The Input-output Status and Farmers' Willingness to Choose Ecological Operation of Hickory

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Abstract This study takes Lin'an City which early carries out the experiment of ecological operation of hickory as the study site. On the basis of the input-output data on hickory and farmers' land, we analyze the input-output status of hickory land which practises ecological operation, the operators' willingness to accept ecological operation and the influencing factors. The results show that in the short term, ecological operation of hickory will have a certain negative impact on the economic benefits; within the experimental area, the degree of operators' willingness to accept ecological operation of hickory is high, and the operators have a clear understanding of long-term comprehensive benefits which may be brought by ecological operation; the ecological experiment and demonstration of hickory have achieved certain results; family income level, characteristics of householders, education and training, and so on, are the main factors that affect the operators' willingness to choose ecological operation. Finally, for how to further improve the promotion efficiency of ecological operation of hickory, we put forth some constructive recommendations.

Key words Input and output, Willingness to choose, ecological operation, Hickory

1 Introduction

Hickory (*Carya cathayensis*), the unique economic tree species in the southern China, is mainly distributed in the Tianmu Mountain (northwestern Zhejiang and southern Anhui)[1]. Since the late 1990s, hickory has become an important source of income for farmers in the main producing areas. In some main producing areas of hickory, such as Lin'an and Chun'an, the share of hickory income in farmers' income is as high as 60% to 70%. Driven by economic interests, the hickory area is incessantly expanded, and the operation intensity of woodland is also increasingly enhanced. In order to increase yield, the operators often use considerable chemical fertilizers, pesticides, herbicides and other chemicals. More seriously, in order to facilitate the harvest, the operators will comprehensively clean up the vegetation under hickory tree, leading to decline in soil fertility, deterioration of soil erosion, increase in pests and diseases, and many other ecological problems, posing a serious threat to sustainable operation of hickory.

In view of this, at the beginning of the 21st century, the forestry scientific and technical personnel advanced the ecological operation model of hickory on the basis of the pilot study of a certain size. The ecological operation of hickory is the complex mode of operation with the sustainability, integrating biodiversity conservation, biological pest control, ecological restoration and other technologies, conducive to restoring and improving the forest productivity. The main measure is to restore the under-forest vegetation in the hickory woodland, and reduce the use of chemical fertilizers, pesticides and especially herbicides in the operating process of hickory[2-4]. Some preliminary studies have shown that the ecological operation of hickory can achieve good ecological benefits, but there are still few researches on the input-output status of ecological operation of hickory, the operators' willingness to accept ecological operation, and the operators' cognition of ecological operation. Therefore, this study takes Tuankou Town and Changhua Town in Lin'an City which early carried out the ecological operation of hickory as the object. On the basis of the input-output data on hickory and farmers' land, we conduct comparative analysis of input-output differences under ecological operation of hickory and non-ecological operation (traditional operation). Based on this, we analyze the input-output status of hickory land which practises ecological operation, the operators' willingness to accept ecological operation and the influencing factors, in order to provide a decision-making reference for formulating scientific, rational and effective outreach program of ecological operation of hickory, and also provide a reference for other practices of ecological operation of economic forest.

2 Overview of the study site and sample distribution

2.1 Overview of the study site This study takes Lin'an City which early carries out the experiment of ecological operation of hickory as the study site. According to statistics, in 2008, the total growing area of hickory in Lin'an City reached 30 600 hm^2, with yield of 11 900 t and total output value of 1.548 billion yuan; the hickory income accounted for 60% to 70% of farmers' income in the main producing areas. The hickory industry has become the leading industry for promoting farmers' income increase and enhancing economic development in rural areas of Lin'an City.

