Low cost revegetation of slips near Gisborne

S.J. QUILTER[1], C.J. KORTE[2] and D.R. SMITH[2]
[1] *AgResearch, PO Box 640, Gisbome*
[2] *AgResearch, PO Box 8144, Havelock North*

Abstract

An experiment was conducted to identify plants suitable for low cost revegetation of soil slip scars after Cyclone Bola. Species of grasses (8), herbs (3) and legumes (13) were oversown onto slips without fertiliser, and evaluated for 3 years under normal hill country sheep/beef grazing. Grasslands Maku *Lotus pedunculatus*, *Trifolium pratense* and *Lotus corniculutus* all increased total herbage cover. *L. pedunculatus* provided 85% of the production obtained from pasture on surrounding uneroded land, and 6 times the production of unsown plots on slips.

Keywords: Cyclone Bola, *Lotus pedunculatus, Lotus corniculatus*, revegetation, slips, *Trifolium pratense*

Introduction

Cyclone Bola in March 1988 resulted in approximately 18 000 ha of soil slip erosion in the Gisborne/East Cape region. Recommendations for restoring slips (Suckling 1966; Lambrechtsen 1986) are relatively expensive. Research was initiated to identify a low cost revegetation alternative which could be used on an extensive scale.

The objective was to identify plants able to establish and persist on slips without the need for ground preparation, extra fertiliser or protection from grazing. Two experiments were conducted, with one experiment sown in spring 1988, and the second experiment sown in autumn 1989. Establishment in the first experiment was largely unsuccessful, owing to heavy rainfall after sowing which washed seed from slips, followed by summer/autumn drought which further reduced plant populations (Quilter & Korte 1990). This paper reports the results for the successful autumn sowing.

Materials and methods

Full details of the experimental treatments and layouts is given in Quilter & Korte (1990). The experiment was conducted on a farm near Gisbome, using slips exposed in Cyclone Bola. The soil on slips was on steep slopes (20-50°), of low fertility (pH 6.3, Olsen P 6, K 7, sulphate S 3), and shallow (5-8 cm deep exposed subsoil overlaying mudstone).

The experiment was a randomised block design, with 10 blocks. To allow for a range of slip sizes, each block was spread over 1 to 4 similar slip faces, with plots (2 m x 2 m) arranged horizontally in a single line across each slip. This design reduced possible seed contamination between plots due to seed being washed

Table 1 Grass and herb treatments (treatment numbers shown in parenthesis), seed sowing rate, and point analysis results (sown species and total grass cover). Square-root transformed values used in analysis of variances and in testing of cover differences. Cover values presented are back-transformed means.

Grass or herb treatment	Seed (kg/ha)	Total grass[1] cover (%) 1990	1991	1992	Sown species cover (%) 1990	1991	1992
1. Droughtmaster ryegrass	30	13	13	12	10	5 a	5
2. Maru phalaris	10	16	13	11	3 a	3 a	5
3. Kara cocksfoot	8	11	14	20	7	6	12
3. Wana cocksfoot	8	15	14	17	9	7	7
4. Muster browntop	4	16	13	15	13	6	12
5. Massey Basyn Yorkshire fog	20	17	16	15	11	2 a	4 a
6. Crested dogstail	10	12	13	14	4 a	l a	4 a
7. Tiki smooth brome	25	10	10	13	2 a	Oa	l a
6. Yarrow	4	14	15	10	4 a	4 a	2 a
9. Puna chicory	6	11	12	4 ab	l a	l a	l a
10. Sheep's burnet	6	14	13	11	2 a	l a	Oa
11. Standard fertilised mix		12	20	16	10	9	7
12. Unsown control		10	14	13			

a Significantly different from Standard treatment
b Significantly different from Control
1 Sown species (grass or herb) plus volunteer grass

Table 2 Legume treatments (treatment number shown in parenthesis), seed sowing rates, and point analysis results (percentage sown species cover and total legume cover). Square-root transformed values were used in analysis of variances and in testing of cover differences. Cover values presented are back-transformed means.

