Harvesting sulla for yield and quality

E.M.K. Minneé, SJ Bluett, and S.L.Woodward
Dexcel, Private Bag 3221, Hamilton

Abstract

Deciding when to harvest sulla (*Hedysarum coronarium*) can be a compromise between herbage yield and forage nutritive quality. Sulla, which grows up to 1.5 metres tall, is tolerant of dry conditions and has been shown to have beneficial effects on ruminant production and health. A trial was conducted at Hamilton, New Zealand, to compare crop yield and nutritive quality of sulla harvested when it reached 30, 45, 60 and 75 cm high (retaining a stubble of 15cm) over one growing season. Results show harvesting at 75 cm versus 30 cm increased total DM yield by 30%. Increasing harvest height increased total fibre content from 13.1 to 20.1 g/100g DM, ($P<0.001$) and lowered crude protein concentration from 18.8 to 15.7 g/100g DM, ($P<0.001$), soluble sugars from 23.1 to 21.5 g/100g DM, ($P<0.01$) and predicted organic matter digestibility from 89 to 82 g/100g DM, ($P<0.001$). These factors were associated with the decline in the proportion of leaf with increasing harvest height from 49.1 to 31.6% of harvested DM. Increased harvest height reduced the concentration of calcium and potassium in the DM by about 10% ($P<0.01$), however there was a larger reduction in sulphur concentration with increased maturity ($P<0.001$) from 0.24 to 0.18% of DM ($P<0.001$). Phosphorous and magnesium concentrations were unaffected. Total condensed tannins (CT) declined from 6.0 to 5.5 % DM with increased harvest height ($P<0.001$), but all values were within the range regarded as beneficial for animal performance. Concentrations of all nutrients indicated a very good quality forage for sheep and cattle at all harvest heights and harvesting for maximum yield may not compromise quality. These results, although agronomically important, were small and may not produce noticeable effects on animal production.

Additional key words: Condensed tannins, *Hedysarum coronarium*, harvest height, legumes.

Introduction

Sulla (*Hedysarum coronarium* L.) is a herbaceous biennial legume that contains condensed tannins (CT). The plant has a semi-erect growth habit with a capability of reaching 1.50 metres tall (Foote, 1988) and is tolerant of low fertility soils and dry conditions (Douglas, 1984). Sulla is widely used as green feed, hay and silage in Mediterranean countries, where it originated. However, it is not commonly used on commercial farms in New Zealand, despite numerous studies showing the potential benefits of feeding sulla to livestock. Woodward *et al.*, (2002) showed that dairy cows fed sulla had higher milksolids production compared with cows fed ryegrass dominant pastures. Niezen *et al.*, (1995) demonstrated higher liveweight gains, reduced faecal egg counts and lower worm burdens in sheep fed sulla compared to those fed lucerne. These benefits can be attributed to the higher nutritive value of sulla (high concentrations of soluble carbohydrate and low concentrations of fibre), and the presence of CT in the forage. Condensed tannins can prevent bloat and reduce protein degradation in the rumen (Waghorn *et al.*, 1998) to better meet the demand for high productivity (Wang *et al.*, 1996; Burke *et al.*, 2002). The high nutritive value of sulla also means that it is potentially useful as a supplementary feed in periods when the quality of ryegrass-dominated pastures declines (i.e. summer).

Sulla's main growth period is from spring to late autumn, winter growth is poor when exposed to frost. Highly variable yields and poor persistence has generally resulted in its limited use on New Zealand farms. However the potential benefits of sulla as a forage suggest the need to develop guidelines for harvesting sulla that are specifically suited to New Zealand farming systems. Sulla has been shown to perform well under a cut and removal management system, and is also well suited to ensiling. Ensiled sulla preserves well, has low ammonia levels and good aerobic stability (Niezen *et al.*, 1998), whereas grazing sulla crops is potentially hazardous as the plant's delicate crown is susceptible to trampling and overgrazing by stock, which can lead to plant loss.

This experiment investigates the effect of different harvest heights on the cumulative yield and quality of sulla over one growing season.

Materials and Methods

The trial was conducted on a mixture of silt loam soils at Dexcel's No. 5 dairy farm in the Waikato region of New Zealand. The site was prepared in March 2002 by spraying out existing pastures with Roundup® at 4 l/ha, and cultivating to prepare a fine seedbed. Bare sulla seed (*cv.* Grasslands Aokau) was inoculated with *Rhizobium hedisari* and sown by roller-drill in April 2002 at a rate of 15 kg/ha.

The experimental design comprised four treatments replicated eight times in a randomised block design, giving a total of 32 plots, each measuring 2 m x 5 m. Treatments consisted of four different target harvest sward heights: 30cm, 45cm, 60cm and 75cm. Measurements were made throughout the growing season from September 2002 to April 2003.

