

WHY **OVERDRILLING** RED CLOVER IN **MANAWATU** LOWLAND FAILED

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Abstract

Experiments examining methods of establishing *Pawera* red clover in Manawatu found that overdrilling failed to produce the wider spread of seasonal production and higher yield obtained when *Pawera* is combined with ryegrass using conventional cultivation. In discussing responses obtained production is separated into two components — plant number and plant size. These components collectively determine the contribution made by *Pawera*. Results are presented to show the potential for using machinery, technique and management options to improve the performance of overdrilled *Pawera*. The feasibility of these is discussed. Deficiencies in present knowledge are also emphasised.

Keywords: Red clover, overdrilling, plant number, plant size

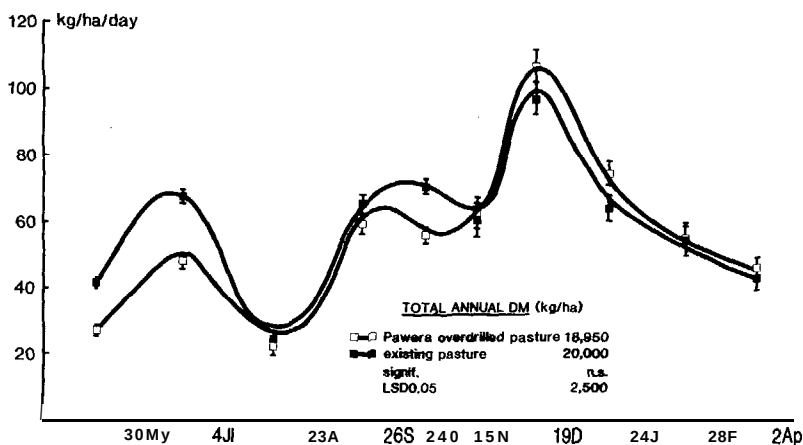
INTRODUCTION

The release of several new herbage cultivars in New Zealand means increased possibilities for improving pasture production and research has aimed to investigate their full potential. Considerable improvement is possible in the Manawatu by combining red clover with ryegrass (Harris & Hoglund, 1980). With red clover growth peaking during late January/early February this mixture provides a wider spread of production and higher yield than a grass monoculture or grass-white clover mixture — a significant contribution for farming systems which rely on growth in the summer/autumn period. The highest yielding and most stable of several such mixtures (Pineiro and Harris, 1978; Harris et al., 1980) combined 'Grasslands *Pawera*' red clover with 'Grasslands *Nui*' perennial ryegrass. These results all relate to establishment from cultivated seedbeds. A more recent series of experiments has examined the production obtained when *Pawera* is introduced directly into existing ryegrass-dominant swards by overdrilling.

INITIAL OVERDRILLING RESULTS

Studies began in 1979 in co-operation with the Agricultural Mechanisation Department, Massey University. In the initial study several methods of introducing *Pawera* were examined, including oversowing, overdrilling and conventional cultivation, using the best available technology (for details see Kunelius et al., 1982). ~~The results from overdrilling were disappointing. Those *Pawera* plants present in the sward were unable to raise total production from overdrilled areas above the level obtained from the unchanged, ryegrass-dominant pasture. The seasonal spread of production, following an initial depression for overdrilled pasture due to banded herbicide, was similar on both areas throughout the two years measured. This applied to both autumn and spring drillings. Figure 1 shows results for the first year of production. Overdrilling *Pawera* had failed to give the improvement sought.~~

