中国四川旱坡地植物篱农作系统能流特征

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摘要 关于农业生态系统能流特征的研究很多,但关于植物篱农作系统能流特征的研究很少。在四川盆地雨养丘陵农区 2/3 的耕地土壤侵蚀严重,为了控制土壤侵蚀和提高耕地生产力,该区域大量栽种了植物篱。该研究通过了解作物与植物篱之间的能流交付作用,通过系统能量投入水平提高与结构优化,建立环境友好的农作系统,最终实现坡地农业的可持续。通过两年田间小区试验,详细记录所有劳力投入、化肥投入、农药投入、农事管理活动以及落叶的数量并折算为标准能量单位。作物收获后所有生物产量的能量根据其各部分的转换值折算为标准能量。系统能流特征及效率通过统计分析完成。通过研究主要获得了以下 3 个结论: 1) 作物-植物篱系统产出能和输入能的数量和结构变化主要受植物篱子系统类型的影响。与大面积旱坡地传统农作物生产系统比较,植物篱农作系统能有效提高系统光能利用率、人工输入能效率,耕地单位面积总产出能也会增加,坡度越大,相对增幅亦越大;由于能极显著减少无机能施入量,这有利于降低化肥农药使用量,减少对环境的污染和破坏。2) 作物-果树类植物篱系统输入能总量和有机能输入量大幅度增加,因此有利于优化输入能结构,促进坡地生态系统良性循环和集约高效农业发展。3) 作物-草本植物篱系统人工辅助能的输入量大幅度下降,由于它所需投入能少,有机能耗和无机能耗均低,人工输入能效率很高而生物产量也较高,并且它们提高了与其间作的其它作物的能量产投比,因此提升了整个系统能量产投比率;由于保水固土的生态功能显著,使它能在四川广大山地、丘陵区退耕还林还草工程中发挥重要作用。

关键词 旱坡地 “作物-植物篱”系统 能结构 能效率

ENERGY FLOW CHARACTERISTICS OF ALLEY CROPPING ON HILLSIDES IN SICHUAN, CHINA

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Abstract *Aims* Energy flow characteristics of alley cropping have been rarely studied, although alley cropping is common in Sichuan in order to control soil erosion and promote productivity. Our aims are to understand growth pattern and production mechanization of crops, determine effects of hedgerows on main crops in order to realize positive interactions, promote the level and structure of energy inputs, optimize and establish an environment-friendly farming system and realize sustainable agriculture on hillsides.

Methods We recorded labor input, fertilizer, pesticides, farming activities and leaf fall on the soil surface in trial plots for two years. After harvesting, we separated plant parts to determine economic yield and biological yield, calculated energy of the different parts according to a conversion ratio of energy and studied energy structure and energy efficiency of alley cropping by statistical analysis.

Important findings In comparison with the traditional agricultural system on hillsides, there were differences between hedgerows and crop in shape and spatial distribution of crown and roots, such that light, heat, water and soil were utilized continuously in time and in space, resulting in enhanced efficiency of light utilization, efficiency of input labor energy utilization and total output energy per unit area on steeper hillsides. Moreover, input of inorganic energy of alley cropping was reduced significantly and use of chemical fertilizer and pesticide could be reduced, resulting in environmental protection. Quantity and structure change of output and input energy of alley cropping was affected mainly by the type of hedgerow subsystem. Total energy input (including organic energy) of hedgerow system with fruit trees was increased, which was useful for improving input energy structure and ecosystem and enhancing intensive agricultural development. A hedgerow system of shrubs and herbs could reduce input labor energy, decreasing input energy and input energy consumption greatly and re-

sulting in increased efficiency of input labor energy utilization and biomass and energy output/input ratio of the main crops. Alley cropping conserved water and soil, thereby playing an important role in agricultural reform in the vast mountainous and hilly area of Sichuan.