Legume treatments	Seed (kg/ha)	Total legume cover (%) 1990	1991	1992	Sown species cover (%) 1990	1991	1992
I. Tahora white clover	8	9 b	4	4	9	2	3
1. Prop white clover	8	9 b	8	9	8	7	5
2. Pawera red clover	10	8 b	10	5	8	2	O a
2. Enterprise red clover	10	12 b	9	8	11	8	3
3. Maku lotus	8	9 b	19 ab	13 ab	9	18 a	12 a
4. G32 birdsfoot trefoil	10	8 b	18 ab	18 ab	5 a	8	13 a
5. White clover ramets		5 a	9	8	4 a	5	1
8. Canary clover	20	2 a	8	8	I a	2	2
7. Yukon sweet clover	10	4 a	7	7	I a	O a	2
8. Palestine strawberry clover	8	8 a	10	8	5 a	12	4
9. Aokau sulla	30	2 a	8	5	I a	O a	O a
10. Tallarook subterranean clover	20	8	14	14 ab	8	11 a	12 a
10. Lotus tenuis	10	2 a	8	10	O a	2	7
11. Standard fertilised mix		13 b	8	6	12	5	8
12. Control		3	9	6			8

a Significantly different from Standard treatment
b Significantly different from Control

down the slip. Each block had 12 treatments (Tables 1 and 2): an unsown/unfertilised control, a standard seed/fertiliser treatment and 10 oversowing treatments. A standard treatment plot (30 kg/ha Droughtmaster perennial ryegrass (*Lolium perenne*), 8 kg/ha inoculated and coated Grasslands Huia white clover (*Trifolium repens*), plus fertiliser equivalent to 250 kg/ha superphosphate) was located on each slip to allow comparison of slips within a block. The oversowing treatments were designed to allow separate analysis of 10 inoculated legume species (Table 1) and 10 grasses/herb species (Table 2). Each oversowing plot had one of the 100 possible legume/grass mixtures, each legume species and each grass/herb species being represented once in each block, and each mixture combination being represented once in the whole experiment. White clover, red clover (*Trifolium pratense)* and cocksfoot (*Dactylis glomerata*) were represented by 2 cultivars, with half the replicates sown with each cultivar. Subterranean clover (*Trifolium subterraneum)* and Lotus *tenuis* were sown *in* 5 blocks. Seeds were oversown by hand directly onto plots on 5 May 1989, without fertiliser or ground preparation.

Sheep and cattle grazed the experimental paddock during the experiment. Plots were topdressed annually in summer with the rest of the paddock (100 kg/ha superphosphate).

Measurements included seedling counts at 6-8 weeks after sowing, point analysis (Radcliffe & Mountier 1964) for total and sown species ground cover each winter, and herbage production from selected treatments using exclusion cages from August 1990 to October 1991. For herbage production, herbage was trimmed to 25 mm using an electric shearing handpiece, a cage (0.504 m^2) was placed, and pasture was harvested when herbage on the best plots reached 200 mm in length. Herbage production was measured on five blocks, and only for selected plots (control, standard seed/fertiliser treatment, and treatments with a high percentage ground cover). Production was also measured on uneroded pasture areas beside slips.

Measurements on non-legume and legume species listed in Table 1 and Table 2 were analysed separately after transformation to normalise variance.

Results

Establishment

Seedling counts at 6-8 weeks as reported by Quilter & Korte (1990) indicated that 20-40% of viable legume and 15-46% of viable grass/herb seed had established (except *Lotus corniculatus 85%* and *Sanguisorba minor* 2%). Mean seedling populations (/m^2) were 30-480 for legumes, 120-1020 for grasses, and 20-610 for herbs.