(a) AUTUMN DRILLING



(b) SPRING DRILLING

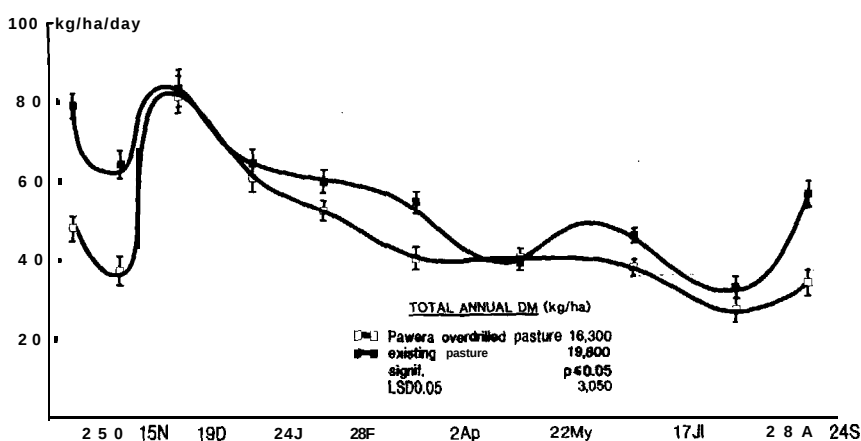


Fig. 1 Seasonal distribution of dry matter production for (a) autumn drilling, (b) spring drilling. (Means shown $\pm$ standard error.)

ANALYSIS OF PRODUCTION

Measured here as successive changes in herbage mass (after Hodgson, 1979) production can be expressed simply as the product of two components:

$$\text{Production (kg DM/ha)} = \text{plant number (l/ha)} \times \text{plant size (kg DM)}$$

Separate identification of these components enables closer examination of the performance of overdrilled Pawera.

In the overdrilling study of Kunelius et al., (1982) failure occurred because, for the number present, plants were not large enough to achieve the levels of production required from Pawera. It is difficult to determine what are "acceptable" numbers and sizes of plants, and thus hard to isolate one or other as a problem. Hay et al. (1978) in Southland reported that 12 plants/m² were able to contribute 35% of summer production and this was considered an acceptable density. However the same does not appear to be true for Manawatu conditions, Densities of 10-16 plants/m² which resulted after only one year in overdrilled areas contributed little and were considered unsatisfactory for this situation where resident pasture growth was markedly greater (Kunelius et al., 1982). Size and number together determine production. Suitable information on these factors is lacking, and further investigation should examine both as opportunities to improve overall production. There appears to be considerable scope for increases in both when compared with levels obtained by conventional cultivation. Results from a recently completed study re-examining several of the earlier treatments (Table 1) show consistently lower values of size and number in overdrilled areas compared with conventional cultivation, indicating that performance is well below agronomic potential. It remains to be determined how much more of that potential overdrilling can realise.

Table 1: EFFECT OF METHOD OF ESTABLISHMENT ON PAWERA PLANT NUMBERS AND PLANT SIZE OVER TWO SUMMERS

Method	Plant density (/m ²)		Mean top dry wt. (g)	
	Feb 1981	Apr 1982	Feb 1981	Apr 1982
Conventional Cultivation				
Pawera + Nui	69	36	3.1	7.6
Overdrilled Pawera (5 cm paraquat band)	19	5	1.0	2.8
Direct Drilled Pawera (paraquat blanket)	44	13	2.1	5.3
Signif.	P ≤ 0.001	P ≤ 0.001	P ≤ 0.01	P ≤ 0.01
LSD 0.05	21	8	1.1	2.1
LSD 0.01	28		1.6	2.9

POTENTIAL FOR INCREASING PLANT NUMBER

Initial Seedling Numbers

Plant numbers can be influenced by the size of the initial seedling population. In a recently completed trial higher seeding rates resulted in a proportionate increase in the size of the initial seedling population, and importantly, a significant ($P < 0.001$) seeding rate effect was still evident in the density of remaining plants after two years (Table 2). But the same study indicated that to sufficiently increase Pawera contents through attention to seeding rates alone could require

Table 2: EFFECT OF SEEDING RATE ON PAWERA NUMBERS ONE MONTH AND TWO YEARS AFTER DRILLING.

