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Forage production from shrubs on saline land

C. V. Malcolm, Research Officer, Soils Division

In the first volume of the Journal of the Department of Agriculture in the year 1900, the results of experiments at Tulare Experiment Station in California on the growing of Australian saltbushes are reported.

Seed was first sent from Australia by Baron von Mueller in June, 1881. Three species of saltbush (Atriplex semibaccata, A. nummularia and A. vesicaria) are all reported to have grown well.

Although C. A. Gardner (later W.A. Government Botanist) in 1929 suggested the growing of saltbushes for forage, the earliest and clearest recommendations are those of Teakle and Burvill in 1945, who reported favourable results with trailing saltbush (Atriplex semibaccata) in Departmental experiments and with A. paludosa, a saltbush tried at Goomalling by a farmer.

Early research tended to concentrate mainly on the possibility of returning salt affected land to normal production. Cultural treatment, the use of soil additives such as gypsum and the sowing of plants such as cereals and Wimmera ryegrass were tried and some were recommended. Exclusion of stock was regarded as important.

These measures were successful on areas which were only mildly salt affected but were unsatisfactory on areas where bare salt land comprised more than about 30 per cent of the area concerned. Even on mild areas results were extremely variable, depending on the season.

An interesting by-product of this research was that protection from grazing allowed the encroachment of natural salt tolerant plants onto the experimental areas. In some cases the best plots were those which received no treatment other than fencing.

Interest gradually turned from annual plants to salt tolerant perennial forage plants for revegetating salt-affected areas. Smith and Malcolm in 1959 recommended the use of bluebush (Kochia brevifolia), old man saltbush (Atriplex nummularia) and creeping or trailing saltbush (Atriplex semibaccata).

However, experiments aimed at establishing these shrubs on a wide range of salt-affected areas disclosed a number of problems.

Bluebush grew extremely well on salt-affected soils which were well drained and in particular on those soils which previously carried Morrel Eucalyptus longicornis) and Kondinin blackbutt (E. Kondininensis), but it was not satisfactory on any areas which became waterlogged in winter.

Creeping saltbush provided an excellent cover in some years but because it was short-lived, tended to fade out without very careful management.

Old man saltbush (Atriplex nummularia) made good growth on a wide range of salt-affected soils but was difficult to establish, did not spread itself naturally from seed and had an upright growth habit which made efficient grazing use difficult.

Despite these difficulties many farmers have established areas of salt tolerant perennial shrubs on saline soils and are making valuable use of them for grazing, especially in the late summer and autumn when other feed is scarce.

On highly saline and waterlogged soils, samphires (Arthrocnemum spp.) have been found to regenerate readily if grazing is controlled and if there are, in the general vicinity, plants from which the seed can spread.

It became apparent in the early 1960s that there were gaps and shortcomings in the range of shrubs being used for revegetating salt land.

Testing of some collections provided by the University of W.A. indicated that Atriplex rhagodioides (silver saltbush) offered some advantages over the other shrubs and a collection programme aimed at finding the best shrubs for revegetating salt-affected land with useful forage was initiated.

Collection of new shrubs

The collection activities have been detailed in Department of Agriculture Technical Bulletins Nos. 6, 8 and 22.

A small collection trip was first made into the Murchison and Eastern Goldfields areas (Wilcox and Malcolm, unpublished data). An overseas collection trip was then undertaken in the U.S.A., Algeria, Tunisia, Turkey, Israel, Iraq and Iran. Field testing of these collections commenced in 1968.

As opportunity arose some other collections from within Australia were added and promising shrubs from other countries such as Chile and Argentina were added to the collection by correspondence and exchange.

When it became evident that some Australian species offered a great deal of promise, special collection trips were made into the Murchison, Eastern Goldfields and Nullarbor areas of Western Australia in order to obtain a good coverage of the best material available in these species.

As the shrub testing programme has proceeded, other applications of the work have been discovered. Consequently, some of the species collected have been for purposes such as coastal dune planting and revegetation of mine dumps and road verges.

In all, 716 collections are now held.

Testing Primary testing

Although all plants collected are, in general, thought to be capable of growing on saline soils in Western Australia, it is possible in the primary testing phase to considerably reduce the number of plants in the test programme.

Emphasis was first placed on testing for areas receiving less than 380 mm (15 in.) annual rainfall.
and sites typical of well-drained and poorly-drained salt land were selected at Quairading and Dangin respectively. Subsequently, test sites in higher rainfall areas have also been used for shrub testing.

