THE COMPARISON OF DIFFERENT SHORT-TERM ROTATION SYSTEMS OF WINTER FORAGE CROPS WITH RICE IN SUBTROPICAL PLAIN REGION OF SOUTHWESTERN CHINA

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ABSTRACT
The objective of this study was to explore the possibility of growing winter forage crops in the present farming system with simple grain production only in subtropical plain region of southwestern China. The result showed that the four rotation systems i.e. *Astragalus sinicus* (70%) + *Lolium multiflorum* (30%) →rice, *Medicago hispida* (75%) + *Lolium multiflorum* (25%) →rice, *Lolium multiflorum* (20%) + *Vicia villosa* (80%) →rice and *Astragalus sinicus* (80%) + *Brassica napus* (20%) →rice obtained good forage values (TDOM 3.35-4.12 t/ha, CP 1.12-1.31 t/ha, ME 2.53-3.19 X 10^4 MJ/ha), at the same time, obtained better rice yields (DW 6.35-7.17 t/ha) and soil condition than that of (CK) →rice. These four rotation systems have been used by local farmers.

KEYWORDS
Short-term rotation, winter forage crop, rice, subtropical plain region

INTRODUCTION
Subtropical zone of China is located between latitude 22° N and 32° N of the equator and longitude 102° E and 125° E of the Greenwich Meridian. The average annual temperature is about 15-20°C, annual rainfall is about 1000-2000 mm. The major kinds of soils are yellow earth, red earth, purple soil and paddy-field soil in this area, pH 5-6.5 of soil. There is a big population of people in subtropical zone of China, usually, rural people have only 0.06-0.15 ha arable land. It is required for farmers to use the limited land to produce grain, industrial crops and fruits, therefore, the forage crops are very few. Farmers do not like to use arable land to grow perennial forage plants due to the longer time of land occupied by them. The further development of animal industry has been hindered by the lack of forages, thus it is very important to find an approach for forage production in these regions. In the past, there were only some reports on the annual legumes for green manure (Jiao Bing *et al, 1986*).The research on rotation system of forage crops with rice were very few (Zhou, 1989; Yang *et al, 1995*) and there was also a lack of a wide range of forage crop research (Badawy, 1976).

The purpose of this study is to explore the possibility of growing annual winter forage crop mixtures and to avoid the defect in the present farming system with simple grain production only, in the mean time, to improve the ecological and economic benefit of the field ecosystem in subtropical zone of China.

This project has been carried out in the plain region of Mei-Shan County during the period of 1991 to 1994 and the data of this report are the average values and the common tendencies in three years.

METHODS
The focal point of this study should be the growing of winter forage crops as much as possible, based on the full and rational utilization of the vacant arable land in the plain area of subtropical zone of China. Seven common annual winter forage crops and twelve treatments were used in this experiment and every treatment was repeated four times. The plots were arranged by random distribution in plot group of the experimental field and the area of each plot was 15 m^2. Dry matter yield 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 of forage crops was observed to know the effects of forage crops on soil. The soil samples for chemical analysis were collected from the 4 repeated plots of each treatment. Sowing time of forage crops was in September and October, the harvesting time of forage crops was from January to April of next year. Transplanting and harvesting time of rice was in May and August of each year, respectively.

Twelve treatments, mixture rates and the symbols of this experiment were as follows:

Astragalus sinicus →Rice (A→R)
Astragalus sinicus (50%) + Medicaga hispida (50%) →Rice (AM→R)
Astragalus sinicus (80%) + Brassica napus (20%) →Rice (AB→R)
Astragalus sinicus (70%) + Lolium multiflorum (30%) →Rice (AL'R)
Medicago hispida 'Rice (M→R)
Medicago hispida (75%) + Lolium multiflorum (25%) →Rice (ML→R)
Vicia villosa →Rice (Vv→R)
Vicia villosa (50%) + Astragalus sinicus (50%) →Rice (VvA→R)
Lolium multiflorum →Rice (L→R)
Lolium multiflorum (20%) + Vicia villosa (80%) →Rice (LVv →R)
Vicia faba (50%) + Astragalus sinicus (50%) →Rice (VfA→R)
Lie fallow (Check)→Rice (CK→R)

The Duncan's multiple range test was used test for differences among the mean values of herbage and rice yields among the treatments.