Key words hillside, alley cropping, energy structure, energy efficiency

When farming on sloping lands in China, farmers generally plant their crops up-and-down the slope and cultivate their land with minimal concern for soil erosion. This causes loss of not only topsoil but also plant nutrients. In addition, this causes siltation of valleys, rivers and dams, resulting in down stream flooding, and threatens the environment of the area. With serious soil erosion, the soil could quickly lose its productivity to the point where it can no longer sustain crop growth. Since sloping lands cover vast areas in China and are being encroached upon and cultivated every year, it is imperative that appropriate technologies for managing these lands be introduced to farmers to minimize damage to the lowland areas and avoid farmers slipping into poverty because of degraded soils. Sustainable agriculture on sloping lands can eventually be achieved. Therefore, researchers (Munoz-Carpena *et al.*, 1993; Longley & Sotherton, 1997; Schellinger & Clausen, 1992; Baijukya & PETERS, 1998; Ehui *et al.*, 1990; Mepa & Gunasena, 1995; Lahda *et al.*, 1993; Liu *et al.*, 2004; Tian *et al.*, 2003; Lal, 1995) introduced and studied alley cropping systems on sloping lands in order to protect valuable agricultural land and understand the socio-ecological benefit of this system towards our environment.

The energy efficiency and structure of crop are the main characteristics of energy flow system and important study areas of ecological system of farming land. It will help to understand the interactions between hedgerows and main crops by studying the characteristics of energy flow of alley cropping. By regulating and controlling energy flow system, it is to promote ecological system of farming land and optimization of agricultural production factors. A great number of scientists (de Wit, 1992; Ma & Edwards-Jones, 1997; Panesar & Fluck, 1993; Jones, 1989; Zhang, 2002; Wei *et al.*, 2001; Ye & Wang, 2001) studied energy flow in the area of agricultural ecological system, but very little, if there is, study of energy flow characteristics of alley cropping has been implemented. In the rain-fed hilly masses of central area of Sichuan Basin, there is over two thirds of farming land with serious soil erosion (Huang, 1987; Aldhous, 1993; Thurow & Juo, 1995). Introduction of alley cropping can effectively control soil erosion and promote the productivity of farming lands in this area (Kiepe & Young, 1992; Cai &

Luk, 1995; Poudel *et al.*, 2000; Zhang *et al.*, 2001a, 2001b; Deng *et al.*, 2002; Chen *et al.*, 2002). This study is aimed to understand growth pattern and production mechanization of crops, the effect of hedgerows on main crops in order to realize positive interactions between hedgerows and crops, promote the level and structure of input energy, optimize and establish environment-friendly farming system and finally to realize sustainable agriculture on sloping lands.

1 Materials and Methods

1.1 Study area

The rain-fed hilly area in central Sichuan Basin is located in sub-tropical area with an annual precipitation of 1 000 mm. The rainfall distributes unevenly over the year and main landform is hills, so the droughts happen frequently and soil erosion is serious. The cropping index of this area is 40.8% which is much higher than the average provincial level (13.5%). The population density is 565 person·km⁻² which is 3.21 times of the provincial level. The project site is located in Xiangshui catchment, Ziyang, representing typical soil type and landform of rain-fed hilly area in central Sichuan Basin. Project catchment is in the upper reach of the Yangtze River and is 90 km away from Chengdu, capital of Sichuan Province. The annual light energy is $37\,620 \times 10^6 \text{ J} \cdot \text{hm}^{-2}$ and annual average temperature 17.3 °C. There are frequent storms from May to October and 80% of annual precipitation is distributed in this period. The soil developed from Jurassic material with sandy loam texture. The main crops on sloping lands were wheat (*Triticum sativum*), corn (*Zea mays*), sweet potato (*Dioscorea esculenta*), groundnut (*Arachis hypogaea*), water lemon (*Citrullus lanatus*), etc. They were often intercropped with other crops, for example, corn was intercropped with sweet potato and groundnut intercropped with sweet potato, etc.

1.2 Trials design

The trials were located in the field station of Sichuan Academy of Agricultural Sciences in Ziyang. The plot area was 140 m² (7 m × 20 m). The crops of control treatment (traditional practice of farmers without hedgerows) were planted up and down slope, while crops of other treatments planted along the contour with hedgerow width

of 1 m. There were 3 hedgerow strips in one plot. There were 3 trials and the treatments are as the following :

Trial 1 : this field had slope steepness of 23 degrees with 4 treatments. The treatments were : 1) wheat (winter crop) , groundnut intercropped with sweet potato (summer crops) plus Chinese date (*Calligonum densum*) (hedgerow crop) ; 2) wheat , groundnut intercropped with sweet potato plus vetiver (*Vetiveria zizaniodes*) ; 3) wheat , groundnut intercropped with sweet potato ; 4) wheat , groundnut intercropped with sweet potato plus false indigo (*Amorpha fruticosa*).

