

Sowing rate effects on biomass production of a forage oat in the Qinghai-Tibetan Plateau

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Abstract

Oat (*Avena sativa* L.) has been a quality forage for the livestock husbandry in the Qinghai-Tibetan Plateau. But farmers tend to use high sowing rates to avoid forage production risks, which does not always give the optimum yield. An field experiment was carried out to explore the response of dry matter production of forage oat Jiayan No.2 to sowing rates in three locations of the Qinghai-Tibetan Plateau: Tianzhu county (TZ), Haiyan county (HB) and Hongyuan county (HY). The five sowing rates were set as 30, 60, 90, 150 and 240 kg·ha⁻¹. Sowing rates had a significant effect on the biomass of forage oat. In TZ, the highest biomass at heading and milking stage was 14.96 t·ha⁻¹ and 22.93 t·ha⁻¹ under 240 and 150 kg·ha⁻¹, respectively. In HB, 15.28 t·ha⁻¹ and 16.75 t·ha⁻¹ biomass yield at heading and milk stage, respectively were observed under 60 kg·ha⁻¹. In HY, the largest biomass yield at two growth stages was up to 3.60 t·ha⁻¹ and 7.49 t·ha⁻¹ under 150 kg·ha⁻¹, respectively. However, sowing rates had no significant effect on the stem/leaf biomass ratio of the plant. Based on the findings of this study, 60 and 150 kg·ha⁻¹ had great significance on achieving high yield and it is recommended for high forage oat biomass production in the Qinghai-Tibetan Plateau.

Introduction

Forage production is the main limiting factor in the livestock production due to the extremely harsh environmental conditions of the Qinghai-Tibetan plateau China, posing a serious threat to the development of local livestock sector (Zhao and Shi., 2004, Fu *et al.*, 2013). Oats is a common annual forage crop with a good productive performance, which can effectively mitigate the situation of forage shortage and promote the development of livestock farming (Xiao *et al.*, 2014). In forage production, sowing rate is one of the important factors that affect forage yield and quality. Due to the genetic characteristics of the varieties and the differences of the production regions, too high and too low sowing rate are not conducive to the growth and development of the forage. Therefore, planting density is of great significance to promote high yield and good quality of forage. The objective of this experiment was to evaluate the responses of DM yield and growth features of a forage oat Jiayan No.2 at three sowing rates in the Qinghai-Tibetan plateau.

Materials and Methods

The experiment was conducted at three locations: Tianzhu county, Gansu province, Haibei county, Qinghai Province and Hongyuan county, Sichuan province, the sites descriptions were shown in table 1.

It was a randomized complete block design with five sowing rates (30, 60, 90, 150 and 240 kg·ha⁻¹) with four replications. Forage oat (*Var.* Jiayan No.2) seeds were sown by hand at a row space of 20 cm on the 13th May 2019 in 18 m² (3 m × 6 m) plots in each site. The distance between two adjacent plots was one meter. At the heading and milk stage, 1 m length of row was randomly sampled from within the plot away from the edge by cutting. The fresh weight of the stem and leaf were measured after partitioning. All plant samples were oven-dried for about 48 hours at 80- to a constant dryness to determine the dry weight, the stem/leaf ratio and biomass were calculated respectively.

Table 1. Site description

Sites	Location	Elevation (m)	Annual temperature (-)	Annual precipitation (mm)	Soil AN (mg/k)	Soil AP (mg/kg)	Soil AK (mg/k)
Tianzhu, Gansu(TZ)	37°09'N-102°51'E	2742	-0.1	416.0	310.2	17.4	104.2
Haibei, Qinghai(HB)	36°58'N-100°51'E	3156	0.5	369.1	88.0	10.2	168.2
Hongyuan, Sichuan (HY)	32°47'N-102°34'E	3504	1.1	738.0	450.0	6.8	198.0

Results

Biomass yield

Sowing rates had a significant effect on the biomass production for forage oats in three locations of the Qinghai-Tibetan Plateau. In TZ, under sowing rate of 240 kg·ha⁻¹ at heading stage had biomass yield of up to 14.96 t·ha⁻¹, which was higher than under 30 and 60 kg·ha⁻¹ by 40.6 % and 28.8 % respectively ($P<0.05$), but the 150 kg·ha⁻¹ sowing rate at milk stage had biomass yield of up to 22.93 t·ha⁻¹, which was higher than under sowing rate of 30, 60 and 90 kg·ha⁻¹ by

32.0 %, 29.5 % and 26.4 % respectively ($P<0.05$). In HB, the biomass yield under sowing rate of 60 kg·ha⁻¹ had the maximum value at both heading and milk stage, up to 15.28 t·ha⁻¹ and 16.75 t·ha⁻¹ which was higher than under sowing rate of 30 kg·ha⁻¹ by 43.9 % and 31.8 % respectively ($P<0.05$). In HY, the biomass yield under sowing rate of 150 kg·ha⁻¹ had the maximum value at both heading and milk stage, being 3.60 t·ha⁻¹ and 7.49 t·ha⁻¹, which was higher than under sowing rate of 30 kg·ha⁻¹ by 30.2 % and 37.1 %, respectively ($P<0.05$) (Figure 1).

