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# A COMPARISON OF CONTINUOUS RIPPING-MOUNDING WITH SPOT RIPPING-MOUNDING

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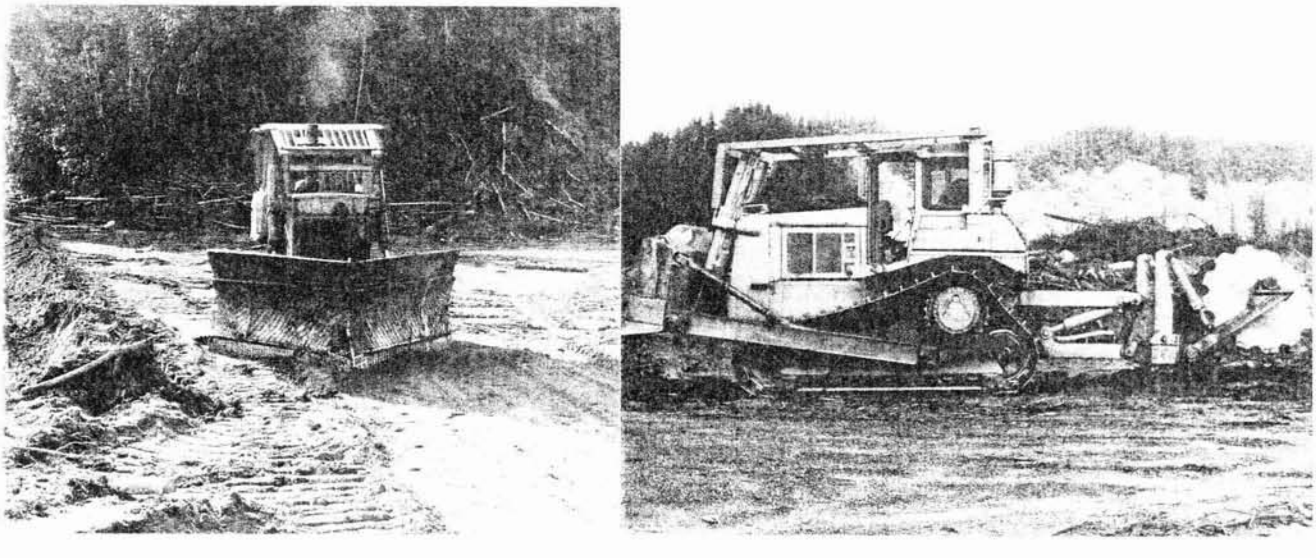

*Figure 1 - V-blade for lane clearing and ripper-mounder unit mounted on tractors*

## ABSTRACT

*Site pre-assessments, production studies and post-assessments of the sites for both operations showed that two pass continuous tractor-based ripping and mounding could be carried out at a rate exceeding 1.0 hectare per productive machine hour, at a cost of $348 per hectare. Excavator-based spot ripping-mounding could be performed at a rate of 0.29 hectares per hour, at a cost of $434 per hectare.*

*Post-assessment of planting sites showed that on average, the excavator was building a higher mound (45cm), than the tractor-ripper mounder (30cm). The excavator operation was also ripping deeper (71cm) than the tractor (45cm). The excavator spot ripping-mounding achieved the mounding specification 94% of the time whilst the tractor operation achieved it 35% of the time.*


*Figure 2 - Excavator with spot ripper-mounder attachment*

## INTRODUCTION

Excavator-based site preparation for both cultivation and slash clearing is widely used overseas, especially in Canada, where there has been a rapid expansion in the number of excavators being used for site preparation in the last five years (Clark, 1992).

The use of excavators for site preparation is also gaining popularity in New Zealand. Windrowing of heavy slash on rolling to steep terrain with excavators fitted with a slash rake and modified tracks (Hall, 1992) as an alternative to burning, is now a common practice in much of the South Island.

Excavators are proving popular because they are commonly available, reliable, have an established service back-up, can operate on steeper slopes than tractors (Karsky 1994) and can be used for a number of tasks within a forest simply by changing the equipment attached to the boom.

