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CONTOUR FURROWING TECHNOLOGY FOR RANGE CULTIVATION AND RESEEDING

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ABSTRACT

As a result of recent technological improvements, contour furrowing has become the accepted method of reclaiming scalds in semi-arid far western New South Wales. Landholders in the Broken Hill district now support a full time commercial rehabilitation scheme.

The Broken Hill Land Reclamation Demonstration Program commenced in 1986 as a four year investigation and demonstration program with the following objectives: develop contour furrowing technology; demonstrate the technology to landholders; make available the resources necessary for widespread implementation of the program.

The significant developments of this program include the improvement of mouldboard design and ripper tyne configuration. These improvements have resulted in a longer furrow life, greater water holding capacity behind each furrow, and increased the volume of soil moisture storage. Erosion caused by excess runoff and wind is reduced, and runoff is harvested for plant growth and soil improvement.

Survey of the furrows using a laser level system has enabled the survey/furrowing/reseeding process to become a one pass operation. This has not only reduced the cost per hectare but has also increased the accuracy compared with other survey techniques. Increased survey accuracy has maximised the volume and area of water ponding behind each furrow and also reduced the possibility of breaching.

Results of contour furrowing trials at Broken Hill have indicated the importance of seedbed design and seed placement on the establishment of perennial saltbush species *Atriplex vesicaria, A. nummularia* and bluebush species *Maireana astrotricha* and *M. pyramidata*.

Evaluation of twelve furrow zones indicated the most suitable sites for seed establishment. The sides of the furrow were found to be the most suitable sites for seed establishment. Poor establishment occurred from seed sown in the ponded zone above the furrow, the apex of the windrows and in the bottom of the furrow channel.

Further trials investigated the suitability of three sowing methods: broadcasting; hand (precision) sowing at the preferred furrow zone; and a mechanical sowing method which incorporates low cost seedbed preparation and seed placement. These trials demonstrated the need for accurate seed placement in relation to the preferred furrow zone and control over sowing depth.

Future trials will aim at improving the reliability of seed delivery and sowing depth, articulation of the mouldboard and pre-sowing seed treatment.

INTRODUCTION

Contour furrow/reseeding is a technique which has been developed for the reclamation of scalds in semi-arid rangelands. As a direct result of recent improvements in technology, contour furrowing/reseeding has become an accepted method of scald reclamation in far western NSW. Landholders in the Broken Hill district now support a full time operation where a tractor, furrow/reseeding machinery, laser survey equipment, and a plant operator are hired at commercial rates.

Since the commencement of the Broken Hill Land Reclamation Demonstration Program in 1986, over 10,000 hectares have been treated by contour furrow/reseeding in the Broken Hill district.

The significant technological developments of this program include:

- the improvement of mouldboard design and ripper tyne configuration;
- the survey of furrows using laser levelling technology;
- seedbed design.

These developments and the effect each has on the reclamation system are described in this paper.

FURROW DEVELOPMENT

The machinery currently used to construct the furrows consists of a wheel tractor (100 hp) and a three point linkage furrow/seeder. There are two leading agricultural tynes which break up the soil in front of the double mouldboard. Figure 1 illustrates the changes to contour furrowing equipment which have taken place over the past twenty years.

The net result has been a larger furrow with considerable water ponding capacity and an expected effective furrow life of over ten years.

The furrow produced is approximately 1.6 metres across, 45 cm deep, with windrows 25 cm high. The size of the furrow is important as this will directly affect the life of the furrow and water ponding capacity. It is essential that ripped soil is removed from the furrow to reduce the effect that rapid slaking has on the life of the furrow.

The larger the furrow, the greater the number of favourable seasons that will occur during its effective life and therefore the greater the probability of complete reclamation occurring. There is a trade off between furrow size and the spacing required between each furrow for effective control of runoff. There is an optimum furrow size which is related to cost/benefit, and the potential to cause an erosion problem with oversized furrows (2).

The main functions of each furrow include the following:

- to increase the initial water holding capacity of the soil by ripping during furrow construction. Ripping reduces the probability of storm damage to new furrows by increasing initial infiltration rates.