Cover

Total grass cover on slips was not significantly ($P<0.05$) affected by oversowing of grasses (Table 1). Browntop (*Agrostis capillaris*) and cocksfoot had the highest sown grass cover in 1992, 12% and 10% respectively, double the cover of ryegrass. Grasslands Tiki smooth brome (*Bromus inermis)* had a significantly lower sown grass cover than perennial ryegrass. Application of fertiliser at sowing had no consistent effect on the perennial ryegrass cover, there being no significant (P<0.05) effect in 1990 and 1992.

Oversowing of Grasslands Puna chicory *(Cichorium intybus)* significantly reduced total cover in 1992 (Table 1). The result probably reflected suppression of volunteer grasses by chicory in summer together with winter dormancy of chicory. Sown species cover was low for the three herbs evaluated.

Compared with the unsown control, total legume cover was significantly (*P<0.05*) increased by oversowing Grasslands Maku lotus (*Lotus pedunculatus*), birdsfoot trefoil (Lotus *corniculatus*) and subterranean clover (Table 2). The level of sown legume cover was generally low. Based on these measurements, and visual observations in spring and summer, the following species were considered to have been unsuccessful: white clover oversown as ramets, canary clover *(Dorycnium hirsutum),* Yukon yellow sweet clover (*Melilotus officinalis*), Palestine strawberry clover *(Trifolium fragiferum*), and Grasslands Aokau sulla *(Hedysarum coronarium).*

During the course of the experiment slips were colonised by volunteer plants. Colonising species included (in descending order of % cover in September 1991) white clover 12%, suckling clover *(Trifolium dubium)* 5%, browntop 4%, flatweeds *(Taraxacum officinale, Plantago lanceolata*) 4%, clustered clover *(Trifolium glomeratum)* 4%, lotus *(Lotus pedunculatus*) 3%, chewings fescue (*Festuca nigricans)* 3%, winged thistle (*Carduus tenuiflorus*) 2%, ryegrass (*Lolium perenne)* 2%, sheep's sorrel *(Rumex acetosella*) 1%, sweet vernal grass *(Anthoxanthum odoratum*) 1%, cocksfoot 1%, couch *(Agropyron repens*) 1%, subterranean clover 0.4%, Yorkshire fog (*Holcus lanatus*) 0.4%.

Herbage production

Annual herbage production from the unsown control plots was approximately a tenth of the production measured from pasture on uneroded areas beside slips (Table 3). Oversowing the standard ryegrass/clover mixture with fertiliser did not significantly increase annual herbage production compared with the unsown control. Of the grasses oversown, Yorkshire fog was the only species to significantly increase total herbage production. The effect was largely due to associated legumes on the plots measured, with annual Yorkshire fog production (470 kg DM/ha) being no different (P<0.05) from that of other grasses measured.

Both red clover and Maku lotus significantly increased total herbage production from slips relative to the unsown control. Mixtures with Maku had herbage production almost equal (85%) to production from pasture on uneroded land beside slips, and 6 times greater than production from unsown control plots. Of the annual yield from lotus plots, 81% was contributed by lotus. For plots with red clover, 87% of annual herbage production was contributed by red clover. In summer the contribution of lotus and red clover was greater: 93% and 91% respectively. Legumes were the main component of herbage production (57%) for plots oversown with the standard mix.

Table 3 Total dry matter (DM) yields of grass/legume mixtures in comparison to unsown control plots, standard ryegrass white clover plots, and pasture on uneroded land beside slips.

