

Low cost overdrilling technology for pasture establishment

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Abstract

A prototype strip seeder was developed to establish grasses and legumes in the semi-arid and montane environments of the Mackenzie Basin and Central Otago. Specifications of the strip-seeder required for cost-effective performance were identified on the basis of previous direct drilling investigations in this environment, and included: (a) removal of a strip of existing vegetation to reduce competition; (b) creation of seed bed tilth; (c) controlled and separate placement of seed and fertiliser; and (d) compaction of the drilled seed bed to enhance contact between seed and soil. The prototype strip seeder was built around a modified Duncan 730 multi-seeder chassis, and was used to install spring and autumn trials at Eamscleugh in Central Otago and at Ohau Downs in the Mackenzie Basin. Mechanical improvements were made as the trials progressed. The experience gained, and results from the trials, confirm the suitability of the prototype strip seeder concept for successfully introducing grasses and legumes into this terrain.

Keywords direct drilling, strip seeder, seed placement, seed depth, sowing depth

Introduction

Semi-arid and montane tussock grasslands have suffered a significant loss in production and profitability over recent years. Drought, uncontrolled rabbit populations and invasion of **hawkweed** (*Hieracium species*) are among the factors causing this loss.

The potential exists to alleviate this situation by the cost-effective introduction of pasture species which are better suited to the environment. These species include drought-tolerant grasses and legumes which are able to extend the growing season and better equate feed supply demand (Scott *et al.* 1985; Chapman *et al.* 1990) but, because of the environment, they are slow and difficult to establish.

Different methods of introduction have been attempted with varying degrees of success. Full

cultivation will eliminate vegetative competition, but costs are high and the risk of erosion excessive. Direct drilling, together with herbicides, has been tried, but in early spring when moisture levels are adequate for germination, existing species are not growing and their control by herbicides is unreliable (Pollock 1989). Strip seeding, in which some of the competing vegetation is mechanically removed and a tilth created over a width of approximately 100 mm, has resulted in successful plant establishment (Dunbar *et al.* 1980), but machines used to date are not sufficiently robust to withstand the stony conditions typical of this terrain.

The drills that have been tried also lack the control of seed placement depth which is important for successfully introducing improved pasture species into this country (Woodman *et al.* 1990; Seaney & Hensen 1970). Single disc drills rely on spring pressure to achieve penetration and are not sensitive to changes in ground contour or changes in the surface vegetation. The commonly used triple disc drill suffers from the above problems and also loses depth control when the leading disc rolls over stone or rock. Hoe type drills used for direct seeding often have the tines fixed to a rigid chassis and therefore the individual tines are not able to follow changes in ground contour (Woodman *et al.* 1990).

The objective of the project reported here is to develop a technically effective and mechanically sound single-pass direct drill prototype to enable reliable and cost-effective pasture development or renovation in stressed semi-arid and montane environments. Details of the agronomic data on establishment trials using the prototype strip seeder and a conventional triple disc drill have been given by Lowther *et al.* (1992). The present paper describes mechanical aspects of the prototype strip seeder and evaluates its performance in meeting design specifications.

Materials and Methods

Development of performance specifications

A joint MAF/AEI project was started in 1989 to overcome the mechanical limitations to seedling establishment. A

prototype machine was completed in March 1990 and a trial programme initiated. The concept was based on the joint MAF/AEI experience with strip seeding using the Roto-drill and Hunter Rotary Strip Seeder. Both these machines used a rotary cutting head which gave good reduction of competition and showed that there were mechanical alternatives to herbicides. But their main failing was the mechanical damage to the machines when working on rocky ground. For the new machine, it was decided to retain the concept of strip seeding but to achieve it in another way.

Disc drills developed by Asher & Eckert (1973) showed that an angled dished disc, suitable for rocky conditions, could be used to scalp off a turf ribbon. The use of the Danish KKK "S" tine by the Duncan Till Seeder demonstrates that this tine can be used for penetration of uncultivated ground. By using this tine to place fertiliser, separation from the seed can be achieved.

