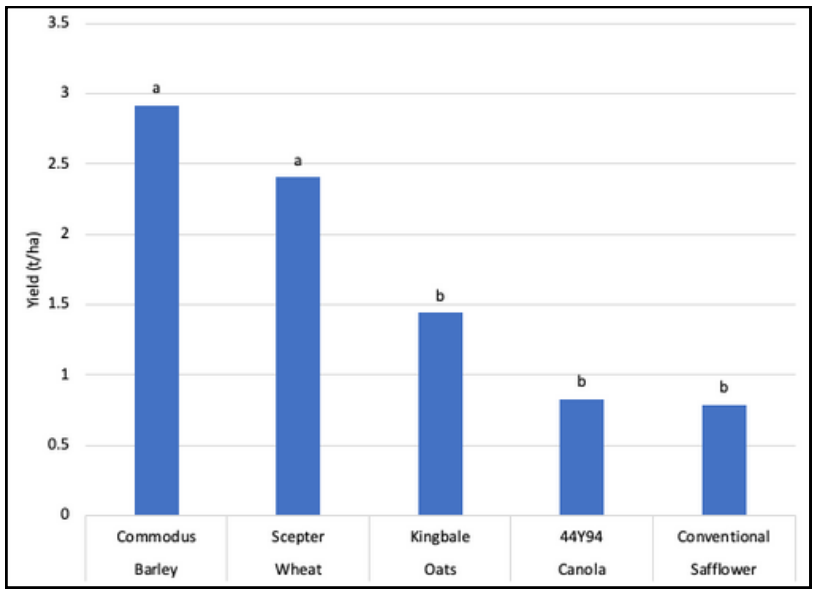


Figure 4. Mean plot yield. Treatments means with letters in common are not significantly different from one another

NEXT STEPS

More research is needed to tease out crop suitability for dry saline land, particularly across a range of wet, average and dry years. However, best practice remains to choose crops with a higher reported salinity tolerance to improve chances of establishing a crop.

That being said, crop rotations are important to control weeds and break cereal root and foliar disease cycles. Growing the same crop repeatedly is challenging, including on saline soils.

When trying to restore ground affected by dry saline land, obtaining and maintaining soil cover is key, particularly over the summer period. For large areas where cereals are most appropriate, targeting barley or oats into these situations may be optimal, particularly while patches of dry saline land remain. However, if early season rainfall lowers soil salinity enough to establish a different crop (see case study 'opportunistic sowing into dry saline land after rain'), or some other method of soil cover is achieved, and maintain over summer, then this may open the door for more diversity in rotation.

On larger and more severe scalds, consider saltbush or other permanent, salt tolerant plants to establish cover and prevent the scald from spreading and becoming worse.

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REFERENCES

Hughes B (2020) Understanding Your Soils Manual. PIRSA Rural Solutions Coorong LAP Meningie Soil Health Field Day

PROJECT INFORMATION

Trials run by Sam Trengove, Trengove Consulting and Stefan Schmitt, Ag Consulting and Research.

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