THE BENEFICIAL EFFECTS OF SHORT-TERM ROTATION SYSTEMS OF WINTER FORAGE CROPS WITH MAIZE ON DRY FARMING LAND OF SOUTHWESTERN CHINA

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ABSTRACT
The objective of this study was to sift out the suitable and better short-term rotation systems of winter forage mixture with maize on dry farming land for the local farmers in Southwestern China. Four species of legume, Italian ryegrass and maize were used to organize six treatments for this experiment. The result showed that the three rotation systems of *Astragalus sinicus* (80%) + *Lolium multiflorum* (20%) ' *Zea mays*, *Medicago hisida* (70%) + *Lolium multiflorum* (30%) ' *Zea mays* and *Vicia villosa* (75%) + *Lolium multiflorum* (25%) ' *zea mays* obtained good forage values (TDOM 4.06-4.36 t/ha, CP 1.10-1.58 t/ha, ME 3.18-3.39X10^4 MJ/ha, Ca 33.62-52.49 kg/ha, P27.79-30.59 kg/ha) while the yields of subsequent crops were lower than that of CK under conditions not significantly different between those three treatments and CK.

KEYWORDS
Short-term rotation, winter forage mixture, maize, dry farming land, low mountainous area

Introduction
In the mountainous area of the subtropical zone of China, some arable lands were still allowed to lie fallow by farmers in winter (Zhou, 1981). On the other hand, there was a real lack in winter and the following spring (Huon *et al, 1992*, Zhou, 1989) of herbage for animals. Thus, the purpose of this study was to sift out the suitable and better short-term rotation systems of winter forage crops with maize for the producing of animal herbages (Shie, 1990; Mahai *et al*, 1992). This study was carried out at Yaan county during the period of 1991 to 1994 and all of the data are the average value and common tendency in three years.

METHODS
The experimental field was located at 30° 8'N and 103° 14'E with the altitude of 620 m. The weather is subtropical climate and wet seasonal wind area. The average annual temperature was 16.2°C and the annual precipitation was 1774 mm. The frost-free period in one year was of 304 days. The soil of the experimental field is purple soil with a pH value of 6.65.

Four species of legumes, Italian ryegrass and maize were used to organize six short-term rotation systems for this comparative experiment. The six treatments, mixture rates and symbols were as follows:

Astragalus sinicus (50%) + Medicago hispida (50%) 'Zea mays (AM '^{1}Z)
Astragalus sinicus (80%) + Lolium multiflorum (20%) 'Zea mays (AL '^{1}Z)
Medicago hispida (70%) + Lolium multiflorum (30%) 'Zea mays (ML '^{1}Z)
Vicia villosa (75%) + Lolium multiflorum (25%) 'Zea mays (VL '^{1}Z)
Pisum sativum (70%) + Lolium multiflorum (30%) 'Zea mays (PL '^{1}Z)
Lie fallow (Check) 'Zea mays (CK '^{1}Z)

The sowing time of forage crops was in September or October and harvesting time was from December to next April. The sowing and harvesting time of maize were in April to May and August, respectively. Every treatment was repeated four times and the plots were arranged by random distribution in plot groups of the experimental field. There were 24 plots and the area of each plot was 15m^2 in this experiment. The suitable cutting times, dry matter of yield and root mass of forages and dry weight of subsequent crops were determined. The mixture forage samples for chemical analysis and evaluation of feeding value were collected from the four plots of each treatment. The soil condition of each treatment after growing forage crops was observed from soil profile to know the effect of forage crops on soil. The soil sample of each treatment for chemical analysis was collected from the 4 repeated plots. The Duncan's multiple range test was used test for differences among the mean values of herbage and maize yields among the treatments.

RESULTS AND DISCUSSION
Yield and root mass of forages and maize yield. The data in table 1 showed that the DM yields of forages and the DM of forage root mass in treatments of AL ' Z, ML ' Z, VL ' Z and PL ' Z are significantly higher ($P<0.05$) than that in treatment of AM ' Z at the rate 30.41-48.71% and 80.00-180.00%, respectively. The maize yields of the four treatments mentioned above were a little lower than that of CK but not statistical different. The treatment of AM ' Z with the mixture of two species of legume obtained lower forage yield and root mass of dry matter than that in other treatments. The difference of maize yield between each two treatments is not significant($P<0.05$).

Comparison of forage values on different rotation systems. The forage value comparisons were determined according to the yields of CP, TDOM and ME in forages per hectare of each treatment. The results (Table 2) showed that the three treatments with mixtures of legumes and grasses i.e. AL ' Z, ML ' Z and VL ' Z obtained much better forage values (CP 1.10-1.58 t/ha, TDOM 4.06-4.36 t/ha, ME 3.18-3 .39X10^4 MJ) than that of the other two treatments i.e. AM ' Z and PL ' Z (CP 0. 97-1.21 t/ha, TDOM 2.86-3.75 t/ha, ME 2.21-2.90°X10^4 MJ).