Studies done by Morrison & Gerik (1985) show that depth control wheels that are fixed beside the seed placement coulters give the best performance in controlling the depth at which the seed is placed.

Based on these experiences, the specifications for the MAF/AEI prototype strip seeder were set as follows:

1. Remove a ribbon of turf using an angled disc.
2. Create tilth and place fertiliser using a cultivator type tine.
3. Place seed at controlled depth in the loose soil with a separate seed placement coulters.
4. Cover the seed and firm the soil around it with a press wheel.
5. Ensure mechanical reliability in rocky terrain.

The machine constructed in 1990 put together the desirable and workable concepts that previous experience indicated would have the most chance of success. It was built with the aim of field testing the concepts of the soil engaging components.

Strip seeding drill componentry

The drill, as originally constructed, was based on a Duncan 730 Multi-Seeder chassis and uses the standard Duncan seed metering units and coulters lift assembly. The ground-engaging parts are carried on two separate drag arm assemblies. On the leading drag arm are attached opposing pairs of 300 mm dished discs, each at a 35° angle to the direction of travel. Following the discs and attached to the same drag arms are 'S' tines which have a fertiliser delivery tube added. These tines have replaceable points. The depth of penetration of the angled discs and "S" tines is controlled by a depth wheel. Seed is placed in the tilth created by the "S" tine using an Aitchison Industries coulters which has a small flat

disc set at an angle to a fixed shoe. Depth of seeding is controlled by an adjustable depth wheel running beside the seed coulters. The seed placement coulters is followed by a press wheel which is attached to the seed coulters by a double coil spring.

The seed coulters and press wheel assemblies are connected by parallel arms to an independent cross beam. Coil springs provide down pressure. Fluted roller metering units are used to meter both seed and fertiliser. The conductor tubes are thick wall, smooth bore rubber tubing with an inside diameter of 13 mm. A low pressure air system is used to assist the flow of seed and fertiliser down the tubes, with air being supplied by a fan driven by a 12 volt electric motor.

Description of trials

Trials were conducted in the Mackenzie Basin and in Central Otago; they are fully described by Lowther *et al.* (1992). Their purpose was to compare the establishment and persistence of species sown with the prototype strip seeder with that of species sown by a conventional triple disc drill, and to evaluate the mechanical performance of the prototype machine.

Measurement of seed and fertiliser placement

The techniques used to sample and measure seed and fertiliser placement were as described by Kaviani *et al.* (1985), suitably modified to enable direct data entry to a personal computer for immediate analysis. The technique consists of taking undisturbed 'Vee' samples of a length of row. The seeds are germinated by placing the samples in a glasshouse. After seed emergence, the samples are placed on a three-dimensional measuring apparatus. The emerged shoots are then used to trace down to the original seed position. Fertiliser is found by progressively cutting away the face of the sample. For the autumn sown trials, the samples were not placed in a glasshouse; seed depth was measured before emergence.

Results

Seed and fertiliser placement

Seed depth was set in the field for all trial sites at approximately 12mm for both the prototype strip seeder and the triple disc drill. Each machine was evaluated by taking four randomly selected 'Vee' samples from each of three (of the four) replicates of one grass and of one legume species sown in the spring trials. The results are presented in Table 1.

Sampling from the autumn trials was limited to those coulters which had been modified to answer

specific questions about the performance of the prototype strip seeder. Results are given in Table 2.

Results of the agronomic evaluation of the ability of the prototype strip seeder to successfully introduce new pasture species into semi-arid and montane terrain are presented in Lower et al. (1992). They confirm the indisputable superiority of this method.

Discussion

Disc openers: The angled disc openers performed satisfactorily under a range of conditions. In ideal conditions they would remove a ribbon of turf and root mat approximately 100 mm wide and 25 mm deep. Competition removal at the various field sites was assessed as a percentage of the ideal. At Eamscleugh, 89% removal was achieved, and at Ohau Downs, 83%. When drilling in dense **hawkweed** it was observed that large blocks of root mat would tear away due to the shallow rooting of this plant. These larger blocks (up to 300 by 500 mm) caused trash blockages at the fertiliser tines.

