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Low-growing indigenous groundcover plants' establishment study

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Executive summary

Low-growing indigenous groundcover plants' establishment study

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Planting low-growing indigenous groundcover plants to control weeds may benefit the ecology instead of compromising it, compared with current practice. However, a lack of knowledge prevents this idea from transforming into practice. In this study, we asked three questions: what is the growth rate of selected groundcover plants on loam soil under Marlborough field conditions (trial plots were carefully selected and managed to avoid water, nutrient, weed, wind, and shade stress); does the growth rate of groundcover decrease without irrigation; and does evapotranspiration from groundcover plants use less or more soil water compared with bare soil evaporation?

The indigenous groundcover plants we selected were *Coprosma propinqua* var. *martinii* 'Taiko', *Muehlenbeckia axillaris* and *Veronica odora* var. *prostrata.* A digital camera was used to monitor monthly plant size. Half the replicates of each species were irrigated to provide optimum soil moisture conditions, while the other half were only watered by rainfall. Soil moisture was measured on groundcover trial plots and bare soil plots before irrigation or rain. In addition, weeds emerging through the groundcover canopy and from bare soil plots were counted and removed every 2 months to assess the ability of groundcover to suppress weeds.

We found that under stress-free Marlborough field conditions, to cover a bare soil strip of 0.4 m × 1 m surface area within 6 months would require close to three *Coprosma propinqua* var. *martinii* 'Taiko', three *Muehlenbeckia axillaris* or five *Veronica odora* var. *prostrata* plants per linear metre. The non-irrigated treatment produced slightly smaller plants compared with the irrigated treatment (but not statistically significant). Soil water loss through groundcover plant evapotranspiration exceeded bare soil evaporation. Therefore, compared with bare soil, horticultural crops could face more water stress during groundcover establishment, unless sufficient water is available. All three groundcover species were effective at weed suppression.

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1 Introduction

Most horticulturists control weeds by applying herbicide or cultivating. Both practices create a bare soil surface, which degrades soil organic matter (Haynes 1981; Francis et al. 2001; Wardle et al. 2001), flora and fauna, and damages soil structure. People are concerned that herbicides might enter the human body and cause harm through direct contact or residues in groundwater (Carretta et al. 2022). Cultivating stony ground or terraces is very challenging, making organic practice difficult. As a possible alternative, planting low-growing indigenous groundcover plants to control weeds could benefit the agro-ecology instead of compromising it. Promoting the use of low-growing indigenous groundcover plants will help increase sustainable practises, biodiversity and help towards mitigating the impact of climate change. However, a lack of knowledge prevents this idea from transforming into practice.

Planting density and water usage of groundcover plants are among the unknowns. We need to know how fast the groundcover plants grow (and potentially in different situations) to determine planting density. In the academic literature, only two PhD studies (one in Palmerston North and one in Waipara) have investigated the growth rate of selected native New Zealand groundcover plants (Foo et al. 2009; Shields et al. 2016). Various nurseries provide growth rate and water usage information; however, the information often differs, which is likely because of varied growing conditions. Botanists described many indigenous groundcover plants as low-water users (Metcalf et al. 2014). It would be beneficial to know if irrigation would boost growth rate during establishment, and if groundcover plants' evapotranspiration uses more or less soil water compared with bare soil evaporation.

In this study, we asked three questions:

- What is the optimum growth rate of selected groundcover plants on loam soil under Marlborough field conditions (trial plots were carefully managed to avoid water, nutrient, weed, wind, and shade stress)?
- Will the growth rate of groundcover decrease without irrigation?
- Does evapotranspiration from groundcover plants use more or less soil water compared with the bare soil evaporation?

2 Method

2.1 Trial design

We selected three perennial indigenous plants (Figure 1) based on their growth density, height, establishment speed, and hardiness. According to the literature (Foo et al. 2011; Metcalf et al. 2014; Shields et al. 2016) and nursery information, these plants form a dense mat that does not thin on the ground surface during winter. They grow medium-fast to fast, and height of mature plants is less than 0.3 m. They are all frost tolerant and free of diseases. All plants were planted directly into the ground in late spring 2021.