•to control and concentrate runoff by ponding water on the uphill side of the furrow. Infiltration rates increase over time as a result of soil improvements from water ponding effects (1).

•to provide sites for primary and secondary seed establishment which are not prone to flooding or salinity and which provide adequate soil moisture conditions and micro-environment for germination and establishment.

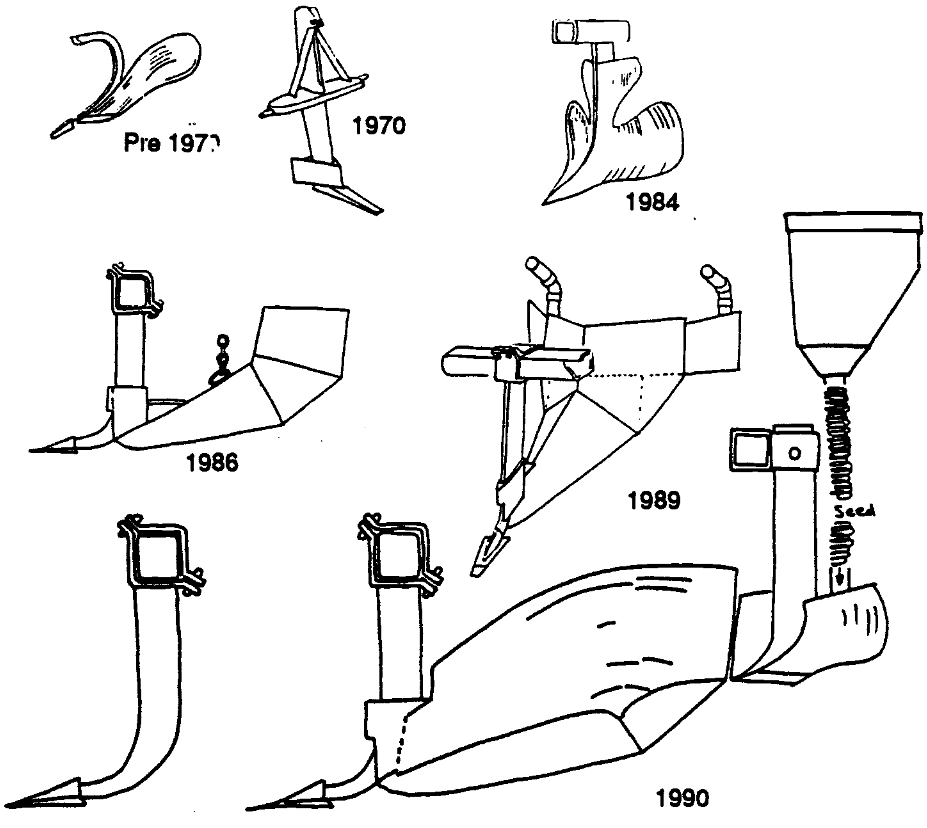

Figure 1. Changes to furrowing equipment 1970 to 1990.

SURVEY METHODS

One major advantage of contour furrowing is the ability of the furrows to pond large volumes of runoff. To maximise the ability of each furrow to pond water, accurate and continuous survey of each furrow is essential.

Contour survey techniques were evaluated for accuracy and new technology developed to minimise the labour and capital costs associated with furrow surveying.

<u>Survey Systems</u>
Various survey methods have been evaluated to determine the most accurate and efficient system including: a dumpy level; water level; vehicle mounted laser level (3); and tractor mounted remote controlled laser level. As a result of the evaluation, it was recognised that there was a need for accurate and continuous survey. Survey with a dumpy level (for example) is a point survey method which is labour intensive and often leads to inaccuracy between survey points. Over short distances furrows could deviate from the contour draining water away from the high points and concentrating runoff in the low points.

This often resulted in poor revegetation of runoff areas and breaching of furrows where water became concentrated at low points.

The survey system which proved to give the most accurate survey result at the lowest cost was the tractor mounted remote controlled laser system. This system consists of a trailer mounted hydraulic mast and laser transmitter which can be raised or lowered by remote control from the tractor cabin. The laser signal receiver is mounted on a manually operated hydraulic mast on the front of the tractor. The tractor operator manually steers the tractor either uphill or downhill according to the display of level indicator lights.