Cultivation of cutover soils is a commonly accepted practice, especially in the compacted pumice soils in the Bay of Plenty. Pinus radiata root growth is inhibited when the soil strength exceeds three Megapascals (Mason and Cullen, 1986). Pumice soils in the Bay of Plenty commonly exceed this level below a depth of 30 to 40cm. On sites with compact soils, the deep cultivation provided by ripping operations can reduce the incidence of severe juvenile instability (Mason, 1985) and sometimes increases tree growth, depending on the soil type. However, the results of different studies are conflicting (Mason, 1992).

The development of mounding over rip lines was to allow trees to be planted directly over the rip line without being placed in the hollow created by the ripper tine. Much of this development, and the early use of ripper-mounders, were on cutovers that had been burnt, and were largely clear of logging slash.

There has, however, been a move away from burning in the last five years. Two of the reasons for not burning cutovers are retention of nutrients contained in the slash on-site and the adverse public reaction to the highly visible smoke clouds created by burn-offs. This means that cutovers, especially those from ground-based logging operations with delimbing at the stump, now have considerable volumes of slash still lying on them (Hall, 1994) when the cultivation treatments are carried out. The high volumes of slash makes it difficult to work a continuous furrow ripper-mounder on such sites as the slash collects around the ripper tine and interferes with the discs.

Much of the published production data for ripping and mounding operations were collected when the operations were carried out on burnt cutovers. In many cases such data are no longer applicable. Many of the current tractor-based continuous furrow ripping and mounding (TRM) operations are performed in two passes. The first pass is to clear a lane through the slash and the second to cultivate (Figure 1).

There is also a wide range of attachments available for excavators for cultivating soils. These attachments range from basic ripper tines to more sophisticated hydraulically powered rotary cultivator-mounders such as the VH-Mulcher and the ROTREE mounder. A recent development in the Bay of Plenty is an excavator-based spot ripper-mounder (ES), (Figure 2), which consists of a winged ripper and a mounding rake.

For a number of reasons concern has been expressed about the impacts of the TRM operations on sites. This concern relates to soil disturbance and compaction resulting from multiple passes by heavy machinery over the cutover. Excavators have the ability to treat multiple rows (three to five) in one pass over the site, whereas the TRM operations require two passes for one row. This allows the excavator operation to create less soil disturbance and compaction for a similar area treated. On rolling terrain, the potential for sedimentation will be reduced.

There is little published information on cultivation with excavators in New Zealand conditions. The study reported here evaluates a two-pass tractor-based continuous furrow ripping-mounding operation and an excavator-based spot ripping-mounding operation in order to determine their site effects, production rates and costs.

*ACKNOWLEDGMENTS*

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## METHODS

Two adjacent areas of flat cutover in Tarawera Forest were chosen for the study. Each site was assessed before and after the cultivation treatment as follows:

**1. Site pre-assessment**

Before the cultivation treatments, the following variables were measured on both sites:

a. Slash volume (Warren and Olsen, 1964)
b. Existing soil disturbance from logging (%), (McMahon and Evanson, 1994)
c. Stump stocking, number of uprooted stumps, average stump diameter
d. Soil shear strength.

**2. Site post-assessment**

The following variables were measured after the cultivation treatments:

a. Soil disturbance (%)
b. Stump stocking and number of uprooted stumps
c. Spacing of the cultivation treatments
d. Average mound heights and rip depths
e. Strengths and volumes of cultivated soil, cultivation profiles.

The volume of slash was not re-assessed, it was assumed to be still on the site having been re-arranged but not removed.

**3. Production data**

Production studies were carried out on both operations using activity sampling combined with gross productive time and measurement of the area treated.

## RESULTS AND DISCUSSION

**Pre-assessment**

The two treatments were applied to similar sites as the results from the pre-assessment showed (Tables 1,2 and 3).

*Table 1 - Stump stockings and diameters*

| | ES | TRM |
|---|---|---|
| Total stumps per hectare | 450 | 475 |
| Uproots per hectare | 10 | 7 |
| Mean stump diameter | 43 cm | 39 cm |

Soil shear strength was measured to determine whether the blocks were of similar soil strength and whether there was a need to rip the soil.

