Yield and N content response of winter wheat to 2 fallow lengths after 4 years of lucerne in the Gansu Loess Plateau, China

Yu-Ying Shen[1], Chong-Yue Gao[1], Zhi-Biao Nan[1], Bill Bellotti[2], Wen Chen[2], Ya-Li Zou[1], Murray Unkovich[2], Michael Robertson[3] and Merv Probert[3]

1 College of Pastoral Agriculture Science and Technology, Lanzhou University, Key Laboratory. of Grassland Agro-Ecosystem,
Lanzhou 730020 , P.R. China), www.lzu.edu.cn Email: yy.shen@lzu.edu.cn
2 School of Agriculture and Wine, University of Adelaide, Roseworthy Campus, SA 5371,Australia www.adelaide.edu.au)
3 CSIRO Sustainable Ecosystems/APSRU, QLD 4067, Australia www.CAE. CSIRO.au

Abstract

A field experiment was conducted from 2001 to 2003 to determine the yield and N-content response of winter wheat after 4 years of lucerne in the Gansu Loess Plateau. Fallow lengths had no effects on the sequent wheat yield in 2002 and 2003 (p> 0.05). Fertilizer application significant increased winter wheat yield after lucerne removal. With N application, grain yields (3.71 t/ha for short fallow, 4.43 t/ha for long fallow) and straw yields (7.11 t/ha for short fallow, 8.17 t/ha for long fallow) were higher than those without N (3.15 t/ha or 3.33 t/ha grain for short or long fallow, 5.85 t/ha or 5.19 t /ha straw for short or long fallow). Neither fallow length nor N application had significant effects on nitrogen content of grain or straw for the first winter wheat (P>0.05).For the second wheat crop, N application did not increased straw yield but significantly improved grain yield (P<0.05). However previous fallow length and N application had significant effect on N content of grain for the second winter wheat,. N content of straw under short fallow or long fallow with N application was 68% or 24% higher than that without N application.

Media summary

Fallow lengths had no effects on wheat yield after lucerne removal in the Gansu Loess Plateau. Fertilizer application significantly improved sequent crop yield

Key words

Dryland farming; rotation;

Introduction

Lucerne (*Medicago sativa* L) has a long cultivation history in the Loess Plateau of China. It plays an important role for developing sustainable farming systems because of its high yield, quality forage, and soil nitrogen enhancing ability to improve soil N status through N_2 fixation. In 2003, the total area sown in lucerne around the country was 200 million ha, and reached 0.53 million ha in the western Loess Plateau. Crop yield reductions were found after lucerne because of soil water deficits in the profile (Gao 1994; Li et al., 2000; Hirth, 2001). The yield losses varied depending on soil condition, rainfall pattern, and rotation systems used. There has been little research looking at impact of the time of long-term lucerne stands removal on crop yield and quality in the Loess Plateau. A field experiment was conducted in the Xifeng, Gansu to examine the effects of fallow length after 4 years of lucerne on the wheat yield and N content.

Material and methods

Experiment site

The experiment was conducted at the Qingyang Experimental Station (35?40'N, 107?51'E, elevation 1 298m a.s.l) of Lanzhou University, which is located on the rainfed agricultural production zone of the western Loess Plateau in China. The long-term average annual precipitation is 561mm. The highest and

lowest extreme temperatures recorded were 40? in July and -23? in January. The mean annual crop growing season is 255d. The soil is a sandy-loam with 70% silt and 23% clay.

Experimental design

A lucerne (*Medicago sativa* cv Longdong) ley was established in the spring of 1998 with sowing rate of 15 kg/ ha In 2001, lucerne was dug out on 13th May 2001 for the long fallow treatment (LFl), and on 17th August for the short fallow treatment (LFs). Winter wheat (*Triticum aestivum* L. cv Xifeng 24, W stands for winter wheat below) was sown on 14th September 2001 and then again on 18th September 2002 for the second crop. To determine fertilizer effects on wheat growth, a split plot design was used with LFl and LFs as main treatments and fertilizer application (123 N kg/ha) as sub-treatment. Plot size was 20 m by 4 m, each with 4 replicates.

Crop yield measurement and plant N analysis

Grain yield and dry matter of straw were measured at harvesting on plot base. Harvesting was conducted by sickle. Edge effect was discarded at harvest. Thousand-grain weight was measured in the laboratory. N% of grain and straw were determined by distillation method.

Statistical analysis

A split plot design with time of lucerne removal as main treatments and N application as sub-treatments, was used to analyze data on wheat yield and plant N concentration in 2002 and 2003 using Statistica for Windows (release 4.5, Stat Soft Inc., 1993). Differences between treatments with level of probability greater than 0.05 were considered non-significant.

