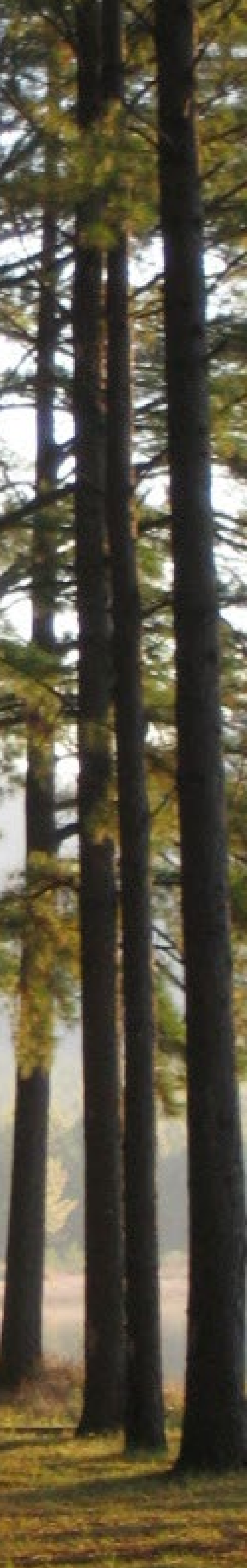


Operation review of brushcutter nylon wear for two different nylon diameters from two different manufacturers

Forestry Operations Research technical note: 02/2019

Marius Terblanche, Simon Ackerman and Heather Mcdermid

UNIVERSITEIT iYUNIVESITHI STELLENBOSCH UNIVERSITY 100 1918 · 2018

saam vorentoe · masiye phambili · forward together

AgriWetenskappe EyeeNzululwazi zoLimo AgriSciences

Forest Operations Research

DRIVING SUPPLY CHAIN EFFICIENCY

Executive summary

The study was commissioned to test the durability, productivity and fuel consumption of different nylons used on brush cutters. Two nylons were identified, paired (by diameter) and tested in one trial (per nylon diameter) fitted randomly to two brush cutters. The operators of the brush cutters were trained and had similar operating styles. The trial compared a Stihl 3.0mm nylon with a contractor brand 3.5mm nylon.

Results show a decreased nylon wear for the Stihl 3.0 mm as opposed to the contractor 3.5 mm nylon. These results were not statistically significantly different. Productivity was lower in S2 as opposed to the C3 nylon, and fuel consumption lower in S2 as opposed to the C3 nylon, although not statistically significant.

However even though the results were not statistically significantly different, there were still differences in mean values reported. These results were combined into a cost calculator taking into account nylon wear, productivity and fuel consumption. These results showed on R/PMH and R/ha that Stihl 3.0 mm was cheaper to apply than Contractor 3.5 mm.

Table of Contents

1 Introduction

A study to test the wear, productivity, and operating costs of applying two different types of brush cutter nylon was proposed. These nylons were paired (according to thickness, as per use) and tested on randomly assigned equally sized plots in the KwaZulu-Natal Midlands during March 2019.

The study design, results and discussion are as follows.

2 Methods

Our study area was located at the Shaw Research Centre near Howick, KwaZulu-Natal. Temperature ranged from 28C to 12C, with on and off showers on the days of testing.

In excess of 20 plots were pegged and marked with barrier tape. All plots were rectangular and of same size; 200 m^2. Each nylon type was tested over 10 plots, or an area of 2 000 m^2. To account for variability in vegetation between plots, plots were randomly assigned to the nylon types. The study design for the tests are detailed in **Table 1**.

Table 1: Description of which nylons types tested on each day, as well as by which machine and which operators

Nylons	Machine	Operator
Stihl 2 (3.0mm)	A	A, B
Contractor (3.5mm)	B	B, A

Two machines were timed simultaneously on two plots of the trial at a time. Each machine was fitted with a particular type of nylon for each test of the trial. To prevent the operator influencing wear on the nylon, for example if one operator was more prone to hitting the ground or other operation anomalies, the operators switched machines after each five plots of work. Details of the nylons tested are indicated in **Table 2**.