The laser transmitter can operate over a radius of 700 m and over a fall of three metres (3 m). This range minimises the time required to shift the transmitter mast and would allow either one or two tractors to operate efficiently from one transmitter.

The development of the tractor mounted survey technique has assisted in reducing the survey, furrowing and direct seeding to a one pass operation.

Survey Layout

Once a site has been selected, the appropriate seed determined and necessary grazing management implemented, the survey/ furrowing/ reseeding commences from the top of the slope and/or runoff area. This will prevent storm damage from occurring during the construction phase. The optimum spacing between furrows in 220 mm rainfall areas near Broken Hill is between 7 m and 15 m depending on slope and expected runoff rates. Where excessive spacing occurs between furrows as a result of surveying on changing slopes, the space is filled by short furrows at the desired spacing.

While continuous survey is superior to point survey techniques, a certain amount of driver anticipation is required to ensure that sharp depression are properly surveyed or avoided. Specific site problems can occur where furrows are constrained by farm tracks or fence location. Obstructions such as these can reduce the area of pond behind each furrow and may result in local washouts when runoff from tracks is not adequately controlled.

SEEDBED DEVELOPMENT

The primary objective of rangeland reclamation is the re-establishment of desirable perennial pasture species on previously degraded sites.

Where adequate stands of desirable perennial species are located throughout the area to be treated, natural dispersion of seed, in conjunction with contour furrowing, may be sufficient to ensure that regeneration occurs. However, as is more often the case, such seed sources do not exist in sufficient quantity and consequently a program of seed re-introduction is necessary for furrowing to realise its true long term benefit.

In 1987 a series of field experiments investigated the effectiveness of a number of seed placement sites in relation to various furrow zones shown in Figure 2.

The initial experiment involved sowing seed of *Atriplex, Maireana* and *Eragrostis* species in the major furrow zones. The experiment was repeated at three locations having different soil types and erosion status. Equal quantities of seed were sown by hand in 12 rows. Results were measured as seedlings established by row as percentage of total seedlings established (Figure 3).

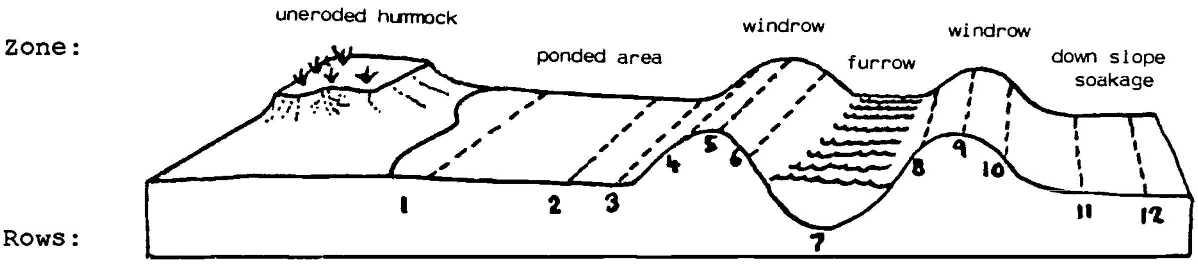

Figure 2. Seed placement in relation to furrow zones.

Though not always the site of highest establishment, the positions on the sides of the windrow were consistently favourable to establishment, that is rows 4, 6, 8 and 10 are superior as primary seed placement sites. Other zones e.g. rows 3, 11, and 12 which also showed favourable establishment are likely to act as sites for secondary seedling establishment.

