



University of Kentucky
UKnowledge

International Grassland Congress Proceedings

XXIV International Grassland Congress /
XI International Rangeland Congress

Forage Yield of Oat on the Four Altitude Regions of the Qinghai-Tibetan Plateau

H. B. Zhang
Lanzhou University, China

C. T. Liu
Lanzhou University, China

J. Q. Deng
Lanzhou University, China

X. L. Yang
Lanzhou University, China

Follow this and additional works at: <https://uknowledge.uky.edu/igc>



Part of the [Plant Sciences Commons](#), and the [Soil Science Commons](#)

This document is available at <https://uknowledge.uky.edu/igc/24/2-2/29>

This collection is currently under construction.

The XXIV International Grassland Congress / XI International Rangeland Congress (Sustainable Use of Grassland and Rangeland Resources for Improved Livelihoods) takes place virtually from October 25 through October 29, 2021.

Proceedings edited by the National Organizing Committee of 2021 IGC/IRC Congress

Published by the Kenya Agricultural and Livestock Research Organization

This Event is brought to you for free and open access by the Plant and Soil Sciences at UKnowledge. It has been accepted for inclusion in International Grassland Congress Proceedings by an authorized administrator of UKnowledge. For more information, please contact UKnowledge@lsv.uky.edu.

Forage yield of oat on the four altitude regions of the Qinghai-Tibetan Plateau

Zhang, H. B.; Liu, C.T.[†]; Deng J. Q.[†]; Yang, X. L.*

* State Key Laboratory of Grassland Agro-ecosystems, College of Pastoral Agriculture Science and Technology, Lanzhou University, Lanzhou 730020, P. R. China

[†]Corresponding author: yangxianl@lzu.edu.cn

Key words: Forage oat; Dry matter; Absolute growth rate; Leaf area index (LAI); Biomass

Abstract

Forage oat (*Avena sativa* L.) for livestock in Qinghai-Tibet Plateau may be used biomass under widely different altitude conditions. To assess the effect of altitude on the biomass of oats, we conducted an experiment to explore the adaptability of forage oat Jiayan No. 2 in different altitudes for better agronomic traits and higher forage yield. Four regions included Hezheng county (2207 m a.s.l) and Tianzhu county (2407 m a.s.l), Gansu province, Haiyan county (3042 m a.s.l), Qinghai province and Hongyuan county (3460 m a.s.l), Sichuan province were selected, and agronomic data as well as dry matter yield were determined. The results showed that the phenology of heading stage was between 75-80 days after sowing in four regions. The growing degree-days (GDDs) at the heading stage decreased with the increasing of altitude. There was significant difference among Hezheng, Tianzhu, Haiyan and Hongyuan. The plant height of forage oat was 116.67 ± 2.18 , 119.47 ± 1.92 , 101.52 ± 3.51 , and 59.04 ± 6.86 cm, respectively. The leaves area index (LAI) of oats was 3.60 ± 0.61 , 4.78 ± 0.91 , 6.41 ± 0.96 and 1.08 ± 0.24 , respectively. The forage yield was 11.96 ± 2.98 , 11.35 ± 1.58 , 11.99 ± 0.84 and 2.17 ± 0.36 t·ha⁻¹. The absolute growth rate (AGR) of biomass was 27.15 ± 6.96 , 24.84 ± 3.61 , 35.63 ± 3.10 and 4.94 ± 0.95 g·m⁻²·d⁻¹, respectively. From perspective of forage yield and plant height, planting forage oat below 3500 m a.s.l is a preferable way to stabilize forage production in Qinghai-Tibet Plateau.

Introduction

Livestock production is the main industry in Qinghai-Tibet Plateau. However, low yield and the low quality of forages particularly limit local livestock production. Oat (*Avena sativa* L.) is a widely used cool-season annual forage in China and globally (Favre et al., 2019). Oat forage can be used for hay, pasture, or silage. Therefore, it is beneficial to cultivate forage oat in Qinghai-Tibet Plateau for livestock during the winter.

However, the forage production is restricted by the high altitude. As the altitude rises, the temperature gradually decreases. Temperature and altitude are important factors affecting crop production in this area. Previous studies mainly focused on the effect of sowing date or fertilizer of forage oat production (Luo et al., 2017). Few studies reported the effect of different altitudes of Qinghai-Tibetan Plateau. In this research we quantized absolute growth rate (AGR) that account for forage oat dry matter accumulation per day in order to compare different regions at different altitudes and altitude. This also enabled the time when forage oat production is optimized when cultivated in different regions. We are unaware of other studies that have applied similar approaches to calculate integrated yield and altitude for forages in Qinghai-Tibetan Plateau.