All shrubs collected for wheatbelt salt land revegetation are raised in the glasshouse and planted into the primary test sites at Dangin and Quairading in late winter to early spring. Records are kept of survival, growth and reproduction. Plants which fail to establish are replanted in the following year. Marked differences are noted between the different collections in terms of survival, vigour and seed production.

In this way it is possible to identify those accessions worth promoting to a further testing phase. The primary testing programme continues as further shrubs are received.

Wider testing
To test shrubs selected in the primary testing programme for their adaptation to specific soil and climatic conditions in Western Australia, 17 sites scattered through the agricultural areas from latitude 29 to 34°S were selected. Each site was chosen as typical of saline areas in a particular locality. Further sites have subsequently been selected in areas receiving more than 380 mm annual rainfall.

The test plants were raised in the glasshouse and planted into the field in late winter and early spring. If conditions were dry a small amount of water was applied at planting time but no subsequent attention was given. Detailed soil sampling was carried out during the first summer and the full results are to be printed in a Technical Bulletin.

As a result of the wider testing programme it was possible to narrow the field of interest still further and to select certain species for intensive testing. Where material was limited for these species further collections were sought from overseas or special collecting trips were made within Australia.

Variety testing
Two main variety testing trials are in progress. In the first, all available collections of the most promising overseas species have been planted in a trial together with a limited number of outstanding Australian species for comparison. Establishment, growth, recovery after grazing, flowering and seed production are being recorded. In a similar trial numerous collections of the most promising Australian species are being compared.

Seed production and harvesting
Possible methods for establishing salt tolerant shrubs using conventional machinery including scattering the seed on the surface of worked ground or planting it at a shallow depth.

Sometimes these methods are successful but they are not reliable. Moreover, they suffer the disadvantage that a large amount of seed is required. Possible solutions to the seed supply problem include developing mechanised seed collection methods and developing establishment methods which use much...
less seed. Both approaches are being investigated. For samphire, mechanical seed harvesting methods using a forage harvester and side delivery rake have been successful.

Supplies of seed of bluebush and saltbush through normal commercial channels have always been limited. In a co-operative project with the W.A. Institute of Technology, a mechanical harvester for bluebush seed is being designed. It is hoped the machine can be adapted for harvesting saltbush seeds.

A possible source of seed of silver saltbush is on stations in the Murchison. Some of the special collections made in the area came from extensive areas of silver saltbush bearing large amounts of seed. Seed collected in this area would probably find a ready market.

Bluebush seed requires careful handling after harvesting. It must be dried and stored under dry conditions. (Details of cleaning and harvesting of bluebush seed are contained in Department of Agriculture Bulletin No. 2839.) Seed of most saltbush species can generally be stored, air dry, for several years without serious deterioration.

Establishment of some species of saltbush can be improved by threshing the seed. However, the details for most species under field conditions have yet to be worked out. In order to obtain pure seed of saltbushes (*Atriplex* spp.) it is desirable to grow them in isolation because different species of *Atriplex* commonly cross-pollinate. Seed production plots of several promising collections have therefore been established and it may be necessary to establish further such plots for any outstanding selections made in the variety testing trials.

**Germination**

Laboratory studies conducted by the Department of Agriculture have revealed some surprising facts concerning the salt tolerance of saltbush, bluebush and samphire seeds at the germination stage.

Although these plants occur naturally on highly saline soils and have a high salt content in their tissues when mature, they are no more salt tolerant than normal crops.
and vegetables at the germination stage.

It has also been shown that under salty conditions all of the species tested have relatively narrow temperature requirements for optimum germination. As salt is reduced, so the range of temperatures over which satisfactory germination will occur is broadened. Not only do salt and temperature above and below the optimum cause reductions in germination, they also reduce the speed of germination.

These laboratory results indicate that when bluebush, saltbushes and samphire are establishing on saline soils under natural rainfall conditions, there is a very delicate balance between temperature, salinity and the germination and establishment of the seedling.

Establishment

Seed

Normal seeding equipment was used in early attempts to establish salt-tolerant shrubs on saline soils in Western Australian agricultural areas. The seed was either sown through the tubes in the normal manner or spread on the surface of cultivated ground. The results obtained were very unreliable. Factors such as flooding, wind blasting, competition and insect attack were all observed to be capable of causing serious establishment problems.

However, the potential for good establishment and growth is shown when seed lodges in favourable niches in the environment.

This led to a series of detailed field experiments in which special treatments such as threshing, pelleting, limestone, gypsum and sand and grass mulch were all tested for their effect on bluebush establishment. Limited trials were also conducted on seed of saltbushes. The best results were obtained by placing the seed on the surface of the ground and covering it with a grass mulch. To apply the principles of this work on a field scale the "Mallen" Ridge Mulch Seeder was developed*.