Results

The plots experienced a dry year in 2000; a wet autumn in 2001; a wet late spring in 2002; and a dry spring and summer, and a wet autumn in 2003 (Fig. 1).

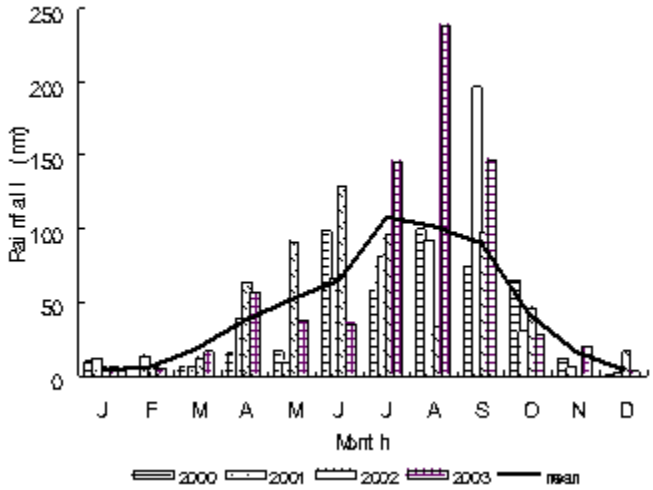

Fig. 1 Monthly rainfall during 2000-2003 at Xifeng , Gansu province, China

Winter wheat yield

Fallow lengths had no effects on the first wheat yield. Grain yield under LFsW was 187 kg /ha lower than that under the LFlW, but straw yield was 263 kg/ha higher ($p > 0.05$) than that under the LFlW. Fertilizer

application significantly increased both grain and straw yield (P<0.05). For short fallow treatment (LFsW), grain and straw yields with fertilizer application were 562 kg/ha and 1096 kg/ha respectively higher than those without fertilizer application. For long fallow treatment (LFlW), a increase of 1261 kg/ha on grain and 2583 kg/ ha on straw with N application were found compared with those without fertilizer (Fig 2). But there was no significant difference in HI and 1000-grain weight (data was not shown). Fallow lengths again did not influence grain and straw yields for the second wheat crop in 2003. N application increased grain yield (P<0.05) but did not affect straw yield (Fig.2).

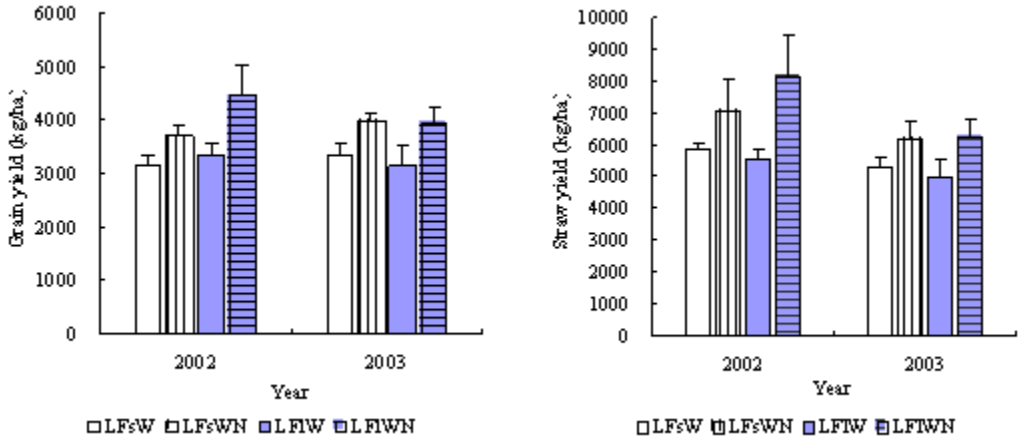

Fig. 2 Grain and straw yield of winter wheat under 4 treatments: Lucerne removed on 13th May 2001 and winter wheat sown in 2001 and 2002 with 0 N (LFlW) or with 138 N kg /ha (LFlWN); Lucerne removed on 17th August 2001, winter wheat sown in 2001 and 2002 with 0 N (LFsW) or with 138 N kg/ha (LFsWN)

N content of grain and straw

Neither fallow length nor N application had significant effects on nitrogen content of grain or straw for the first winter wheat crop (P>0.05). Previous fallow length and N application had significant effects on N content of grain for the second winter wheat crop. There was no significant difference on N content in straw between long fallow and short fallow (P>0.05), N content of straw under LFsWN or LFlWN was 68% or 24% higher than that under LFsW and LFlW (table 1).