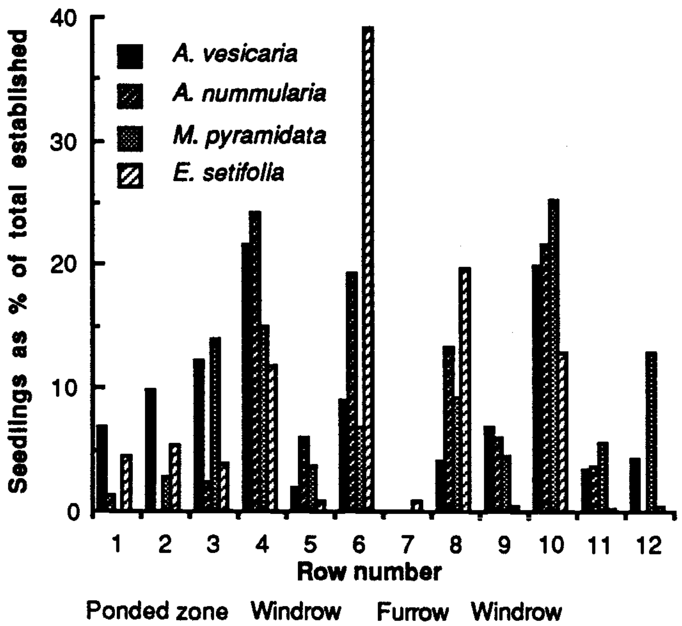

Figure 3. Seedling establishment by row as a percentage of total establishment (average of all sites).

In addition further investigations of furrow zone establishment were undertaken. Seed sown by hand at the high water mark of ponded furrows (which had received rain the previous day) also germinated successfully. These results and observations of favoured zones of natural revegetation led to the development of the furrow shelf seeder. The shelf is created by the addition of wings to the furrow delver which shifts the furrow windrows horizontally, approximately 100 to 150 mm away from the furrow (see Figure 4.) The old ground level is usually covered by 15 to 25 mm of ploughed soil and seed is dropped onto this shelf and lightly covered with soil using trickle chains.

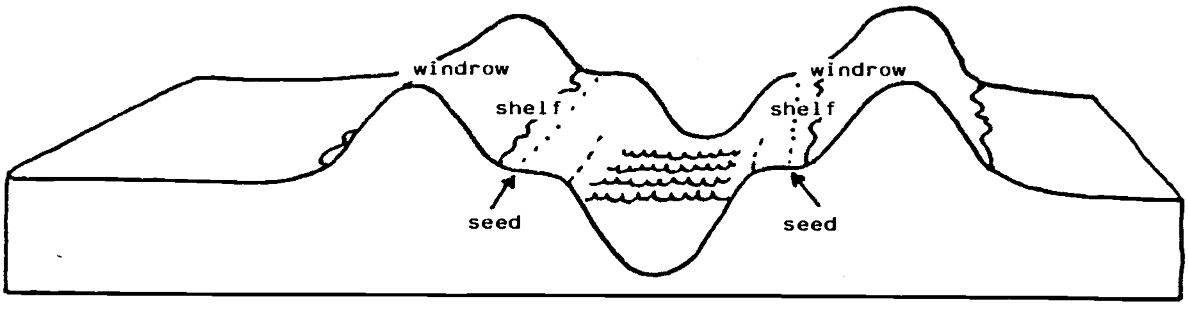

Figure 4. Cross section of furrow shelf.

A second set of replicated field experiments were initiated in October 1988 and February 1989 to:

- investigate the suitability of three sowing methods/niches in relation to the furrow for direct seeding, i.e. broadcasting of seed over the entire furrow surface, hand sowing into the niche on the windrow (rows 6 and 8 from the previous trial), and the furrow shelf seeder.

- evaluate the usefulness of permethrin (Hortico, ant, spider and cockroach surface spray residual insecticide) as an ant repellant seed treatment.

- evaluate the furrow shelf seeder currently being used by the N.S.W. Soil Conservation Service at Broken Hill, i.e. the furrow shelf seeder.

Species used in these trials were low bluebush *Maireana astrotricha*, old man saltbush *Atriplex nummularia* and bladder saltbush *Atriplex vesicaria*.

<u>Methodology</u>
Laboratory tests were made to determine the viability of 50 g seed samples. This involved:

•weighing a grab sample of seed from hand collected seed from local seed sources.removal of all non seed material and weighing the pure seed.
•estimating the percentage of pure seed in sowing samples.
•estimating the 100 seed weight in the bract (average of 400 seeds).
•determining the percentage of filled bracts by removing bract and counting whole germinable seeds.
•testing the germination percentage from 2 x 25 seeds removed from bracts and grown on cotton wool at room temperature.
•estimating the number of viable seeds in each 50 g sample.
•repeat for samples treated with permethrin at approximately 30 ml of 3 g/l permethrin 25/75 per 50 g seed sample.