RESULTS AND DISCUSSION
Yields and root mass of forages and rice yields. The results (table l) show that: the forage yields of DM in treatments of L→R, LVv→R, AL→R and ML→R are significantly higher ($P<0.05$) than others at the rate 23.41-85.17%. The yield of rice in the treatments with legumes only or legume plus Brassica were higher than the treatment of CK'R at the rate 4.44-13.78% and it was lower than CK at the rate 2.22-7.11% in the treatments with Italian ryegrass. The legumes in different rotations brought a good ecological and economic benefit. According to the synthetical evaluation of the yields, root mass of forages and rice yield, the treatments of ML→R, AL→R, LR and VfA→R are better than others.

Comparison on the forage values of different treatments. The data in Table 2 showed that the yields of CP, TDOM and ME in the treatment of L→R were the highest and the yields of CP, TDOM and ME in the treatments of AL→R, LVv→R and ML→R were at the secondary sequence. All of these showed that the forage values per unit of area were increased by Italian ryegrass due to it obtaining a high yield of forage dry matter.

Contents and stores of mineral in forages of different treatments. The stores of minerals were the amount of minerals in the forages per hectare. The result of mineral evaluation on the stores of Ca, P and Mg etc. related to animal nutrition showed that the treatments of LVv'R, AL'R, L'R and ML'R were better than other treatments.

Comparison of soil condition. The analysis results of soil samples

collected after the last cutting of forages were shown in Table 4. The evaluation according to the influence of forage crop to soil showed that the treatment of AB→R was the best one and the treatments of AM→R, AL→R and ML→R were at the secondary sequence. The soil after growing forage crops was improved clearly in structure and nutrition.

Synthetical evaluation on this experiment. Synthetical evaluation was carried out according to the comparison of forage value, yield of subsequent crop and the effects of forage crop on soil. The result of synthetical evaluation showed that the treatments with legume monoculture or mixture of two legume species i.e. A→R, M→R, VvA→R and VfA→R obtained good rice yields (DW 7.05-7.68 t/ha), middle soil condition (TN 0.154-0.192%, OM 1.88-2.64%) and the lower forage values (TDOM 2.58-3.06 t/ha, CP 0.84-1.09 t/ha, ME 1.90-2.22 X 10^4 MJ/ha) due to the low yields of forage dry matter per unit of area. The treatment with Italian ryegrass, i.e. L→R, obtained the best forage values (TDOM 4.96 t/ha, CP 1.31 t/ha, ME 3.72 X 10^4 MJ/ha), but obtained the lowest rice yield (DW 6.25 t/ha only) and the lower soil conditions (TN 0.168%, OM 2.08%). The treatments with the mixtures of legumes with Italian ryegrass or milkvetch with fodder rape i.e. AL→R, ML→R, LVv→R and AB→R obtained good forage values (TDOM 3.35-4.12 t/ha, CP 1.12-1.31 t/ha, ME 2.53-3.19 X 10^4 MJ/ha), at the same time, obtained better rice yields (DW 6.35-7.17 t/ha) and better or lower soil condition (TN 0.142-0.206%, OM 1.88-2.38%) than L→R and (CK) →R. As a result, the four rotation systems of winter forage crops with rice i.e. AL→R, ML→R, LVv→R and AB→R are very useful currently for the farmers in subtropical plain region of China.

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Table 1

The yields and root mass of forages and rice yields

Treatments	Forage yields (DM t/ha)	Forage root mass (DM t/ha)	Rice yields (DM t/ha)
A→R	3.95b	0.25	7.28NS
AM→R	4.52b	0.45	7.25NS
AB→R	4.73b	0.30	7.17NS
AL→R	6.17a	0.48	6.35NS
M→R	4.87	0.29	7.40NS
ML→R	6.01a	0.74	6.43NS
Vv→R	4.76b	0.25	7.15NS
VvA→R	4.64b	0.26	7.05NS
L→R	7.24a	0.20	6.27NS
LVv→R	6.32a	0.33	6.60NS
VfA→R	3.91b	0.32	7.68NS
(CK)→R	--	--	6.75NS

[a, b,c] values on the same column with different superscripts are different at P<0.05; NS, not significant.

