Performance of *Medicago varia* cv. Gannong No.1 and *Onobrychis viciaefolia* cv. Gansu in the Mixed Agricultural and Pastoral Zone of Western China

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The 22nd International Grassland Congress (Revitalising Grasslands to Sustain Our Communities) took place in Sydney, Australia from September 15 through September 19, 2013.

Proceedings Editors: David L. Michalk, Geoffrey D. Millar, Warwick B. Badgery, and Kim M. Broadfoot

Publisher: New South Wales Department of Primary Industry, Kite St., Orange New South Wales, Australia

Presenter Information
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Keywords: *Medicago varia*, *Onobrychis viciaefolia*, herbage production, nutrient content, Western China.

Introduction

Western China is mostly covered with natural grasslands, particularly in mountainous and alpine areas. Here agriculture and grazing pastures with livestock are widely integrated. Overgrazing and forage shortages are prominent problems for animal production. Cold weather and long drought periods can also lead to serious feed shortages, especially of high quality protein forages (Liu *et al*. 2010). Planting perennial forages with high nutritive value is an important way of increasing forage supply and relieving grassland degradation. *Medicago varia* L. cv. Gannong No.1 (*Medicago*) and *Onobrychis viciaefolia* Scop. cv. Gansu (sainfoin) are examples of perennial legumes with high nutritive value that are grown in semi-arid environments in western China (Cao *et al*. 1991; Chen 1992). These 2 legumes were planted in a site typical of the mixed agricultural and pastoral zone of western China and measurements were made of over-wintering rate, plant height, grass yield and nutrient content to identify their potential to relieve grassland degradation.

Methods

The experimental area was near the town of Yeliguan in Gansu Province (34°59′N, 103°37′E). It is typical of the mixed agriculture and pastoral zone of western China, with an altitude of 2590 m, annual precipitation of 518 mm and mean annual temperature of 3.2°C. Each entry was sown at 3 sowing rates (sainfoin at 70, 100 and 130 kg/ha and Medicago at 7, 10 and 13 kg/ha) in a randomised design with 3 replications (18 plots in total). Plot area was 4.0 m^2 and row spacing was 30 cm. Sowing date was 28 April 2010, when natural grasslands were just turning green. The traits measured include phenological period, plant height, over-wintering rate (earthing treatment as a control), forage yield and nutrient contents, including crude protein (CP), crude fibre (CF), crude ash (CA), ether extract (EE), phosphorus (P) and calcium (Ca). Statistical analysis was made by SPSS (Statistical Product and Service Solutions) software.

Results

Neither forage species flowered in the seeding year, remaining vegetative throughout. Plant height of sainfoin peaked during the period 20 June to 5 July, while plant height of Medicago peaked during the period 520 July . The common trend of plant height for both species was sowing rate 1 > sowing rate 2 > sowing rate 3, indicating that sparse planting can increase plant height and prolong the accumulation of above ground biomass (longer plant growth period). The maximum forage dry matter (DM) yield of sainfoin was 3358kg/ha (for the 100 kg/ha sowing rate) and for Medicago was 1691 kg/ha (sowing rate of 13 kg/ha). Results showed that increasing plant density of Medicago can improve grass yield (data not presented). The over-wintering rate of both species was >96%, with no significant differences (P>0.05) between earthing and no earthing treatments.

Table 1 shows the nutrient contents of both forage species over time for the 3 stocking rates. After 5 August, CP and CA contents of sainfoin under different sowing rates decreased over time, but CF and EE contents gradually increased. CP content of sainfoin under different sowing rates peaked on 5 August and was lowest on 5 October. With its longer growth period, CP, CA, EE contents of Medicago under different sowing rates decreased after 5 August, but CF content was maintained and slightly increased. Its CP content under different sowing rates was maximum on 5 August and minimum on 5 October. CA and EE content showed a decreasing trend with extending the growth period and CF content gradually increased with time. In addition, P content of both species showed a decreasing trend over the whole growth period, but Ca content did not show any significant difference among the sowing rates.

Discussion

Sainfoin and Medicago showed good adaptability and had good nutritional value and moderate forage yields in the study area and both are capable of resolving the problem of a lack of forage protein in the mixed agricultural and pastoral zones of western China. These results are similar to reports by Wei (2001) and Zhang *et al.* (2011). Sowing rate had little influence on flowering, as neither species flowered in the year of seeding, a result previously observed by Zhang *et al.* (2011) and Liu (2010). This has some potential advantages, as it

Table 1. Nutrient content traits (% of dry matter) of sainfoin and Medicago under 3 different sowing rates (SR). CP = crude protein, CF = crude fibre, CA = crude ash, EE = ether extract, P = phosphorus and Ca = calcium.

