Cutting dual-propose winter wheat in rainfed regions of western China

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Abstract

The conventional rainfed farming system of western China has a lack of green forages in early spring, restricting livestock production. To explore if winter wheat could be used as a dual-purpose crop and provide forage in early spring, an on-farm experiment was conducted at Qingyang, China. Winter wheat (*Triticum aestivum* cv Xifeng No.19) was sown in mid September of 2008, three cutting date treatments were imposed April 15 (stem elongation), May 3 (floral initiation) and May 17, 2009 (anthesis), and a no-cutting control. Cutting treatments delayed maturity by up to 14 days and reduced grain yield by between 66 and 96 % compared to the control. The total forage dry matter production was 1200 kg/ha, 1964 kg/ha and 2209 kg/ha, for stem elongation, floral initiation and anthesis respectively. The water-use efficiency for grain production of the control was 6.14 kg/ha.mm while cutting at stem elongation and floral initiation induced a 68% and 76% decrease. Water-use efficiency of biomass production was 14.85 kg/ha.mm for the control, and cutting for forage at stem elongation and floral initiation reduced the water-use efficiency by 38% and 36%. It is concluded that winter wheat cut at elongation could carry one sheep unit with a diet of 2 kg/d for 40 d and yield 642 kg/ha of grain. The delay in maturity caused by the spring biomass harvest would significantly impact on farm management with fewer opportunities to use contract harvesters and a delayed planting of summer crops.

Key Words

Winter wheat, grazing, yield

Introduction

In the western Loess Plateau of China, a lack of green forage in early spring has been a historical issue after winter. This lack of green forage inhibits the growth and birth of pen-fed livestock resulting in delayed livestock economic development. Winter wheat is the main grain crop in Qingyang, Gansu with 40 million hectares sown annually in the region. Winter wheat is sown as a grain-only crop and the possibility of using winter wheat as a dual-propose forage-plus-grain crop to fill the spring feed gap in Northern China has not been explored.

Wheat maintains an important dual-purpose role in agriculture in the USA (Shroyer 1993; Redmon 1995), where at least 2.4 million hectares were used on the southern Great Plains (MacKown 2005). Epplin (1998) reported that almost two-thirds of the Oklahoma crop was intended for dual-purpose. Wheat grazing is also practiced in other countries; Argentina, Australia, Morocco, Pakistan, Syria, Uruguay and the Mediterranean (Rodriguez 1990; Forster 1931). Early studies reported no yield loss from grazing (Forster and Vasey 1931; Swanson 1935) but more recent reviews have shown lower yields from grazed crops than from grain-only crops (Redmon et al. 1995). In Australia, yield loss from grazing was correlated with the length of grazing and loss of reproductive primordia. Yield increases were associated with delayed phenology, deferred water use and reduced lodging (Virgona et al. 2006). A hypothesis that grazing would not reduce grain yield was based on the idea that reduced leaf area leads to less transpiration and the conserved soil water would be used later to fill grain with high water-use efficiency (Angus and van Herwaarden 2001). We undertook a preliminary cutting trial following local practices of cut and carry to assess the impact of defoliation on grain yields.

Methods

Experimental location

The site was located at Qingyang, Gansu China (35?40′N, 107?52′E; elev.1298m). The soil is Heilu soil (Zhu et al. 1983) with a surface (0-30 cm) pH of 8.2, organic matter 6.6 g/kg, total N 0.8 g/kg and a bulk density of 1.24g/m^3.

Design and treatments

Wheat (*Triticum aestivum* cv Xifeng No.19) was sown under conventional tillage on 24 September 2008, at a rate of 225 kg/ha with row spacing of 15 cm. Organic manure fertilizer was applied at 600 kg/ha and urea was drilled at a rate of 187.5 kg/ha in April 2009. Three cutting-date treatments were imposed: April 15 (C1), May 3 (C2), May 17 2009 (C3) and an uncut control (CK). Phenology stages corresponding to the 3 times of cutting were stem elongation, floral initiation and anthesis. A randomized complete block design with 5 replicates was used; each plot area was 3 m ? 3 m.