In one operation the seeder forms a bank, presses a niche near the top of the bank and places seed and chaff mulch in the niche. The furrow beside the bank is designed to catch water and store it in the subsoil for later use by the developing shrub. The pressed niche in the bank provides a favourable environment for germination and establishment. The niche is intended to be slightly above normal ground level so that it does not become flooded. The position of the niche on the bank and the spacing between successive placements of seed and chaff can be varied. The machine is undergoing extensive field testing.

The main growth of new seedlings occurs in summer and autumn and there is a danger that farmers may believe a planting has been unsuccessful and graze planted areas while the seedlings are still very small in the late spring. Exclusion of stock at this stage is vital.

Seedlings

The field testing programme on new shrub collections has been conducted using seedling material, in order to make the best use of limited seed supplies. Bluebush and saltbushes can be established readily on wheatbelt saline soils by planting seedlings in late winter and early spring.

Saltbush seed germinates readily if the outer coverings (bracts) are rubbed off. This treatment is not necessary for bluebush. The seed is spread on sandy soil in a seed box, lightly covered and watered.

The seedlings remain small due to competition in the seed box and may be conveniently stored for a year or more, and pricked out into pots or other containers as time permits. Germination and growth are fastest in warm weather and the plants respond well to fertiliser.

The seedlings should be planted out into cultivated ground in early spring when the soil is still moist but the danger of floods and frosts is lessened. Hand planting is adequate for small areas or for trial plantings, but if present tests are successful, mechanised methods will be available for large-scale seedling planting.

Cuttings
Bluebush does not strike readily as a cutting but many saltbush species, especially those which stem-layer naturally, have been found to strike readily. Cuttings should be of matured shoots about half as thick as a pencil and 15 to 30 cm long, with a small tuft of leaves on the upper end.

Experiments are being conducted to determine the best method of field establishment of cuttings, but they can certainly be struck in containers and then planted out with as little disturbance as possible. Cuttings struck in a sand-peat mix and planted out in spring undisturbed have been found to establish well.

All methods of establishment, whether from seed, seedlings or cuttings, are most successful on freshly cultivated sites. The main advantage of cultivation is to control weeds which would compete with the shrubs for moisture over the first summer. Cultivation also increases the penetration of rain water and can help to lower the salt levels during the critical establishment period. Protection from grazing is essential in the first summer and later grazing should be carefully controlled to allow the establishment of self-sown plants.

Management
Because under south-western Australian conditions shrubs are green when the remainder of the feed in paddocks is dry and less attractive, grazing must be controlled in order to prevent the shrubs being eaten out.

In the first year or two strict control of grazing is necessary to allow the young shrubs to become established and develop a good root system. Later it may be necessary to control grazing in order to allow the older shrubs to throw new seedlings to thicken the stand.

Young seedlings are most susceptible to grazing during the spring and early summer. By autumn a substantial root system has usually developed and the seedlings are more likely to be bitten off than pulled out.

Grazing control is also necessary to allow recovery of grazed shrubs. Under wheatbelt conditions green forage from shrubs is normally most useful in the late summer and autumn when other feed is dry and unattractive. Fortunately, this is a season when the shrubs are not making their most active growth and have usually finished producing some seeds. It is therefore good grazing strategy, from the points of view of both the sheep and the plants, to graze them at this time of year. Normally in winter the shrub forage is not as attractive as green grass, clover and forbs and in the spring and early summer normal pasture is usually abundant.

Salt-tolerant perennial shrubs normally contain sufficiently large amounts of salt for salt intake to be considered in grazing management. A careful watch must be maintained on the overall salt intake of grazing animals. The salt in the feed may be diluted by ensuring that stock have access to abundant fresh water and areas of dry grass or stubble. The intake of salty feed may also be diluted by feeding hay.

The salt level is highest in samphire and lowest in bluebush, with saltbushes intermediate.

Bluebush is known to contain high levels of oxalate but under...
wheatbelt conditions problems arising from this may be avoided by diluting the intake of bluebush with dry annual pasture, stubble or hay.

APPLICATION ON THE FARM

The major factors limiting plant growth on salty areas are salinity, rainfall and waterlogging.

Salt

The most obvious factor limiting plant growth on salty soils is the salt content of the soil. However, salt content varies greatly both with the season and the situation and depth of the soil, so it is difficult to characterise a particular site by means of analysis. In fact, it has been found that the growth of salt-tolerant plants in Western Australia is related to rainfall, the extent of winter waterlogging and the depth of the water table as well as the level of salt in the soil itself.

