Effect of forage brassica on subsequent soil water content and yield of dual-purpose winter wheat in rainfed region of Northwestern China

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Keywords: Loess Plateau, rotation, productivity, yield.

Introduction

The dual-purpose performance of winter wheat used for both forage and grain production has been explored as an alternative practice for filling the feed gap during winter and spring in agricultural areas of the Loess Plateau. Profitability is still restricted however, because of a three month summer fallow period between harvest and planting of the subsequent wheat crop. During this 3 month period 60% of the annual precipitation occurs, limiting the effective use of soil water and compounding the risk of soil erosion. Thus it is important to cultivate some forage crops with higher water consumption, protecting the ecological environment during this period and enlarging the forage resource base through their high forage yield and good quality. A previous study has shown that inclusion of rapeseed into crop rotations could reduce disease in subsequent plantings, leading to an increase in production of the following wheat crop (Brendan and John 2004). Accordingly, dual-purpose winter wheat after forage brassica may be an effective option to meet these requirements. Other studies have shown however, that wheat yield of grazed plots following brassica was reduced by 29% compared with that of grazed plots following fallow, and that average grain yield in grazed plots was reduced by 38% compared with that in ungrazed plots (Kelman and Dove 2007). Additionally, the possibility of severe water stress occurring after forage crop harvest is an important concern. In this study, soil moisture status and forage and grain yield of dual-purpose winter wheat following forage brassica were investigated and compared with those of winter wheat after fallow.

Methods

The experimental trial was established at Qingyang Loess Plateau Research Station of Lanzhou University (35°40 N, 107°52 E; altitude 1298 m a.s.l.) in Gansu Province of China. One plot (1300 m^2) was fallowed after winter wheat harvest until the next sowing, while another plot with the same area was planted with forage brassica (*Brassica campestris* cv. Hunter) on July 22, and harvested at ground level on September 24, 2011. All stubble was removed from the field. Immediately after the forage Brassica harvesting, two different rotation practices, fallow-winter wheat (FW) and brassica-winter wheat (BW), were differentiated and winter wheat was sown in both plots on September 26, 2011. During the wheat growth season, three treatments were performed, an uncut control (No-Cut) and 2 cutting treatments in which the wheat was cut at tillering stage, one was on November 29, 2011 (Cut 1) and another on April 26, 2012 (Cut 2). Cutting was at 2 cm above ground level. The treatments were arranged in a randomised complete block design with 4 replicates, with a plot size of 3 m by 3 m.

The water content of 3 soil layers (0-60; 60-120 and 120-200 cm) at wheat sowing and harvesting was measured by tin method. The biomass of wheat forage after cutting was measured by sampling 3 rows (1 m× 0.15 m×3) of wheat from the centre of each plot. At wheat maturity, grain and straw yields were measured and harvest index and kernel weight were calculated.

Results

Soil water status at wheat sowing and harvest

Precipitation during the growing seasons of brassica and winter wheat were 273 mm and 233 mm, respectively, and the long-term average precipitations (1961-2002) of these two seasons were 299 mm and 249 mm, respectively. There was no significant difference in soil water content between FW and BW at wheat sowing in 2011 (Table 1), indicating that forage brassica didn't extract significantly more soil water when compared with fallow, most likely due to rainfall replenishment, making forage brassica a good choice to gain additional forage and utilise the soil water during summer fallow.

A similar trend occurred at wheat harvesting when rotations were compared (Table 1), showing that the integration of forage brassica didn't influence the water use of the subsequent winter wheat crop. When rotation treatments were taken into consideration, a significant difference was only observed in the 120-200 cm soil layer, indicating less water descended under the BW rotation. Therefore, dual-purpose use of winter wheat following forage brassica could greatly improve water use efficiency.

Forage yield after cutting, grain and straw yields at harvest

No significant difference was found in wheat forage yield between FW and BW (Table 2), indicating that these different rotations had no impact on wheat growth. Both

Table 1. Soil water content of 3 layers (0-200 cm) under different rotations and cutting treatments

Rotation	Cutting date	0-60 cm layer (mm)		60-120 cm layer (mm)		120-200 cm layer (mm)	
		sowing	harvest	sowing	harvest	sowing	harvest
	No-cut	172.2	68.8	178.1	80.0	235.9	115.3
FW	Cut 1	172.2	67.7	178.1	69.1	235.9	115.4
	Cut 2	172.2	68.1	178.1	84.4	235.9	116.4
	No-cut	159.8	68.2	173.5	79.3	234.4	106.9
BW	Cut 1	159.8	70.1	173.5	79.6	234.4	105.9
	Cut 2	159.8	70.4	173.5	85.4	234.4	101.8
F-probability	Rotation	NS	NS	NS	NS	NS	**
	Cutting date	-	NS	-	NS	-	NS
LSD (*P*=0.05)	Rotation×Cutting date	14.94	10.9	7.88	12.3	14.5	9.68

Table 2 Forage, grain and straw yields of winter wheat under different rotations and cutting treatments

Rotation	Cutting date	Forage yield (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index	1000-Kernel (g)
	No-cut	-	5446	6892	0.40	18.44
FW	Cut 1	329.0	4853	6997	0.36	16.29
	Cut 2	1650.3	6693	8048	0.42	17.44
	No-cut	-	5667	7948	0.38	18.26
BW	Cut 1	400.7	4475	6650	0.35	17.85
	Cut 2	1755.4	5293	6201	0.41	18.40
F-probability	Rotation	NS	*	NS	NS	*
	Cutting date	**	**	NS	*	*
	Rotation×Cutting date	NS	*	*	NS	NS
LSD (*P*=0.05)	Rotation×Cutting date	362.7	846	1402	0.06	1.15

Notes: * $P<0.05$, ** $P<0.01$

wheat grain yield and kernel weight were greatly influenced by the rotation and cutting date, but straw yield was not. The grain yield of No-cut in BW was slightly higher than in FW. The grain yields of Cut 1 under FW and BW were 10.9% and 21.1% less than with No-cut, whereas the grain yields of Cut 2 were increased by 22.9% under FW and reduced by 6.6% under BW (Table 2). Using winter wheat for dual-purpose use in spring did not lead to significant reductions in grain yield.

Conclusion

In this experiment, precipitation during the growing seasons was not different from the long-term average precipitations, indicating that it was a normal year. Forage brassica did not consume significantly more soil water than fallow and the forage productivity of dual-purpose wheat was not influenced by its inclusion in the rotation. Al though a slight grain yield penalty was observed, a large amount of forage was available, suggesting that the introduction of forage brassica during summer fallow period could be a favourable practice for filling the feed gap during winter and spring, increasing the profitability of farms in agricultural areas of the Loess Plateau.

Acknowledgements

This work was jointly supported by the grants from the Australian Centre for International Agricultural Research (LWR/2007/191) and the Special Programme of Key Research in Science and Technology of Gansu Province, China (1203FKDA035).

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