Sampling procedure and data analysis

Forage sampling removed 6 rows of 1m length (area: 1m?0.9m) by hand cutting the wheat at ground level to simulate local forage collection practices. Regrowth was measured at maturity from the same area where the previous cuts were taken. Both forage and regrowth was partitioned into leaf, stem and head then dried at 80?C for 48 h. The soil was sampled from each plot both at sampling and maturity. Soil samples were collected to 2.5 m (0-10, 0-20, 20-30, 30-60, 60-90, 90-120, 120-150, 150-200, 200-250 cm) and dried at 105?C for 48 h for soil water and at 40?C for 48 h for nutrient analysis. Water-use efficiency (WUE) for grain was calculated at maturity, WUE of dry matter production combined the forage biomass and final crop biomass. A one-way ANOVA was used for analysis of variance and difference between treatments using Genstat (GenStat Committee 2000).

Results

Weather

During the growth period (October-June) 223 mm of in-crop rain fell, with above-average rainfall in June and July of 2009. The maximum (34.7℃) and minimum (21.4℃) temperatures were slightly above the long-term averages.

DM yield at maturity and forage yield in spring

Cutting delayed the grain maturity compared to the control, which was harvested on June 20, while the maturity dates for the three cuts were July 4, July 7, July 14 respectively. Grain and straw yield was greatly reduced under the spring cutting treatments: grain yield of the control was 1946 kg/ha while the three cutting treatments decreased in yield by 66%, 86% and 96% respectively. There was significant difference in the harvest index between treatments, and this value became lower the later the cutting date (Table 1). Total forage dry matter production was 1225 kg/ha, 1964 kg/ha and 2210 kg/ha, for the 3 cutting times (Table 1).

Table1. Forage yield of spring and DM yield at maturity (kg/ha).

Treatment	Forage	Straw	Grain	Harvest index
CK		3283	1945	0.35

C1	1225	1497	667	0.20
C2	1964	855	263	0.09
C3	2209	397	70	0.03
LSD(P=0.05)	*396*	*279*	*215*	*0.02*

Water balance

Water-use efficiency (WUE) of grain production for the control treatment was 6.14 kg/ha.mm and 14.9 kg/ha.mm for biomass production. The WUE of grain production decreased with each cutting treatment. The water-use efficiency of biomass production was not as consistent with the C2 treatment having a WUE of 9.5 kg/ha.mm .

Table 2. Rainfall, soil water and water use efficiency (WUE).

Treatment	Rainfall (April-15 to maturity) (mm)	∆ soil water (mm)	WUE in grain（kg/ha?mm）	WUE in DM (forage +maturity)（kg/ha?mm)
CK	77.2	12.4	6.1	14.9
C1	86.9	0.5	1.9	9.2
C2	86.9	-20.4	0.9	9.5
C3	118.6	-52.9	0.2	7.6
LSD(P=0.05)	*23.5*	*23.5*	*0.7*	*1.6*

Discussion

Using winter wheat crops in a dual-purpose mode could significantly reduce the late-winter, early-spring feed gap. This work shows 1226 kg/h of valuable green feed was available at stem elongation, which could provide five sheep a diet of 2 kg/d for at least 120 days. However, the impact of this biomass removal on grain yield was severe. The yield reduction observed was in excess of 66% compared to the control and was far greater than the yield reductions (4 ? 20%) presented by Virgona et al. (2006) in their review of 134 comparisons. The impact of grazing on dual-purpose wheats is variable and strongly correlated to the severity and length of grazing (Virgona et al. 2006). In contrast, Gansu farmers cut and carry forages; this imposes a uniform defoliation and removal of reproductive primordia. This low cutting height combined with late cutting dates and the drier than average season may explain the results of this experiment.

This experiment challenges the accepted practice of growing wheat for grain, to growing wheat for forage and grain. However, the large grain reduction is difficult for farmers to accept and the increased time to maturity impedes the efficient management of the rotation. Contract harvesters are only available for a short period so delays in wheat maturity can prevent farmers from having a mechanical harvesting option. However, if an earlier, less severe cutting or a grazing of the wheat crop can reduce the impact on wheat yields, while still providing valuable forage for animals, an increase in household income will result. If current livestock prices remain high, farmers may choose to graze animals on winter wheat despite the potential yield losses and purchase grain to make up the shortfall. This will, however, require a significant shift in household thinking that sees self-sufficiency in grain a priority.

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