NELSON MANDELA UNIVERSITY

Comparing the productivity of pitting machine operators on different sites conditions

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Outline

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Introduction

Pitting in silviculture

- Preparation of tree planting positions
- Performed manually (picks), motor-manually (augers), or mechanically (pitting machines)

Shift to mechanisation

- Manual pitting – labor-intensive, inconsistent pit quality
- Trend – shift towards mechanised pitting for better productivity and consistency

Motivation of the study

- Forestry stakeholders have understanding of pitting machine productivity (pits/shift)
- Unaware of productivity differences associated with operator experience and site conditions

(du Toit et al. 2021; Ramantswana et al. 2021; Zimbodza 2022; Zulu et al. 2024)

Research Objective

Objectives

- Compare the operational productivity of pitting machine operators on burnt and mulched sites
- Evaluate the pit quality (depth and diameter) from each operator across the different site conditions

STUDY SITE

Characteristics	Aspects	
Compartment	F5a	F5b
Area(ha)	34.41	11
Slope	Gentle	Gentle
Ground conditions	Good	Good
Ground roughness	Slightly uneven	Slightly uneven
Soil type	Sandy loam	Sandy loam
Previous species planted	*Pinus greggii*	*Pinus greggii*
Espacement	3 x 3	3 x 3
Harvesting method	Cut-to-length	Cut-to-length
Harvesting system	Fully-Mechanized (Harvester and forwarder)	
Residue status: Burnt/mulched*	Burnt (90%)	Mulched (80%)
Date	19 April 2023	02 May 2023

*% based on visual assessment

Site conditions

Figure 2: Compartment F5a (left) and F5b (right)

