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THE ROTREE SPOT CULTIVATOR-MOUNDER

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Figure 1 - ROTREE mounted on Komatsu PC250LC

ABSTRACT

The ROTREE spot cultivator-mounder was studied in ACT Forests, Australia, in radiata pine cutover. Slash volumes similar to those in New Zealand were present on the site. The soil at the study site was hard, rocky and dry. Production rates averaged 4.6 spots per minute. The ROTREE was able to build a 32 cm high mound over cultivation of 64 cm depth consistently. The cost of the operation was estimated at $125 per productive machine hour or $380 per hectare creating 830 spots per hectare. The ROTREE is capable of spot cultivation for forest establishment on both flat and moderately steep terrain.

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INTRODUCTION

With the introduction of the Resource Management Act 1991, and an increased focus on quality management, forest companies in New Zealand are examining the impacts of all their forest operations on the environment. Mechanical site preparation and cultivation are no exception.

Much of the cultivation carried out in the past has been continuous ripping and mounding performed with units mounted on tractors. The rip lines tended to be continuous and parallel. A large proportion of the site is left severely disturbed. Tractors are generally limited to operating on rolling terrain with slopes of 0° to 20° (18° in ACT Forests operations).

A recent trend, both in New Zealand and overseas, is for mechanical site preparation to be based around excavators. Two examples include excavator windrowing (Hall, 1992) and spot ripping and mounding (Hall, 1995 a, b). Excavators are cheaper to purchase and operate than tractors, are generally lighter and do less damage to the soil. They are also versatile and can be redirected to a number of tasks within a forest by changing the attachment on the boom. Excavators have proven to be capable of working on slopes up to 30°.

A number of cultivation and/or mounding attachments for excavators have been developed overseas. One of these, the ROTREE spot cultivator-mounder developed by ROTREE Corporation in Tasmania, was trialled by ACT Forests, Australia in January, 1996. The machine was studied during this period whilst working in Kowen Forest, near Canberra. The ROTREE used a Cat 325L as the base machine. The cultivation head weighs 3.86 tonnes, has mounding discs of 910 mm diameter and the cultivator tines were 1200 mm long, giving them an effective depth of 600 mm.

ACKNOWLEDGMENTS

LIRO acknowledges the co-operation and assistance of ROTREE Corporation and ACT Forests in this study.

SITE DESCRIPTION

Compartment 301, Kowen Forest. Slope in the trial area was 0° to 10° and the soil was compact clay (30 cm to 60 cm) over shale rock. The clear felled crop was 42-year-old radiata pine, standing at 510 stems per hecctare. The logging system used was a processor and forwarder.

METHODS

Pre-treatment Assessment

A site description was compiled with data collected on: soil disturbance (McMahon, 1995), slash volume (Van Wagner, 1968; Hall, 1996), stump stocking plots (including number of uproots and average stump diameter) and soil shear strength.

Production Study

A combined time and activity sampling study was completed, collecting data on gross productive time, area treated and percent of time spent on various work elements.

Post-treatment Assessment

The following were measured:

- soil disturbance
- the number of stumps uprooted
- spacing and stocking of the treated spots
- shear strength of the cultivated soil
- profiles of the cultivated spots
- mound heights and cultivation depths.