Veronica odora var. *prostrata* | *Muehlenbeckia axillaris* | *Coprosma propinqua* var. *martinii* 'Taiko'

Figure 1. Indigenous groundcover plants selected for the trial.

The trial consisted of 6 replicate plots of bare soil, and 10 replicate plots of each plant species. All plots were arranged in a complete randomised experimental design. Half the replicates of all treatments were hand irrigated to keep soil moisture content constantly above 60%, and the other half received rainfall only.

2.2 Trial setup

A commercially hired digger removed surface grass and the top 100 mm of soil before planting (Figure2). All plants were supplied from the nursery in 1.5-L pots (the original size of all species was 10–15 cm in diameter) and hand-planted into the ground on 11 November 2021. Each trial plot contained one plant in the centre, measured 1 m x 1 m (Figure 2). Wood chips 10-cm deep were placed on the area not yet covered by plants as a mulch to temporarily suppress weeds during the groundcover crop establishment phase. For bare soil plots, an area similar to the average plant size at planting (10–15 cm) at the centre of plots, was not covered by mulch.

Figure 2. Trial site preparation and layout.

2.3 Trial site information

The trial site was located at the Nelson Marlborough Institute of Technology, Blenheim campus. Trial plots were converted from grassland. The whole trial area was fully exposed to the sun. The loam soil was free-draining with good water-holding capacity.

2.4 Measurements

2.4.1 Soil component

The soil across the small trial site was uniform, so 15-cm deep core samples were randomly taken from various parts of the site, using a soil auger. Soil cores were combined and sent to Hill Laboratories for basic soil analysis (Appendix).

2.4.2 Soil moisture

Soil moisture was monitored with a handheld soil water probe every 2 days at the start of the trial and then every 7 days to determine if irrigation was needed to keep soil moisture content constantly above 60%. Several points around the root zone of each trial plot were measured to produce a representative result. Soil moisture was also measured before an irrigation or rainfall event to study how soil moisture was influenced by the chosen native groundcover compared with bare soil plots.

2.4.3 Groundcover plant growth rate

The growth rate of all plants was monitored monthly by taking a digital image of the whole plant. Images were processed in a machine learning software called ilastik. Figure 3 illustrates the image process steps. A few photos were hand labelled for machine training. The machine learning software analysed the colour and texture of labelled images and applied the label to future input images. Processed images were further analysed by R using "countcolors" package to extract information of plant size by counting coloured pixels of the plants calibrated against a reference card of known area.