Trial 2 : this field had slope steepness of 13.5 degrees with 3 treatments. The treatments were : 1) wheat , corn intercropped with sweet potato plus *Coronila varia* ; 2) wheat , corn intercropped with sweet potato ; 3) wheat , corn intercropped with sweet potato plus alfalfa (*Medicago sativa*).

Trial 3 : this field had slope steepness of 8 degrees with 4 treatments. The treatments were : 1) wheat , corn intercropped with sweet potato plus Chinese toon (*Toona sinensis*) ; 2) wheat , corn intercropped with sweet potato plus pear and day lily (*Hemerocallis citrine*) ; 3) wheat , corn intercropped with sweet potato ; 4) wheat , corn intercropped with sweet potato plus loquat (*Eriobotrya*

japonica) and day lily.

1.3 Measurements

Labor input , fertilizer , pesticides , farming activities and leaves falling on the soil surface of each plot were calculated and recorded carefully. After harvesting of crops , different parts of plant were treated and the economic yield and biological yield obtained accordingly (Guangdong Academy of Agricultural Sciences , 1977). Energy of different parts of plant was calculated according to the conversion ratio of energy (Liu , 1984). The energy structure and energy efficiency of alley cropping system were studied by statistical analysis (Bian , 1999 ; Liu , 1982).

2 Results

2.1 Output energy analysis of alley cropping system

The output energy of different sub-systems was calculated according to the economic and biological yield of plots (Table 1). The result of Table 1 shows that after hedgerows introduce into the sloping land with slope steepness of 8 – 20 degrees , output energy of farming system was increased and the structure of output energy changed.

Table 1 Output energy analysis of alley cropping system (Unit : 10³ MJ · hm⁻²)

Field	Plot No.	Output energy of crop (N ₁)				Output energy of hedgerow (N ₂)				Total output energy (P)	± (%)
		Main product	By-product	Sum	N ₁ /P	Main product	By-product	Sum	N ₂ /P		
I	CK	65	64	129	1.000			0		129	0
	1 Chinese date	55	51	106	0.746	21	15	36	0.254	142	9.8
	2 Vetiver	57	54	111	0.691	50		50	0.309	161	24.6
	4 False indigo	53	48	101	0.679	48		48	0.321	149	14.8
II	CK	113	103	216	1.000			0		216	0
	1 <i>Coronila varia</i>	106	95	201	0.862	32		32	0.138	233	7.5
	3 Alfalfa	104	93	198	0.885	25		25	0.115	223	3.1
III	CK	122	106	228	1.000			0		228	0
	1 Chinese toon	113	101	214	0.926	4	12	16	0.074	230	1.2
	2 Pear and day lily	119	105	224	0.849	24	15	39	0.151	263	15.6
	4 Loquat and day lily	106	95	201	0.840	25	13	38	0.160	239	5.1

The treatments of field 1 were : 1 Chinese date hedgerow , 2 Vetiver hedgero and 4 False indigo hedgerow ; the treatments of field 2 were : 1 *Coronila varia* hedgerow and 3 Alfalfa hedgerow ; the treatments of field 3 were : 1 Chinese toon hedgerow , 2 Pear and day lily hedgerow and 4 Loquat and day lily hedgerow

After hedgerows imported into the farming system , the total output energy of unit area was increased considerably. The total output energy of field 1 was increased by 9.8% – 24.6% , while the total energy out of field 2 and 3 increased by 1.20% – 15.61% . It is clearly showed that the percentage of increased output energy was increased with the slope steepness. In other words , the contribution of hedgerows to output energy of system was increasing with the increase of slope steepness. The rea-

sons might be that the soil erosion is more serious with the increase of slope steepness and the ecological function of hedgerows becomes more important. Furthermore , hedgerows can help to change landform and form bench terraces in the field , resulting in the increase of soil depth and water holding capacity (Yin *et al.* , 2001 ; Xu *et al.* , 1999). Therefore , hedgerows have significant influence on output energy of the systems although they only cover small part of area in the field.