The results of these tests are shown in Table 1.

Table 1. Germination and seed viability test result

Species	Average in bract 100 seed weight	% clean seed/50 gram sample	% Filled bracts	Germination %	No. of viable seeds per 50 gram sample
Maat (p)	1.585	91.20	94.30	88	2387
Maat (u)	1.585	91.20	94.30	52	1411
Atvc (p)	1.828	69.98	84.75	54	876
Atvc (u)	1.828	69.98	84.75	78	1265
Atnm (p)	0.538	83.20	81.96	16	1014
Atnm (u)	0.538	83.20	81.96	40	2535

Each individual trial was established as a 4 x (3 x 2) replicated experiment. Fifty gram samples of seed were sown along sections of furrow marked by numbered pegs. Each row of seeds represents one replicate. Four replicates were made of seed sown by three methods and two treatments, giving a total of 24 sites per trial. However at Pine Point this design was not implemented due to operator error. Six replicates were sown using the furrow shelf seeder whereas only two replicates were hand sown and four were broadcast.

Furrow shelf seeder sites were established using the sowing machinery attached to the Soil Conservation Service furrowing plough. For broadcast and hand sown samples the seeder was disconnected and the shelving wings removed to create conventional furrows. Seed was then hand broadcast or hand sown along the conventional furrow.

Hand sown seed was placed in the favourable mid windrow zones identified in the original investigations at K Tank, Appin and Fowlers Gap. Hand sowing enabled reasonable control of sowing depth.

Broadcasting seed was chosen to represent a base level method of establishment. In the past broadcasting of seed over furrows has had very little response. The testing of an ant repellant was seen as a way of overcoming at least one of the limiting factors involved in establishment.

RESULTS

The effect of using permethrin in a miscible oil solvent is evident in these results, as germination percentage of *M. astrotricha* increased whereas the effect was negative for both the *Atriplex* species studied. The variation in germination percentage had a marked effect on the number of viable seeds estimated to be in each sowing sample. These estimates were used to calculate the trial results (Figure 5).

Treatment of seed with permethrin generally resulted in a positive effect on the number of seedlings established as a percent of viable seed sown (NOSEPOVSS) and also on the actual number of seedlings established. This was despite the effect of treatment on the viability of seed indicating that removal of seed by harvesting ants was a significant factor in the trial.

Seedlings were observed in all sown furrows regardless of niche or seed treatment. The Pine Point untreated seed of both *Atriplex* species sown by the furrow seeder out performed both other sowing methods. However, this relationship was not born out for *M. astrotricha*. Also at Glenora the results showed that for both treated and untreated seed of all species, hand (precision) sowing into the niche on the side of the furrow windrow enabled establishment superior to either the furrow shelf seeder or broadcasting of seed.

When seed was treated with permethrin the furrow shelf seeder gave a similar performance to broadcasting at both sites.

When seed was not treated the furrow shelf seeder performed at least as well or better than broadcasting, indicating some difference in seed removal by ants due to seed burial.

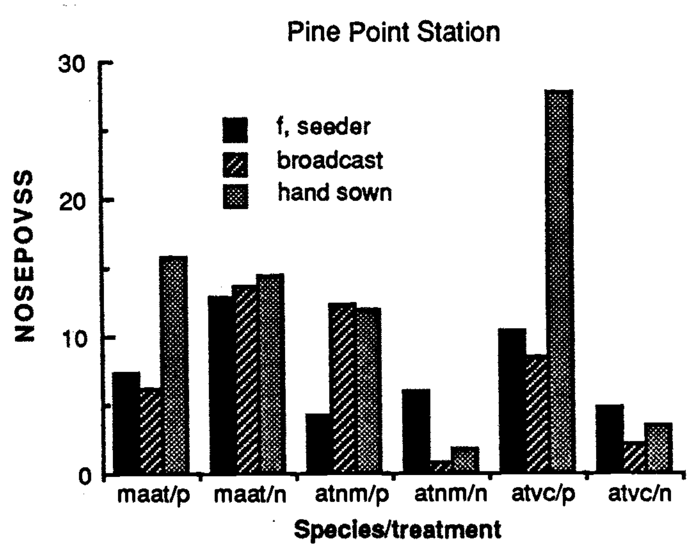

Figure 5A. Seedlings established as a percentage of viable seed sown.