Seed rate (kg/ha)	Plant density (/m ²)	
	1 month	2 years
3.6	17	1
6.6	33	3
10.2	51	4
13.5	83	4
Signif.	P ≤ 0.001	P ≤ 0.001
		1
LSD 0.05	18	2

rates in excess of 15 kg Pawera/ha, pushing the cost of establishment to an unreasonably high level. For rates examined up to 14 kg/ha numbers fell relatively quickly to levels that were unsatisfactory in the Kunelius *et al.* study. Losses of up to 80% of sown seed occurred in the first month after drilling. Intensive measurement of early seed development has suggested that many sown seeds fail to produce emerged seedlings.

The overdrilling equipment used in these studies was considered the best available, incorporating important new design features. The chisel coulter, shaped essentially like an inverted T (Baker, 1976), has been developed to better suit plant requirements. But in the Pawera overdrilling studies considerable variation in coulter depth was observed. Although concern over depth control and coulter type has been expressed for many years (Cross, 1957; Blackmore, 1958) the importance of these effects is poorly defined. Better definition would provide more precise objectives for overdrilling machinery improvement.

Table 3: CENSUS OF PAWERA POPULATION 36 DAYS AFTER DRILLING AT THREE DIFFERENT DEPTHS

Coulter depth (mm)	Percent of seed sown			Dead	
	Emerged P*	N.P.	Live Unemerged	Total	P N.P.
0	48	5	0	53	1 15
13	88	0	1	89	0 0
38	52	0	4	56	0 0
Signif.	P ≤ 0.05			P ≤ 0.05	
LSD 0.05	30			28	

*P Seedling with penetrating radicles

N.P. Seedlings with non-penetrating radicles

Recent studies have shown that *Pawera* is highly sensitive to relatively minor changes in chisel coulter depth. Results from drilling in autumn in a silt loam soil at 10% (w/w) moisture content (Table 3) show that close to 99% emergence was obtained where coulter depth was controlled with the rear lateral wing's 13 mm below the soil surface. Significantly fewer seedlings appeared where the coulter skimmed the surface, and less than half the seed sown successfully penetrated the soil. Sowing deeply also reduced numbers. Just over half the seed emerged, and the rest, although germinated, were restricted by the overlying turf cover and died below ground.

The magnitude of these effects will depend on conditions during emergence and may differ with the species sown. The results obtained for *Pawera* have however established the importance of this aspect of machine design. Further development of overdrilling machinery is required. *Pawera* seed germination appears satisfactory with this coulter provided the lateral wings run below the surface but design aspects of coulter shape, seed placement and depth control must receive closer attention for high seedling emergence.

Seedling-Plant Survival

Many factors can influence post-emergence survival; only those considered of major significance for overdrilled *Pawera* are discussed here. Poor survival where seedlings fail to penetrate the soil surface (Table 2) should be eliminated through closer attention to groove formation suggested above. Fungicide and insecticide seed coatings gave no improvement in numbers (Kunelius *et al.*, 1982). Slug populations have been small and no advantage was measured from molluscicide application. However in other situations slugs have depleted seedling populations (J.F.L. Charlton, pers. comm.). Studies on the significance of nematodes are currently under way. There is no evidence that residues from herbicide used or other toxic residues are present which inhibit and kill overdrilled *Pawera*, but the importance of these has been noted overseas in other situations (e.g. Moshier and Penner, 1978; Davies *et al.*, 1980). This question should receive closer attention in New Zealand.

Timing of drilling determines the conditions into which the seedling grows. With improved drill technology (Baker, 1976) there should be increased scope for drilling at the extremes of the soil moisture scale, giving timing of drilling more latitude as a management variable. Kunelius *et al.* (1982) found that survival was similar for spring and autumn drillings (although speed of development was affected) but no detailed examination of these effects has been carried out. The effects of timing on seedling growth are hard to view in isolation from the effects on the resident sward-seedling relationship. Manipulating this relationship exerts considerable influence over seedling survival.

Reduction of the sward at drilling has been considered an important part of over-drilling for some time. Blackmore (1955) noted the importance of competition from the existing plants in reducing survival and made suggestions on mechanical and chemical means of control. Herbicides were considered to give more latitude in the time overdrilling could be carried out (Blackmore, 1962). However a large part of this control has been essentially arbitrary, guided as much by engineering considerations as by biological ones. Much better understanding of the effects of these operations is required. Examples will be given in the next section.