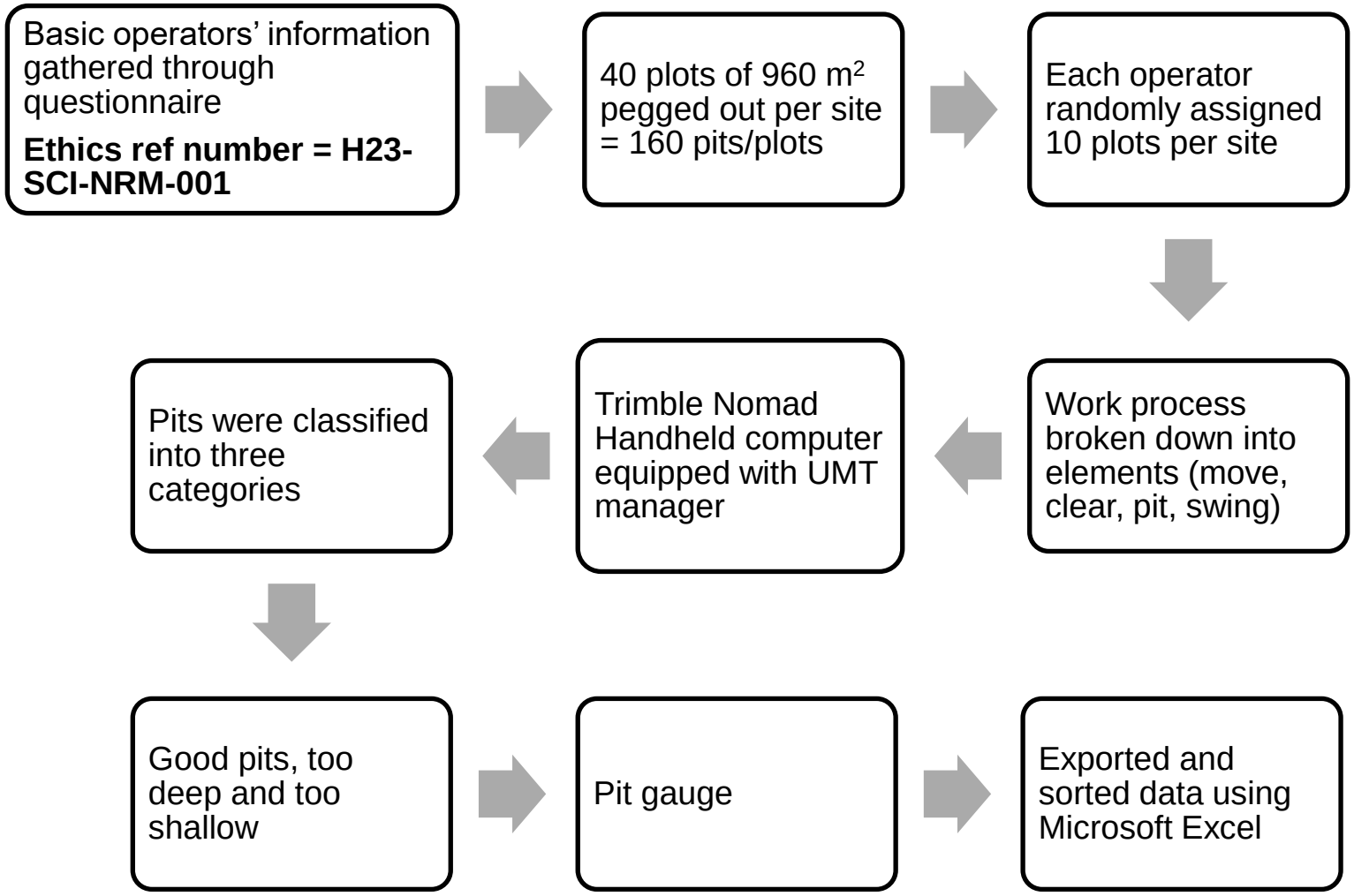
METHODOLOGY

Figure 3: M-PAT Single head pitting machine

Specifications	
Carrier	Tracked-Volvo EC55B Pro excavator 5.5 tons, compact excavator
Engine	Kubota engine – 38KW (50 hp)
Fuel capacity	90 L
Fuel consumption	2.8 to 3 l/hr.
Pitting head	Tungsten chip hard faced tines with tungsten center auger
Pit depth	35 cm with 40 cm center
Diameter	35 cm
Boom reach	4 rows from any fixed position
Ground clearance	38 cm
Working slope	≤ 6 %

(NovelquipForestry 2023)

Data collection process



DATA ANALYSIS

Statistica Software:

- Descriptive statistics guided further analysis
- Non-parametric techniques were used
- The study examined the effect of operator and site preparation technique
- Comparison of mulched versus burnt was done separately for each operator
- The Mann-Whitney U test used to compare site preparation techniques, work elements and pit quality
- Kruskal-Wallis test used to assess significant differences in operator productivity
- Statistical significance was set at p-value < 0.05

(Zulu et al. 2024)