Trait	SR	Sainfoin			Medicago		
		5 Aug	5 Sep	5 Oct	5 Aug	5 Sep	5 Oct
CP	1	15.97±0.26Bb	15.37±0.39Ab	14.48±0.11Aa	18.00±0.44Aa	15.35±0.12Aa	14.59±0.55Aa
	2	16.80±0.26Aa	16.09±0.22Aa	14.49±0.13Aa	18.20±0.29Aa	15.20±0.17Aa	14.12±0.35Aa
	3	16.64±0.14ABa	16.05±0.30Aa	14.68±0.15Aa	18.31±0.33Aa	15.02±0.22Aa	14.04±0.47Aa
CF	1	8.87±0.13Ab	8.69±0.16Aa	8.02±0.06Aa	12.58±0.14Ab	11.99±0.12Ab	11.43±0.11Aab
	2	9.22±0.17Aa	8.73±0.13Aa	8.06±0.13Aa	12.80±0.10Aab	12.08±0.09Aab	11.32±0.15Ab
	3	9.36±0.18Aa	8.76±0.09Aa	8.18±0.14Aa	12.84±0.13Aa	12.27±0.08Aa	11.57±0.06Aa
CA	1	16.37±0.16Aa	18.06±0.08Aa	20.61±0.11Aa	15.64±0.42Aa	18.14±0.07Aa	19.47±0.20Ab
	2	16.20±0.33Aa	18.32±0.23Aa	19.65±0.32Ab	15.34±0.23Aa	18.09±0.15Aa	19.79±0.15Aab
	3	16.15±0.04Aa	18.32±0.20Aa	20.16±0.23Aa	15.28±0.22Aa	18.31±0.11Aa	19.96±0.33Aa
EE	1	2.60±0.05Aa	2.71±0.06Bb	3.12±0.09Aa	3.28±0.06Aa	3.05±0.11ABa	2.80±0.07Aa
	2	2.51±0.07Aa	2.85±0.04Aa	2.96±0.09Aab	3.26±0.04Aa	3.22±0.11Aa	2.86±0.07Aa
	3	2.17±0.10Bb	2.85±0.05ABa	2.85±0.11Ab	3.27±0.02Aa	2.84±0.06Bb	2.74±0.05Aa
P	1	0.23±0.01Aa	0.20±0.01Aa	0.19±0.01Aa	0.24±0.01Aa	0.22±0.01Aa	0.20±0.00Aa
	2	0.22±0.01Aa	0.20±0.01Aa	0.19±0.01Aa	0.24±0.01Aa	0.22±0.01Aa	0.20±0.01Aa
	3	0.23±0.01Aa	0.21±0.01Aa	0.19±0.01Aa	0.24±0.01Aa	0.22±0.01Aa	0.20±0.00Aa
Ca	1	1.99±0.04Aa	2.11±0.09Aa	1.99±0.08Aa	3.12±0.08Aa	3.03±0.09Aa	3.39±0.07Aa
	2	2.04±0.11Aa	1.97±0.07Aa	2.01±0.09Aa	3.16±0.10Aa	3.13±0.05Aa	3.40±0.12Aa
	3	2.09±0.07Aa	2.05±0.09Aa	2.09±0.08Aa	3.10±0.06Aa	3.07±0.06Aa	3.31±0.06Aa

Different lowercase letters refer to significant differences (P<0.05) along columns or rows, while different capital letters refer to highly significant differences (P<0.01).

could allow the plants to better utilize light and heat resources to make high quality hay. Both species had high over-wintering rates, indicating they do not need certain protective measures (such as earthing) to survive the cold winters. While sparse planting increased the time available for accumulation of above ground biomass, sowing rate had little influence on growth rates, in agreement with Miao *et al.* (2009). The accumulation time of above ground biomass depends on early stage management, therefore, management should be targeted to improve their rapid growth rate, prolong growth time, and increase forage yields.

Conclusion

Sainfoin and Medicago showed good adaptability, with good nutritional value and reasonable forage yields, suggesting their potential use as forages for the amelioration of degraded grasslands in the mixed agricultural and pastoral zones of western China.

Acknowledgments

This study was funded by the China agriculture research system project (CARS-40-09B) and special funds for agro-scientific research in the public interest (20130305907).

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