Fertiliser tines: The 10 mm fertiliser tines proved to have insufficient stiffness to penetrate hard ground, especially **that encountered at Ohau Downs in the autumn**. Thicker, 12 mm, tines were used at Eamscleugh. A feature of tines in this class of country is their tendency to dig under stones and bring them to the surface. This is considered to be undesirable, and alternatives are to be investigated.

Fertiliser points: The original points used on the machine did not allow the fertiliser to be deposited at the bottom of the groove and therefore did not give the desired separation from the seed. Table 1 shows insignificant separation between seed and fertiliser for all the spring sowings. Overdrilling points tried at Ohau Downs in the autumn trials gave a separation of 19 mm between the seed and fertiliser in dry, hard conditions.

For the autumn drilling at Eamscleugh, lucerne points were fitted. The ground was much softer than at Ohau Downs and good penetration was easy. Table 2 shows the results from coulter rows on the machine which were set up to specific configurations. The 12 mm tine with a lucerne point has given 45 mm separation of the fertiliser from the seed. The original narrow point on the 10 mm tine has given only 18 mm separation, although the seeding depth is unusually deep.

Seed coulters: In spite of satisfactory agronomic results from the strip seeder, the variations in measured seed depth, as shown by the large values of standard deviation in Tables 1 and 2, indicate that the desired control has not

been achieved. While the factors influencing seed placement depth are not fully understood, field observations suggest that the following factors contribute to the variations.

1. Lumps of turf from the openers and subsequent disturbance by the fertiliser tine interfere with the seed depth wheel.
2. The seed depth wheel runs on the uneven edge of the cultivated strip.
3. Rocks, and variations in soil type and in vegetation, particularly **the root mat, result** in different cultivation depths.

While it is clear that consistent shallow depth control of seed placement will be difficult to achieve for any drilling equipment where ground conditions vary greatly, there is potential to improve the performance of the strip seeder by modifying the design and operation of some components. For example, the depth control wheel on the seed coulters was modified twice during the drilling season, firstly by the removal of a rubber flange and secondly by repositioning the wheel closer to the seed shoe. The second adjustment improved the ability of the seed coulter assembly to travel within the groove created by the opening disc. However, considerable **trash and** turf still remains in the path of the depth control wheel.

Differences between grass and legume sowing depths as shown in Table 1 are considered to be caused by the differences in seed size and shape and how they settle into the soil.

Press wheels: The 50 mm wide press wheels appear to adequately firm the soil around the seed. The press wheels jammed when lumps of trash became lodged between the wheel and its supporting arm.

Mechanical performance: The design philosophy for this machine is to provide flexibility rather than excessive strength to withstand contact with rocks. Although only a relatively small area has been drilled, there have been no mechanical failures to date.

Comparison of establishment costs

The following comparisons are based on cultivation costs supplied by Mr M. Allen, a contractor from Omarama, and figures for triple disc drilling - **\$80/ha**, herbicide application - **\$25/ha**, glyphosate - **\$18.39/l**, and wetting agent applied at 60 ml/ha costing **\$37.80/l**. The cost of seed and fertiliser has not been included. For strip drilling, a commercial rate has been assessed using current rates for direct drilling in similar conditions.

	Light vegetation	Heavy vegetation
Full cultivation	2 grubbings, level, roll, drill \$250/ha	2 disc, 2 light grub, harrow, roll, drill \$330/ha
Direct drill and herbicide	2.5 l glyphosate, drill \$153.17/ha	2 x [2 l glyphosate] drill \$208.10/ha
Strip drill	\$100/ha	\$120/ha

Conclusions

Although the desired control of seed depth has not been achieved, turf removal, fertiliser placement, tilth formation and seed bed compaction have met expectations. Mechanical reliability has also been acceptable.

The enhanced ability to establish reliably new species without the cost of a herbicide gives a substantial financial advantage to the strip seeder, although expected direct machine costs may be up to 50% more than for conventional direct drills.