*Table 2 - Soil shear strength, MPa*

| Depth, cm. | ES | TRM |
|---|---|---|
| 0 | 0.96 | 0.80 |
| 10 | 1.68 | 1.70 |
| 20 | 3.66 | 2.66 |
| 30 | 3.24 | 3.45 |
| 40 | 4.84 | 5.12 |
| 50 | 6.64 | 5.78 |
| 60 | 6.82 | 6.64 |
| 70 | 7.30 | 7.30 |

The volume of all slash, merchantable and non-merchantable, on each site was measured. Although the TRM figures are higher the differences were not significant ($P \leq 0.05$) due to the variation between plots within the blocks.

*Table 3 - Slash volume,($m^3$ per hectare)*

| | ES | TRM |
|---|---|---|
| Stem | 32 | 42 |
| Branch | 10 | 14 |
| Total | 42 | 56 |

**Soil Disturbance**

The percentage of the site which fell into different soil disturbance classes was assessed.

*Classifications:*

1. Undisturbed

2. Slightly disturbed

    a. Litter disturbed
    b. Topsoil exposed
    c. Mixing of topsoil and litter
    d. Piling of topsoil on litter

3. Deep disturbance

    a. Topsoil removed
    b. Erosion

4. Rutted or compacted

    a. 0-15 cm
    b. 15-30 cm
    c. > 30 cm

5. Depression deposit

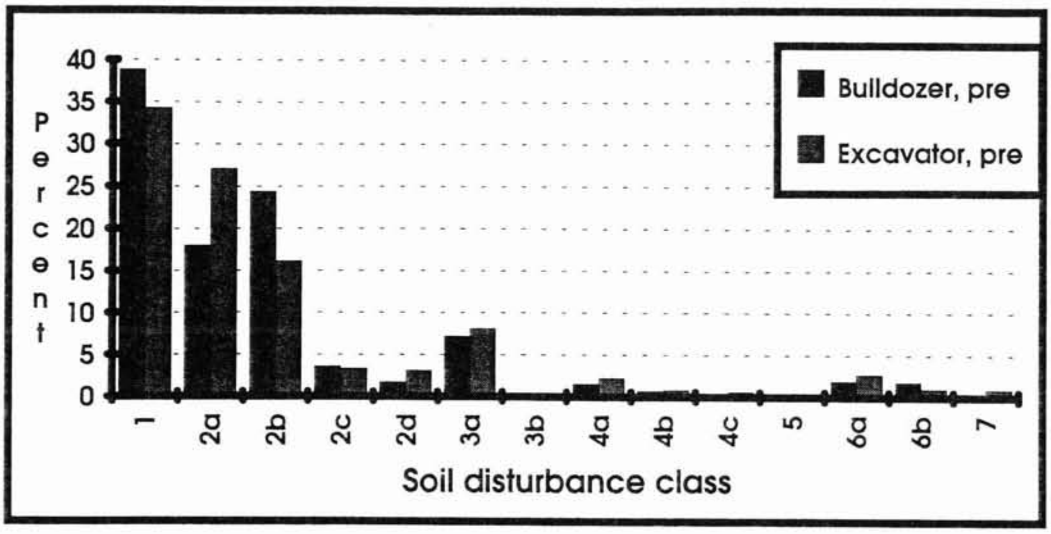
6. Slash piles

    a. < 30 cm
    b. > 30 cm

7. Solid object, stump or rock.

The levels of different disturbance classes were similar for both sites prior to the site preparation treatments (Figure 3). Despite the logging operation, there were still significant areas of undisturbed soil.

*Figure 3 - Distribution of soil disturbance classes before treatment for both site preparation operations*




## Post-Assessment

Both of the operations reduced the amount of undisturbed soil (Figure 4), from over 30% to less than 10%. The corresponding increases were in classes 2b and 3a for the ES and 3a for the TRM. The TRM created substantially more deep disturbance.