Under natural rainfall conditions in the agricultural areas the yield of shrubs on salt-affected soils is related to the salt content of the soil solution in the root zone.

Rainfall

The growth and adaptation of salt-tolerant shrubs in Western Australia is related to total annual rainfall. Bluebush is best suited to areas receiving 300 to 380 mm (12-15 inches) of rainfall.

Most of the saltbushes under test also grow well in this rainfall zone although it tends to be too dry for coastal species such as *A. cinerea* and *A. hypoleuca*.

Waterlogging

Waterlogging is important both during the establishment period and when plants are mature. Bluebush and saltbush seedlings are susceptible to waterlogging but mature old man saltbush plants have survived several months' shallow inundation in areas where mature bluebush plants were killed. Silver saltbush (*A. rhagodioides*) occurs naturally on flood plains and in river beds and is adapted to waterlogged conditions.

Recommended species and soil conditions

Although the shrub testing programme is not completed, interim recommendations can be made for forage shrubs best suited to use on saline soils in the agricultural areas.

**Non-waterlogged (less than 380 mm annual rainfall)**

For saline areas which are not subject to winter waterlogging the naturally occurring bluebush (*Kochia brevifolia*) is recommended.

Some new collections have grown as well as bluebush but none has shown comparable ability to colonise rapidly. Bluebush has high protein and relatively low salt levels and recovers well after grazing.

Non-waterlogged salt land is most common in soils which previously carried Morrel (*Eucalyptus oleosa* var *longicornis*) and Kon-dinin Blackbutt (*E. kondininensis*). The soils are neutral to alkaline, rich in lime, high in salt and of medium to fine texture with little or no change in its clay content down to profile. On sites best suited to bluebush there is no free water within 2 metres of the surface.

**Mildly waterlogged**

In the broad valleys in the Western Australian wheatbelt and on the fringes of many seepage areas, salt-affected soils carrying a variable cover of salt-tolerant annual species.

These areas often become wet in winter but are seldom flooded for prolonged periods. There is usually free water within 2 metres of the soil surface. The soils vary from deep sands through loamy soils to fine textured alluvial soils.

The salt content and the pH vary tremendously. Some of the soils are highly acidic and others alkaline and rich in lime. In some cases there is little change in the texture down the profile and in others there is a marked change from a sandy surface to a dense clayey subsoil.

The main feature these soils have in common is that they are saline due to secondary salination, that is, salt has come into the soils following agricultural development. In some cases the soils already contained salt before clearing and this has become redistributed, often near the surface. Bluebush will grow on many of these sites but in a wet year it is likely to be killed out over extensive areas due to waterlogging.

The best suited forage shrub for these areas on present information is silver saltbush (*Atriplex rhagodioides*). Old man saltbush also makes good growth on mildly waterlogged salt land but in view of the disadvantages of its upright growth and its failure to reseed naturally, it is not recommended ahead of silver saltbush.

The common wheatbelt saltbush (*Atriplex bunburyana*) grows well on mildly waterlogged wheatbelt salt land and reseeds better than old man saltbush. If seed supplies can be obtained, it should be planted.

Other shrubs which make reasonable growth but are not as good as silver saltbush on present indications are *A. glauca*, *A. lentiformis*, *A. undulata* and *A. paludosa*. It is possible that *A. lentiformis* (quail brush), a shrub from southern Californian deserts, may be as good as silver saltbush in the northern wheatbelt.

**Mildly waterlogged (more than 375 mm annual rainfall)**

Shrub testing in higher rainfall areas is in its early stages and the indications are that species such as silver saltbush and *Atriplex cinerea* may be the most successful (*A. J. Clarke, priv. comm.*).

**Waterlogged**

In the wetter parts of seepages and in those sections of the broad wheatbelt valleys which become waterlogged for appreciable periods in most winters as well as being subject to periodic inundation, the most suitable shrub species are the samphires (*Arthrocnemum* spp.). Seed of samphire can be mechanically harvested and it can be successfully sown over large areas. Details of methods are contained in a separate article.

These preliminary recommendations may act as a useful guide to landowners for deciding which shrub species may be suited to their land. It should be remembered that on many wheatbelt salt areas it is possible to obtain good growth from planting Puccinellia. The growth of this grass is discussed in Department of Agriculture Bulletin No. 3312.

* In some earlier publications *A. rhagodioides* was given the common name "swamp" saltbush. It has subsequently been found that the name silver saltbush has precedence and should be used.