

# Integrating Forage into Traditional Farming System in the Western Loess Plateau, China--Challenges, Constraints and the Future

Yuying Shen
*Lanzhou University, China*

Murray Unkovich
*The University of Adelaide, Australia*

Zhibiao Nan
*Lanzhou University, China*



**The 21st International Grassland Congress / 8th International Rangeland Congress took place in Hohhot, China from June 29 through July 5, 2008.**

Proceedings edited by Organizing Committee of 2008 IGC/IRC Conference

Published by Guangdong People's Publishing House

# Integrating forage into traditional farming system in the western Loess Plateau , China —Challenges , constraints and the future

*Yuying Shen*[1] , *Murray Unkovich*[2] , *Zhibiao Nan*[1]
[1] *College of Pastoral Agriculture Science and Technology , Lanzhou University , Key Laboratory of Grassland Agro-Ecosystems , Lanzhou 730020 , China , E-mail : yy shen@ lzu .edu .cn*
[2] *School of Earth and Environmental Science , University of Adelaide , Roseworthy SA 5371 , Australia*

**Key points :**
1 . Integrated systems involving grain crop-forage and ruminant animals may strike a balance between the imperatives of increasing productivity and income whilst reducing soil erosion in the Loess plateau
2 . Significant achievements in crop-forage integration have been made in the region
3 . Small scale households need starting capital for livestock production
4 . Relatively steady government policy would help the integration system to further develop

**Key words :** forage legume farming system , *Medicago sativa* , resource use efficiency

**Introduction** The Loess Plateau in China , covers about 400 ,000 $km^2$ over 17 provinces and dryland farming accounts for 80-88% of the total 16 .91 million ha of arable land in the region ( Li et al . , 1990) . The region has a long farming history and some parts have been cultivated for around 6000 years . Severe soil erosion together with high rainfall variability require constant management responses . It has been reported that soil erosion in the region can range from 3720 t $km^{-2}$ $year^{-1}$ to a maximum of 120 ,000 t $km^{-2}$ $year^{-1}$ , the highest in China ( Liu , 1999) . For years , subsistence farming systems generated limited cash income for the regions farmers . Official figures have shown that the regional GDP is 68 million RMB yuan , with a net income per capita only 70% of the country s average , furthermore some 10 million people are considered to be living in conditions of poverty within the region . Together these factors highlight the retarded economy and vulnerable ecological environment of the Loess Plateau .

An integrated farming system including grain , forage , cash crops and livestock has been proven to be suitable for sustainable development and food security ( Entz , et al 2005) . Experiences from other countries around the world such as India , Uruguay and Argentina provide successful examples of different integrated farming systems which have accomplished sustainability on both environmental and economic fronts .

The objective of this paper is to show potential ways to respond to the problems existing in the region . Given the unique nature of the Loess Plateau , we would like to show what sort of constraints exist to further implementation of integrated farming systems , and future prospects for integrated farming systems in the region .

**Food security insuring** Livestock systems have been a major component in agricultural systems as far back as 4000 years ago in the Loess Plateau . Livestock and cultivation systems have changed over time , frequently driven by food demand and population pressure up until late 1950 s Great Leap Movement , when monoculture grain systems became the dominant system , and continue to be so today ( Dang et al ,2007) . These monoculture grain systems have contributed to low soil fertility , with wheat yields as low as 430 kg .$ha^{-1}$ in some of the growing areas ( Yang , 2007) . Feeding the population has always been the first priority in China . By the end of 2010 , the population in the Loess Plateau is predicted to be around 360 million . It is estimated that grain demand for the region will be 140 thousand t based on 400 kg per capita ( Yan & Lei , 2007) . Meanwhile , the limited land resources available for arable farming in the region has been a struggle faced for centuries , to highlight this , while China s population has increased to 1275 million from 669 million , arable land has decreased to 36 million ha in 2005 , from 105 million ha in 1961 , with an average of 0 .11 ha per capita . This is much lower than the average of other developing countries and of the world average ( Yang , 2006) .