Table 2

Comparison of forage values

	Contents				Yields			
	CP (%)	CF (%)	TDOM (%)	ME (MJ/kg)	CP (t/tha)	CF (t/ha)	TDOM (t/ha)	ME (X10^4 MJ/ha)
A→R	2.127	25.82	65.32	4.81	0.84	1.02	2.58	1.90
AM→R	20.80	27.88	63.72	4.67	0.94	1.26	2.88	2.11
AB→R	23.68	21.78	70.82	5.35	1.12	1.03	3.35	2.53
AL→R	19.45	25.93	68.88	5.17	1.20	1.60	4.25	3.19
M→R	19.71	29.57	62.83	3.80	0.96	1.44	3.06	1.85
ML→R	19.30	27.79	57.07	4.79	1.16	1.67	3.43	2.88
Vv→R	22.90	26.26	62.61	4.43	1.09	1.25	2.98	2.11
VvA→R	21.55	26.72	65.09	4.78	1.00	1.24	3.02	2.22
L→R	18.09	26.80	68.51	5.14	1.31	1.94	4.96	3.72
LVv→R	19.94	27.37	65.19	4.68	1.26	1.73	4.12	2.96
VfA→R	22.51	24.30	67.52	5.14	0.88	0.95	2.64	2.01
(CK)→R	--	--	--	--	--	--	--	--

Table 3

Mineral contents of ofrages and the stores of them in the forages of per unit of area

	Contents (%)					Stores (kg/ha)				
	Na	Mg	P	K	Ca	Na	Mg	P	K	Ca
A→R	0.13	0.32	0.35	2.74	0.97	5.18	12.82	13.75	108.30	38.16
AM→R	0.47	0.31	0.37	2.46	1.17	21.14	13.82	16.65	110.98	52.88
AB→R	0.15	0.30	0.41	2.77	0.94	7.08	14.25	19.52	131.03	44.34
AL→R	0.21	0.26	0.37	3.84	0.70	12.80	16.02	22.99	236.74	43.45
M→R	0.69	0.25	0.27	2.33	0.84	33.45	12.18	12.97	113.47	41.08
ML→R	0.49	0.25	0.31	3.28	0.86	29.41	15.26	18.40	197.02	51.18
Vv→R	0.07	0.31	0.43	3.07	0.92	3.30	14.80	20.48	145.96	43.56
VvA→R	0.11	0.30	0.36	2.81	0.84	5.03	13.97	16.61	130.35	39.17
L→R	0.33	0.26	0.35	4.18	0.60	23.66	18.60	25.38	302.47	43.64
LVv→R	0.18	0.28	0.43	3.72	0.84	11.53	17.65	27.40	235.38	53.28
VfA→R	0.32	0.26	0.34	2.05	0.75	12.35	10.24	13.33	80.34	29.37
(CK)→R	--	--	--	--	--	--	--	--	--	--

Table 4

Comparison of soil condition after growing winter forage crops

Treatments	TN	AN	pH	OM	Water
A→R	0.154	13.59	5.5	2.07	1.38
AM→R	0.157	13.97	.54	2.64	2.11
AB→R	0.26	17.01	5.9	2.38	1.51
AL→R	0.204	16.63	6.2	2.31	1.51
M→R	1.92	12.91	6.3	2.36	1.59
ML→R	0.169	18.03	5.9	2.35	1.53
Vv→R	0.153	12.73	5.7	1.88	1.34
VvA→R	0.183	15.26	6.0	2.20	1.52
L→R	0.168	13.60	5.7	2.08	1.42
LVv→R	0.142	13.60	5.9	1.88	1.51
VfA→R	0.180	14.51	6.3	2.36	1.47
(CK)→R	0.169	15.23	6.3	2.28	1.54