Grazing has largely been overlooked as a management variable for over-drilling in New Zealand perhaps because fear of damaging young seedlings during

early growth prompted early workers to recommend light, infrequent grazing (Blackmore, 1955, 1958; Cross, 1955, 1956, 1959; Robinson, 1957; Robinson & Cross, 1957, 1960, 1963). Most recommendations apply to situations where herbicide was not used and apply to ryegrass or winter-feed introduction into clover-dominant pastures. There is little quantitative supporting information. Recent experiments with overdrilled Pawera highlight the importance of early grazing. Although seedling losses can be higher immediately after grazing, a system removing herbage to 10-20 mm at 3-weekly intervals in the 7 months after autumn drilling (HF) resulted in significantly higher plant numbers than less intensive systems over the same period (Table 4). Numbers generally were low because of the high initial losses discussed earlier, but the difference in the HF treatment was maintained until the study ended in April 1982.

Although each has been discussed in isolation these options make up an integrated system. Interactions may be present between them. Studies are currently under way at Grasslands Division to better define such effects.

Table 4: EFFECT OF FIRST 7 MONTHS GRAZING MANAGEMENT ON PLANT NUMBERS FOR AUTUMN OVERDRILLED PAWERA

Grazing Apr 1980 to Nov 1980	Plant density (/m ²)		
	6 months Oct 1980	1 year Mar 1981	2 years Apr 1982
HF*	27	14	9
HI	17	6	2
LF	15	5	1
LI	15	5	0
Signif.	N.S.	P< 0.05	P< 0.05
LSD 0.05	18	7	5
LSD. 0.01			8

*H = hard; F = frequent; L = lax; I = infrequent

POTENTIAL FOR INCREASING PLANT SIZE

West et al. (1980) suggested that applications of nitrogen enhance legume seedling growth in soils with low N availability. For the Manawatu situation (Kunelius et al., 1982) application of nitrogen as urea showed no benefit in terms of seedling size, in fact there was a trend towards a smaller contribution from Pawera, presumably because of improved resident species growth. Stimulating resident growth during early seedling development should be avoided.

Many options discussed for plant survival will affect plant size. However size and number are considered separately because the responses may differ widely in magnitude and significance. Unlike numbers which cannot rise without further inputs, size has the potential to make up deficiencies once constraints are removed. The importance of these plastic responses is presently not known.

Reduction of the resident vegetation improves size. Band spraying (Blackmore, 1962) provides a relatively simple example. There is much scope for

variation with the technique; herbicide type, width and rate are three important variables. Research in New Zealand (Collins, 1970; Baker *et al.*, 1979) and overseas (Kay, 1964, 1966; Squires, 1976; Boatman *et al.*, 1980) has examined responses in several conditions. The basic findings are reflected in the results in Table 1 for band and blanket applications of paraquat. Larger plants are associated with greater removal of the resident sward. Blanket applications of paraquat increased Pawera plant size by 110% and 90% in the first and second summers respectively. However the improvements in Pawera performance were unable to compensate for the loss of resident production and total production was 33% and 10% lower on these areas in the first and second years.

Where the objective is to increase total sward production the final decision on reducing the resident sward (either by grazing, spraying or other) must be a compromise between improving introduced plant performance and retaining the resident sward. As a consequence plant size could remain well below agronomic potential. This relationship needs further investigation.

CONCLUSIONS

1. Considerable potential exists for increasing the yield contribution from over-drilled Pawera.
2. Improvements in both plant size and plant number are possible. High early losses can be overcome by improved machinery design. A better understanding of the effects of spraying, grazing and overall timing on resident and introduced species is required.
3. With the restraint of having to maintain production from the resident sward there may be more potential for increasing plant numbers than plant size. Further research must examine the possibility that a large number of small plants is the most effective way to success.

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