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However, excessive operation of hickory has caused serious ecological and environmental problems. To address these issues, under the joint efforts of the hickory research experts and local forestry department, the Lin'an government has promulgated a series of policy documents (such as *Pollution-free Hickory Cultivation Technique Rules*, and *Opinions on the Development of the Hickory Industry*), and in particular stressed that it is necessary to positively experiment on and promote the pattern of ecological operation of hickory. At present, Lin'an City has established 3 500 hm^2 of different types of ecological operation experimental bases of hickory in Changhua Town, Tuankou Town, and other towns. The main ecological operation patterns include "hickory + rape, oil-tea camellia", "hickory + Chinese milk vetch, trefoil, rye-grass", and "hickory + Adinandra millettii, Chinese torreya".

2.2 Sample distribution In order to obtain the data needed by the study, this study takes Tuankou Town and Changhua Town in Lin'an City which early carried out the ecological operation of hickory as the sample towns; selects 2 villages which early carried out the ecological operation of hickory from each sample town as the sample villages; randomly selects 8 farmers from each village, a total of 32 farmers, as the sampling survey farmers.

For each sample farmer, this study selects 3 hickory plots, a total of 96 plots. In view of the fluctuation in the hickory production, this study inquires in detail about the hickory input-output in the plot, the basic characteristics of the family, the basic characteristics of hickory operation plot, and willingness to choose ecological operation of hickory in 2009 and 2010. In addition, we also conduct questionnaire survey on the basic economic and social situation of sample villages and hickory operation. The specific sample distribution is shown in Table 1.

Table 1 Sample distribution

	Farmers		Plot	
	Amount	Proportion//%	Amount	Proportion//%
Changhua Town	16	50.00	48	50.00
Tuankou Town	16	50.00	48	50.00
Total	32	100.00	96	100.00

Data source: The survey data.

3 Comparative analysis of hickory input-output under different operating modes

The input-output difference in the hickory operation under different modes of operation is a major factor determining farmers' choice of operation mode. Based on the above-mentioned input-output data of hickory, this section will conduct comparative analysis of the input-output difference in the hickory operation under different modes of operation. The quality of different plots and tree age have a great impact on hickory input-output status, thus in order to make the analysis more comparable, this study chooses the plots of the same site quality and trees with the similar age for comparative analysis. Table 2 is the comparison of hickory input-output under different operating modes.

Table 2 Comparison of hickory input-output under different operating modes

	Ecological operation	Non-ecological operation
Total input//yuan · hm^2	15 982.55	13 371.91
Fertilizing, weeding labor//man-day · hm^2	30.41	16.77
Pesticide sprinkling labor//man-day · hm^2	6.96	15.49
Harvest labor//man-day · hm^2	34.20	36.70
Other labor (i)//man-day · hm^2	9.53	6.07
Total labor//man-day · hm^2	81.09	75.03
Total labor costs (ii)//man-day · hm^2	11 643.12	11 346.95
Fertilizer cost//yuan · hm^2	1 459.79	1 143.10
Among them: organic fertilizer, special bio-fertilizer//yuan · hm^2	951.51	452.26
Pesticides and herbicides cost//yuan · hm^2	76.07	399.72
Other costs (iii)//yuan · hm^2	2 803.57	482.14
Total costs of material input//yuan · hm^2	4 339.43	2 024.96
Total output//yuan · hm^2	49 063.35	52 480.53
Dry seed output//kg · hm^2	1 063.24	1 143.20
Dry seed income//yuan · hm^2	48 422.62	52 349.90
Other incomes (iii)//yuan · hm^2	640.73	130.63
Net profit//yuan · hm^2	33 080.80	39 108.62

Data source: The survey data.

Note: (i) Other labor mainly includes the woodland care, under-forest operation and under-forest grass growing. (ii) Due to the great difference in the labor unit price between hickory protection and picking, the total labor costs are calculated in accordance with the sample mean of 95.71 yuan · man-day^{-1} and 209.22 yuan · man-day^{-1}, respectively. (iii) Other costs mainly include under-forest operation costs and grass seed input costs. (iv) Other incomes are mainly the under-forest composite operating income.

According to Table 2, we can draw the following three conclusions:

(i) Overall, there are differences in the overall input-output level of ecological operation and non-ecological operation.