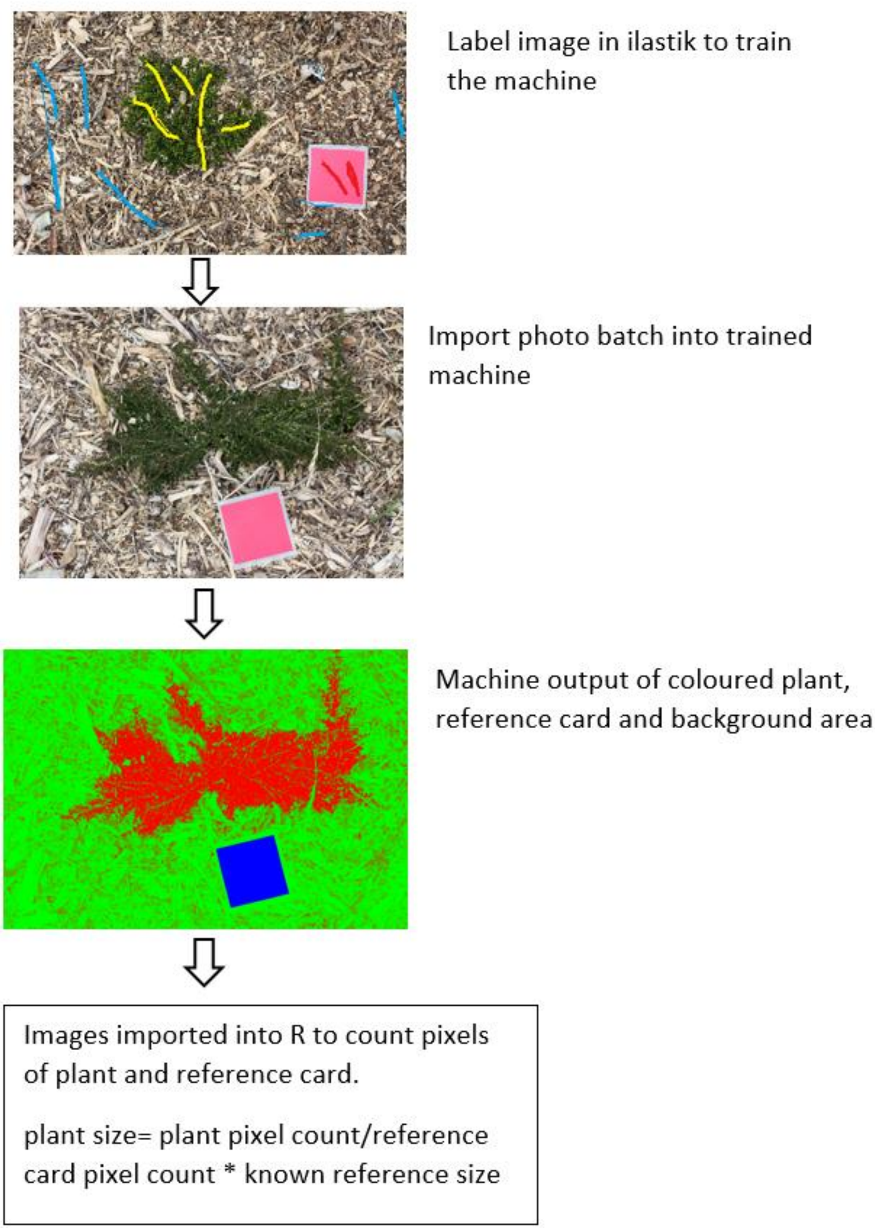


Figure 3. Illustration of machine learning image processing steps.

2.4.4 Weed suppression

Weeds growing through the groundcover canopy and on bare soil plots were counted and removed by hand every 2 months. Weeds growing outside the plant canopy were hand removed at each monitoring occasion.

3 Results

3.1 Groundcover plant growth rate

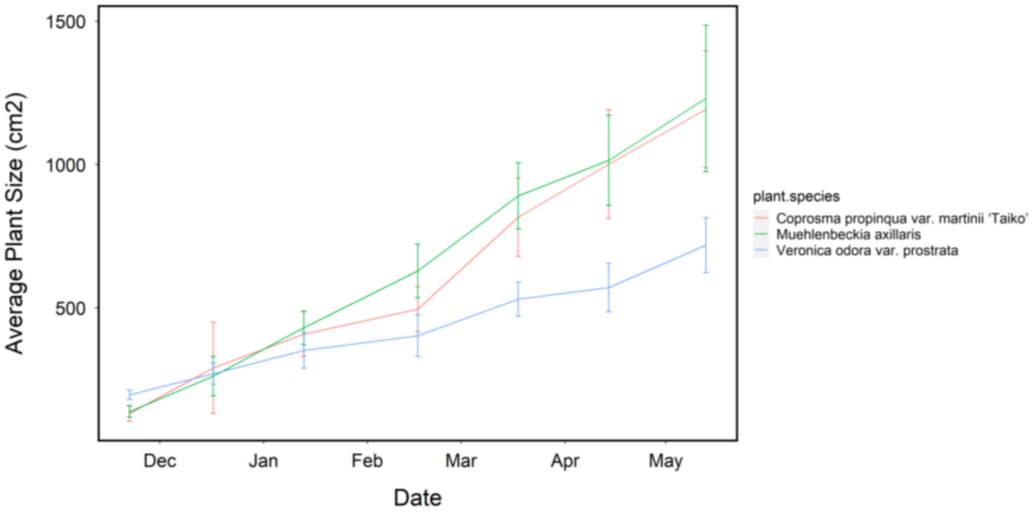
Under optimum soil moisture conditions, both *Coprosma propinqua* var. *martinii* 'Taiko' and *Muehlenbeckia axillaris* reached around 1260 cm^2, *Veronica odora* var. *prostrata* reached around 764 cm^2 after 6 months in the ground. To cover a strip of 0.4 m × 1 m surface area 6 months after planting, we would need around three Coprosma *propinqua* var. *martinii* 'Taiko', three *Muehlenbeckia axillaris* or five *Veronica odora* var. *prostrata* per metre (Table 1). None of the species grew taller than 30 cm.