*Figure 4 - Distribution of soil disturbance classes after treatment for both site preparation operations*

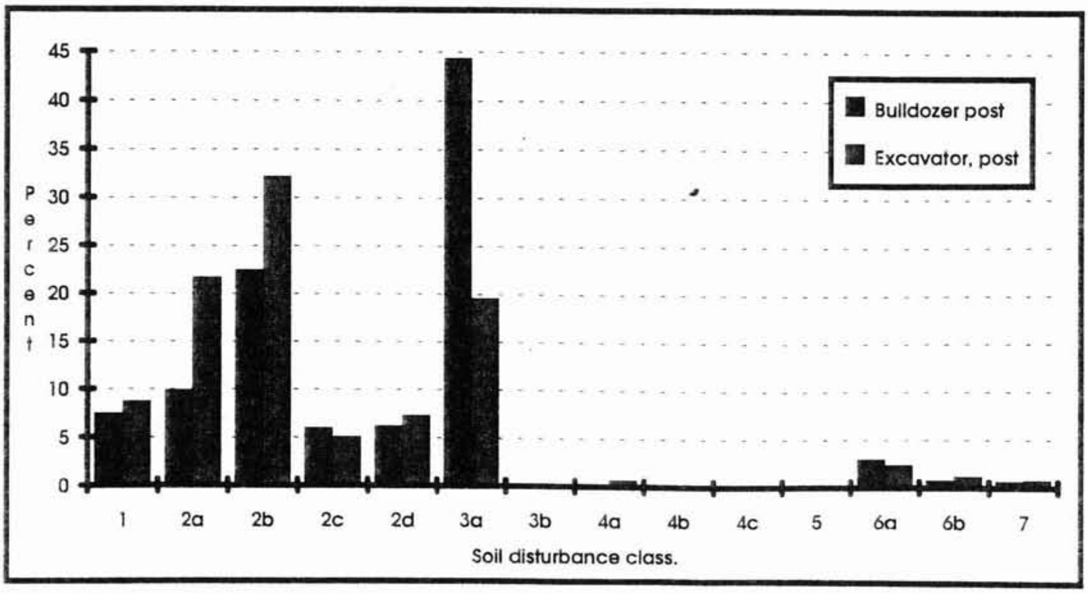


*Table 4 - Stump stocking after treatment*

| | ES | TRM |
|---|---|---|
| Total | 435 | 480 |
| Uprooted | 30 | 120 |

The TRM was uprooting four times as many stumps as the ES (Table 4). This is due to the excavator's ability to adjust its spacing and place spots so as to avoid stumps.

The soil strength within the cultivated zones was measured but did not vary with the type of machine. The soil was well shattered in both cases, sufficient to ensure that root growth would not be impeded. The volume of shattered soil available per tree was also measured and this averaged 1.7m³ for the ES and 1.6m³ for the TRM. The profile of the ripped and mounded soil created by both operations was measured.

The profile shown in Figure 5 varied with length, as while the tractor-mounted ripper-mounder worked in continuous furrows, the depth of the rip and height of the mound altered due to obstacles such as stumps requiring the ripper to be raised.