Mean sward height was measured weekly using a metre ruler, taking 20 random measurements per plot. Treatments were harvested when the average sward height from the eight replicate plots reached the target harvest height for that treatment.

Herbage yield was measured by harvesting a 1m strip from the centre of each plot using a ride-on rotary mower, retaining a stubble height of 15 cm. Mown samples were weighed and a sub-sample of 200g was taken, dried at 95 °C for 48 hours and reweighed to determine dry matter yield.

Prior to harvesting, 10 herbage samples were hand clipped to stubble height at random locations throughout the plot and bulked for each plot. From this, a 150 g sub-sample was frozen, freeze dried and ground through a 1mm sieve and analysed by NIRS (near infrared reflectance spectroscopy) for indicators of feed quality (Corson *et al.*, 1999) and estimation of condensed tannin concentration. A second sub-sample was dissected into sulla stem, leaf, flowers, pods, other species and dead material for estimation of botanical composition. Samples were dried at 95 °C for 48 hours and weighed to calculate the percentage of components on a dry matter basis. Treatments were compared using analysis of variance using Genstat (version 4.1).

Results

Herbage Yield

Sulla harvested at the lowest target harvest height (30 cm) had the lowest yield of 7.6 t DM/ha, from six harvests over the growing season. Increasing harvest height to 45 cm and 60cm increased yields to 8.3 and 8.6 t DM/ha respectively, and reduced the number of harvests for the season to four. The greatest total yield of 9.4 t DM/ha was achieved at the highest height of 75 cm, from three harvests over the growing season.

Botanical composition

The botanical composition of the herbage from each treatment is shown in Table 1. Percentage of other species was reduced with increased harvest height, accounting for 17.6 % of DM from the 30cm treatment, compared with 7.8 % on the 75cm treatment ($P<0.05$). Percentage of stem increased as harvest height increased, from 43.3 % on the 30cm treatment to 56.0 % of DM on the 75cm treatment ($P<0.001$). The percentage of sulla leaf was highest at the 30cm harvest height: 49.1 %, compared with 31.6 % at 75cm harvest height (P<0.001). There was no significant difference in the percentage of flowers between treatments, however seedpods accounted for 6.7 % of the DM on the 75cm treatment, which was significantly greater than any other treatment (P<0.001).

Table 1. Botanical composition of sulla sward (% of DM) and proportion of other species (% of DM) at each harvest height[a].

Harvest height (cm)	Sulla stem	Sulla leaf	Sulla flowers	Sulla pods	Other species
30	43.3	49.1	7.2	0.4	17.6
45	48.3	44.1	5.7	1.9	8.7
60	53.0	39.4	7.1	0.5	13.0
75	56.0	31.6	5.6	6.7	7.8
SED	2.55	1.34	0.82	0.55	3.07
P	<0.001	<0.001	0.355	<0.001	0.017

[a] Data averaged over all harvests.

Forage Quality

Dry matter content, chemical composition and indicators of nutritive value of herbage from each treatment are summarised in Table 2. Dry matter content was similar across all treatments, ranging from 15.0 to 15.6 % of the herbage fresh weight. The 75cm treatment had the highest neutral detergent fibre (NDF) concentration, averaging 20.1g/100g DM, compared to 13.1 g/100g DM from the 30cm treatment. Crude protein (CP) concentration was significantly higher at 30cm, averaging 18.8g/100g DM, compared to the 75 cm treatment that contained the least at 15.7 g/100 g DM (P<0.001). The concentration of soluble sugars (SSS) was similar for all treatments, ranging from 21.5 to 23.3 % g/100g DM (P<0.05). Increasing harvest height decreased estimated metabolisable energy (ME) content from 12.8 to 12.0 MJ/kg DM and organic matter digestibility (OMD) from 89.3 to 83.0 g/100 g DM. Increasing harvest height reduced the concentrations of calcium (from 1.35 to 1.27g/100g DM) (P<0.001), potassium (from 2.58 to 2.32 g/100g DM) (P<0.05) and sulphur (from 0.24 to 0.18 g/100 g DM) (P<0.001), but did not affect concentrations of phosphorous (0.26 g/100 g DM) or magnesium (0.22 g/100 g DM).

Table 2. Chemical composition and nutritive characteristics (g/100 g DM, unless otherwise stated) of sulla at each harvest height[a].