Table 1. Final average plant size of the three trialled groundcover species under irrigated and non-irrigated treatments monitored by digital camera.

	Coprosma propinqua var. *martinii* 'Taiko'	*Veronica odora* var. *prostrata*	*Muehlenbeckia axillaris*	*p*-value
Irrigated				
Average plant size (cm^2)	1264.8 a[2] (212.17)[3]	763.8 b (104.7)	1263.4 a (177.64)	<0.001[1]
Number of plants needed to cover 1 m × 0.4 m strip	3.2[4]	5.2	3.2	
Non-irrigated				
Average plant size (cm^2)	1120.6 a (188.25)	673.2 b (66.33)	1198.6 a (336.48)	<0.001
Number of plants needed to cover 1 m × 0.4 m strip	3.6	5.9	3.3	

[1]Probability (*p*) values less than or equal to 0.050 are significant.
[2]Means within a row with the same letter are not significantly different (5% LSD comparison).
[3]Values in brackets are standard deviation of the mean. n = 10.
[4]Number of plants needed are calculated by: 100 (cm)*40 (cm)/average plant size (cm^2).

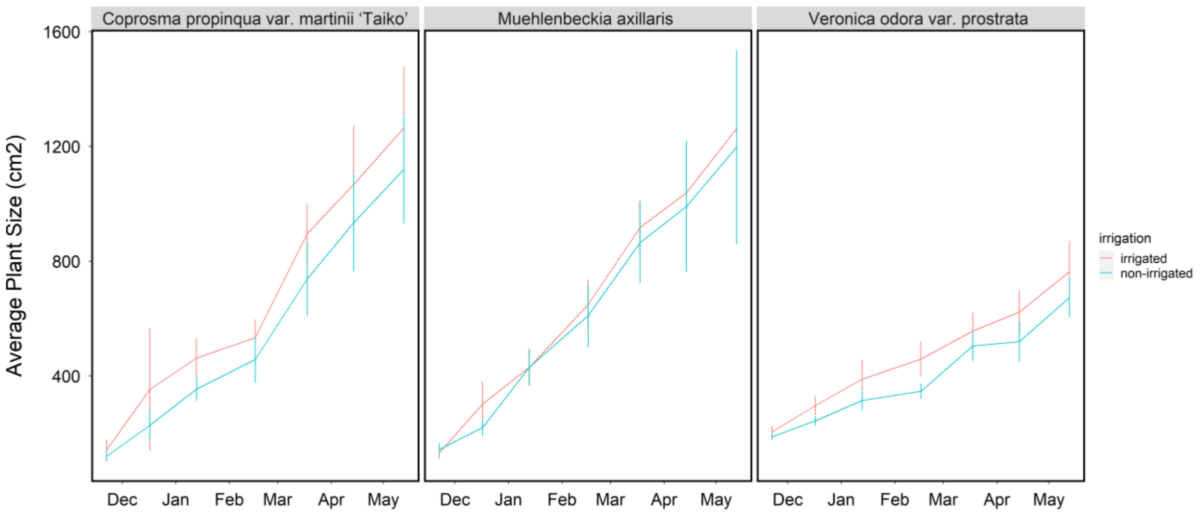
Veronica odora var. *prostrata* had the lowest growth rate and the smallest plant size at the end of the monitoring period (Figure 4). *Coprosma propinqua* var. *martinii* 'Taiko' and *Muehlenbeckia axillaris* reached similar plant sizes at the end of the monitoring period. *Coprosma propinqua* var. *martinii* 'Taiko' grew slower than *Muehlenbeckia axillaris* in January and February but caught up in mid-April.



Error bars indicate the standard deviation of the mean.

Figure 4. Average plant size of the three trialled groundcover species monitored monthly by digital camera.

Trial plots without irrigation produced on average 140 cm^2 smaller plants for *Coprosma propinqua* var. *martinii* 'Taiko' (Table 1), 90 cm^2 smaller for *Veronica odora* var. *prostrata*, and 60 cm^2 smaller for *Muehlenbeckia axillaris* after 6 months in the ground, compared with the irrigated plot. However, the differences were not statistically significant (Figure 5).