The dry seed yield per hectare under ecological operation is 1 063.24 kg, the total input cost is 15 982.55 yuan, and the net income is 33 080.80 yuan. The dry seed yield per hectare under non-ecological operation is 1 143.20 kg, the total input cost is 13 371.91 yuan, and the net income is 39 108.62 yuan. Compared with non-ecological operation, the yield per unit area under ecological operation declines by 79.96 kg and the yield decreases by 6.99%, but the total input per hectare is 2 610.63 yuan more than that under non-ecological operation, increasing by 19.52%; net income declines by 6 027.82 yuan, a drop of

15.41%.

(ii) There are great differences in labor input level and structure of ecological operation and non-ecological operation.

From the perspective of the total input of labor per hectare, ecological operation will be 6 man-days more than non-ecological operation, but there are great differences in the labor structure. In terms of weeding and fertilizing labor, ecological operation is 13.64 man-days more than non-ecological operation, which is related to the fact that ecological operation mainly uses manual weeding, applies more organic fertilizers and special bio-fertilizers[6]. In terms of pesticide sprinkling labor, ecological operation is 8.53 man-days less than non-ecological operation, which can in part indicates that ecological operation helps to reduce pests and diseases[7].

(iii) There are also great differences in material input costs of ecological operation and non-ecological operation.

In detail, in the ecological operation plot, the total material input cost per hectare is 4 339 yuan, 2.14 times that of non-ecological operation plot. In terms of the cost of under-forest grass growing and other operating input costs, the ecological operation plot will be 2 321.43 yuan more than the non-ecological operation plot, and the former is 5.81 times the latter. In terms of the fertilizer input costs, ecological operation will be 316.69 yuan more than non-ecological operation, and especially for the input costs of organic fertilizer and special bio-fertilizer, the former is 2.10 times the latter. In terms of the input costs of pesticide and herbicide, ecological operation is 323.65 yuan less than non-ecological operation.

4 Analysis of farmers' willingness to choose the ecological operation model and its influencing factors

The operators' awareness of the ecological operation pattern and their willingness to choose it, is a direct factor determining whether this operation model can be promoted. The above analysis shows that in the short term, the ecological operation pattern will have a certain degree of negative impact on the economic benefits of hickory operation, which may affect the operators' willingness to accept this operation model to some extent, thereby affecting the promotion of the ecological operation pattern of hickory.

However, it is important to note that in the short term, the ecological operation of hickory will have a negative impact on the economic benefits, but in the long term, after implementing the ecological operation, it will gradually restore and improve woodland production capacity, and ultimately achieve improvement in economic efficiency and the ecological environment. Of course, to achieve this goal, the forestry science and technology personnel need to carry out extensive publicity and education on the basis of experiment and demonstration, so that the operators of hickory fully understand the long-term comprehensive benefits may be brought by the ecological operation. Therefore, based on the above-mentioned comparative analysis of input and output, it is necessary to analyze the hickory operators' awareness of ecological operation and their willingness to accept it.

This section will be based on survey data, to conduct a brief analysis of the operators' awareness of ecological operation, their willingness to choose, and the influencing factors.

4.1 Farmers' willingness to choose the ecological operation model In the survey, we conduct direct inquiry about the operators' willingness to adopt the ecological operation pattern of hickory and the reasons, and what the operators' reply reflects is the operators' awareness and acceptance of the ecological operation pattern, but not the judgment made solely on the basis of short-term economic benefits. The results are shown in Table 3.

Table 3 Farmers' willingness to choose the ecological operation model and the reasons

	Proportion//%	The specific reasons	Mention number	Mention frequency//%
Willing	84.38	It can bring good economic benefits	22	81.48
		It can bring good ecological benefits	18	66.67
		The guidance of the technical department	5	18.52
		Other reasons	2	7.41
Reluctant	9.38	The yield is reduced	2	66.67
		The labor input is increased	1	33.33
		Other reasons	0	0.00
Uncertain	6.25	No time and vigor	2	100.00
		Other reasons	0	0.00

Data source: The survey data.