*Figure 5 - Rip-mound profile of the TRM*

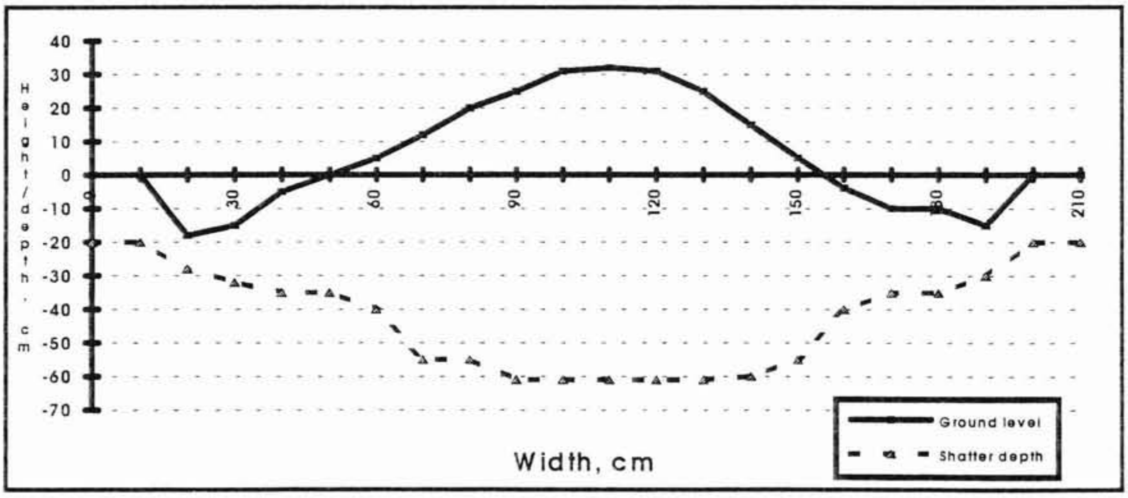



*Figure 6 - Rip-mound width profile of the ES*

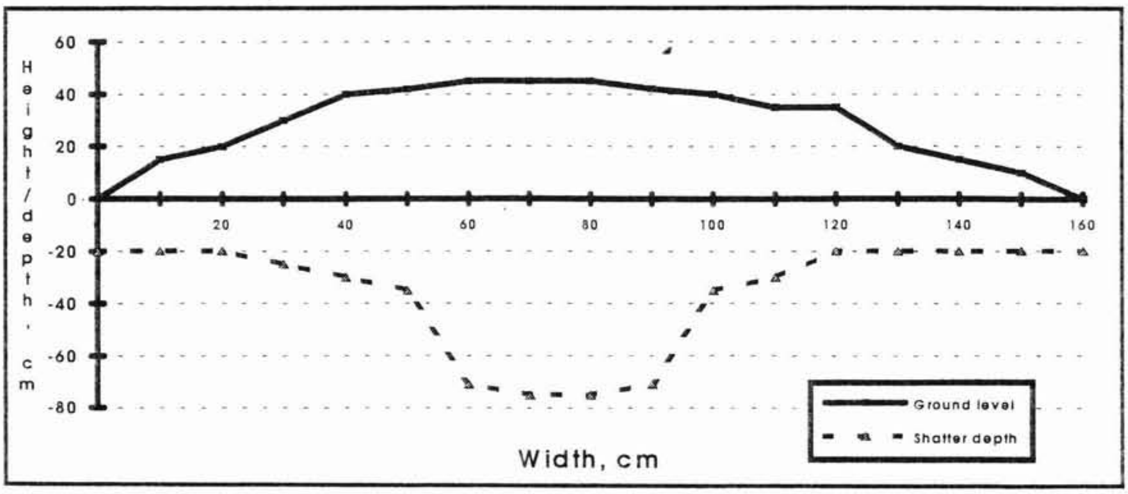
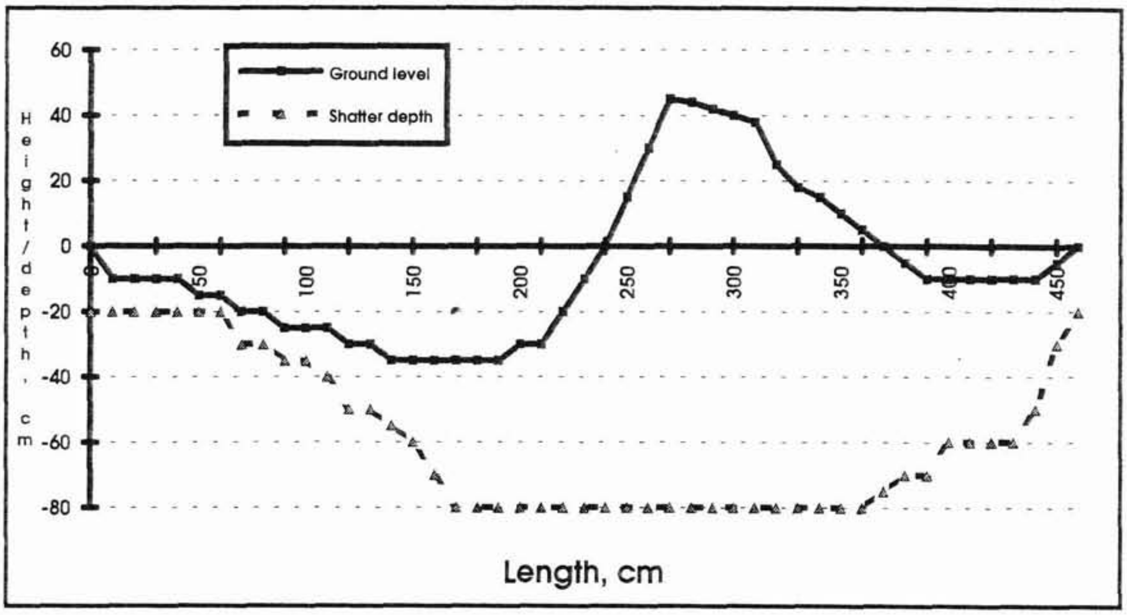