	Dry matter yields (kg/ha)				
	Spring[1]	Summer	Autumn	Winter	Annual
Uneroded pasture	3950	600	1120	990	6160
Control	500	70	110	150	620
Standard	1020	230	370	300	1920
Grass means[2]					
Ryegrass	670	370	230	300	1770
Cockstoot	770	190	140	150	1250
Browntop	950	760	460	490	2670
Yorkshire fog	1510 b	1120 ab	1040 b	750 b	4426 b
LSD (*P=0.05*)	890	690	600	570	2720
Legume means[3]					
White clover	690	110	200	150	1160
Red clover	1460 b	1320 ab	950 ab	660 b	4420 ab
Maku lotus	2220 b	1300 ab	710 b	670 ab	5240 ab
Birdstoot trefoil	1100	1220 b	330	540	3700
LSD (*P=0.05*)[4]	1120	640	530	460	2660

[1] Spring=Sep, Oct. Nov; Summer=Dec, Jan, Feb; etc.
[2] Total DM yields averaged across all companion legume combinations.
[3] Total DM yields averaged across all companion grass combinations
[4] LSD for legume means calculated using harmonic mean of plot numbers.
a Significantly different from Standard treatment at *P=0.05*
b Significantly different from Control at *P=0.05*

Discussion

The establishment achieved in this experiment was considerably less than achieved in experiments with high seed rates, high fertiliser rates and exclusion of grazing from slips. For example, Lambrechtsen (1986) indicated that a plant cover of 86% should be achieved 6 months after oversowing slips with 50-150 kg/ha seed, together with frequent application of generous amounts of fertiliser containing nitrogen and exclusion of grazing animals. In this experiment, 6 months after oversowing, cover was 33% for the standard mix treatment (Quilter & Korte 1990), and 17% 3 years after oversowing. High input revegetation of slips as discussed by Lambrechtsen (1986). although more effective than low cost methods evaluated in this experiment, is considered uneconomic for large scale erosion events like Cyclone Bola.

Maku lotus, red clover and possibly birdsfoot trefoil were the plant species identified in this research as offering most potential for low cost revegetation of slips. None of the oversown grasses significantly increased herbage production or plant cover over what was achieved naturally in the unsown control plots. Oversowing white clover and perennial ryegrass, the species normally oversown by farmers, did not significantly improve herbage production or plant cover compared with the unsown control.

It is of interest to speculate as to the reasons for the success of lotus and red clover. Nitrogen fixation, successful establishment, and perhaps rooting pattern were important. The predominance of legumes in all mixtures indicated that nitrogen and nitrogen fixation was the predominant factor affecting plant performance and persistence. Soil on recently eroded slips has low carbon and nitrogen levels (Lambert et *al.* 1984). Establishment of lotus and red clover was successful, plant populations being *Lotus corniculatus* 480/m^2, Maku lotus 290/m^2 and red clover 90/m^2. The success of Maku lotus could be expected, the species being well adapted to low soil fertility (Levy 1970) and being naturalised in the pasture surrounding the slips. The reasons for success of red clover and birdsfoot trefoil probably relate to the ability of the root system to obtain moisture and nutrients. Perhaps the tap-root of red clover and birdsfoot trefoil was able to penetrate cracks in the mudstone, whereas white clover roots were restricted to the thin layer of soil on slips.

Red clover is usually a short-lived species, and is unlikely to be suitable for longer-term revegetation of slips. Lambert *et al.* (1993) reported that red clover was fast establishing on slips in the Wairarapa, but subsequently declined to be a minor sward component after 2 years. There was a strong trend for red clover cover to decline during this experiment (Table 2). The herbage production ranking of red clover would undoubtedly have declined if herbage production measurement had continued after October 1991.

The role of subterranean clover for oversowing slips was not fully evaluated in this experiment. Cover measurements indicated that the species could increase legume cover, but this may just have been a reflection of the winter growth of the species. Measurements of herbage production were made on two replicates, and the annual legume yield was similar to plots sown with white clover, 810 ± 900 kg DM/ha and 210 ± 190 kg DM/ha respectively. Based on experiments and observations Suckling (1966) recommended that subterranean clover be included in oversowing seed mixtures for slips, and the species was the main legume to colonise slips in the Wairarapa (Lambert *et al.* 1984). By contrast, in subsequent oversowing trials on slips in the Wairarapa (Lambert *et al.* 1993), oversown Mt Barker subterranean clover did not make a significant contribution to revegetation.