Table 3 reveals the following conclusions and implications:

(i) Overall, the operators' willingness to accept ecological operation of hickory in the ecological operation experimental area of hickory at present is high.

The data show that the proportion of farmers willing to carry out ecological operation is as high as 84.38%; the proportion of farmers not willing to carry out ecological operation is 9.38%; the proportion of farmers uncertain about whether they are willing to carry out ecological operation is 6.25%. This result seems to be inconsistent with the comparative analysis results of input and output.

The comparative analysis results show that the ecological operation will have some negative effects on the economic benefits of hickory operation, but why the operators would be willing to carry out ecological operation? This research suggests that this may be related to the fact that the operators surveyed are in the ecological operation demonstration area of hickory, and through several years of demonstration, promotion, and forestry science and technology personnel's extensive publicity, the operators have a clear understanding of the long-term com-

prehensive benefits possibly brought by the ecological operation. This can be reflected from the operators' reply of reasons why they are willing to carry out the ecological operation. 81.5% of the operators believe that the ecological operation can bring better economic benefits, and 66.7% of the operators believe that the ecological operation can bring better ecological benefits.

(ii) Although the demonstration of ecological operation of hickory has made certain achievements, there is still a need to further deepen publicity and education.

The survey data indicate that in the experimental area of hickory, the willingness of the hickory operators to accept the ecological operation of hickory is high, but it should be noted that there are still some deviations between the ecological operation of hickory understood by the operators of hickory, and the ecological operation required by the forestry science and technology personnel.

Specifically, the operators generally believe that growing under-forest vegetation (such as grass or shrub) in the hickory woodland is the ecological operation, and there is no strict limit on the use of chemical fertilizer, pesticide, herbicide, *etc.* Growing under-forest vegetation in the hickory woodland can improve the forest quality and reduce soil erosion to some extent, but the ecological operation in the strict sense needs to strictly limit the use of chemical fertilizer, pesticide, and especially herbicide.

Therefore, in the future demonstration and promotion, the forestry science and technology personnel should strengthen the publicity and education of ecological operation, so that the operators have a more comprehensive and accurate understanding of the ecological operation.

4.2 The main factors that affect farmers' willingness to choose The above analysis shows that the ecological operation has a certain negative impact on the short-term gains, but under the forestry science and technology personnel's support and publicity, the degree of operators' willingness to accept the ecological operation pattern has been relatively high; there are still about 16% of operators who are not willing to accept the ecological operation pattern or not certain about whether to choose ecological operation or not.

Thus, through the correlation analysis between the operators' willingness to choose and the operators' family characteristics, this section discusses the main factors determining the willingness to choose ecological operation of hickory except input and output (Table 4).

Table 4 The relationship between farmers' willingness to choose ecological operation and the main influencing factors

The main influencing factors		Ecological operation//%	Non-ecological operation//%
Per capita household income level//yuan	≤6 000	50.00	50.00
	6 000 – 12 000	77.78	22.22
	≥12 000	80.95	19.05
The share of hickory income in household income//%	≤50	82.35	17.65
	50 – 80	100.00	0.00
	≥80	64.71	35.29
Number of labor forces in the family	≤2	80.00	20.00
	3 – 4	68.42	31.58
	≥5	100.00	0.00
Age of householders//years	≤50	80.00	20.00
	50 – 60	75.00	25.00
	≥60	50.00	50.00
Educational level of householders//years	≤6	40.00	60.00
	6 – 9	62.50	37.50
	≥9	89.47	10.53
Whether the householders are village cadres	Yes	100.00	0.00
	No	60.00	40.00
Whether there are people in the family having received specialized agricultural technical training	Yes	91.67	8.33
	No	25.00	75.00

Data source: The survey data.