For thousands of years livestock production in most parts of China has been dominated by a pig-grain crop system ( Ren et al , 2005a) . Within this pig-grain system , humans and pigs share the same grain supply , resulting in increased overall grain requirement . With a forage-crop-ruminant livestock system , for cut or carrying utilization , ruminant livestock ( cattle , sheep and goat) are fed by forage crops and the food grains consumed by humans Such forage-crop-ruminant livestock systems have been recognized as a major direction for agricultural development for north-western China ( Ren et al , 2005b) . The system incorporates such features as better water use efficiency , and environmental friendliness and sustainability than pig-crop systems ( Qian , 2005) , and can take full advantage of the nutrition efficiency in agriculture , reduce the pressure on food security and optimize food structure . If 20% of total land are allocated for forage production within a farming system , total primary vegetative production can be two times higher than grain production only , one third of pig production could be replaced by the herbivores , and production efficiency is further improved ( Ren et al , 2005) . The ratio of pigs to herbivore livestock in the region would be close to that seen in Europe and North America . The whole of China's grain output has grown steadily , with meat and milk yield particularly increasing in recent years , suggesting that grain production proportion could be reduced by

planting forage crops without affecting protein production as protein output of a legume forage is 7 times that in cereal grain .

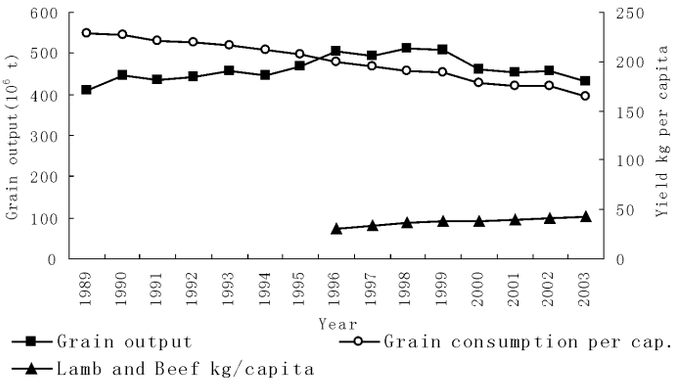


**Figure 1** *Grain output in total , grain consumption per capita and meat yield per capita in China (Ren et al , 2005)*

**Environmental perspective** Soil fertility , erosion and siltation problems are high priority environmental issues for the region . Research in the region has shown that diverse forage-grain-rotations can deliver increased protection of land and water resources , and increase the productivity and well-being of rural communities by raising productivity whilst reducing soil erosion . Primary productivity on the Loess Plateau is driven by rainfall (within temperature constraints) , but the water is frequently used inefficiently , often with high runoff and erosion resulting in lost production . A fundamental research goal is to increase resource use efficiency within farming systems , raising productivity whilst reducing soil erosion . Forage crops can be key elements of these new farming systems . Compared with grain crops , wheat in particular , both annual or perennial forage crops have better productivity during the autumn , thus , rainfall use efficiency and radiation use efficiency for forage are relatively higher . In recent years , lucerne (*Medicago sativa* L) has become one of principle legumes in the region with high yield and good quality fodder , it s planting area reached 519 thousand ha in 2005 in Gansu Province , a 31% increase in 2001 .

Soil N fertility is another indicator of environmental quality . It was reported that N fertilizer use efficiency was only 30% ~ 35% , with excessive accumulation of $NO_3$-N in the soil profile below the crop rooting depth , this is due largely to unbalanced and excessive use of N fertilizers within grain monocultures , and application rates of 500 kg ha/yr , five time over the crop requirement . in many places was reported (Yang , 2006) . On the other hand , unfertile sloping land , did not receive fertilizer N (Yan & Lei , 2007) . However , lucerne has significant beneficial impacts on soil nitrogen use and carbon sequestration . Within a lucerne-wheat rotation production system , residual soil N after a lucerne phase was available for following crops , reducing $NO_3$ N leaching and waste and increasing N use efficiency (Table 1) .