The levels of herbage production measured in this experiment should not be taken as the absolute levels which could be obtained under grazing. The measurement system with infrequent cuts could be expected to favour the legumes which had high production. The results do, however, indicate the potential for herbage production from slips, if plants like Maku lotus can be encouraged by appropriate grazing management.

Although white clover showed no significant response to phosphate and sulphur application at sowing, red clover and lotus would be expected to respond. Further research is required to evaluate oversowing of these legumes with fertilisers.

This experiment considered oversowing of the slip face, and ignored the debris accumulation zone below the slip. When farmers oversow using aircraft the seed mixture would normally be formulated for oversowing both areas. We observed that the accumulation zone normally revegetated within 6-12 months of deposition, from turf fragments and natural reseeding. However, some farmers wish to obtain a more rapid cover, and oversowing perennial ryegrass and white clover is suitable for this purpose.

It has normally been recommended that slips should be oversown as soon as practicable after they occur (Suckling 1966). However, sowings on the East Coast have given variable establishment (King & Blakemore 1978; Quilter & Korte 1990), mainly due to heavy rain washing seed from slips and drought killing seedlings. Further research is required on this aspect, especially if lotus is used as the main legume for revegetation.

Conclusions

The main conclusion from this research was that farmers should oversow Maku lotus and red clover on slips for revegetation under grazing. The red clover would not be expected to persist, but was shown in this and other research (Lambert *et* al. 1993) to be a useful early coloniser of slips. Inclusion of ryegrass and white clover in the oversowing mixture can be expected to have little benefit in revegetation of the slip shear plane, but will often assist in the revegetation of the debris accumulation zone below the slip.

ACKNOWLEDGEMENTS

The Agricultural and Marketing Research and Development Trust (AGMARDT) for partial funding; the late Dr M.B. Forde for suggestions on species choice and supply of seed; G.J. Patterson, Kiteroa Station, for allowing use of land and access to the experiment; N. Rawlings, M.H. Gray and K.S. MacLean for assistance with field work.

REFERENCES

King, M.; Blakemore, S.D. 1978. Analysis of slip oversowing. Unpublished report, Wairarapa Catchment Board, Masterton.

Lambert, M.G.; Trustrum, N.A.; Costall, D.A. 1984. Effect of soil slip erosion on seasonally dry Wairarapa hill pastures. ***New Zealand journal of agricultural research 27: 57-64.***

Lambert, M.G.; Trustrum, N.A.; Costall, D.A.; Foote, A.G. 1993. Revegetation of erosion scars in Wairarapa hill country. ***Proceedings of the New Zealand Grassland Association*** 55: (this volume).

Lambrechtsen, N.C. 1986. Management and uses of grasses, legumes and herbs - an introduction. pp. 119-245 *In* Plant materials handbook for soil conservation. Volume: 2 Introduced plants. C.W.S. Van Kraayenoord & R.L. Hathaway ***eds.*** Water and Soil Miscellaneous publication number 94.

Levy, E.B. 1970. Grasslands of New Zealand. Wellington. Government Printer.

Quilter, S.J.; Korte, C.J. 1990. Species choice and timing of planting for revegetation of subsoil exposed by slip erosion. pp. 236-241 In Proceedings of the workshop Issues in the restoration of disturbed land. P.E.H. Gregg, R.B. Stewart and L.D. Cut-tie ***eds.*** Massey University, Palmerston North.

Radcliffe, J.E.; Mountier, N.S. 1964. Problems in measuring pasture composition in the field. Part 1. Discussion of general problems and some considerations of the point method. New ***Zealand journal of botany 2:*** 90-97.

Suckling, F.E.T. 1966. Hill pasture improvement. Newton King and DSIR. Palmerston North.

■