Evaluation of crop production and water use efficiency of autumn-sown annual forage crops on the rainfed region of Loess Plateau China

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Keywords: Annual forage crops, water use efficiency, crop production.

Introduction

The Loess Plateau is one of the most important rainfed regions in China, but rainfall is the most significant factor limiting crop production. In this region rainfall from July to September accounts for 56% of the annual total, providing enough water resources for the growth of autumn-sown crops. Although increasing forage production with autumn sown crops is considered an important means of balancing crop forage and livestock management, suitable species with high yields and good water use efficiency (WUE) are not well defined.

The relationship between yield and water use efficiency has been shown to vary with plant species and harvest time (Siahpoosh *et al.* 2011), indicating that good water management can increase yields. It is therefore necessary to establish efficient water management strategies to increase the yield of autumn-sown crops. The objective of this study was to evaluate annual production of forage crops under autumn sowing conditions and identify their optimal WUE, based on crop production and evapo-transpiration (ET).

Methods

Study site description

The study was conducted at the Qingyang Research Station of Lanzhou University (35°40′ N, 107°51′ E, 1298 m a.s.l.), in north-west China. The dominant soil type is a sandy loam with average water content at field capacity of 0.223 kg/kg and wilting point of 0.07 kg/kg. Average annual pan evaporation is1504 mm, approximately three times greater than annual precipitation.

Experimental design and species used

Eight annual forage crops, Sudan grass (*Sorghum sudanense* cv. Fengcao No.1), soybean (*Glycine max* cv. Heifeng No.48), small millet (*Setaria italic* cv. Longgu No.11), millet (*Panicum milliaceum* cv. Longmei No.9), common vetch (*Vicia sativa* cv. Longjian No.3), pea (*Pisum sativum* cv. Lvwan No.1), oat (*Avena sativa* cv. Qingyin No.2) and spring wheat (*Triticum aestivum* cv. Longjian No.3), were examined in this experiment in 2012. Treatments were sown in 5 m x 6 m plots, arranged in a randomized complete block design with 4 replications.

Measurements

The annual forage crops were cut manually to determine above-ground biomass production every two weeks after emergence (WAE) until first frost. Soil water content was monitored at the following depths: 0−0.1, 0.1−0.2, 0.2−0.3, 0.3−0.6, 0.6−0.9, 0.9−1.2, 1.2−1.5 and 1.5 −2.0 m for each plot at 2-weekly intervals, using a neutron moisture meter. Actual ET for each crop, defined as the amount of precipitation for the period between sowing and harvesting plus or minus the change in soil water storage in the 2 m soil profile, was computed by a soil water balance equation. Drainage and run-off were both assumed to be zero.

Results

Annual forage crop dry matter production

Crop dry matter varied with species (Fig. 1). In the growing season, dry matter of sudan grass was significantly higher than the other species (P<0.05), producing 5.8 t/ha, 9.9 t/ha and 9.0 t/ha at 8, 10 and 12 WAE, respectively. Oats was the next highest producing crop from 8-12 weeks after emergence. The dry matter yield of common vetch was lower than other plants from 8-10 weeks after emergence.

Water use efficiency (WUE) and correlation of dry matter with ET

Sudan grass had the highest WUE in the growing season because it had the highest dry matter production under autumn sowing conditions, while the WUE of spring wheat was the lowest (Table 1). Correlation analysis showed that millet produced 53.2 kg/ha dry matter for each 1 mm of ET, which was the highest amongst the 8 species, followed by sudan grass. Of the dry matter variation, 91.5% was explained by ET for millet, and 83.2% for sudan grass.