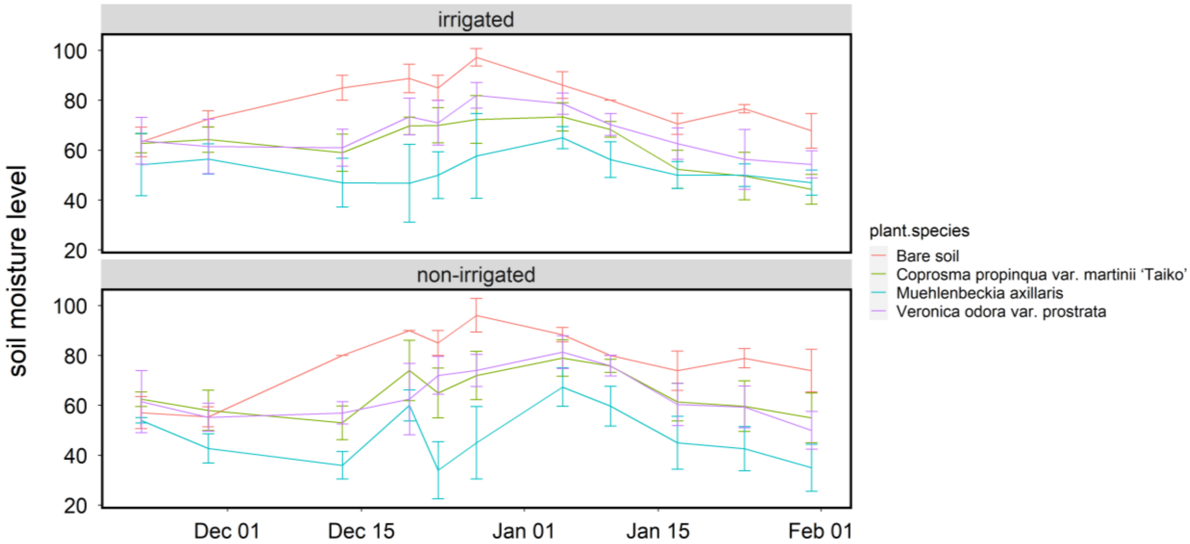


Error bars indicate the standard deviation of the mean.

Figure 5. Average plant size of the three trialled groundcover species under irrigated and non-irrigated treatment monitored monthly by digital camera.

3.2 Soil moisture impact of groundcover plants

Bare soil plots consistently had the highest soil moisture content compared with all groundcover treatments (Figure 6). Soil moisture content in *Muehlenbeckia axillaris* plots were the lowest, while *Veronica odora* var. *prostrata* and *Coprosma propinqua* var. *martinii* 'Taiko' plots had very similar soil moisture content.



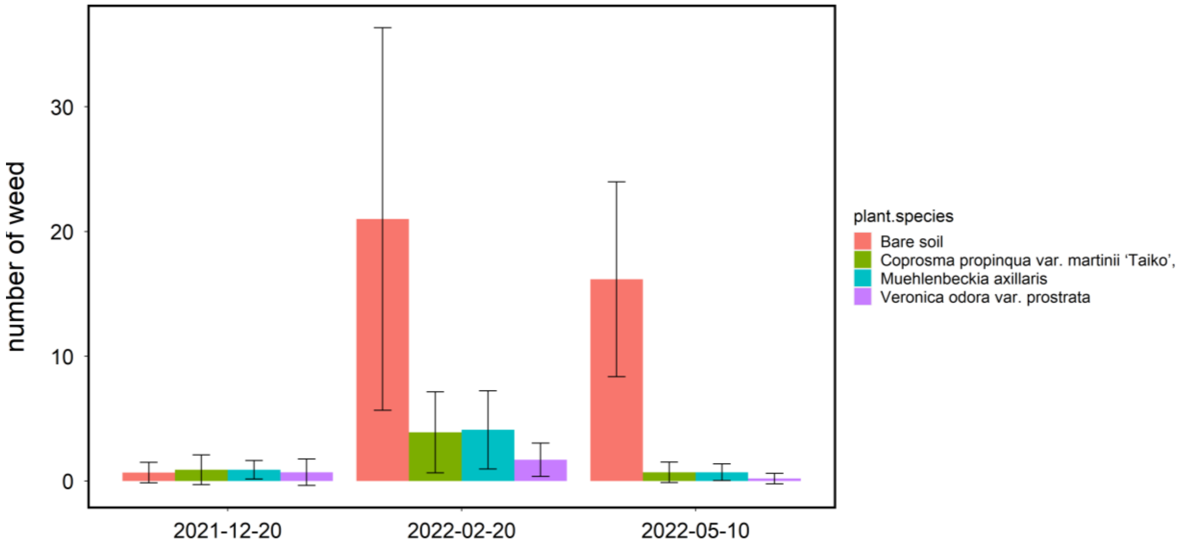
Error bars indicate the standard deviation of the mean.