Therefore, the objective of this study is to determine the effect of growing degree-days (GDDs) in different altitudes on the forage oat production by analysing the forage oat plant height, biomass, LAI, and absolute growth rate (Amanullah et al., 2017).

Methods and Study Site

Field experiments were carried out during mid-May to late-September in 2019 at Hezheng (35.39 °N, 103.29 °E) and Tianzhu (37.16 °N, 102.85 °E) counties, both in Gansu Province, Haiyan county (36.98°N, 100.88°E) in Qinghai province as well as Hongyuan county (32.78°N, 102.53°E) in Sichuan province. The mean annual precipitation of the four regions were 592.8, 416.0, 369.1, and 738.0 mm, respectively. The mean annual air temperature of the four regions were 5.8, -0.1, 0.5, and 1.1 °C, respectively. The four altitude were 2206.9, 2769.0, 3042.0, and 3460.0 m (a.s.l).

The seeds of the forage oat variety (Jiayan No. 2) were obtained from the grassland research institute of Qinghai animal husbandry and veterinary academy. The forage oat was planted at seeding rate of 90 kg ha⁻¹ and inter-row distance of 20 cm. Sowing date were 24, 20, 13, and 26th May at Hezheng, Tianzhu, Haibei, and Hongyuan, respectively. All plots were kept free of weeds by hand hoeing.

The experimental design was randomized complete block design with four locations and four replications in each location. These resulted in 16 plots and each plot had a land area covering 18 m² (3 × 6 m). After the forage oat sprout at a distance of 5 rows from the edge of each plot, 10 plants were randomly selected and identified. Plant height was measured in cm from soil surface to tip of the panicle. The leaf area index (LAI) of each plot was measured using a model LP-80 plant canopy analyser (ACCUPAR LP-80, METER Group, Inc. USA). Forage oat was mowed when 50 percent of the plant was at heading stage and the biomass was sampled from 1 m-length randomly at a distance of 5 rows from the edge of each plot. Sampled plants were placed in an oven for half an hour at 105 °C to kill the fresh tissues and then dried at 65 °C to a constant weight to determine the biomass yield. The absolute growth rate (AGR) was calculated as the net accumulation of biomass per unit area per time: $AGR = (DM_2 - DM_1) / (t_2 - t_1)$ (g m⁻²) / (t₂-t₁) (d) where DM₂, DM₁ represents dry matter in heading stage and seeding stage. t₂-t₁ is the time (day) the forage oat attained the next stage. The temperature data was obtained online from the China Meteorological Data Service Centre (<http://data.cma.cn>) and it was used for the determination of growing degree days (GDDs).

Analysis of variance (ANOVA) was used to analysed the data using SPSS 25.0. Differences between the means of plant height, biomass, LAI and AGR were compared using Fisher's Least Significant Difference test at 5% probability level ($P < 0.05$).

Results

The growth period for heading stage at the four regions was shown in **Table 1**. Forage oat from sowing to heading stage spent 75, 80, 79, 79 d in Hezheng, Tianzhu, Haiyan, Hongyuan, respectively. The local growing degree-days (GDD) of heading stage was 1164.6, 1097.7, 882.8, 819.5 °C, for the different locations accordingly. With the rising altitude, the GDD tend to decrease gradually. However, the forage oat almost used the same period to reached heading stage.

Table 1. The phenological period of forage oat among different regions in 2019

Location	Sowing date (Day Month)	Seedling stage (Day Month)	Heading stage (Day Month)	Growth period for heading stage (d)	Local GDDs of heading stage (°C)
Hezheng	24 May	25 Jun	7 Aug	75	1164.6
Tianzhu	20 May	24 Jun	6 Aug	80	1097.7
Haiyan	13 May	30 Jun	30 Jul	79	882.8
Hongyuan	26 May	5 Jun	13 Aug	79	819.5