RESULTS AND DISCUSSION

Time Study Results

- Total duration: 33 hours, 57 minutes

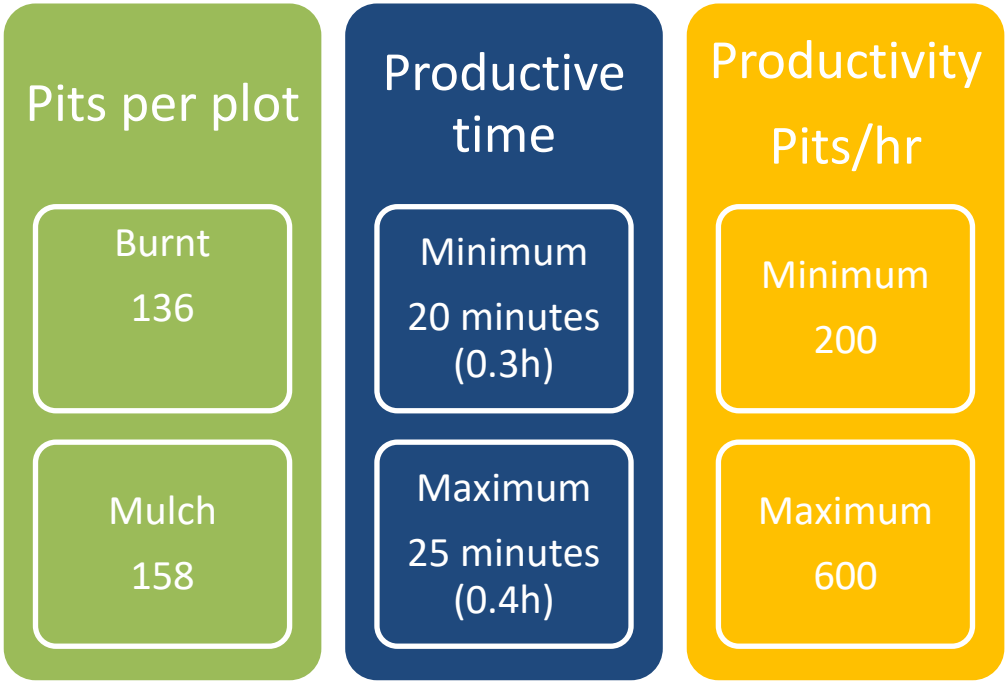


Figure 4: Results overview

Operators' information

Operator	Gender	Experience (year)	Previous experience	Formal training	How often over past 12 months
1	Male	5	No	Yes	Operate machine at least once a week
2	Female	1 & 4 months	No	Yes	Less than 10 times a month
3	Male	2	No	Yes	Operate machine at least once a week
4	Female	5	No	Yes	Operate machine at least once a week