**Table 1** *Grain yield , N content , WUE , N balance for winter wheat crop within lucerne-winter wheat rotation system (Xifeng , Qingyang city , Gansu) . Values followed bythe same letter within a column are not significantly different by analysis of variance .*

| Wheat growth year after lucerne | N rate for wheat (kg/ha) | Grain yield (t/ha) | N in grain (kg/ha) | WUE in grain (kg $ha^{-1}$ $mm^{-1}$) | N input (kg/ha) | N output (kg/ha) | N budget (kg/ha) |
|---|---|---|---|---|---|---|---|
| The first year | 0 | 3 .15a | 3 .34a | 6 .3 | 4 .8 | 112 .43 | -107 .63 |
| | 138 | 3 .71ab | 4 .43b | 7 .5 | 142 .8 | 161 .20 | -18 .40 |
| The second year | 0 | 3 .35 | 3 .34a | 6 .0 | 4 .8 | 55 .90 | -51 .10 |
| | 138 | 3 .98 | 4 .43b | 7 .1 | 142 .8 | 121 .07 | 21 .73 |
| The third year | 0 | 3 .72a | 3 .35 | 9 .9a | 4 .8 | 62 .28 | -57 .48 |
| | 138 | 5 .89b | 3 .98 | 15 .8b | 142 .8 | 96 .59 | 46 .21 |

**Government policy supporting firmly** Successful integrated farming systems depend on policy support . The Chinese government has been focused on food grains , rural support and environmental concerns across the Loess Plateau and in the other parts of the nation since 2001 . Central government strategies aim to reduce farmer reliance on grain production , increase the production of cash crops and livestock and relocate farming villages to more fertile lands (Unkovich & Nan , 2008) . Subsidies of 100 kg

grain , 50 RMB cash per mu (1 ha equals 15 mu) or nursery seedling distribution (part of the subsidy is to provide seedlings to farmers in exchange for farmland retired to forage or forest land) . This is known as the grain for green campaign , which has encouraged change in usage of slopeland from grain production to pasture or woodland . More ruminant livestock have been raised after this land use conversion in order to maximize resource use . Consequently livestock production supported by a cut and carry forage system has provided substantial economic benefits . Local governments made a regulation declaring that only those who planted pasture has a right to share the returns from that pasture , whereas previously , all converted land were collective property , and individual farmers had no utilization rights (Dong , et al 2005) .

The National Ecological Restoration agenda claims that some 50 million ha of degraded grassland should be revegetated by 2030 , including new sown pasture in the cropping area . By the year 2010 some 3 .2 million ha , one third of slopeland , will be converted into green land in the Loess region (Liu & Su , 2006) , this land will have the dual functions of forage production and supporting ecological sustainability (Ma et al , 2007) .

**Economic perspective** OECD (2005) stated that while China has advantages to develop labor intensive farming , it is disadvantaged to develop land intensive farming , like grains and fruits . This effectively means that the basic Chinese farming system is likely to change from a traditional grain dominant production to a mixed farming system . Within an intensive integrated farming system in the region , 47% of income derived from livestock production is considered to be a viable economic structure (Ren , et al 2005a) . In terms of the fragility of the physical conditions of the western Loess Plateau , It is suited to the development of a selective grain farming system , with environmental protection forestry and commercial forage production operating within the global economy (Zhang &Liu , 2007) . Geographically , the western Loess Plateau (located in central China) has advantages to transport forage and livestock products to other parts of the country , and the forage output from the integration system could feed into forage deficient northern China and the Tibetan Plateau which has resulted from rangeland degradation (Ren , et al 2005b) .

**Diversity of integration farming system in the region** With precipitation and soil types varying across the region , crop types , livestock and cash crop systems are diverse . Taking Qingyang and Dingxi city for example , both located on the Gansu Loess Plateau . Qingyang has higher annual rainfall than Dingxi , and here a maize-winter wheat-soybean rotation is typical , with three crops in two years and apple trees provide income on the tabeland . Beef cattle are also distributed on the tablelands and sheep are common on the slopes . Lucerne and other forages are becoming more important to support both regional livestock production and commercial hay production enterprise . However in Dingxi , where the average spring wheat yield is only 1 .0 t/ ha because of drought environment , few other enterprises are developed . Lucerne with a deep root system could be adopted in this lower rainfall area , providing quality feed for livestock and protecting sloping land . In traditional systems such as those common in Dingxi the livestock are fed on poor quality crop stubble and the provision of lucerne is likely to substantially improve animal production .