Table 1 Grain and straw N content (? se) of winter wheat after 4 years lucerne in the Gansu Loess Plateau

Treatment year	N in grain (%)		N in straw (%)	
	2002	2003	2002	2003
LFsW	2.63?0.03	1.77?0.09[a]	0.52?0.03	0.28?0.02[b]
LFsWN	2.61?0.02	2.53?0.05[b]	0.54?0.04	0.47?0.01[a]
LFlW	2.56?0.00	1.44?0.04[b]	0.48?0.01	0.23?0.01[b]

LFlWN	2.67?0.02	2.31?0.11[a]	0.52?0.03	0.48?0.03[a]

For treatment code meaning sees figure 2

Discussion

Crop yield loss after lucerne in the lucerne-cereal rotation system due to soil water deficit has been reported (McCallum, 2001). Previous research revealed fluctuating yield loss of the first wheat crop after lucerne from 0 to 0.87 t/ha, with an average of 0.40 t/ha. Yield loss decreasing with each year after lucerne as the soil profile was progressively recharged by rainfall (McCallum, 2001). Hirth et al. (2001) reported that the first crop yield after lucerne was strongly dependent on rainfall during the growing season. Our result illustrated that previous fallow length after 4 years lucerne i.e. lucerne removed in May or in August had similar effect on the first winter wheat yield. There was a total of 196 mm rainfall received in September, 2001, which recharged soil water content in the soil profile and improved soil moisture situation. For the second wheat crop, all plots received same rainfall and soil profile started with a similar water content (Fig.3), the yields had no response to previous fallow length again. However, fertilizer had a significant effect on the first wheat crop yield after lucerne, indicating yield response to fertilizer for the first wheat could be due to combined effects of P and N as P deficit after perennial lucerne is very common. Previous research revealed that N nutrition problem to crop after lucerne is more important than annual legume. Hirth et al. (2001) reported that autumn mineral N concentrations peaked 1-2 years after lucerne removal. The relatively weak response of straw DM to N supply in the second crop in this study might support his finding..

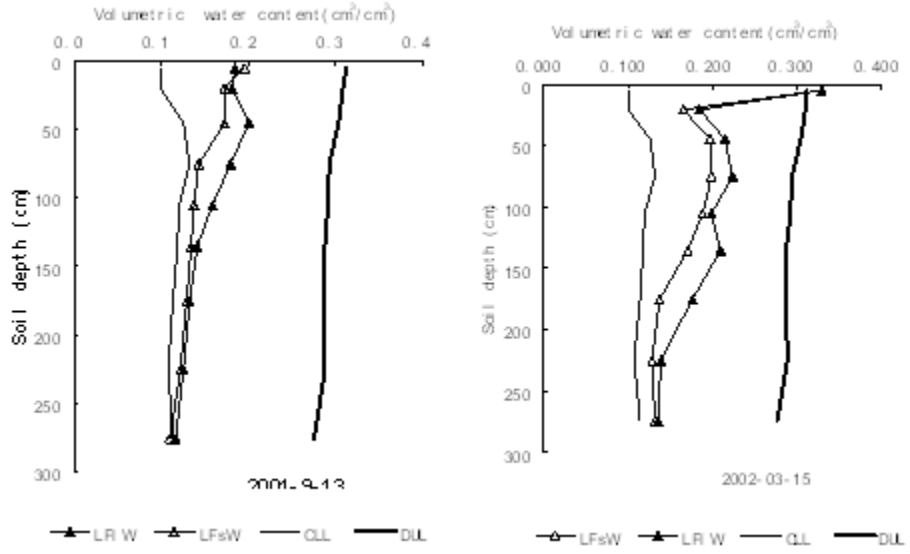

Fig.3 Soil water content at soil profile in March, 2002

Conclusions

No fallow effects were detected on grain yield and straw yield for the winter wheat crop after 4 years of lucerne in the Gansu Loess Plateau in 2001 to 2003. Additional N supply significantly increased grain and straw yields and maintained the N contents of grain and straw for the first winter wheat.

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References

Gao CY (1994). Practical significance of rotation. In: Ren J.Z. (Ed) China-Australia Gansu Grassland Agricultural Systems Research and Development Project. Gansu Sci. & Tech. Press, Lanzhou, pp.56-61.

Hirth JR., Haines PJ, Ridley AM and Wilson KF （2001). Lucerne in crop rotations on the Riverine Plains, 2. Biomass and grain yields, water use efficiency, soil nitrogen, and profitability. Aust. J. Agric. Res. 52, 279–293.

Li FR, Zhao SL, Geballe GT (2000). Water use patterns and agronomic performance for some cropping systems with and without fallow crops in a semi-arid environment of northwest China. Agriculture Ecosystems & Environment. 79, 129-142.

McCallum MH, Connor DJ, O'Leary GJ (2001). Water use by lucerne and effect on crops in the Victorian Wimmera. Aust. J. Agric. Res. 52, 193-201.