RESULTS AND DISCUSSION

Soil Disturbance

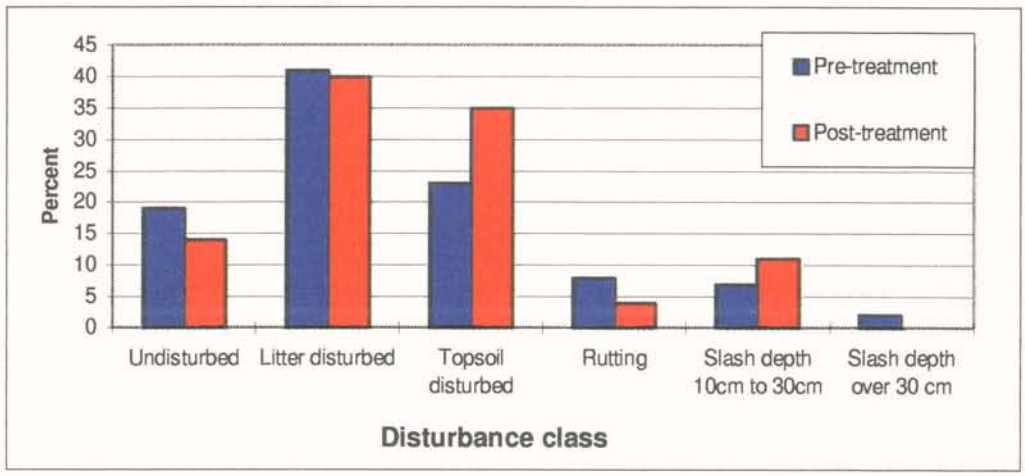


Figure 2 - Soil disturbance (%) pre- and post-treatment

The operation increased the proportion of the site with deep disturbance, much of this related to the deliberate creation of mounds (Figure 2). The amount of rutting created by the logging operation appears to be reduced, with some of the ruts being incorporated into the mounds.

Slash Volume

Table 1 - Slash volume m^3 per hectare

	Slash volume
Branch	15 m^3 per hectare
Stem	67 m^3 per hectare
Total	82 m^3 per hectare

The total volume of slash was 82 m^3/per hectare (Table 1) with a substantial volume of stem waste. Slash distribution was uneven due to the processor's work pattern, with parallel lanes of branches, stem waste and clear site.

The volume of slash per hectare is not affected by the cultivation treatment, but is redistributed as the machine moves slash aside to access the ground at the correct spacing.

The operation had no effect on the number of uprooted stumps, although the original stocking was high (510). Stump diameters averaged 35 cm.

Soil Shear Strength

The soil on this site was dry at the time of the trial and extremely hard (Figure 3). There was some variation in strength between ridge tops and gully bottoms due to different moisture levels. Generally, the soil strength was so high that cultivation was necessary to ensure that tree root development was not inhibited (Mason and Cullen, 1986).

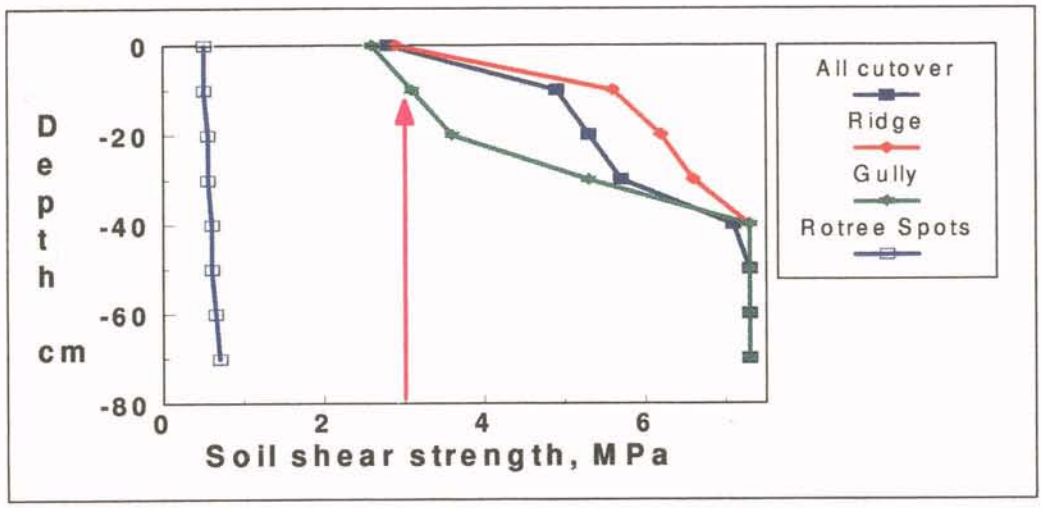


Figure 3 - Soil shear strength

Note - The arrow at the 3 MPa level indicates the point at which radiata pine root growth is inhibited.