Comparison on the contents and stores of forage mineral. The Na contents of AM ' Z and ML ' Z were higher (0.28-0.37%) than other treatments (0.11-0.20%) and the Mg contents of AM ' Z, VL ' Z and PL ' Z were better than other treatments. The treatments with grasses obtained good contents of P and K and the treatment with the mixture of two species of legumes had a good content of Ca. Evaluation on stores of the main important mineral i.e. Ca, P and Mg to animal nutrition showed that the treatment of VL ' Z obtained a good store of mineral while the stores of mineral in the treatments of ML ' Z and PL ' Z were in the second place.

Comparison of soil conditions after growing forage crops. The data (table 4) showed that the TN contents in the soil after growing forage crop mixtures were higher and increasing 26.56% than that of CK. The content of available nitrogen and organic matter of the soil after growing forage crops in treatment of AL ' Z was also higher than that of CK.

Synthetical evaluation. Synthetical evaluation was also conducted by the comparison of forage values, yields of subsequent crops and the effects of forage crops on soil. The treatments of AL ' Z, ML ' Z and VL ' Z obtained good forage values (TDOM 4.06-4.36 t/ha, CP 1.10-1.58 t/ha, ME 3.18-3.39X10^4 MJ/ha, Ca 33.62-52.49 kg/ha, P 27.79-30.59 kg/ha) while the yields of subsequent crops were lower than that of CK. The maize yields were not significantly different between these treatments and CK. These short-term rotation systems of winter forage mixtures with maize have been used by farmers especially in middle and low mountainous regions of southwestern China.

ACKNOWLEDGMENTS

The authors wish to thank the staff members of the two grassland institutes in Sichuan Agricultural University of China and Munich Technique University of Germany for assistance. The authors are indebted to the GTZ and DFG of Germany for financing this research project, to the NCNSF and NCE of China for supporting this project.

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Table 1
Average yield and root mass of forages and maize yield

Treatments	Forages (DM t/ha)	Forage root mass (DM t/ha)	Maize (DW t/ha)
AM→ Z	3.88	0.35	4.71
AL→ Z	5.31	0.70	4.37
ML→ Z	5.77	0.98	4.55
VL→ Z	5.73	0.63	4.26
PL→ Z	5.06	0.94	4.23
(CK)→ Z	—	—	4.57

Table 2
Forage value comparisons of different rotation systems

	Contents				Yields			
Treatments	CP (%)	CF (%)	TDOM (%)	ME (MJ/ha)	CP (t/ha)	CF (t/ha)	TDOM (t/ha)	ME (X10^4 MJ/kg)
AM→ Z	25.00	21.65	73.71	5.70	0.97	0.34	2.86	2.21
AL→ Z	20.72	21.47	76.46	5.99	1.10	1.14	4.06	3.18
ML→ Z	21.84	22.01	75.56	5.88	1.26	1.27	4.36	3.39
VL→ Z	27.57	20.42	76.09	5.74	1.58	1.17	4.36	3.29
PL→ Z	23.91	21.34	74.11	5.73	1.21	1.08	3.75	2.90
(CK)→ Z	—	—	—	—	—	—	—	—

Table 3
Contents and stores of forage mineral

	Contents (%)					Stores (kg/ha)				
Treatments	Na	Mg	P	K	Ca	Na	Mg	P	K	Ca
AM→ Z	0.37	0.34	0.42	2.17	0.98	14.21	13.12	16.40	84.19	37.85
AL→ Z	0.11	0.27	0.52	4.16	0.63	5.88	14.55	27.79	220.96	33.62
ML→ Z	0.28	0.26	0.49	3.74	0.70	16.23	14.92	28.18	215.67	40.15
VL→ Z	0.17	0.31	0.53	3.98	0.92	9.71	17.88	30.59	228.2	852.49
PL→ Z	0.20	0.33	0.49	3.62	0.97	10.23	16.67	24.56	183.24	49.32
(CK)→ Z	—	—	—	—	—	—	—	—	—	—

Table 4
Comparison of soil condition

Treatments	TN (%)	AN (mg/100g soil)	pH	OM (%)	Water (%)
AM→ Z	0.157	11.11	6.2	1.35	4.84
AL→ Z	0.162	17.82	6.2	1.51	4.86
ML→ Z	0.128	15.56	6.2	1.40	4.69
VL→ Z	0.135	10.98	6.2	1.38	4.87
PL→ Z	0.145	10.98	6.3	1.38	4.72
(CK)→ Z	0.128	16.24	6.1	1.48	4.62