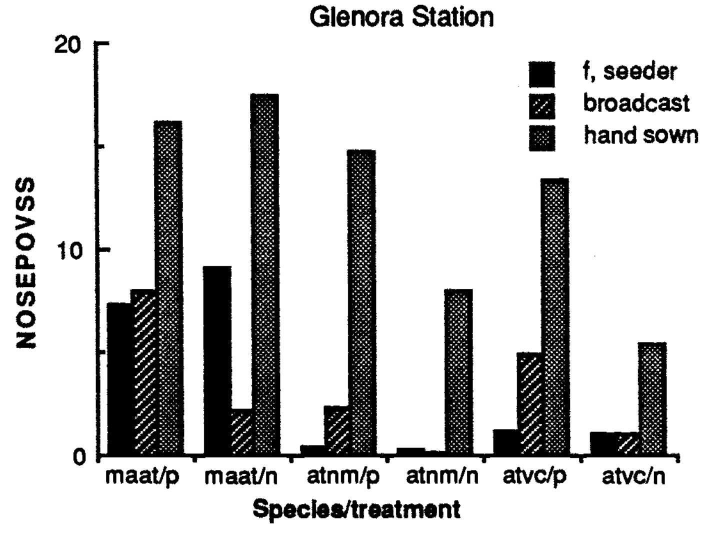

Figure 5B. Seedlings established as a percentage of viable seed sown.

NB. n = untreated, p = permethrin, atvc = *A. vesicaria*, atnm = *A. nummularia*, and maat = *M. astrotricha*. NOSEPOVSS = Number of seedlings established as a percentage of viable seed sown.

DISCUSSION

As a result of recent technological improvements, contour furrowing has become the accepted method of reclaiming sheet eroded areas in semi-arid far western New South Wales. Landholders in the Broken Hill district now support a full time commercial reclamation scheme.

The Broken Hill Land Reclamation Demonstration Program commenced in 1986 as a four year investigation and demonstration program with the following objectives: develop contour furrowing technology; demonstrate the technology to landholders; make available the resources necessary for widespread implementation of the program.

The contour furrowing/reseeding system developed under this program has improved the potential for reclaiming sheet eroded areas in semi-arid rangelands by: improving poor soil conditions; harvesting runoff; and by taking advantage of both direct seeding and natural regeneration. The improvements in mouldboard design and ripper tyne configuration have created a furrow which has the ability to control runoff by ponding water and allowing rapid infiltration of moisture into the soil profile by ripping (4).

Observations of regeneration of contour furrowed areas indicated the need for development of direct seeding technology in areas where a natural seed source was inadequate.

The seeding trial results and field evaluation suggest there are a number of factors required to increase establishment rates from direct seeding. These factors include: the sowing of seed in the optimum furrow zone; the accurate (precision) placement of seed; the application of ant repellant to the seed prior to sowing; and the need to sow a range of species each of which can be expected to respond to rain falling at particular times of the year.

Each furrow zone has a specific micro-environment which will affect the establishment of desirable perennial rangeland species from seed. The primary sites of seed establishment were identified as the position on the side of the furrow windrow. While the micro-environment in each furrow zone changes with each rainfall event and ponding frequency, the windrow sides gave most consistent results and have therefore been chosen as seed placement sites.

The furrow zone 7 (Figure 2) is unsuitable due to flooding, and zones 5 and 9 are unsuitable due to expected salt accumulation at these points. The establishment rates from the hand planting of seed was consistently higher than broadcasting or furrow shelf treatments. These results indicate the benefits of placing seed accurately (precision seeding) and at a consistent depth. The following modifications to the furrow shelf seeder are expected to improve the establishment rates:

•articulation the mouldboard and shelf seeder. The mouldboard and shelf seeder used in the trials would not form the desired shelf unless the tractor and implement were operating in a straight line. To maintain consistent shelf characteristics the mouldboard and shelf seeder will need to be articulated.

•a hydraulic seeder drive has replaced the ground drive mechanism to ensure constant seeder operation.