Figure 6. Average soil moisture content of three groundcover species and bare soil, under irrigated and non-irrigated treatments before each irrigation event.

Within the same groundcover treatment, soil moisture content of the irrigated and non-irrigated treatments was very similar (Figure 6).

3.3 Groundcover weed suppression

Weed emergence was low 1 month after planting (Figure 7), but weeds were evident on bare soil plots 3 and 6 months after planting. The weed count for groundcover treatments was significantly lower than for bare soil treatment. The low weed count of groundcover plots indicates all three chosen groundcover species are effective at weed suppression.



Error bars indicate the standard deviation of the mean.

Figure 7. Weed count of three groundcover species and bare soil.

4 Discussion

Under stress-free Marlborough field conditions, to cover a strip of 0.4 m × 1 m surface area 6 months after planting, we would need around three *Coprosma propinqua* var. *martinii* 'Taiko', three *Muehlenbeckia axillaris* or five *Veronica odora* var. *prostrata* per linear metre. Wood chips 10-cm deep were placed around the plants to suppress weeds in the uncovered area. After 6 months, weeds started to emerge as the mulch decomposed and thinned. The mature *Coprosma propinqua* var. *martinii* 'Taiko' can grow up to 1.5 m wide, *Muehlenbeckia axillaris* 2 m, and *Veronica odora* var. *prostrata* 1 m, according to various nursery information. To reduce initial planting density – thus reduced establishment cost – it is worth testing the application of thicker or other types of longer lasting mulch. Investigating if selected groundcover plants could spread and suppress already established weedy areas may also lead to reduced planting density.

The non-irrigated treatment produced slightly smaller plants compared with the irrigated treatment. However, the difference was not statistically significant. Similar soil moisture content between irrigated and non-irrigated plots (Figure 6) indicates the irrigation did not create obvious soil moisture differences between treatments. The non-irrigated plots preserved sufficient water because of good soil water holding capacity and mulching.

Constantly higher soil moisture of bare soil plots reveals that soil water loss through groundcover evapotranspiration exceeded bare soil evaporation. Therefore, compared with having bare ground around, the horticulture crops could face more water stress with the groundcover during the groundcover establishment stage, unless sufficient water is available. It would be interesting to investigate if groundcover plants' evapotranspiration changes once they reach mature size.

The low weed count of the groundcover plots indicates all three groundcover species are effective at weed suppression.

This study is a step toward filling the knowledge gap regarding using indigenous groundcover plants. Further research is needed to overcome the many challenges, such as affordable establishment methods, maintenance, groundcover lifespan, and re-establishment, before practical application on a large scale is possible.

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Appendix. Basic analyses of soil samples collected from trial area

Analysis		Level Found
pH	pH Units	6.5
Olsen Phosphorus	mg/L	9
Potassium	me/100g	0.54
Calcium	me/100g	5.7
Magnesium	me/100g	1.48
Sodium	me/100g	< 0.05
CEC	me/100g	11
Total Base Saturation	%	73
Volume Weight	g/mL	1.07
Boron	mg/kg	0.7
Organic Matter	%	2.3
Total Carbon	%	1.3
Iron	mg/kg	332
Manganese	mg/kg	59
Zinc	mg/kg	2.7
Copper	mg/kg	2.4
Cobalt	mg/kg	1.3
Soil Sample Depth	mm	0-150
Soil Type		Sedimentary

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