**Table 2** *Comparison of integrated farming systems in two different locations (Nolan , et al 2008) .*

| Locations | Rainfall (mm) | Soil | Integrated system | Conventional system |
|---|---|---|---|---|
| Qingyang | 560 | Hei Lu soil | Beef and dairy cattle , Chinchilla rabbits | Traditional cattle systems pen fed by wheat , maize stubble |
| | | | winter wheat , maize apples , watermelon , canola , lucerne | Mostly grain production and some cash crops |
| Dingxi | 350 | Huangmian soil | Dairy cow , long tailed sheep , pigs | traditional grazed sheep systems |
| | | | spring wheat , Potato , linseed , lentile , pea , lucerne | Grain production , dominant , Spring wheat and , some cash crops , lucerne |

**Case study one-Zhidan county , Shanxi Province** Zhidan county has a total land area of 378 ,000 h and a population is 133 ,800 , of which 108 ,500 are located in the countryside . The county used to be aided by the central government due to the poor condition of the local economy . The county was poorly vegetated with 70% of the land showing at least some sign of erosion . Since pen fed sheep has become a major industry , it is reported that 55% of the total income is derived from livestock production , with 16 % from grain cropping and the other 29 % from non agricultural sources . Total net income per capita was RMB 4633 yuan (Yan & Lei . 2007) .

**Case study two-Qinayang , Gansu** In 2007 , some 150 ,000 ha of lucerne was sown , and 2 .44 million sheep and goats and 0 .65 million beef cattle were raised in whole Qingyang City . The introduction of livestock enterprises here has enabled local farmers to get out of low a income situation caused by monoculture grain production .

Huachi County located in the northeast of Gansu , has 60 ,000 ha of arable land , a population of 130 ,000 , and an average rainfall of 498 mm , most of which falls from July to September . Rangeland covers 160 thousand ha and is used for extensive

livestock production . To meet sustainable development objectives , lucerne was planted in a wide area and harvested for pen feeding . Specialized livestock , cashmere goats , are raised for wool production . Some 32 ,000 sheep and 39 ,000 beef cattle are also raised . After an integrated farming system was implemented including lucerne , livestock production output increased from RMB 0 .55 million yuan in 2001 to RMB 0 .71 million yuan in 2006 , through increased production . The traditional household livestock mixture of having cattle for draught power , pigs for Chinese New year consumption and chickens for pocket money has been changed . Now , forage livestock production is a backbone industry in Huachi county . However a lack of sufficient quality forage for large scale livestock production during the winter time remains a problem faced by many local farmers .

In Huanxian County , boarding Ningxia Hui autonomous region in the north , the area planted under Lucerne was 20 ,000 ha , with some 65 ,000 cashmere goats raised for wool in recent years . Farmers calculated the profit from the lucerne pasture and found out that perennial pasture could be maintained for at least 10 years , under proper management with a saving in N input and reduced plough requirements , compared with grain crop production systems (Lu ,2008) .

**Case study three-Pingliang-Gansu** Kongtong district , Pingliang , have developed a successful beef cattle industry . Pingliang is boarded by Ningxia Hui autonomous region to the north and Shanxi province in the South . A total of 132 ,600 beef cattle were raised , and some 40 ,000 ha of lucerne was planted in 2002 , with some 2 ,986 households raising livestock . By the end of 2006 , commercial beef production output was at 89 ,7000 t , increasing by 49 .5% over that achieved in 2002 . A number of hay processing enterprises were established and these add value to local lucerne production . By the end of 2006 , the beef industry , including raising , processing and marketing achieved a profit of 1 .2 billion RMB . Income from beef cattle accounted for one third of total income in the region , increasing by 300% compared with that in the year 2002 . Livestock income was 1 .8 billion RMB in the city , with a net income per capita in the rural area of 689 RMB , ,accounting for 38% of the total net income , half of which came from livestock production .

**Constraints and Future Prospects** Lack of start-up capital for most of the small scale producers is a major constraint for further development of livestock industries . Local governments encourage government employees to act as co-signers to help farmers get a loan for livestock purchases . Like the other parts of China , the yearly migration of labour from the country to the city has been a common phenomenon since late last century . This increases cash flow back to the rural areas and can aid in developing larger scale forage production and animal feeding systems .

