The role of lucerne in developing the agricultural systems of eastern Gansu, China

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Summary. On the eroded landscape of the loess plateau of north-central China, lucerne, *Medicago sativa,* has the potential to increase livestock productivity, reduce soil erosion and transfer nutrients (via manure) from slopeland to the cropping sector. Agronomic research has confirmed the hardiness of the local lucerne landrace, indicated the potential of North American cultivars and phosphorus fertilisers, and explored the risks associated with hay-making. The extension of such agronomic research results to farmers must take account of social and economic factors within a broad systems framework.

Introduction

Xifeng City (35?44' N, 107?38' E) in Qingyang prefecture, Gansu province, is at the centre of the loess plateau. Its soils are deep and workable (60-70% of particles 0.02-0.05 mm in size), and with an average annual rainfall of 550 mm, 80% of which falls within the 150 frost-free days, it is a prime grain producing area. However, the soils are fragile and, because of its long history in cultivation, the landscape is deeply dissected with an erosion modulus of 5,000-25,000 t/km^2/yr (3). Pasture improvement based on lucerne has long been important in stabilising erosion and sustaining productivity of the plateau (4,5). This paper describes the efforts of the Gansu Grassland Agricultural Systems Research and Development Project to identify the constraints on productivity and use of the traditional lucerne pastures, and to develop research and extension procedures to overcome them.

Methods

In 1986-87, fifty farmers from five villages in Xifeng were interviewed; the biological, economic and social parameters of their households were determined, priority problems identified and representative enterprise budgets integrated in a linear program systems analysis (6). Quadrat sampling was undertaken to determine the role of slopeland (i.e., eroded land with greater than 8? slope) in the farming system and to identify factors influencing the productivity and use of the lucerne pasture. Three factors were investigated in detail at a field site: lucerne cultivars, the role of phosphorus in lucerne establishment, and lucerne cutting management and hay production. Promising findings were tested in multi-locational trials and the results evaluated in economic terms by budget and risk analyses (1). Extension recommendations on lucerne establishment and haymaking were disseminated through bulletins, training, radio messages and field days.

Results

The farming system of Xifeng City is characterised by a high human population (1.1 ha of allocated crop land and 1.0 ha of slopeland per household of 5.4 persons), intensive cropping (average wheat yield of 3.1 t/ha) and a livestock component (one draft animal, one sheep, one pig and 15 rabbits per household, on average, in 1986) fed mainly on crop residues (6). Of the 1 ha of slopeland, 0.8 ha is sown to improved pasture (0.75 ha lucerne, 0.02 ha sainfoin, *Onobrychis viciaefolia,* and 0.06 ha astragalus, *Astragalus adsurgens).* Despite being on common land, these pastures are managed by individual households. Not being subject to the intensive grazing that characterises native pasture, erosion can be reduced by up to 47% and runoff by 37% (3). Since most lucerne is cut and carried fresh to yarded livestock, its nutrient content is ultimately transferred as manure to cropland. Up to 36 t of a 3:1 soil:manure mix, 100 kg urea and 70 kg calcium superphosphate (14% P_20_5) are used per ha of wheat land in Xifeng (6).

Lucerne cultivars from homoclimes in North America have enhanced early growth relative to the local Qingyang landrace, but this advantage declines with each successive year after planting. In one on-station trial, the yield of Qingyang lucerne as a proportion of that of DK 135, increased from 0.4 in 1987, to 0.8 in 1988, and to 1.3 in 1990 (P<0.01, for the difference between the two cultivars). At more marginal sites (e.g., TuQiao in Table 1), the early yield advantage of the introductions declined more rapidly. A compromise between short- and long-term productivity can be achieved by a mixture of sainfoin and Qingyang lucerne. In the first year of production a 50:50 mix of sainfoin and Qingyang lucerne increased yield of herbage by 20% (P<0.05) compared to the average of the two grown as pure stands (5). There is also a beneficial synergism between the two species in the nutrition of ruminants (7).

Table 1. The total dry matter yield (t/ha) and yield rank (out of 16 cultivars) for the three best North American lucerne cultivars and for the local Qingyang landrace, at two slopeland sites, in the first year (two cuts) and second year (three cuts), after establishment in 1988.

Site	Dongfeng gully (annual rainfall 550 mm)				TuQiao slope (annual rainfall 400 mm)			
Year	1989		1990		1989		1990	
Cultivar	Yield (t/ha)	Rank	Yield (t/ha)	Rank	Yield (t/ha)	Rank	Yield (t/ha)	Rank
Qingyang	1.8	11	5.8	3	1.3	15	2.7	1
DK135	2.2	1	6.5	1	1.6	13	1.4	13
Trident	2.2	2	5.8	4	2.1	2	2.5	3
Glory	2.1	3	5.3	6	2.3	1	1.7	9
l.s.d. (P=0.05)	NSD		2.3		0.8		NSD	
c.v. (%)	26.9		27.2		26.6		55.9	

l.s.d. and c.v. (%) is based on 16 cvv. grown out in 2x2 m plots, in randomised block designs with three replications per site.