Site Preparation Effects

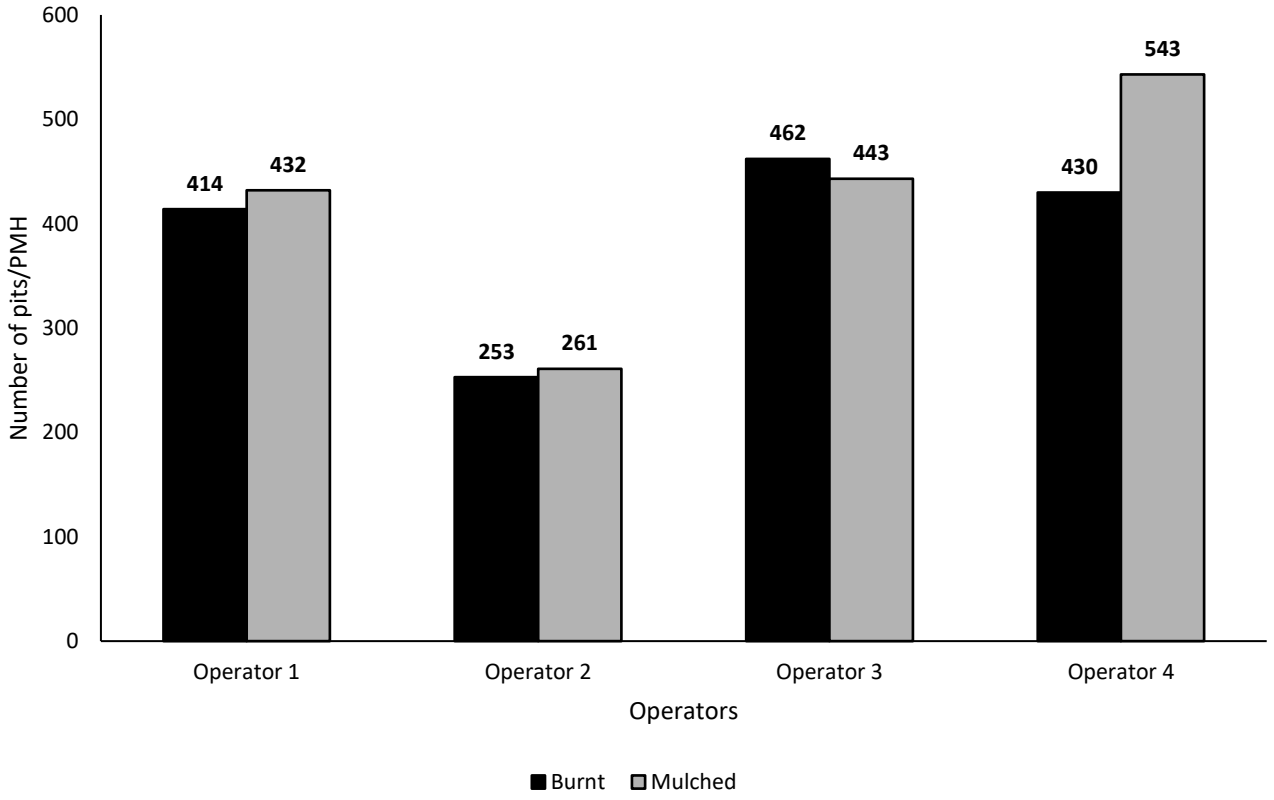


Figure 5: Productivity on burnt and mulched sites

(Zulu et al. 2024)

Cycle elements time distribution

Element	Operator 1	Operator 2	Operator 3	Operator 4
Move s/pit Burnt	1.9	3.9	2.4	2.4
Move s/pit Mulched	1.9	2.9	1.7	1.8
P-value	0.7440	0.0191	0.0126	0.0588
Clear s/pit Burnt	0.1	0.1	0.1	0.1
Clear s/pit Mulched	1.2	0.7	0.6	0.1
P-value	0.0002	0.0032	0.0002	0.3625
Pit s/pit Burnt	3.5	5.1	2.9	2.9
Pit s/pit Mulched	2.9	4.8	3.1	2.4
P-value	0.0033	0.6501	0.1124	0.0284
Swing s/pit Burnt	2.1	5.6	2.3	2.9
Swing s/pit Mulched	2.0	5.5	2.5	2.3
P-value	0.3691	0.7624	0.3258	0.0126