While the existing prototype equipment has confirmed the advantages of the strip seeding system, further development has the potential to improve performance and further increase agronomic gains.

REFERENCES

- Asher, J.E.; Eckert, R.E. Jr. 1973. Development, testing and evaluation of the deep furrow drill arm assembly for the Rangeland Drill. *Journal of range management* 26 (5): 377-378.
- Chapman, H.M.; Lowther, W.L.; Trainor, K.D. 1990. Some factors limiting the success of *Lotus corniculatis* in hill and high country. *Proceedings of the NZ Grassland Association* 51: 147-150.
- Dunbar, G.A.; Horrell, R.F.; Costello, E.I. 1980. Overdrilling of dry hill country. *Proceedings of Lincoln Farmer's Conference*.
- Kaviani, N.; Gibbs, R.N.; Horrell, R.F. 1985. Seed placement measuring technique for direct drilling machines - a note. *NZ journal of experimental agriculture* 13: 191-194.
- Lowther, W.L.; Fraser, W.J.; Horrell, R.F.; P.D. Johnstone. 1992. Comparison of pasture establishment from a conventional disc drill and a prototype strip seeder drill. *Proceedings of the NZ Grassland Association* 53: 47-50.
- Morrison, J.E.; Gerik, T.J. 1985. Planter depth-control: 1. predictions and projected effects on crop emergence. *Transactions ASAE*. 28 (5): 1415-1418.
- Pollock, K.M. 1989. Grass establishment and perform-

Table 1 Seed and fertiliser depth • spring trials.

		Average depth (mm)	Standard deviation
Oahu Downs			
Triple disc	Grass	13.9	4.9
	Legume	16.1	6.9
Strip drill	Grass	15.6	7.4
	Legume	16.8	5.9
Earnsclough			
Triple disc	Grass	12.7	4.0
	Legume	19.6	5.6
	Fertiliser	17.1	6.2
Strip drill	Grass	19.6	6.4
	Legume	23.1	5.2
	Fertiliser	25.6	6.7

Table 2 Seed and fertiliser depth with modified coulters - autumn trials.

		Average depth (mm)	Standard deviation
Strip drill Oahu Downs	Grass	15.9	6.1
Narrow over-drilling point	Fertiliser	33.9	10.6
10 mm tine	Depth difference	16.0	
Strip drill Oahu Downs	Grass	10.5	4.3
Standard over-drilling point	Fertiliser	29.6	6.2
10 mm tine	Depth difference	19.3	
Strip drill Earnsclough	Grass	36.1	7.6
Narrow over-drilling point	Fertiliser	56.2	9.0
10 mm tine	Depth difference	16.1	
Strip drill Earnsclough	Grass	29.5	5.3
Lucerne over-drilling point	Fertiliser	63.3	4.4
10 mm tine	Depth difference	33.9	
Strip drill Earnsclough	Grass	23.1	5.6
Lucerne over-drilling point	Fertiliser	66.4	6.8
12 mm tine	Depth difference	45.3	
Triple disc Earnsclough	Grass	40.1	4.0
	Fertiliser	41.1	5.4
	Depth difference	1.0	

- ance on a hill country soil fertilised with nitrogen. *NZ journal of agricultural research* 32: 7-15.
- Scott, D.; Keoghlan, J.M.; Cossens, G.G.; Maunsell, L.A.; Floate, M.J.S.; Wells, B.J.; Douglas, G. 1985. Limitations to pasture production and choice of species. In Burgess, R.E.; Brock, J.L. (Eds). *Using Herbage Cultivars. Grasslands Research and Practice Series No. 3*. NZ Grassland Association: 9-15.
- Seaney, R.R.; Henson, P.R. 1970. Birdsfoot Trefoil. *Advances in agronomy* 22: 119-157.
- Woodman, R.F.; Doney, R.J.; Allan, B.E. 1990. Effects of drilling depth on seedling growth of seven dryland pasture species. *Proceedings of the NZ Grassland Association* 52: 167-170.