Mound Profile

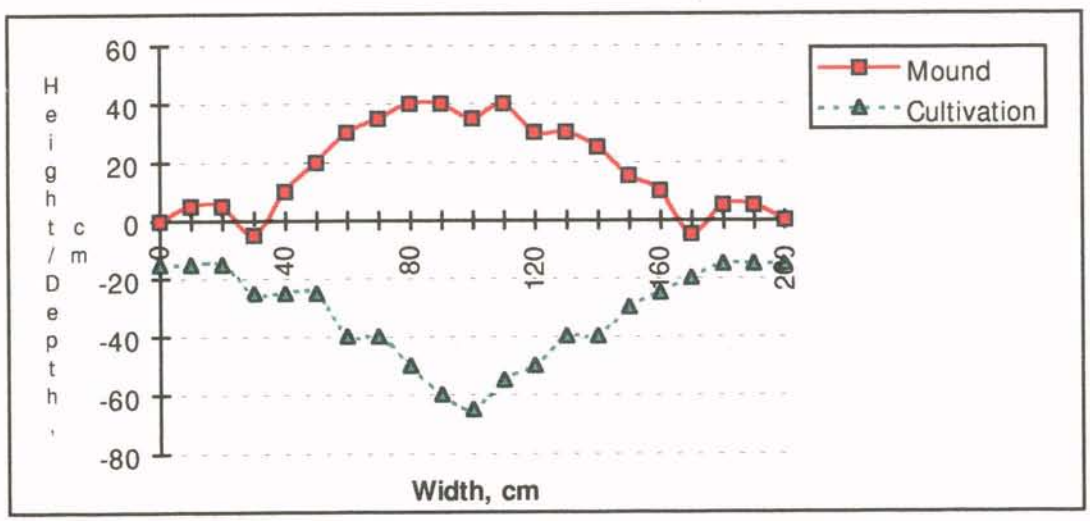


Figure 4 - ROTREE cultivation profile

The ROTREE is designed to build a raised circular mound over a cultivated cone. The profile in Figure 4 represents a cross-section of the cultivated spot. The total volume of cultivated soil per spot averaged 0.80 m^3. The profile shown in Figure 4 is that of spots immediately after cultivation. Some settling of the soil, resulting in lower mound heights, can be expected.

There was no observed change to the soil profile as a result of the cultivation by the ROTREE, that is the ROTREE does not mix the soil, it loosens it. There was some evidence that the A horizon dried out more than the uncultivated surround but that the B horizon remains moist.

The cultivated area (1.5 m in diameter or 1.8 m^2) remained weed free for at least four months after planting.

Planting Spot Quality

A specification of a 30 cm mound over a 60 cm cultivation depth was set. The ROTREE achieved this 89% of the time (Table 2). All quality failures were due to insufficient cultivation depth. This was largely due to the layer of shale rock under the soil sometimes occurring at less than 60 cm.

Table 2 - Planting spot quality

Average mound height	32 cm
Average Cultivation depth	64 cm
% Acceptable Quality	89 %

The target spacing for this operation was 4 m by 3 m (833 spots per hectare). The result was a spacing 3.9m by 2.9m, giving a stocking of 880 per hectare.

The litter and topsoil layers are mixed by the action of the cultivator tines and the discs. The sub-soil is cultivated, but mixing of the sub-soil with the top soil is minimal.

One of the concerns expressed by forest managers considering rotary spot cultivation, regardless of the equipment being used, is the possibility of the glazing or compaction of the sides of the cultivated hole. If this occurs it may inhibit roots from penetrating the side of the hole and developing a good root system. Glazing or compaction of the sides of the hole were not observed at this site.