•a seed cleaner is being installed to reduce the blocking of seed boxes by debris and ensure constant delivery of seed.

•a press wheel will be added to provide greater soil to seed contact, to reduce the slumping of the windrow onto the shelf, and to form a shallow "V" shaped niche on the shelf.

Further trials are required to determine the optimum position of the furrow seed shelf in relation the windrow.

Due to the uncertainty of rainfall in the Broken Hill district seed sown in any reseeding program may be required to remain on the ground or in a niche for quite long periods before establishment can take place. Greenslade (5) and other workers have identified harvester ants as having "the potential to adversely influence revegetation through their effects on seed banks. Elaiosome collectors on the other hand especially species of *Rhytidoponera*, may be beneficial by accelerating the process of plant dispersal and establishment."

Campbell and Gilmore (6) in their work on area aerial sowing of pastures identified two low toxicity chemicals permethrin and bendiocarb for use in protecting surface sown seed from removal by harvester ants.

Permethrin acts as an anti-feeding mechanism preventing the removal of seed by ants. Ants will pick up the seed and then discard it. Bendiocarb on the other hand is taken back to the nest and consumed killing the ants. As ants tend to eat their own dead the chemical is soon spread throughout the nest effectively killing all the adults in the nest. Bendiocarb breaks down after about 10 days and ant eggs that hatch after this period will re-establish the nest.

Permethrin has a long lasting residual activity and is not readily broken down by either sunlight or contact with the soil. Claims by the manufacturer indicate that it will remain effective for a period of at least three months and possibly longer. Permethrin was chosen for these experiments on the grounds that it has a high LD50 (approximately 1500 mg/kgLW), it is long lasting and is unlikely to have any detrimental effect on elaiosome collector species of ants.

Campbell and Gilmore (6) found that using permethrin in a miscible oil solvent had a detrimental effect on the germinability of phalaris and subclover seed but no detrimental effect if applied as a wettable powder. The results presented here also show the adverse effect on germinability for the two *Atriplex* species, of using permethrin in a hydrocarbon solvent. Further tests are required to assess the affect of permethrin on the germination of chenopod seed when the chemical is in a wettable powder form.

Treatment of seed with permethrin generally resulted in a positive effect on the number of seedlings established per viable seed sown and also on the actual number of seedlings established. This was despite the effect the treatment had on the viability of seed which indicates that removal of seed by harvesting ants was a significant factor in the trial.

The development of mouldboard technology has increased the effective life of the furrows to over 10 years. During the first one to two years it is expected that primary establishment of desirable perennials will occur on the windrows which elevate the seedbed above the flooded zone. After a period of approximately two years soil changes such as increased infiltration, a decrease in salinity and surface cracking in the ponded zone will allow secondary establishment of perennial species. Over a 10 year period the established perennials can be expected to set seed and volunteer successfully on a number of occasions increasing the overall sward density. Towards the end of the effective life of the furrow, the desirable vegetation is expected to be well established, no longer requiring the furrow for water harvesting or other purposes.

As a result of an evaluation of a number of survey techniques, the need for accurate and continuous survey was recognised. Furrows not on the contour reduced revegetation at high points and resulted in breaching of furrows where runoff became concentrated at low points. It was recognised (4) that furrows surveyed accurately and continuously on the contour, ponded the maximum amount of water.

To increase accuracy and reduce the labour requirement of other survey techniques the tractor mounted laser survey system was developed. This survey system has operated successfully for over three years enabling the furrowing, surveying and direct seeding to become an efficient one pass operation.

CONCLUSION

The commercial application of contour furrowing/reseeding technology in the Broken Hill district is a direct result of: improvements in mouldboard design and ripper configuration; the development of the laser survey system; and the development of direct seeding technology. For successful reclamation of sheet eroded semi-arid rangelands, the application of this technology has most effect in the context of property and paddock strategy planning (2).

The cost of reclamation technology is an important factor with contour furrowing earthworks and laser survey currently costing $10 per hectare (100% tax deductible). The availability of volunteers for collection of "local" seed and the efficiencies gained by shifting plant and equipment within landholder groups has made the commercialisation of the contour furrow/reseeding program possible.

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