Lucerne grown on loess soil responds to phosphorus fertiliser. Trials on-station, have shown that the effect of a basal application of calcium superphosphate at 20 kg P/ha persists until at least the end of the second year (2). In one trial where phosphorus was applied to Qingyang lucerne at five diverse sites, four showed a statistically significant response in the first cut (Table 2). However, analysis based on the opportunity cost of hay, revealed that the highest treatments 80 kg P/ha) were uneconomic at the first cut. The mean yield across sites, for the 20 kg P/ha treatments, although significantly higher than the control, gave a low marginal rate of return, with the banded being better than the broadcast. Variability between sites was high, with the average of the two poorest sites giving negative returns.

Table 2. Hay yield from the first cut, net benefit, marginal rate of return, and mean net benefit of the two poorest sites, out of five sites on which Qingyang lucerne was planted with different rates and application methods of calcium superphosphate.

Treatment[a]	P_0	$P_{20}Br$	$P_{20}Ba$	$P_{80}Br$	$P_{80}Ba$
Mean yield (t/ha)[b]	1.6	2.7	3.0	3.4	4.3
Net benefit (Yuan/ha)[c]	156	164	175	-198	-94
Marginal rate of return (%)	0	5	46		
Net benefit of poorest sites	45	7	-43		

[a] P_0 = control; $P_{20}Br$ = 20 kg P/ha broadcast; $P_{20}Ba$ = 20 kg P/ha banded; $P_{80}Br$ = 80 kg P/ha broadcast; $P_{80}Ba$ = 80 kg P/ha banded.
[b] Mean yield of five sites [l.s.d. (P=0.05) is 760 kg/ha].
[c] 1 Yuan = A$0.25.

In 1990, quadrats from 30 slopeland sites gave a first-cut yield in mid-June of 3.3?1.4 t DM/ha and a second cut in mid-August of 1.0?0.6. Cutting stage is critical in the management of Qingyang lucerne. Early flowering represents the best balance between forage quality and sustainable yields (Table 3). While lucerne hay is an excellent complement to low-quality crop residues, there are labour constraints because hay-making coincides with the cultivation of important cash crops like tobacco. Long-term weather data reveals that there is a high risk of rain during hay-making. Less than 10% of lucerne grown on slopes is turned into hay, farmers preferring fresh cut-and-carry (2). Lucerne used for hay is usually not harvested until late flowering. This hay often has a crude protein of 12% or less.

Table 3. The response of Qingyang lucerne to different cutting stages, after establishment in 1985 (yield = t/ha)'.

Stage	10% bud		10% flower		80% flower	
Year	1986	1987	1986	1987	1986	1987
First	3.4	2.6	5.9	5.1	6.2	6.7
Second	1.4	2.0	3.6	3.9	4.0	3.8
Third	1.0	1.7	1.2	1.8	1.3	1.2
Protein %	21.2	21.9	22.2	21.2	18.2	18.2

[a] All yields based on three replicate plots (11.25 m^2) in a complete randomised block design on-station.

Discussion

The lack of immediate unambiguous returns from supplying scarce resources to marginal livestock enterprises, is a constraint on the adoption of improved forage production practices by subsistence farmers (1). The appropriate extension strategy is to:

- continue the policy of providing free seed and technical support for low-cost planting of Qingyang lucerne on slopes;
- consider restoration of cash subsidies that proved successful in stimulating lucerne plantings in the period 1983-85;
- focus hay-making on the first lucerne cut, and use species such as annual vetches to exploit the hay-making opportunities of late autumn when rainfall and labour-demand are low.

More research is required to determine if phosphorus fertilisers and specialised lucerne cultivars should be promoted for medium-term rotations with crops on tablelands and terraces. On difficult gully and slopeland unsuited to lucerne, research should continue on minimal-care legumes, such as annual medics which have shown promise in preliminary trials (2).

References

44. CIMMYT 1988. From Agronomic Data to Farmer Recommendations: An Economics Training Manual. (CIMMYT: Mexico).

45. Gansu Grasslands Agricultural Systems Research and Development Project 1991. Annual Report, March 1991. (AIDAB: Canberra).

46. Huanghe Conservancy Commission 1988. In: Soil and Water Conservation in the Huanghe River Valley, Shanghai.

47. Li Qi and Liu Z.H. 1986a. J. Grasslands and Forage in China, Lanzhou. 3, 13-15 (in Chinese).

48. Li Qi and Liu Z.H. 1986b. J. Grassland and Forage in China, Lanzhou. 3, 49-51 (in Chinese).

49. Yang M.Y. 1987. A Bio-economic Model of Farm Systems in the Southern Tablelands of the Loess Plateau, China. MSc Thesis, Gansu Agricultural University, Lanzhou.

50. Yu Feng, Eagleton, G.E. and Leng, R.A. 1991. In: Recent Advances in Animal Nutrition in Australia. (Ed. D.J. Farrell) (University of New England Publishing Unit: Armidale). p. 1 1 A