Production Rates and Costs

The ROTREE averaged 4.6 spots per minute which, at a stocking of 833 spots per hectare, gave a production rate of 0.33 hectares per productive machine hour (PMH). This equates to 3 PMH per hectare at a cost of $380 per hectare. This was a short production study. Based on these observations, the ROTREE could be expected to work at an average of four spots per minute over the long term. On difficult sites with heavy slash the production would be slower, and on clear sites it may be higher. A standard LIRO costing (Riddle, 1994) based on an eight-hour day (7.25 PMH), new machine prices and allowing 10% profit gave an hourly rate of $125.

The overall rate of production and the cost per hectare will be dictated not only by the site factors, such as slash volume, slope and soil type, but also by the number of spots per hectare required and the number of spots per minute the machine can make on the site. Table 3 presents a range of costs per hectare based on varying stockings and production rates given an hourly rate for the machine of $125. The shaded area of the table represents the range of costs that are likely to be typical.

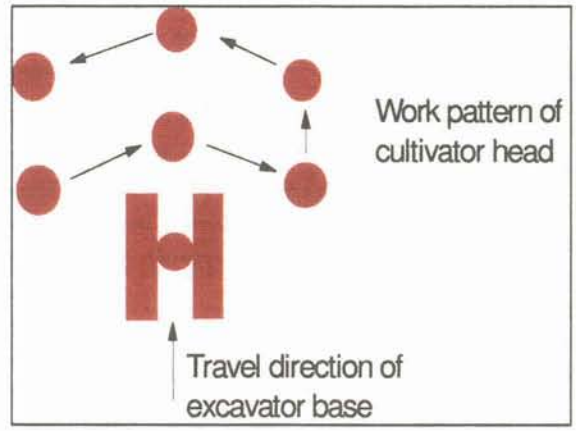
Table 3 - Estimated range of production rates and costs ($/ha)

	Spots per minute							
Spots/ha	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**	**5.5**	**6.0**
1200	1000	830	715	625	555	500	455	420
1100	920	765	655	570	510	460	420	380
1000	830	695	595	**520**	**465**	**420**	380	350
900	750	625	535	**470**	**420**	**375**	340	315
800	670	555	475	**420**	**370**	**335**	303	280
700	580	585	420	**365**	**325**	**290**	265	240
600	500	420	360	**315**	**280**	**250**	230	210

Table 4 - Time study results

Element	% occurrence
Walk, Access	0.5 %
Walk, Operation	18.2 %
Slew	15.6 %
Cultivate	58.7 %
Sweep	1.3 %
Stuck	0 %
Turn	2.1 %
Reverse	0.1 %
Clear Head	0.2 %
Personal delay	0 %
Operational delay	3.4 %

Figure 5 - Machine work pattern



The majority of the machine's time (58.7%) was spent creating planting spots (cultivate, Table 4). The other productive elements, slewing and walking between groups of spots were the other major activities. Together, these totalled 92.5% of the time. Turning and operational delays make up the bulk of the outstanding time. Operational delays included time spent by the operator checking spot spacing.

The machine's work pattern was to create three parallel rows of spots in each pass across the site. The excavator base moves forward three metres at a time and creates three spots from each stop point (Figure 5). The centre row of spots passes under the machine between the tracks as it moves forward.

CONCLUSIONS

Overall, the ROTREE produced a good quality planting site from very difficult soil conditions.

The production rate was 4.6 spots per minute. The time and cost per hectare will be heavily affected by the number of spots per hectare required as well as the site conditions.

The mound was created without the need to make a large hole next to it to provide the soil for the mound. Mounds were on average 32 cm high over cultivation 64 cm deep.

Cultivation depth was sometimes limited at this site by the presence of rock under a shallow layer of soil.

The ROTREE is capable of working in and through heavy slash on slopes of up to 30°.

Further research on the effects of cultivation on tree growth and stability and root form and development would be of benefit to the forest industry in New Zealand and Australia.

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

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