Hedgerows formed by different plants changed the structure of output energy. For instance , field 1 had the steepest slope and low productivity comparatively. After crops , particularly high biological yield of vetiver , was planted as hedgerows , the ratio of output energy from main crops to the total output energy in different plots decreased from 100% to 67.9% – 74.6% , while the output energy of the hedgerows taken up 25.4% – 32.1% of the total output energy. In field 2 and 3 , although hedgerows occupied the same area as that in field 1 , the ratio of output energy from the main crop to the total output energy in different plots only decreased from 100% to 86.2% – 92.6% . The reasons might be that when the slope was steeper , the more factors influencing the growth of main crops existed , so the crops can not realize their potential production. Because the condition of the fields , when most suitable crops with high biological yield was selected to form hedgerows , the ratio of output energy of the main crops to total output energy was decreased accordingly. Because the field with moderate slope had deeper soil and better condition of moisture and nutrients , the main crops can grow better. Therefore , the higher output energy of the main crops was achieved and the ratio of output energy of main crops and total output energy was higher.

2.2 Input energy analysis of alley cropping system

The magnitude and structure of input energy of alley cropping system was mainly influenced by the type of hedgerows formed by different crops instead of slope steepness (Fig. 1 – 3).

Fig.1 Input energy analysis of alley cropping of high slope steepness (field 1)
M₁ : organic energy input , included seed , labor and organic fertilizer energy inputs M₂ : inorganic energy input , included machinery , chemical fertilizer and pesticides energy inputs T_i : Total input energy , included organic energy input , inorganic energy input and solar energy

Fig.2 Input energy analysis of alley cropping of mid-slope steepness (field 2)
M₁ , M₂ , T_i : See Fig. 1

Fig.3 Input energy analysis of alley cropping of low-slope steepness (field 3)
M₁ , M₂ , T_i : See Fig. 1

When hedgerow crops of Chinese date , pear , loquat , etc. , which had significantly different biological characteristics with main crops of wheat , corn , sweet potato , groundnut , etc. , were imported into farming system , the total input energy increased remarkably with the increase of organic input energy. For instance , input energy and organic energy increased 21.6% and 69.8% , respectively , in plot 1 of field 1 with Chinese date alley cropping and 43.7% and 146.1% , respectively in plot 2 of field 3 with pear plus day lily alley cropping. The reason for significant increase of input energy and organic energy was that organic fertilizer , like pig manure , was applied in a great amount to feed fruit trees which formed part of hedgerows and fallen leaves of fruit trees was also the source of input energy and organic energy. Meanwhile , inorganic energy input was decreased greatly , for instance , input energy of plots with Chinese date , vetiver , pear plus day lily and loquat plus day lily was decreased by 31.3% , 39.6% , 30.2% and 30.0% , re-

spectively. The result clearly showed that the application amount of organic fertilizer was increased , the structure of input energy optimized and micro environment of field promoted by alley cropping(Tang , 2003).

When vetiver in plot 2 and false indigo in plot 4 , field 1 , *Coronilla varia* in plot 1 and alfalfa in plot 3 , field 2 were employed as hedgerow crops , input labor energy of system was reduced significantly because these hedgerow crops had a strong root system and grew well under rough condition. Organic and inorganic energy of system in the plots with these hedgerow crops were reduced 20.6% – 30.0% and 40.5% – 41.0% , respectively , compared with that of the check plot. This alley cropping pays an important role on the farming in the mountainous and hilly area of Sichuan because of its less input and significant ecological functions.

Compared with traditional farming pattern , such as the check treatments of “ wheat – groundnut + sweet potato ” in field 1 and “ wheat – corn + sweet potato ” in field 2 and field 3 , the input inorganic energy of alley cropping was reduced significantly , decreasing by 30.0% – 41.0% . At present , irrational use of fertilizers and pesticides causes serious pollution and harms environment continuously (Guo *et al.* , 2003 ; Zhang *et al.* ,

1995). By optimizing farming pattern , the structure of input energy was changed and rational use of fertilizers and pesticides enhanced , resulting less chemicals input and less pollution on the environment .

2.3 Energy efficiency analysis of alley cropping

2.3.1 Conversion analysis of energy of alley cropping with different hedgerow crops

Utilization efficiency of solar energy was the basic characteristic in the energy flow system and key factor of energy efficiency. Because hedgerows could conserve the soil and increase water holding capacity of soil , they helped the main crops to use solar energy more effectively. Meanwhile , the canopy and root system of hedgerow crops were completely different from those of the main crops , alley cropping formed a system which utilized resources , like light , heat , water , fertilizer , etc. , more effectively in terms of time or space (Zou , 1990 ; Zhang & Huang , 1998). The results showed that in the rain-fed sloping lands of Sichuan hilly area , alley cropping could increase utilization efficiency of solar energy. Alley cropping with vetiver hedgerow , false indigo and pear plus day lily increased utilization efficiency of solar energy by 24.62% , 14.78% and 15.60% , respectively (Fig.4).