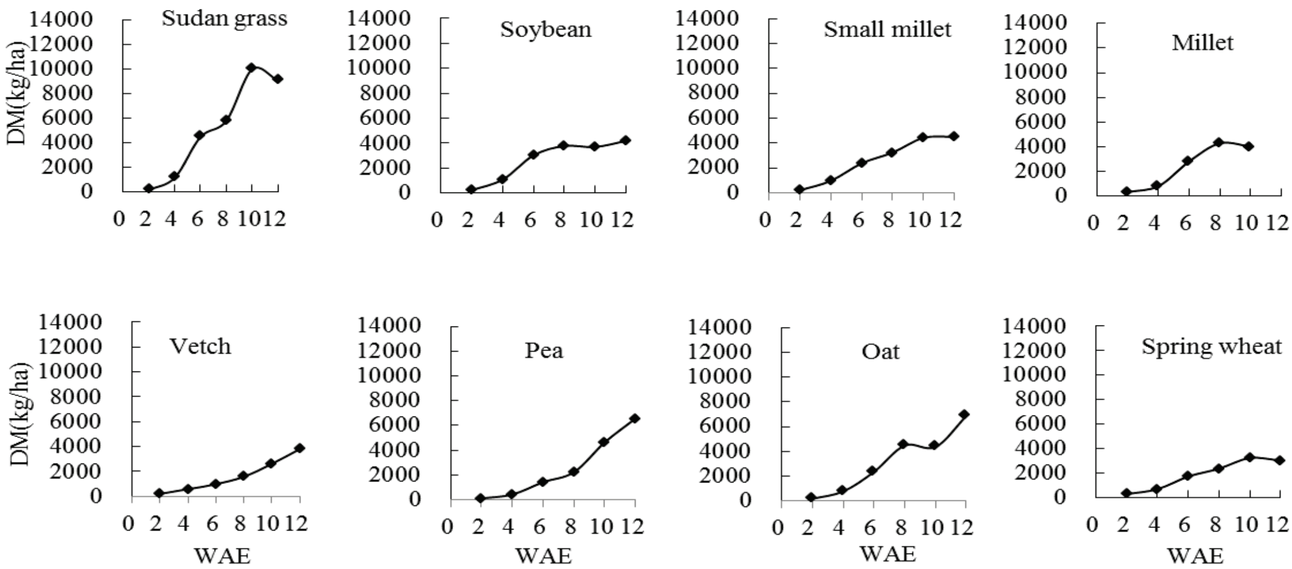

Figure 1. Dry matter accumulation (kg/ha) for 8 annual forage crop species at Qingyang, China in 2012.

Table 1. Maximum dry matter, water use efficiency and correlation parameters of dry matter with ET for 8 annual forage crop species

Crop	Maximum dry matter (kg/ha)	Water use (mm)	Water absorbed from soil (mm)	Growing season precipitation (mm)	Precipitation/ water use (%)	WUE (kg/ha/mm)	Correlation parameters[1]		
							a	b	R^2
Sudan grass	9994	226.1	42.4	183.7	81.3	44.2	51.9	-544.9	0.83
Soybean	5123	218.4	34.7	183.7	84.1	23.5	30.4	-3.0	0.89
Small millet	5844	246.9	63.1	183.7	74.4	23.7	53.2	-206.1	0.88
Millet	4900	179.4	36.0	143.4	79.9	27.3	44.0	-371.2	0.92
Vetch	3921	217.8	34.1	183.7	84.4	18.0	21.3	108.0	0.70
Pea	6651	209.4	25.7	183.7	87.7	31.8	42.8	-766.9	0.91
Oat	7715	244.7	61.0	183.7	75.1	31.5	25.6	-0.4	0.55
Spring wheat	3384	238.6	54.9	183.7	77.0	14.2	23.2	255.1	0.78

[1]Correlation equation: $y=ax+b$, where x is ET amount and y is dry matter yield of each species.

Conclusion

This study indicated that some annual forage crops were good forage resources as hay or silage under autumn-sown conditions in the Loess Plateau. Of the 8 species tested, Sudan grass was the most suitable for this purpose because it had higher yield and water use efficiency. This study also showed a positive linear relationship between evapo-transpiration in the growing season and dry matter among these forage crops.

Acknowledgements

This work was supported by the Special Program of Key Research in Science and Technology of Gansu Province, China (1203FKDA035).

References

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