*Figure 7 - Length profile of the ES*




The width profile of the ES was different from that of the TRM profile. It had a wider, higher mound over a deeper rip (Figure 6). The ES profile varied with length as it was a spot treatment rather than a continuous treatment (Figure 7).

The ES created a rip of up to 80cm depth for up to 3m. A small hole was created over part of the rip, which provided the material to form the mound.

## Spacing

The target for both operations was 6.0m by 2.7m or 617 plantable sites per hectare. The TRM achieved an average of 6.1m between rows and as the rip-mound was continuous 2.7m between trees was always theoretically possible. This spacing gave 610 planting sites per hectare.

The ES achieved an average of 6.0m between rows and 2.8m between spots, or 595 spots per hectare. The ES had greater variability in its spacing, especially between spots.

## Planting Spot Quality

The specification set for the quality assessment of the planting spots was a 30cm high mound free of woody debris likely to impede planting centred over a 60cm rip. A sample of rips and mounds was measured in both treatments. Average rip depths and mound heights and the percentage of the planting sites which met the specification are presented in Table 5.

*Table 5 - Planting site assessment*

| | ES | TRM |
|---|---|---|
| Mound Height, cm | 45 | 30 |
| Rip Depth, cm | 71 | 45 |
| Acceptable Quality, % | 94 | 35 |

The most common reason for failure to meet the prescription was inadequate rip depth. The ES achieved an acceptable level of quality, the TRM did not. Of the spots rejected for the TRM, 89% were for rip depth less than the required 60cm.

The TRM unit was fitted with a ripper that extended 1.0m below the tool bar. However, when the tractor traversed the cutover, the height of the tool bar was continually being adjusted both intentionally (operator raised the tool bar to clear an obstacle), and unintentionally (front of tractor dropped and tool bar rose when traversing stumps). The ripper could not be operated at full depth and the tool bar was often 30 to 40cm clear of the soil surface. Making the ripper longer did not solve this problem. The ripper on this unit was adjustable, and was extended to a length of 1.25m below the tool bar. When this was done, even with the tool bar fully raised the ripper could not be lifted completely free of the ground. This lead to problems with clearing stumps and production dropped substantially.

**Production Rates and Costs**

Each operation was time studied for two days. For the purposes of this comparison a "standard" working day of 7.00 am - 4.00 pm, not including travel time was assumed. This gave a total of nine hours on site. Two 0.5 hour smoko breaks were taken and 0.5 hours was allowed for fuelling, greasing and warming up the machines. Deducting those breaks gave a 7.5 machine hours per day. Costing of the machinery was completed using new machine prices and the standard LIRO costing format (Riddle, 1994). Production rates and costs are presented in Table 6.

*Table 6 - Production rates and costs*

| | ES | TRM |
|---|---|---|
| Hectares per hour | 0.29 | 1.03 |
| Hectares per day | 2.18 | 7.72 |
| Cost per hour | $125 | $358 |
| Cost per hectare. | $434 | $348 |

The hourly cost for the TRM is made up of $158 per hour for the V-blade lane clearing operation using a 100 kW tractor and $200 per hour for a 150 kW tractor pulling the ripper-mounder.

At the end of each study, some method changes were made and the operations were observed for short periods (one to two hours) to assess the likely effects of these changes.

For the ES, the number of movements used to create the mound was reduced. This change increased production (to 0.38 hectares an hour) and reduced the cost (to $330 per hectare). However, the quality of the spots created was affected with the mound not being as well centred over the rip line. Some minor changes to the geometry of the spot ripper-mounder would probably overcome this.