Fig.4 Energy conversion efficiency analysis

P : total output energy N_1 : output energy of crop N_2 : output energy of hedgerow T_1 : total input energy T_2 : input energy of crop T_3 : input energy of hedgerow

Agricultural production system was influenced by human activities greatly and it was the objective to achieve high benefit on the premise of harmless to the health of system. The results showed that when vetiver , false indigo , *Coronilla varia* and alfalfa were selected as hedgerow crops , they needed less input energy while achieved high-

er biological yield. So the output/input ratio (P/T_1) of energy of system was increased by 64.15% , 45.03% , 41.50% and 40.79% , respectively. Further analysis showed that these alley cropping patterns increased output/input (N_1/T_2) ratio of energy of the main crops by 40.93% , 8.21% , 39.38% and 42.91% , respective-

ly.

When Chinese date , pear and loquat were used as hedgerow crops , the output/input ratio(N_2/T_3) of energy of hedgerow system itself was reduced because of higher input energy(mainly organic fertilizer) for the growth of fruit trees and lower output of the young fruit trees , resulting in the decline of output/input ratio(P/T_1) of the whole systems by 9.7% , 19.52% and 26.76% , respectively. But the increase of input energy provided a good condition for the growth of the main crops , the output/input ratio(N_1/T_2) of energy of the main crop was increased greatly by 23.22% , 48.56% and 33.53% , respectively.

2.3.2 Organic and inorganic energy consumption analysis of alley cropping

The result(Fig. 5) of organic and inorganic energy consumed by unit output energy(M_1/P , M_2/P) showed that alley cropping with fruit tree hedgerow had higher organic energy consumption(M_1/P). Organic energy con-

sumption of alley cropping with Chinese date hedgerow of field 1 , pear plus day lily hedgerow and loquat plus day lily hedgerow of field 3 was increased 54.83% , 113.49% and 134.13% respectively compared with that of control treatment , while alley cropping with herbal hedgerow had lower organic energy consumption. Organic energy consumption of alley cropping with vetiver hedgerow and false indigo hedgerow of field 1 , *Coronilla varia* hedgerow and alfalfa hedgerow of field 2 was reduced 42.02% , 30.67% , 28.30% and 32.08% , respectively , compared with that of control treatment.

The inorganic energy consumption of all alley cropping treatments was decreased by 33.07% – 52.06% compared with that of control treatment. The result of regression and correlation analysis of energy consumption level(X) and input energy level(Y) showed that there was not significant regression and correlation relationship between inorganic energy consumption and total input energy , while other relationships listed below were significant.

Fig.5 Organic and inorganic energy consumption analysis of alley cropping
 M_1 , M_2 : See Fig. 1 P : See Fig. 4

$$Y_{\text{Total input energy}} = 9 \quad 032 \quad + \quad 171 \quad 657$$

$X_{\text{Organic energy consumption}}$
$$|t = 3.13| > t_{0.05} \text{ } p = 2.26 \text{ , } r = 0.721 \text{ } 4$$

$$Y_{\text{Total input organic energy}} = 10 \quad 137 \quad + \quad 169 \quad 402$$

$X_{\text{Organic energy consumption}}$
$$|t = 13.45| > t_{0.01} \text{ } p = 3.25 \text{ , } r = 0.721 \text{ } 4$$

$$Y_{\text{Total input inorganic energy}} = 13 \quad 841 \quad + \quad 125 \quad 964$$

$X_{\text{Inorganic energy consumption}}$
$$|t = 2.47| > t_{0.05} \text{ } p = 2.26 \text{ , } r = 0.636 \text{ } 4$$

In the farming system , more input did not always

mean more benefit. For instance , more fertilizer applied might result more losses and reduced utilization efficiency (Ju *et al.* , 2002). Because the relationships of energy consumption of unit output energy of alley cropping and input organic and inorganic energy were significantly based on the regression and correlation analysis , particularly the significant relationship between organic energy consumption and total input organic energy , energy consumption was the main issue concerned against input energy .