Table 2: Description of the nylon by its thickness, length and weight per roll, and price

Supplier	Brand	Nylon Code	Line thickness (mm)	Length per roll (m)	Weight per roll (kg)	Price (dealer cost)
Stihl	Stihl round	S2	3.0	280	2.2	R292.00
Cutter line	Cutter line	C3	3.5	187	2	R180.00

All nylons were cut to a standard length, weighed, and numbered prior to study execution as a way to measure the wear after use. Nylon was replaced when each plot was completed, or if the nylon was wore down to the point of being ineffective and the operator requested replacement.

The Time Study App on, Android tablets, to time the operators' work as per the South African standards described on www.forestproductivity.co.za (Ackerman *et al.*) was used. By recording the time (in decimal minutes) each nylon was used before it needed replacement, the amount of area the nylon cut, and its final weight, we were able to calculate nylon use per productive machine hour (PMH) (**Equation 1**), nylon use per area (**Equation 2**), as well as operator productivity (m^2/PMH and PMH/ha) (**Equation 3**).

$$N_{ut} = (N_L / T) * 60 \quad (1)$$

Where: N_{ut} = Nylon used per time (g/PMH)

N_L = Nylon lost (g)

(Weight before – weight after)

T = Time (min)

$$T_{\%} = (T_N / T_P) * 100 \quad (2)$$

Where: $T_{\%}$ = Percentage of time nylon was used in plot

T_N = Time nylon was used (min)

T_P = Time for whole plot(min)

$$A = 200 * (T_{\%} / 100)$$

Where: A = Area cut by nylon (m^2)

$T_{\%}$ = Percentage of time nylon was used in plot

$N_{ua} = N_L / A$

Where:	N_{ua}	=	Nylon used per area	(g/m^2)
	N_L	=	Nylon lost	(g)
			(Weight before – weight after)	
	A	=	Area cut by nylon (m^2)	

Productivity (m^2/PMH) = 200 / (T_p * 60) (3)

Where:	T_p	=	Time for whole plot

Productivity (PMH/ha) = (10000 / (200 / T_p)) / 60

Where:	T_p	=	Time for whole plot

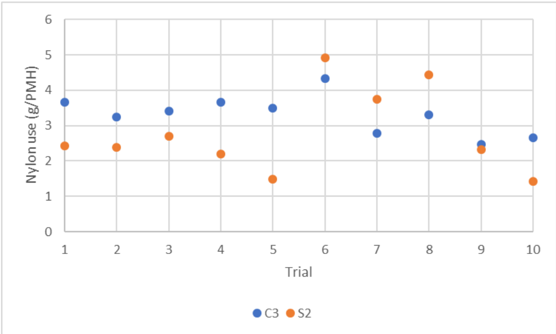
In addition to timing the operators as they worked, volume of fuel the machines consumed was also recorded. We noted how many times the machines had to be refilled, then used a graduated beaker to measure the leftover fuel at the end of testing (**Equation 4**).

$F_t = F*n + (F - F_L)$ (4)

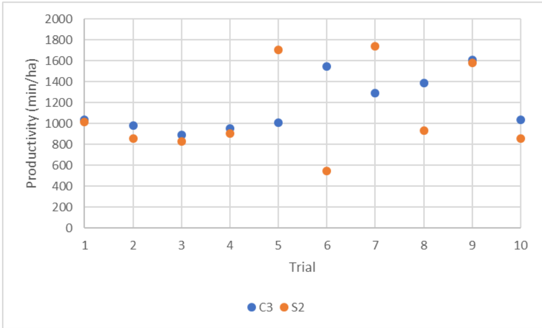
Where:	F_t	=	Total fuel used	(l)
	F	=	Fuel stored in tank (l)	
			Constant	
	n	=	number of refills	
	F_L	=	fuel left in tank	(l)

3 *Results and Discussion*

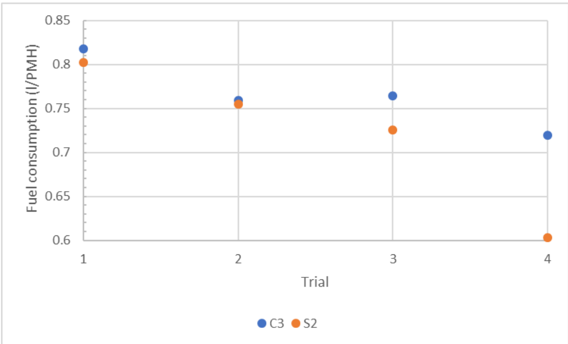
The graphs for the measured observations for each of the diagnostics comparing nylon C3 to S2 tested appear in **Figure 1**.



a)



b)



c)

Figure 1: Graphs of a) Nylon use per trial, b) Productivity per trial site and c) Fuel consumption per refuelling cycle for each nylon.