**Commercial hay production and processing enterprise capacity** The price of lucerne hay in 2007 increased by 20% compared with that in the year 2006 , meanwhile the price of production inputs such as N fertilizer and other chemicals increased by up to 1000 RMB per ha , and transportation costs have also increased . Legume biological N fixation could replace some chemical fertilizer in these systems . Nevertheless , lucerne hay production remains profitable . With commercial lucerne hay production increasing , a number of hay processing factories were set up in the region . Small scale feed processing facilities are constrained by the scattered distribution of lucerne fields , and lucerne hay delivery to some processing factors was stopped by expensive transportation costs . Furthermore a lack of efficient harvesting machinery for the slope land constrains green lucerne harvesting at the flowering stage for slopeland lucerne .

**Conclusion** Interest in forage production has never been as high in the history of western Loess Plateau . Integrated farming system with grain crop-forage-ruminant animals is a way to strike a balance between the imperatives of increasing productivity and income whilst reducing soil erosion . Significant achievements have been made in the region under the support of the Chinese government in regards to both ecological and economic concerns . To implement forage-grain-livestock integration system in the Loess plateau will not cause a grain shortage crisis , because the system avoids competition between food resources for humans and livestock (pigs) . However , small scale households need starting capital for livestock production and coordinated hay production and processing enterprises will be required . Relatively steady government policy would help the integrated farming systems to further develop .

**References**

Dang , X .H . , Liu G .B . ,Quan B . , Wang , S .Y . , 2007 . Several issues of Eco-economic construction in the area of the Loess Plateau . *Ecological Economy* . (1) : 24-27 .

Dong , S .K . , Kang , M .Y . , Xiong , M . , Liu , X .C . , 2005 . Analysis on Sustainability of Policy of Turning Cultivated Land Back into Forests and Grasslands (TCFG) in Loess Plateau Region of China . *Journal of Soil and Water Conservation* . 19 (2) :41-44 .

Entz , M .H . , Bellotti , W . D . Powell , J .M . , Angadi ,S .V . , Chen ,W . Ominsiki K .H . 2005 .Evolution of integrated crop-livestock production systems . In D A McGilloway (Ed) . Grassland a global resource :137-148 .Wageningen Academic publishers ,

Liu , Z .X . , Su Q . ,2006 . Ecological Restoration and its Effects on Grain Production in the Corrasive Region of Loess Plateau , China . *Population , Resources & Environment* .16(2) :99-104 .

Liu , G . , 1999 .Soil conservation and sustainable agriculture on the Loess Plateau : challenges and prospects . Ambio 28 , 663-668 .

Ma , Y . , Chen L , Ding , H , Chen X . 2008 .Response of Farmer Households to Grain for Green Project" and Quantitative

Analysis of Its Affecting Factors ,-A Case Study of Daniu Watershed in Gansu Province . *Scientia Geographica Sinica* . 28 (1) :34-39 .

Unkovich , M . , Nan , Z .B . ,2008 . Problems and prospects of grassland agro-ecosystems in western China . . *Agriculture , Ecosystems and Environment* 124 , 1-2 .

Nolan , S , Unkovich , M . Shen ,Y .y . ,Li L .L .and Bellotti , W .D . 2008 . Farming systems of the Loess Plateau , Gansu Province , China ,*Agriculture , ecosystem and Environment* . 124 ,13-23 .

OECD , 2005 , Highlights and policy recommendations . reviewing of Agricultural polices .

Qian , Z .Y . , 2002 . Water resources allocation , ecological environmental construction and sustainable development strategic study for northwestern China . A project report submitted to the Chinese State Council .

Ren J Z . , Lin H .L . , Hou , X .Y . , 2005a . Developing the Agro-Grassland System to Insure Food Security of China . *Scientic Agricultura Sinica* . 40(3) :614-621 .

Ren , J Z , Nan , Z .B . ,Lin H .L . , 2005b . Taking the grassland agro2system to insure food security . Acta Pratacul Turae Sinica , 14(3) :1-10 .

Lu ,Y . F . , 2008 , Seeding forage crop as grain . Qingyang city government Newsletter , April 28 .

Yan , J .C . , Lei ,H Z . ,2007 . Evidence of relationship between livestock production of household and income under background of gain for green-A case study for Zhidan county Shanxi . *Journal of Agrotechnical Economics* , 88-92 .

Yang ,H .S . , 2006 .Resource management , soil fertility and sustainable crop production : Experiences of China . Agriculture , *Ecosystems and Environment* . 116(1-2) : 27-33 .