Table 4 shows the following aspects:

(i) The operators' willingness to choose ecological operation of hickory is positively correlated with the number of family labor, household per capita income level, and farmers' educational level. The above input-output comparative analysis shows that the ecological operation requires more labor and material inputs, and for the operators with more labor forces and high family income level, the input constraint of these elements is relatively small, therefore, the willingness to carry out ecological operation is relatively high, which is consistent with the intuitive judgment. In addition, for the people with high educational level, they will probably accept the new things, and their willingness to carry out ecological operation is relatively strong[10].

(ii) The operators' willingness to accept ecological operation of hickory is negatively correlated with householders' age. The reason is that the younger the operators, the stronger the ability to understand and accept new things, thus the acceptance degree will be relatively higher. This conclusion is also consistent with the study conclusions of Shen Yueqin, *et al.*[11].

(iii) The village cadres and farmers who have received specialized agricultural technical training will have stronger willingness to choose ecological operation than non-village cadres

and farmers who have not received specialized agricultural technical training, indicating that the cadres and technical training may be the ideal object and means for carrying out agricultural technology extension.

(iv) There is no clear linear relationship between the share of hickory income in household income and farmers' willingness to choose ecological operation of hickory. The possible reason is that for the farmers with small share of hickory income, whether to implement ecological operation has no significant impact on their household income.

5 Conclusions and recommendations

This study takes Tuankou Town and Changhua Town in Lin'an City which early carried out the ecological operation of hickory as the study site. On the basis of the input-output data on hickory and farmers' land, we analyze the input-output status of hickory land which practises ecological operation, the operators' willingness to accept ecological operation and the influencing factors.

(i) In the short term, the ecological operation of hickory will have some negative impact on the economic benefits. Compared with non-ecological operation, the yield per unit area under ecological operation declines by 79.96 kg and the yield decreases by 6.99%, but the total input per hectare is 2 610.63 yuan more than that under non-ecological operation, increasing by 19.52%; net income declines by 6 027.82 yuan, a drop of 15.41%.

(ii) At present, the operators' willingness to accept ecological operation of hickory in the experimental area is high, indicating that the operators of hickory have had a more comprehensive understanding of the long-term comprehensive benefits that may be brought by the ecological operation, and the demonstration and promotion work of ecological operation of hickory has already achieved some success, but there are still some deviations in farmers' ecological operation of hickory.

(iii) The level of per capita household income, the cadre family background, agricultural technology training, farmers' educational level, and the number of family labor, have a positive effect on farmers' adoption of ecological operation pattern; householders' age has a negative effect on farmers' adoption of ecological operation pattern; the impact of share of hickory income in household income on farmers' adoption of ecological operation pattern is not clear.

Based on the above analysis, we put forward the following recommendations:

(i) Ecological operation of hickory is an effective means to promote sustainable development of hickory. In the short term, ecological operation will have some negative impact on the economic benefits of the operators, but in the long term, after carrying out the ecological operation, the woodland production capacity will be gradually restored and improved, ultimately achieving improvement in economic efficiency and the ecological environment. Therefore, the ecological operation of hickory has good application prospects, and it can provide a reference for the ecological operation of other economic forests.

(ii) The government should strengthen study, demonstration and publicity support on ecological operation, to make the operators have a more comprehensive and accurate understanding of ecological operation. At the same time, given that the ecological operation will have some negative impact on farmers' economic benefits in the short term, it is necessary to compensate for the farmers participating in ecological operation by the way of fertilizer or grass seed subsidies, to promote farmers' enthusiasm for participating in ecological operation.

(iii) The ecological operation of hickory should be promoted for the targeted group. There are great differences in different farmers' willingness to accept ecological operation. At the initial stage of promoting ecological operation pattern, the village cadres and the highly educated farmers who have strong ability to accept new things should be selected as the demonstration households, and the demonstration effect can drive the surrounding farmers to participate in the ecological operation of hickory.

Finally, it should be noted that the ecological operation of hickory is still in the small-scale pilot study stage, and large-scale research samples have not yet been obtained at present, so there is a need to conduct further research on its comprehensive benefits (especially the economic benefits and ecological benefits) in the future.

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