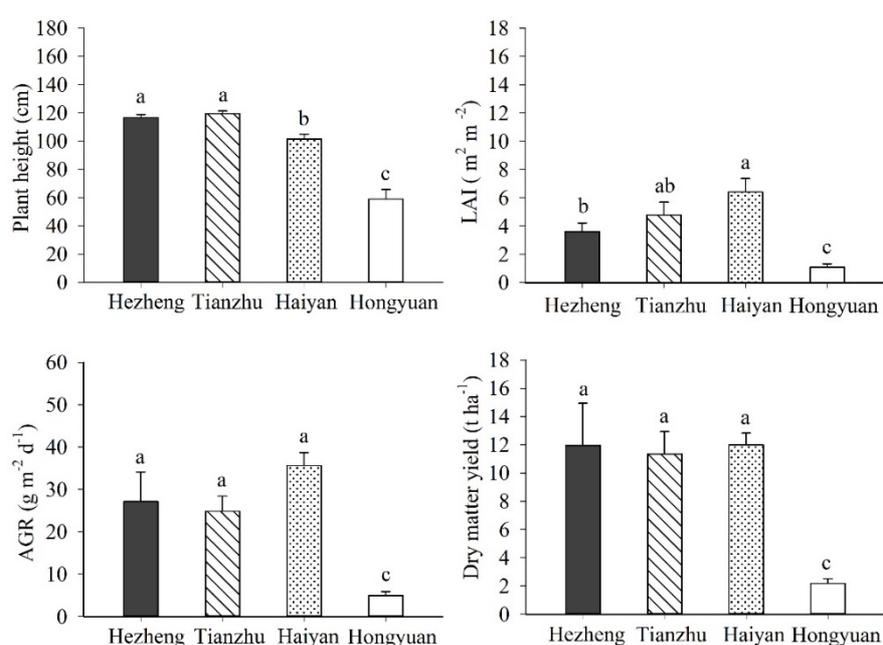


Fig. 1. Plant height, LAI (leaf area index), AGR (absolute growth rate), and dry matter yield at heading stage in the growing season of 2019. Values presented are means with standard error bar. Different letters indicate significant differences between treatments ($P < 0.05$)

Fig. 1 shows the mean plant height of forage oat when the forage was mowed at heading stage. The highest mean plant height was found in Tianzhu county with values of 119.47 ± 1.92 cm, which is more than that of Hezheng county, Haiyan county, Hongyuan county by 2.41% 17.68% and 102.35%, respectively. Leaf area index (LAI) was presented on **Fig. 1**. The mean values of LAI were 3.40 4.78 6.41 and 1.08 for Hezheng, Tianzhu, Haiyan, Hongyuan, respectively. Haiyan county has the greatest ($P < 0.05$) LAI of the forage than the other regions. The AGR of the forage oat at Hezheng county, Tianzhu county and Haiyan county were statistically similar, but greater ($P < 0.05$) than that of Hongyuan county. The dry matter yield of the forage oat at the four different regions were 11.95 11.35 11.99 and 2.17 t ha⁻¹, respectively. There is no significant difference between Hezheng county, Tianzhu county and Haiyan county. Meanwhile, the forage dry matter yield at Hongyuan county was less ($P < 0.05$) compared to the other regions. Forage oat showed greater dry matter at Hezheng county, Tianzhu county and Haiyan county than Hongyuan county, we conclude that forage oat Jiayan No.2 performed better at these three regions.

Conclusions

This study we used absolute growth rate that account for forage oat dry matter accumulation per day and compared various regions with different altitude in the Qinghai-Tibetan Plateau. We found that there are significant prospects to planting forage oat Jiayan No.2 below the altitude of 3500 m a.s.l to enhance livestock production in the Qinghai-Tibetan Plateau. The result showed that forage oat variety Jiayan No.2 had the highest dry matter yield in Haiyan county region.

Acknowledgements

This research was funded by the China Forage & Grass Research System (CARS-34). The authors would like to thank the staff of institute of Qinghai animal husbandry and veterinary academy, Sichuan Academy of grassland sciences for their assistance with the work. The authors would also like to thank the editor and anonymous reviewers for their valuable comments and suggestions, which substantially improved the manuscript.

References

- Amanullah, K., B, A.S., Lal, K.A. and Khalid, N., 2017. Impact of variable NPK source on water use efficiency and growth rates of winter grasses (cereals): *Wheat, rye, barley and oats*. *African Journal of Agricultural Research*, 12(49): 3421-3432.
- Favre, J.R., Albrecht, K.A., Gutierrez, L. and Picasso, V.D., 2019. Harvesting Oat Forage at Late Heading Increases Milk Production per Unit of Area. *Crop, Forage & Turfgrass Management*, 5(1).
- Luo, C., Wang, S., Zhao, L. and Xu, S., 2017. 7-Seeding ratios and phosphate fertilizer on ecosystem carbon exchange of common vetch and oat. *Nutrient Cycling in Agroecosystems*, 109(2): 149-160.