2.3.3 Input labor energy efficiency analysis of alley cropping

The level of labor productivity was determined by energy efficiency of system which influenced greatly the development and popularization of alley cropping. So how to increase the labor productivity was concerned widely. The

result(Table 2) showed that the input labor energy efficiency(P/L_1) of alley cropping was higher than that of the control treatment , particularly the input labor energy efficiency of the alley cropping with herbal hedgerows was increased by 67.88% – 102.32% .

Table 2 Input labor energy efficiency analysis of alley cropping

		I				II			III			
		1	2	CK	4	1	CK	3	1	2	CK	4
P/L_1	Ratio	15.03	19.18	9.48	17.67	26.43	15.10	25.35	25.11	19.26	15.90	18.07
	$\pm(\%)$	58.54	102.32	0	86.39	75.03	0	67.88	57.92	21.13	0	19.75
N_1/L_2	Ratio	13.18	13.87	9.48	12.56	23.80	15.10	23.42	25.32	26.53	15.90	23.84
	$\pm(\%)$	39.03	46.31	0	32.49	57.62	0	55.10	59.25	66.86	0	49.94
N_2/L_3	Ratio	25.46	133.02		127.32	85.48		68.86	22.77	7.58		7.97

L_1 :total input labor energy L_2 :input labor energy of crop L_3 :input labor energy of hedgerow The treatments of field 1 were 1 Chinese date hedgerow , 2 Vetiver hedgerow and 4 False indigo hedgerow ; the treatments of field 2 were 1 *Coronilla varia* hedgerow , and 3 Alfafa hedgerow ; the treatments of field 3 were 1 Chinese toon hedgerow , 2 Pear and day lily hedgerow and 4 Loquat and day lily hedgerow P, N_1, N_2 : See Fig. 4

After studying crop sub-system of alley cropping , it was found that input labor energy efficiency(N_1/L_2) of field 1 and field 2 with steeper slope was increased by 32.49% – 57.62% , while input labor energy efficiency (N_1/L_2) of field 3 with moderate slope steepness was increased by 49.94% – 66.86% . The difference of percentage did not mean better erosion control effect of hedgerows grown on moderate slope steepness , in contrast , the erosion control effect of hedgerows on steeper slope was better. The reason of higher input labor energy efficiency in the field with moderate slope steepness might be that the main crops used resources effectively. It resulted in much better growth (Zou , 1990 ; Zhang & Huang , 1998 ; Wu *et al.* , 1991).

Hedgerows , as sub-system of alley cropping , particularly vetiver , false indigo , *Coronilla varia* and alfalfa , had very high input labor energy efficiency (N_2/L_3) , reaching 133.02% , 127.32% , 85.48% and 68.86% , respectively. While sub-system formed by fruit tree hedgerow in field 3 had very low input labor energy efficiency(N_2/L_3) because of their higher input and lower output of fruit trees in their early stage of growth.

3 Discussions and Conclusions

After hedgerow was introduced into farming system to form alley cropping , the total output energy of unit area of sloping lands was increased. When the slope was steeper , the percentage of increase was higher and the output energy of hedgerow sub-system taken up higher proportion against total output energy.

The magnitude and structure of input energy of alley cropping was mainly influenced by hedgerow sub-system

instead of slope steepness. There was a great increase of total input energy and organic input energy caused by fruit tree hedgerow which was beneficial to optimize the structure of input energy and promote ecological system on sloping lands. The herbal hedgerow , with low input energy and wonderful erosion control ability , greatly lowered the input labor energy of whole system and played an important role in soil conservation in vast hilly and mountainous area of Sichuan. Alley cropping reduced input inorganic energy significantly resulting environment-friendly chemicals input compared with traditional farming system of wheat and corn intercropped with sweet potato.

The canopy and root system of hedgerow crops were completely different from those of the main crops. Alley cropping formed a system which utilized resources , like light , heat , water , fertilizer , etc. , more effectively in terms of space and time. So the utilization efficiency of solar energy and input labor energy efficiency were increased. In the alley cropping with herbal hedgerows , energy output/input ratio of the whole system was increased remarkably because of its lower energy input , lower organic and inorganic energy consumption and higher input labor energy efficiency. While in the alley cropping with fruit tree hedgerows , energy output/input ratio of the whole system was low because of its higher input and lower output of fruit trees in their early stage of growth.

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