Based on these graphs, T-tests were done to test if there were differences in the mean values calculated for each of the diagnostics for nylon C3 and S2, these results are presented in **Table 3**.

Table 3: T-tests for trial two (α = 0.05)

	Nylon use (g/PMH)		Productivity (time/ha)		Fuel consumption (l/PMH)	
	C3	S2	C3	S2	C3	S2
Mean	3.30	2.80	1174.17	1097.01	0.76	0.72
Variance	0.30	1.39	68830.86	175595.23	0.0016	0.0072
Observations	10	10	10	10	4	4
Hypothesized Mean Difference	0		0		0	
df	13		15		4	
t Stat	1.22		0.49		0.92	
P(T<=t) one-tail	0.12		0.31		0.20	
t Critical one-tail	1.77		1.75		2.13	
P(T<=t) two-tail	0.24		0.62		0.40	
t Critical two-tail	2.16		2.13		2.77	

At first glance the results indicate decreased nylon wear in favour of S2 against C3, these results were not statistically significant. Productivity was lower in S2 against C3 and fuel consumption was also lower for S2 against C3, but not statistically significant.

Since there is no significant difference between S2 and C3, we can now instead compare nylon cost along with the fuel consumption and productivity (R/PMH and R/ha). The weight (g) of nylon lost per trial were equated to length (cm) lost by determining the average weight per cm of nylon for each type of nylon. On average C3 and S2 weighed 0.13 and 0.08 g/cm respectively. These were then used to calculate the cost effectiveness of the nylons used, taking into account the durability and the cost per cm for each of the nylons in the trial, see **Table 2** and **3** and **Equation 5**.

Nylon cost (R/ha) = cost (R/PMH) * productivity (PMH/ha) (5)

Where: cost (R/PMH) = length use (m/PMH) * cost (R/m)

As there were many samples of each nylon, the nylon cost (R/ha) was calculated for each sample and then averaged. A fuel price of R22.50 (obtained from a supplier) was used.

The results of these figures are presented in **Table 4**

Table 4: Results of costing figures for each nylon per trial

Brand	**Nylon Code**	**Nylon cost (R/Ha)**	**Nylon cost (R/PMH)**	**Productivity (m^2/PMH)**	**Prod (PMH/Ha)**	**Fuel Consumption (L/PMH)**	**R/PMH**	**R/ha**
Stihl 3.0mm	S2	6.41	0.37	619.73	18.28	0.72	16.6	267.86
Contractor 3.5mm	C3	4.77	0.24	532.53	19.57	0.75	17.17	322.50

The results show Stihl 3.0 mm was cheaper to use as opposed to the Contractor 3.5 mm. The reduced fuel consumption and increased productivity of the Stihl 3.0 mm influencing this.

Based on the costs of the nylon, it is more cost effective to choose Stihl 3.0 mm over Contractor 3.5 mm in conditions present in trail 2. A cost calculator, combining the durability, productivity and fuel consumption has been developed for use by OEM suppliers and contractors to cost and manage their productivity for these operations.

4 *References*

Ackerman P, Gleasure E, Ackerman S, Shuttleworth B. (2014). Standards for Time Studies for the South African Forest Industry. (Accessed 15 April 2018) Available at: http://www.forestproductivity.co.za/?page_id=678.

5 Disclaimer

These results are based on time and motion studies conducted by trained researchers from Stellenbosch University. While every effort has done to ensure the study areas selected covered the most representative sample of terrain and conditions present in most other operations, these result are only valid for the area or conditions tested during the time and motion study. Background sheets have been created to characterise the study site and these are available to ensure further application of these study result can be done on areas that represent the original site.