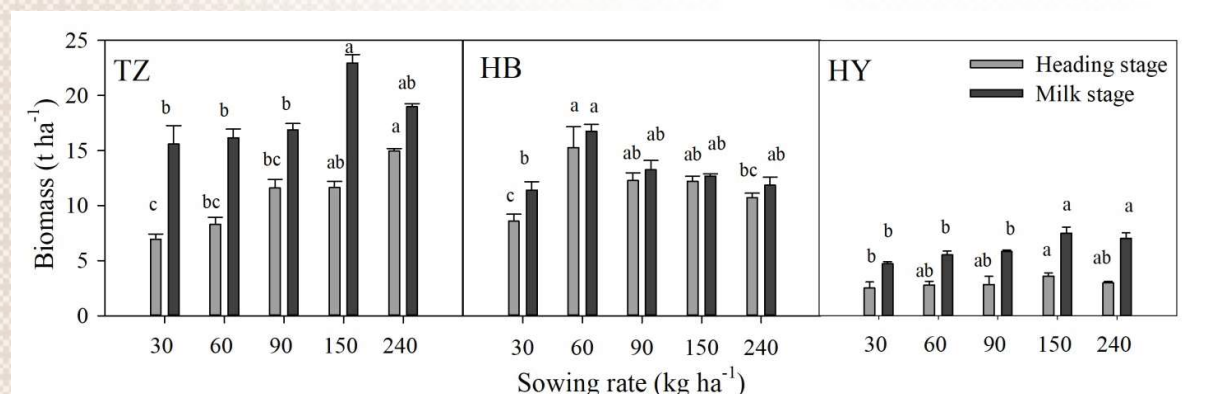


Figure 1: Biomass yield of forage oat under five sowing rates in three locations of the Qinghai-Tibetan Plateau

Note: Different lowercase letters indicates that the indexes of oat at different sowing rates are significantly different at 0.05 level.

Stem/leaf biomass ratio

There was no significant effect of sowing rate on the stem/leaf biomass ratio of the oat in three sites

in the Qinghai-Tibetan Plateau ($P>0.05$). stem/leaf biomass ratio of forage oat under sowing rate at 60 and 150 kg·ha⁻¹ were up to the maximum at both heading and milk stage in HB and HY respectively, it had for 240 and 150 kg·ha⁻¹ separately had the minimum value at heading and milk stage in TZ (Table 2).

Table 2: Stem/leaf biomass ratio of forage oat under five sowing rates in three locations of the Qinghai-Tibetan Plateau

Sowing rate (kg·ha ⁻¹)	Sites					
	TZ		HB		HY	
	Heading stage	Milk stage	Heading stage	Milk stage	Heading stage	Milk stage
30	1.37±0.13a	3.70±0.23a	1.67±0.27a	3.56±0.34a	1.40±0.13a	2.38±0.11b
60	1.52±0.07a	3.94±0.27a	1.84±0.12a	3.81±0.23a	1.66±0.36a	2.88±0.53ab
90	1.39±0.16a	3.55±0.11a	1.57±0.49a	3.68±0.09a	2.14±0.58a	3.45±0.61ab
150	1.51±0.04a	3.39±0.07a	1.34±0.56a	3.59±0.21a	2.30±0.06a	4.08±0.15a
240	1.37±0.03a	3.74±0.12a	1.33±0.13a	3.57±0.26a	1.64±0.04a	3.41±0.22ab

Note: There are significant differences in different lowercase letters in the same column at the 0.05 level.

Discussion

Sowing rate is an important factor to ensure high yield and quality of forage, in global wide, the DM production of oat increased 14 % with the increasing of sowing rate, the greatest DM yield was not always achieved with the increase of sowing rate. These results are similar to what was reported in a previous study (Jing *et al.*, 2019). The low yield at the low sowing rate could be attributed to fewer seeds being sown, while poor light transmittance of the sward may limit tillering by the plants which could prevent achieving high yield at the high sowing rate. Therefore, adopting reasonable planting density can promote the growth of plants and increase the number of effective plants to achieve high yield of forage. In addition, this study also showed obvious regional effects, with biomass of forage oat having different optimum sowing rates in different regionals, and the biomass of TZ and HB was significantly higher than that of HY. This may be caused by the elevation of HY is the highest and rainfall pattern is more variable in the year, which had an negative effects on the biomass production of oat. The region of high altitude may need high sowing rate to reproduce forage oat production.

Stem/Leaf biomass ratio is one of the indexes to measure the quality of forage, where higher leaf can improve the quality of forage and improve the palatability (Gong *et al.*, 2019). This study showed that the sowing rate had no significant effect on the stem/leaf biomass ratio of forage oat Jiayan No.2, which is consistent with previous research (Lin *et al.*, 2019). Therefore, sowing rate had little effect on quality in this study.

Sowing rate had a significant effect on the biomass yield of forage oat in the Qinghai-Tibetan Plateau, while different sowing rates had no significant effect on the stem/leaf biomass ratio. Therefore, through comprehensive analysis we recommend that sowing rate of 60 kg·ha⁻¹ in Heibei, Qinghai province, 150 kg·ha⁻¹ both in Tianzhu, Gansu province and Hongyuan, Sichuan province for forage production of forage oat Jiayan No.2 to promote the sustainable livestock pastoral system in the Qinghai-Tibetan Plateau.

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