Pit quality

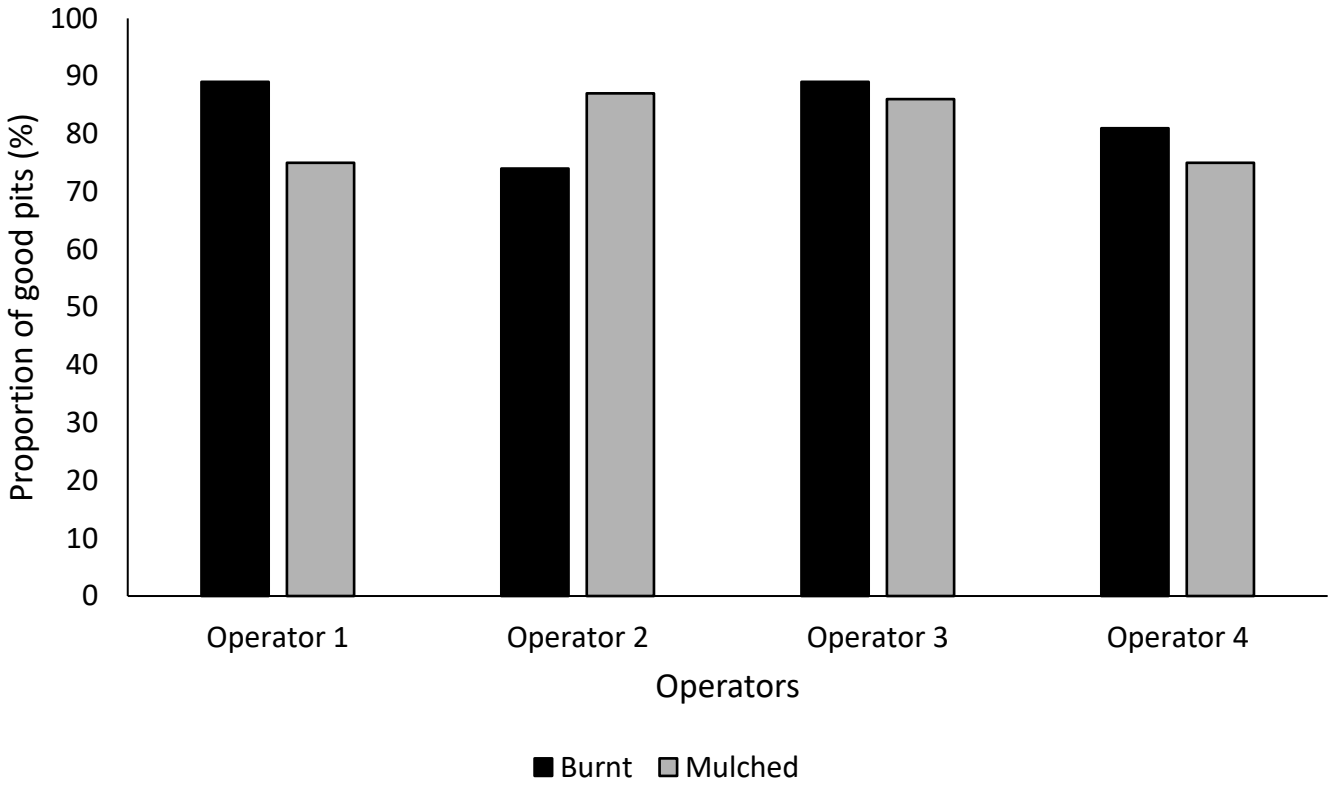


Figure 6: Good pits on burnt and mulched site

CONCLUSION

- Operators' productivity differed, with more experienced operators performing better
- Marking of pit positions on mulched sites increased productivity and pit density
- Pit quality was linked to operator skill rather than site preparation technique
- All sites should be marked to ensure optimal seedling placement and uniform growth
- Use of existing stump lines must only be conducted after thorough verification of the spacing

RECOMMENDATIONS

Significance:

The study highlights the impact of operator experience and site preparation on productivity and pit quality, providing a baseline for future studies and improvements in commercial plantations in South Africa

Recommendations:

- Further studies should include more operators, additional sites, and different spacings

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Mechanical site preparation in South Africa: comparing the productivity of pitting machine operators under different site conditions

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ABSTRACT

Pitting is the preparation of a tree planting position. In South Africa, various contractors and grower companies have gradually adopted pitting machines over the past decade, to overcome the challenges of manual pitting, such as low productivity, poor ergonomics, and inconsistent pit quality. Even though most forestry stakeholders understand productivity requirements (e.g. pits/shift) from pitting machines, they are often unaware of productivity differences associated with different operators and work conditions. This study aimed to compare the operational productivity and pit quality achieved by different pitting machine operators under different site conditions. The experiment was conducted in two sub-compartments, with two different post-harvest slash treatments: broadcast burning or mulching (and pre-marking). Then, four operators were tasked to dig pits using the same equipment. Operator productivity was assessed by analyzing time study data, while pit quality was estimated by determining pit depth and diameter. The results indicated that Operator 4 performed significantly better on mulched sites (543 pits/PMH) than on burned sites (430 pits/PMH), while Operator 2 was the least productive with 261 and 253 pits/PMH in mulched and burned sites, respectively. The overall average productivity was 120 pits/PMH higher on mulched sites than on burned sites. Although work quality did not correlate with productivity, there were differences between operators on the mulched site. The proportion of good pits varied, but site preparation technique did not significantly affect pit quality. We conclude that operator experience significantly impacts productivity and that marking the pitting spots is important to ensure that the required number of pits per hectare is achieved.

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KEYWORDS
Burned sites; experience; mulched sites; operators; pit quality; productivity

Introduction

The predicted size of the world's forests in 2020 was over 4 billion ha, covering 31% of the Earth's surface. Industrial tree plantations make up 131 million ha, which is 45% of the global planted forests area (FAO ed 2020). South Africa has about 1.2 million ha of timber plantations shared among the following provinces: Mpumalanga (40%), Limpopo (4%),

Pitting is an important silvicultural activity which involves the preparation of a suitable planting position: for that reason, it is important that the depth, width and spacing between the pits are suitable to the purpose (Hechter et al. 2020). In South Africa, pitting can be performed manually, motor-manually or mechanically (Ramantswana et al. 2020) through the use of such tools and equipment as picks, motorized augers, and

Thank you

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