Harvestheight (cm)	DM%[1]	NDF[2]	CP[3]	ME[4]	OMD[5]	SSS[6]	CT[7]
	15.1	13.1	18.8	12.8	89.3	23.1	6.0
45	15.0	15.3	17.7	12.8	88.9	23.3	5.5
60	15.2	17.4	16.0	12.5	86.4	23.3	5.5
75	15.6	20.1	15.7	12.0	83.0	21.5	5.5
SED	0.10	0.63	0.41	0.10	0.69	0.51	0.09
P	0.005	<0.001	<0.001	<0.001	<0.001	0.005	<0.001

[a] Data averaged over all harvests.
[1] DM, dry matter
[2] NDF, neutral detergent fibre
[3] CP, crude protein
[4] ME, metabolisable energy, MJ/kg DM
[5] OMD, organic matter digestibility
[6] SSS, soluble sugars
[7] CT, condensed tannins.

Total concentration of condensed tannins (CT) declined from 6.0 to 5.5 % of DM with increased harvest height ($P<0.001$) (Table 2). On average, 94 % of the sulla CT was unbound (able to form complexes with other molecules), the remainder was bound to either fibre or protein.

Discussion

This study demonstrates that total herbage DM yield, over one growing season, is affected by harvest height. Greatest yields were achieved at the highest harvest height of 75 cm, and that decreasing harvest height resulted in herbage yield reductions. Yield reduction from the highest to the lowest harvest height was around 30 %. However total sulla yields, across all treatments, were lower than expected and much less than the 13 to 18 t DM/ha reported by Rys *et al.* (1988), and up to 20 t DM/ha by Krishna (1993). Reasons for this are unclear, but may be due to crown damage during harvesting or the low rainfall period experienced over the month of February during this trial. This further highlights the requirement for extended research into developing management guidelines for harvesting sulla in New Zealand. However, these results suggest that maximum dry matter yield will be achieved by infrequent harvesting of tall sulla.

Forage quality and condensed tannin concentration was also affected by harvest height. Increasing harvest height caused substantial reductions in CP, ME and OMD, while increasing DM content and NDF. These factors are likely to be associated with the decline in leaf proportion with increasing harvest height. However levels of ME, OMD and NDF across all treatments are within the ranges regarded as good quality forages for high producing ruminants (Kolver, 2000). Concentrations of soluble sugars were only slightly reduced at the highest harvest height, but were still much greater than levels normally found in other legume and ryegrass species (Burke *et al.*, 2000). Soluble sugars will promote rapid microbial growth, contribute to a high feeding value and are responsible for a rapid drop in pH when ensiled (Niezen *et al.*, 1998). Levels of CP in the forage from all treatments in this study are much lower than previously reported for sulla (Burke *et al.*, 2000). Total concentration of CT declined with increased harvest height. Stienezen *et al.* (1996) reported that the leaves of sulla contain the highest concentration of CT in the plant, which may account for the highest concentration of CT being observed on the 30cm treatment which also had the highest proportion of leaf material. Levels of CT found in this study were moderate and therefore likely to provide additional nutritional benefit to ruminants while not considered likely to depress feed intake (Waghorn *et al.*, 1998).

The differences in forage quality and CT concentration between harvest heights found in this study, although statistically significant, may not correspond to such noticeable benefits upon animal performance. Forages from each of the four different harvest heights were found to be of high nutritive quality. Therefore harvesting for maximum yield may not necessarily compromise forage quality. Harvesting sulla at 75 cm in height (treatment 4) achieved maximum yields of high quality forage. Although the forage comprised a high proportion of stem material, sulla is a highly palatable forage for lambs and all components of the plant are readily eaten (Stienezen *et al.*, 1996). It is recommended that the forage be chopped into 5cm lengths before feeding or ensiling to facilitate drying and to minimise wastage (G. Waghorn *pers comm.*). Sulla is an ideal forage for ensiling as it preserves well and has low levels of ammonia (Niezen *et al.*, 1998).

Allowing the sulla to reach 75 cm high also enhanced competitive ability of the crop. Sulla plots on this treatment were harvested less frequently than those harvested at lower target heights. Harvesting at all heights removed most of the sulla canopy and allowed weed species to grow; consequently the plots that were harvested more frequently (those with lower target harvest heights) contained greater proportions of adventive species.

Harvesting at specific harvest heights may provide simple guidelines for management. This study has defined yields from four different harvest heights, but the relatively low yields achieved compared with previous reports suggests a need to understand other aspects of crop management.

Conclusion

Forage quality and yield were affected by harvest height. Increasing harvest height caused reductions in CP, ME and OMD, while increasing DM content, NDF and yield. These factors are likely to be caused by the decline in leaf proportion associated with increased maturity. However forages from each treatment were found to be of high nutritive quality. Therefore, of the four harvest heights investigated in this study, a harvest height of 75 cm will produce the greatest yields of high quality forage, over one growing season.

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