For the TRM operation, the ripper was lengthened to 1.25m from the tool bar. This had the effect of reducing production (to 0.73 hectares per hour) and increasing cost (to $490 per hectare). It had a small effect on the quality of the job, increasing the percentage of acceptable spots to 45% from 35%.

Given the existing work methods in the main study, the TRM at $348 per hectare was $86 per hectare cheaper than the ES. However, the quality of the job was not meeting the specification. Due to the way the TRM was set up, it was unlikely that it would have been able to consistently rip to a depth of over 60cm.

Many current prescriptions for ripping and mounding operations ask for a 50cm high mound over a rip of 1.0m. This is a very difficult specification to achieve and the necessity of these specifications must be questioned given that much of the existing cultivation machinery is not capable of meeting them.

The two operations studied here are at opposite ends of the development scale, with TRMs having been in use for over a decade and the ES for less than a year. The ES is likely to have more potential for productivity gains from increased operator training and experience, improvements to work patterns and further development of the equipment.

*Table 7 -Activity sampling data, ES*

| Element | Productive Time | % Error |
|---|---|---|
| Access | 1.6 % | ±3.3 |
| Walk | 10.7 % | ±3.2 |
| Slew | 10.7 % | ±3.2 |
| Turn | 1.9 % | ±3.3 |
| Sweep | 18.8 % | ±3.1 |
| Rip | 31.9 % | ±2.8 |
| Mound | 24.3 % | ±2.9 |

*Access, Walk, Slew* and *Turn* time for the ES totalled 25% of the productive time (Table 7). *Sweeping* aside debris, *Ripping* and *Mounding* totalled 75%. Any efforts to improve the productivity of this operation should focus on the creating of the mound, not the machine's work pattern.

*Table 8 - Activity sampling data, V-Blade in TRM*

| Element | Productive Time | % Error |
|---|---|---|
| Access | 4.8 % | ±4.5 |
| Walk | 1.6 % | ±4.5 |
| V-Blade | 67.3 % | ±2.6 |
| Reverse | 2.7 % | ±4.5 |
| Stuck | 1.2 % | ±4.5 |
| Side cast | 1.2 % | ±4.5 |
| Turn | 8.2 % | ±4.4 |
| Wait | 12.8 % | ±4.3 |

Note - The V-blade was used to clear slash only and was attempting to avoid pushing up any mounds of soil.

The V-blade had plenty of spare work capacity (Table 8). The tractor ripper mounder had 18% of its time occupied with elements (*Reverse, Stuck, Raise ripper*) related to manœuvering around obstacles (Table 9).

The change to a 1.25m ripper substantially changed some of the results. The V-blade's *Wait* time rose to 40%, the ripper-mounders *Raise ripper* and *Turn* time both rose by 5%, *Reverse* time rose by 10% and *Rip-mound* time dropped by 17%.

*Table 9 - Activity sampling data, Ripper-mounder in TRM*

| Element | Productive Time | Error |
|---|---|---|
| Access | 5.3 | ±4.5 |
| Walk | 4.7 | ±4.5 |
| Rip-mound | 62.8 | ±2.8 |
| Reverse | 11.2 | ±4.3 |
| Stuck | 0.8 | ±4.6 |
| Raise ripper | 5.0 | ±4.5 |
| Turn | 9.6 | ±4.4 |
| Wait | 0.5 | ±4.6 |

These results apply only to the conditions in which the study took place. In an area where the slash and stump stocking levels are low the results may be quite different, with the TRM able to perform much better. On the other hand, if the site was steeper, with broken terrain or heavier slash with high stump numbers, the ES may be the better option.

## CONCLUSIONS

The evaluation and comparison of the tractor-based continuous furrow ripping-mounding and the excavator-based spot ripping-mounding operations showed that:

- The TRM was a faster, cheaper operation
- The TRM uprooted more stumps and created more deep soil disturbance
- The ES achieved the prescription 94% of the time, the TRM achieved it only 35% of the time
- Method changes markedly improved the ES production
- Method changes markedly slowed the TRM production, and quality

785



improved only slightly but was still largely unacceptable.

The productivity and job quality of both operations could be improved with further development of the equipment.

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*The costs stated in this report have been derived using LIRO costing procedures. They are an indicative estimate and do not necessarily represent the actual costs for this operation.*

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